ENVIRONMENTAL STATEMENT
VOLUME 4 – A6.1 NOISE AND VIBRATION – DETAILED ASSESSMENT
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A6.1 NOISE AND VIBRATION – DETAILED ASSESSMENT

6.1 INTRODUCTION

This Appendix describes the detailed assessment of noise and vibration impacts resulting from the construction and operation of the proposed airport and supporting infrastructure. Potential noise and vibration impacts on wildlife on the Island are covered in Terrestrial Ecology and Nature Conservation Chapter 9.

6.1.1 Noise Perception and Terminology

Between the quietest audible sound and the loudest tolerable sound, there is a million to one ratio in sound pressure (measured in pascals, Pa). Due to this wide range, a noise level scale based on logarithms is used in noise measurement called the decibel (dB) scale. Audibility of sound covers a range of approximately 0 to 140 dB.

The human ear system does not respond uniformly to sound across the detectable frequency range and consequently instrumentation used to measure noise is weighted to represent the performance of the ear. This is known as the 'A weighting' and annotated as dB(A).

Table 6.1 lists the sound pressure level in dB(A) for common situations.

Table 6.1 Noise Levels for Common Situations

Typical Noise Level, dB(A)	Example
0	Threshold of hearing
30	Rural area at night, still air
40	Public library Refrigerator humming at 2 metres (m)
50	Quiet office, no machinery Boiling kettle at 0.5m
60	Normal conversation
70	Telephone ringing at 2m Vacuum cleaner at 3m
80	General factory noise level
90	Heavy goods vehicle from pavement Powered lawnmower at operator's ear
100	Pneumatic drill at 5m
120	Discotheque - 1m in front of loudspeaker
140	Threshold of pain

The noise level at a measurement point is rarely steady, even in rural areas, and varies over a range dependent upon the effects of local noise sources. Close to a busy motorway, the noise level may vary over a range of only 5dB(A), whereas in a suburban area this may increase up to 40dB(A) and more due to the multitude of noise sources in such areas (cars, dogs, aircraft etc.) and their variable operation. Furthermore, the range of night-time noise levels will often be smaller and the levels significantly reduced compared to daytime levels. When considering environmental noise, it is necessary to consider how to quantify the existing noise (the ambient noise) to account for these second to second variations.

A parameter that is widely accepted as the underlying background noise level is the L_{A90}. This is the noise level exceeded for 90% of the measurement period and generally reflects the noise level in the lulls between individual noise events. Over a 1-hour period, the L_{A90} will be the noise level exceeded for 54 minutes.

The equivalent continuous A-weighted sound pressure level, L_{Aeq}, is the single number that represents the total sound energy measured over that period. L_{Aeq} is the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period. It is commonly used to express the energy level from individual sources that vary in level over their operational cycle.

The $L_{Amax,fast}$ measurement parameter is the maximum instantaneous sound pressure level attained during the measurement period, measured on the ‘fast’ response setting of the sound level meter. It is most commonly used to assess the potential for night-time sleep disturbance.

Time weighting determines how quickly the sound level meter responds to changes in noise level. The ‘fast’ time weighting averages the measured level every eighth of a second, whereas the ‘slow’ weighting averages every 1 second. The ‘fast’ time weighting most closely follows the response of the human ear to sound level changes and is most commonly specified for environmental noise measurement purposes (including the L_{A90} and L_{Amax} statistical parameters).

Most environmental noise measurements and assessments are undertaken in ‘free-field’ conditions, away from any existing reflecting surfaces (other than the ground). However, it is sometimes necessary to consider noise levels immediately external to a façade when considering the impact on residents inside properties and this normally requires the addition of up to 3 dB(A) to the predicted (or measured) free-field level due to noise reflection from the façade.

Human subjects, under laboratory conditions, are generally only capable of noticing changes in steady levels of no less than 3 dB(A). It is generally accepted that a change of 10 dB(A) in an overall, steady noise level is perceived to the human ear as a doubling (or halving) of the noise level. (These findings do not necessarily apply to transient, non-steady or intermittent noise sources).

6.2 ASSESSMENT METHODOLOGY

6.2.1 Legislation and Policy Context

St Helena has little specific Island legislation or guidance on the assessment and control of noise. Consequently, in the absence of such local legislation or guidance, United Kingdom (UK) standards and guidelines will be applied to the extent possible.

Whilst UK research and studies may not be entirely representative of demographic, sociographic or even geographic conditions on St Helena, any differences in relation to similar low population density environments in the UK are likely to be marginal.

6.2.1.1 General Development Planning

UK Planning Policy Guidance (UK PPG) 24 'Planning and Noise' (UK Department of Environment (DoE), 1994) was issued to:

'…provide advice on how the planning system can be used to minimise the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business … It outlines some of the main considerations which local planning authorities should take into account in drawing up development plan policies and when determining planning applications for development which will either generate noise or be exposed to existing noise sources'

Paragraph 12 of Annex 3 in UK PPG 24 states that forecast noise contours must be prepared or revised

'…where a major aerodrome is the subject of a proposal which will affect its capacity…' in order that the resulting noise climate can be estimated.'

The appropriate assessment routines applicable to this development are discussed in the following sections.

6.2.1.2 World Health Organisation's (WHO) Daytime Noise Levels

The World Health Organisation's (WHO) 'Guidelines for Community Noise' (WHO, 1999) report for external environmental noise levels that;

'Annoyance responses
During the daytime, few people are seriously annoyed by activities with L_{Aeq} levels below 55 dB; or moderately annoyed with L_{Aeq} levels below 50 dB. … '

Table 4.1 of the WHO guidelines recommends environmental daytime and evening limits of 55 dB L_{Aeq} or less over the 16 hour daytime period (07.00hrs-23.00hrs) *'to avoid minimal serious annoyance'*, and 50 dB L_{Aeq} *'to avoid minimal moderate annoyance'.*

6.2.1.3 Construction Noise Policy

In the UK, there are no statutory noise limits for construction activities. Criteria commonly applied to civil engineering contracts are shown in Table 6.2.

Table 6.2 Criteria for Evaluating the Impacts of Noise during Construction

Period	**Day $L_{Aeq,11hour}$ (0700hrs-1800hrs)**	**Evening $L_{Aeq,5hour}$ (1800hrs-2300hrs)**	**Night $L_{Aeq,8hour}$ (2300hrs-0700hrs)**
Noise level limit, dB	75	60	45

Support for the above criteria is found in UK DoE Advisory Leaflet (AL72) (DoE, 1976), which is based on the recommendations of the Wilson Report (Her Majesty's Stationery Office (HMSO), 1963), and gives advice as to levels of construction site noise at residential premises. Consequently, a construction noise level criterion of $L_{Aeq,11hour}$ (0700 hours (hrs) to 1800 hrs) 75 dB has been adopted for the purpose of this assessment.

In order to determine noise impacts during the construction phase, noise level predictions have been carried out in accordance with the methodology set out in British Standard (BS) 5228-1: 1997 (British Standards Institution (BSI), 1997). The predicted façade levels have then been compared with the 75dB $L_{Aeq,10hour}$ noise criterion considered above, prior to making recommendations for noise mitigation.

Using the methodology detailed in BS 5228-1: 1997 (BSI, 1997) and recent measured sound emission data (UK Department for Environment Food and Rural Affairs (Defra), 2005 & 2006), the noise levels generated by construction vehicles on the haul roads have been predicted, thus:

$$L_{Aeq,1hour} = L_{WA} - 33 + 10\log_{10} Q - 10\log_{10} V - 10\log - 10\log_{10} d$$

Where:

- L_{WA} is the sound power level of the plant (in dB);
- Q is the number of vehicles per hour;
- V is the average vehicle speed (in Kilometre per hour (km/h))
- d is the distance of the receiving position from the centre of the haul road (in m)

Predicted noise levels have then been assessed against published annoyance criteria provided by the WHO and in the Design Manual for Roads and Bridges (DMRB) (UK Department of Transport (DoT), 1994).

Minerals Policy Statement (MPS) 2 Annex 2: Noise (Defra, 2005) provides advice on noise suitable noise mitigation techniques. The advice provided is directed at Minerals Planning Authorities applying for a mineral extraction licence. The document recommends that noise impact assessments are carried out in accordance with BS 4142:1997 (BSI, 1997) and BS5228-1: 1997 (BSI, 1997).

6.2.1.4 Construction Vibration Policy

Construction associated with vibration can cause disturbance to the occupiers of affected buildings and high levels of vibration can cause damage to buildings. For people within affected buildings, BS 6472:1992 Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hertz (Hz) to 80 Hz) (BSI, 1992) sets out acceptable magnitudes of vibration for both day time and night time in terms of Vibration Dose Values (VDV) or estimated Vibration Dose Values (eVDV). However, measurement and calculation of VDV or eVDV is a complex and time-consuming process, and the measurement should be carried out inside an affected dwelling. Consequently, it can often not be practicable to use the VDV and eVDV indices to control construction vibration impacts where access to an affected dwelling is not available, or when the vibration will have ceased before any results of monitoring are available and subsequently controls implemented if exceedance of limits is detected. As a result, it is common that disturbance due to vibration from construction activity is assessed using the Peak Particle Velocity (PPV) index as this can be relatively easily measured in real time, outside an affected dwelling with adequate correlation with the impact on occupiers of the building.

There are two sources of guidance for the effects of vibration on buildings:

- BS 5228-4: 1992 (BSI, 1992) provides guidance on damage in relation to vibration from piling; and;
- BS 7385-2: 1993 (BSI, 1993) provides guidance on acceptable values of transient vibration for avoidance of cosmetic damage to buildings.

Human Response to Vibration

It is not uncommon for vibration complaints to be made when in fact the culprit of the perceived vibration is very low frequency noise from 40 Hz to below 20 Hz (infrasound – inaudible to most people). Conversely vibration, usually low frequency, can be transmitted through buildings and then re-radiated as noise, and be felt and heard in occupied spaces. In this case it is proposed to breakthrough structural elements that form part of a building that will be occupied during the work. In these circumstances it is likely that not only will vibration be transmitted to and felt in occupied parts of the same building, but also re-radiate as noise and be heard as well.

The most frequently used standard for the assessment of the human response to environmental vibration in the UK is BS 6472:1992 "Evaluation of human exposure to vibration in buildings [1 Hz to 80 Hz]" (BSI, 1992).

BS 6472 (BSI, 1992) addresses subjective response and suggests the use of either VDV or PPV as appropriate. BS 6472 (BSI, 1992) characterises vibration as:

- Impulsive;
- Continuous; or
- Intermittent.

Demolition and construction generally give rise to impulsive and intermittent vibration. In such circumstances, it is necessary to be able to quickly compare the levels against simple criteria which give an immediate evaluation of the likelihood of a problem without recourse to complex post-processing of results. Under these conditions, criteria based on PPVs are more appropriate than criteria based on VDVs or eVDVs.

BS 6472 (BSI, 1992) gives frequency dependent 'base curves' for vertical and horizontal root mean squared (rms) acceleration and peak velocity. Table 5 in Appendix A of BS 6472 (BSI, 1992) suggests that vibration levels 2 – 4 times higher than the base curve correspond to a 'satisfactory magnitude of building vibration' for continuous daytime vibration in dwellings. The manner in which this can be applied to intermittent vibration is demonstrated by Table 7 in Appendix A of BS 6472 (BSI, 1992) which advises that if daytime 16 hour VDVs are:

- 0.2 – 0.4 $ms^{-1.75}$ there is a low probability of adverse comment;
- 0.4 – 0.8 $ms^{-1.75}$ adverse comment is possible; and
- 0.8 – 1.6 $ms^{-1.75}$ adverse comment is probable.

There are two important implicit assumptions about the subjective response to vibration which are incorporated in the VDV criteria in BS 6472 (BSI, 1992), i.e. that:

- a doubling of vibration level (i.e. applying a factor of 2 to the acceleration or velocity curves) gives rise to a doubling of response; and
- the duration of vibration is relatively unimportant (the 4th root duration dependency implicit in the VDV means that a 16 fold increase in the duration of vibration is needed to double the community response).

Unfortunately BS 6472 (BSI, 1992) gives no guidance as to what is an acceptable level of vibration disturbance; for example, should the aim be for "no", "low", "possible" or "probable" adverse comment? Under which conditions and at what times or durations?

The Association of Noise Consultants (ANC) have also published a guide to good practice (ANC, 2001) in vibration measurement and analysis, and following this guidance helps to reduce the effects of varying methodology or bad practice giving rise to different assessments of fundamentally the same vibration.

In regard to demolition and construction works it is generally necessary to be able to quickly compare measured vibration levels against simple criteria which give an immediate evaluation of the likelihood of a problem without recourse to complex post-processing of results. Under these conditions, assessment criteria based on PPVs are more appropriate than criteria based on VDVs or eVDVs, which are complex and more time consuming to measure and evaluate.

The PPV Action Levels in Table 6.3 below, which are based upon multiples of the vertical velocity base curve from BS 6472 (BSI, 1992), have been reported as being successfully applied to a number of vibration generating projects taking place in relatively close proximity to a mixture of commercial and residential premises. The illustrative notes on community response are offered purely on the basis of experience of several different projects and are potentially helpful because they relate to the response of groups of people who are going about their normal daily business at home or at work rather than the results of laboratory experiments.

Table 6.3 Action Levels for Human Subjective Response to Vibration in Buildings from Construction and Demolition Works

PPV in millimetres per second (mm/s) Measured at Occupied Buildings	Multiplier for BS 6472 Base Curve	Descriptor	Recommended Action	Illustrative Notes on Community Response when Receptors are Normally Occupied
up to 0.56	<4x	Not Significant	None beyond the normal level of community liaison carried out as part of the control plan.	Above about 0.3 mm/s receptors sometimes perceive vibration.
> 0.56 – 1.12	>4x – 8x	Minor	Site Team Informed. Neighbour Liaison Carried Out Specific to the Vibration-Causing Activity.	Receptors generally perceive events above about 0.5mm/s.
> 1.12 – 2.24	>8x – 16x	Moderate	Site Team Informed Neighbour Liaison Carried Out Specific to the Vibration-Causing Activity. Alternative Techniques Considered	At these levels occupants of offices, homes, shops etc. spontaneously make complaints.
> 2.24 – 4.48	>16x – 32x	Substantial	Site Team Informed Neighbour Liaison Carried Out Specific to the Vibration-Causing Activity. Alternative Techniques Considered Permanent Vibration Monitoring Equipment installed if it is likely that levels will regularly exceed 2.24 mm/s	Use of offices, shops, homes etc. is disrupted by repeated events of this level of magnitude.
> 4.48	>32x	Severe	Halt Operation which is Source of Vibration Site Team Informed Neighbour Liaison Carried Out Specific to the Vibration-Causing Activity. Alternative Techniques Considered and liabilities/risks assessed Permanent Vibration Monitoring Equipment Installed	Receptors very concerned about the danger of structural damage and potential resultant hazard. Offices, shops and homes unlikely to remain occupied when repeatedly subject to vibration above

The above matrix can be further simplified to give more easily implemented control limits as follows:

Table 6.4 Guideline Vibration Limits for Occupied Buildings

Type of Building	Vibration PPV (mm/s) 1 to 100 Hz
Any permanently occupied residential building, medical facility or school	1.0
Any occupied hotel or commercial/industrial building	3.0

Vibration Effects on Buildings

Buildings and structures are fairly resilient to vibration; therefore real damage to buildings is rare, although possible; cosmetic damage such as cracking is much more likely than damage to load bearing or structural elements.

Vibration propagation through a building usually results in power losses at each change in the transmission substrate i.e. from ground to foundation to walls to floors etc. However, vibration levels can increase with building height depending on the impedance of the building element. This is because even though vibration power levels are lower at first floor and higher compared to foundation level; the vibration amplitude can be higher at first floor and higher because the upper parts of a building tend to have lower impedance than much heavier and relatively massive concrete foundation slabs and the surrounding ground.

There are two current British Standards, BS 7385: Part 2 (BSI, 1993) and BS 5228: Part 4 (BSI, 1992) (which addresses vibration from piling specifically), which give guide limits for building damage from vibration. BS 7385: Part 1 (BSI, 1990) defines the following different classes of damage:

- Cosmetic – formation or extension of hairline cracks in plaster or mortar;
- Minor – formation of large cracks or loosening and falling of plaster or formation of cracks through bricks or blocks; and
- Major – damage to structural elements of the building.

BS 7385: Part 2: 1993 "Evaluation and measurement for vibration in buildings" (BSI, 1993) gives guidance on the levels of vibration above which building structures could be damaged. The standard states that there is a major difference between the sensitivity of people in feeling vibration and the onset of levels of vibration which damage the structure. Furthermore it states that cracking commonly occurs in buildings whether they are exposed to vibration or not.

It is worth noting that the preferred vibration descriptors used in BS 6472 (BSI, 1992) (eVDV and VDV) and BS 7385 (BSI, 1990, 1993) (PPV) are different, making direct links between human and building response to vibration complex and difficult to articulate.

In order to assess the impacts of vibration appropriate criteria are necessary. In the context of this project three main areas of concern that such criteria need to address to be addressed are:

- Subjective response i.e. effects on people;
- Potential effects on buildings; and
- Potential effects on computers and other equipment which may be sensitive to excessive levels of vibration.

The introduction of BS 7385: Part 2 (BSI, 1993) states that the guidance contained within it was developed from an extensive review of UK data, relevant national and international documents and other published data. BS 7385: Part 2 (BSI, 1993) advises that the assertion that the probability of damage tends to zero at vibration levels up to 12.5 mm/s is not inconsistent with an extensive review of case history information available in the UK. More formally, BS 7385: Part 2 (BSI, 1993) gives vibration guide values (the maximum of three orthogonal components of velocity measured at the base of the affected building) which correspond to the levels at which there is a minimal risk of cosmetic damage. These are summarised in Table 6.5.

Table 6.5 Vibration Limits for Cosmetic Building Damage from BS 7385

Building Type	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Un-reinforced or light framed structures. Residential or light commercial type 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: Values refer to vibration measured at the base or foundation of the building

BS 7385: Part 2 (BSI, 1993) also advises that at frequencies below 4 Hz, there is a minimal risk of cosmetic damage at a displacement of 0.6 millimetres (mm).

Additionally BS 5228: Part 4 (BSI, 1992) also gives vibration limits in terms of the maximum of three orthogonal components of PPV. The limits are therefore directly numerically comparable to the criteria given in BS 7385: Part 2 (BSI, 1993). BS 5228: Part 4 (BSI, 1992) gives what are described as 'conservative' limits below which minor damage is unlikely to occur. These are summarised here in Table 6.6.

Table 6.6 Vibration Limits for Cosmetic Building Damage from BS 5228

Building Type	Limits for Transient Vibration			Limits for Continuous Vibration		
	< 10 Hz	10 – 50 Hz	> 50 Hz	< 10 Hz	10 – 50 Hz	> 50 Hz
Residential in Good Repair	5	10	20	2.5	5	10
Residential with Significant Structural Defects	2.5	5	10	1.25	2.5	5
Industrial/Commercial (light and flexible structure)	10	20	40	5	10	20
Industrial/Commercial (heavy and stiff structure)	15	30	60	7.5	15	30

The limits in BS 7385: Part 2 (BSI, 1993) are higher than those from BS 5228: Part 4 (BSI, 1992). BS 7385: Part 2 (BSI, 1993) specifically states that national standards (which would presumably have included BS 5228: Part 4 (BSI, 1992) which was published earlier) were reviewed. However, BS 5228: Part 4 (BSI, 1992) is not superseded by BS 7385: Part 2(BSI, 1993), so there are two current and contradictory standards in place.

Each project must be considered on its own merits, taking into account the specific activities that will be carried out and the prevailing site conditions. As a general guide, however, it is recommended that that continuous vibration monitoring and building condition monitoring should take place for buildings where:

- It is estimated that vibration levels will be 2.25 mm/s or more;
- Adjacent buildings are attached to the site where major redevelopment works will take place; and
- Potentially structurally unsound buildings are located within 50 m, for major redevelopment works.

For potentially affected buildings in good condition, the 12.5 mm/s figure from BS 7385: Part 2 (BSI, 1993) can be used as a general indicator of whether effects on buildings are likely, providing a very high proportion of low frequency components (less than 4 Hz) are unlikely to arise.

Potential Effects on Computers etc.

BS 5228: Part 4 (BSI, 1992) does contain specific criteria for computer installations and telephone exchanges. Reference is made to a study which resulted in the adoption of a 5 mm/s peak velocity for intermittent vibration affecting a telephone exchange.

With regard to computers, BS 5228: Part 4 (BSI, 1992) quotes a manufacturer's specification of 50 mm/s at 8 Hz and 10 mm/s at 40 Hz for intermittent vibration and notes that allowable thresholds for continuous vibration are set at about 40% of those for intermittent vibration. Based on these figures, a limit of 4 mm/s has been applied for computer installations (to cover both continuous and intermittent vibration) and found to be conservative.

Control Limits for this Project

Table 6.7 below brings together the various sources of guidance on vibration criteria discussed above to form a set of proposed control limits and associated actions for this project, as follows:

Table 6.7 Vibration Control Limits for Protection of Occupiers

Period	Building/Location	Criterion	Purpose
Daytime (0700hrs – 2300hrs)	Inside dwellings Outside dwellings	0.4 $m/s^{1.75}$ eVDV or 1.5 mm/s PPV	Annoyance threshold
Night-time (2300hrs – 0700hrs)	Inside dwellings Outside dwellings	0.13 $m/s^{1.75}$ eVDV or 0.5 mm/s	Annoyance threshold

NB Vibration should be measured at floor level in the nearest persistently occupied space to the works

Table 6.8 Vibration Control Limits for Protection of Buildings and Structures

Building Type	Limits2 for Transient Vibration (PPV mm/s)			Limits2 for Continuous Vibration (PPV mm/s)		
	< 10 Hz	10 – 50 Hz	> 50 Hz	< 10 Hz	10 – 50 Hz	> 50 Hz
Industrial/Commercial (light and flexible structure)1	10	20	40	5	10	20
Industrial/Commercial (heavy and stiff structure)1	15	30	60	7.5	15	30

Note1: Values refer to vibration measured on the part of the structure being worked on at the point it connects to another part of the structure.

Note 2: These limits are intended to restrict the occurrence of "cosmetic" damage e.g. minor cracking, substantive structural damage is not expected at these levels of vibration.

The above guidance can be further simplified to a set of working vibration limits as shown in Table 6.9 below

Table 6.9 Vibration Control Limits for Protection of Persons and Buildings and Structures during works

PPV (mm/s)	Limit Value	Action
<1.5 day <0.5 night	Manage subjective response e.g. notify occupiers of building of commencement of works	Monitor and record vibration levels
7.5	Visually inspect during progress of works to check for damage	Monitor and record vibration levels
15	Stop works	

6.2.1.5 Blasting

To provide suitable rock material for the construction of the Rupert's Bay Wharf, blasting will be undertaken within the temporary quarry in Rupert's Valley. Blasting could also be required during the limited degree of rock dredging that may be undertaken at the proposed wharf site. These operations have the potential to cause disturbance due to noise and vibration. BS 5228:1997 Part 5 (BSI, 1997) provides guidance on controlling vibration and noise from blasting operations as follows:

BS B5228:1997 Part 5 – Annex B: Blasting Vibration Criteria
BS 7385-1: 1990 (BSI, 1990) gives information on the methodology for measurement, data analysis, reporting and building classification.

BS 7385-2: 1993 (BSI, 1993) gives guidance on the assessment of the possibility of vibration-induced damage in buildings due to a variety of sources. This guidance indicates that the lowest value for the possibility of cosmetic damage from transient vibration is 15 mm/s.

BS 6472: 1992 (BSI, 1992) provides guidance on human response to vibration. Tentative guidance is given on the magnitudes of vibration at which adverse comment may begin to arise. Annex C relates to blasting and advice is given on vibration measurement, factors which influence human response and satisfactory vibration magnitudes. A satisfactory magnitude of 8.5 mm/s for 90% of all blasts is quoted in Annex B with up to three blasts per day.

Annex A of Minerals Planning Guidance (MPG) Note 9 (DoE, 1992) and SOEnD Circular 26/1992 (SOEnD, 1992) give illustrative guides to the conditions. These state that:

“ground vibration as a result of blasting operations shall not exceed a peak particle velocity of [6 mm/s][10 mm/sec] in 95 % of all blasts measured over any period of [six months] and no individual blast shall exceed a peak particle velocity of [12 mm/s] as measured at vibration sensitive buildings. The measurement to be the maximum of three mutually perpendicular directions taken at the ground surface.”

This indicates that the statistical limit should be chosen, for example, between 6 mm/s and 10 mm/s and that the maximum value should not normally exceed 12 mm/s.

NOTE. Building Research Establishment (BRE) Digest 403 (BRE, 1995) discusses the issue and refers to the above standards.

BS B5228:1997 Part 5 – Annex C: Blasting Air overpressure Noise Criteria
With regard to airborne noise from blasting BS 5228 Part 5 (BSI, 1997) notes that:

“Whenever blasting is carried out energy is transmitted from the blast site in the form of airborne pressure waves. These pressure waves comprise energy over a wide range of frequencies, some of which are higher than 20 Hz and therefore perceptible as sound, whereas the majority are below 20 Hz and hence inaudible, but can be sensed as concussion. It is the combination of the sound and concussion that is known as air overpressure“.

As the airborne pressure waves pass any single point the pressure of the air rises rapidly to a value above atmospheric pressure, falls to below atmospheric pressure, then returns to normal pressure after a series of oscillations. The maximum value above atmospheric pressure is known as peak air overpressure and is measured in pressure terms and generally expressed in linear decibels (dB (lin)). Routine blasting can regularly generate air overpressure levels at adjacent premises of around 120 dB (lin). This level corresponds to an excess air pressure which is equivalent to that of a steady wind velocity of 5 metres per second (ms^{-1}) (Beaufort force 3, gentle breeze) and is likely to be above the threshold of perception. Windows are generally the weakest parts of a structure and research by the United States Bureau of Mines (Siskind, D.E. et al., 1980) has shown that a poorly mounted window that is pre-stressed may crack at 150 dB (lin), with most windows cracking at around 170 dB (lin), whereas structural damage would not be expected at levels below 180 dB (lin).

Blasting as part of the rock dredging would most likely be carried out under cover of water at high tide, so as to minimise dispersion of debris. Consequently, air over pressure and noise levels would be likely to be reduced compared to conditions where there is no water cover. In the light of the guidance from BS 5228:1997 part 5 (BSI, 1997), the criteria for vibration and airborne noise and overpressure as described above would apply to any blasting operations in place of the criteria described in Table 6.3.

Quarrying Operations
BS 5228-1: 1997 (BSI, 1997) gives general advice on controlling noise from construction plant used on quarries and provides a method of predicting noise impact at local receptors. This method involves the selection of appropriate plant and calculation of noise levels at sensitive receivers, taking account of distance and typical operating times. Defra have recently (Defra, 2005 & 2006) published up to date plant noise emission values in light of engineering advances since the initial publication in 1977. These data include plant associated with opencast mineral workings. MPS 2 Annex 2: Noise (Defra, 2005), provides advice on suitable noise mitigation techniques.

With specific regard to blasting operations MPG 9 Note 2: Applications, Permissions and Condition (1992) states:

"Blasting often gives rise to public concern and it is desirable to impose conditions to regulate the time when blasting is to be permitted (or, in certain circumstances to prevent it altogether), to ensure adequate arrangements are made for public warning and to set limits on ground vibration and air over pressure which can be measured. Conditions prohibiting secondary blasting, or specifying the alignment of the quarry face, may also sometimes be justified".'

6.2.1.6 Airport Operational Noise Policies

Noise from airports can be categorised as being due to either groundside or airside operations. Most airport noise pollution problems are concerned with airside operations in general and take-off and landing operations in particular.

Airborne Aircraft Noise
Take-off commences with engines running at or near maximum thrust before brakes are released. There is a steep initial climb with landing gear being retracted, after which there is a less steep climb with engines throttled back to reduce noise emission. Aircraft are required to adhere to specific minimum noise routes, avoiding areas of human population, as they climb to cruising altitude. Examples would be routes over estuaries, lakes, coastlines and agricultural land. Since take-off noise exposure depends upon aircraft

weight, a large part of which is aviation fuel, some airports operate maximum on-stop flight limits on carriers.

Landing is generally a far less noise generating activity. Airports operate a defined 3° glide-slope, with radio based systems to keep aircraft accurately on line. Air turbulence at the lowered undercarriage, open undercarriage bays and the raised wing flaps is a significant noise source on the approach. However, if the line of approach needs correcting, the use of engine thrust produces high sound levels at the ground. Most airports discourage, sometimes with financial penalties, the use of reverse-thrust braking once the aircraft touches the runway; particularly at night. Again aircraft are required to adhere to specific minimum noise routes of preferred noise routes (PNR) on their approach to the glide-slope.

Groundside Noise

There is no definitive agreement on the method of assessment for ground noise. Various methods have been adopted in the past, and these have lead to assessment of ground noise in terms of the equivalent continuous sound level L_{Aeq}.

The airside operations which give rise to ground noise include:

- Taxiing
- Engine running on the terminal apron
- Manoeuvring on the apron and taxiways
- Auxiliary power units
- Ground support vehicles
- Road Traffic Noise

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

Individuals vary widely in their response to traffic noise, although the average or community response from a large number of people to the same level of traffic noise is fairly stable.

Consequently, a community average degree of annoyance can be related to the $L_{A10,18h}$ traffic noise level. The annoyance caused by the existing traffic noise and the predicted future traffic noise is calculated, therefore, enabling the increase, or decrease in the percentage of people likely to be annoyed to be determined.

As a rule of thumb an increase in a road traffic flow of 25% will increase noise levels by approximately 1 dB(A). It is generally accepted that changes in road traffic noise levels of up to 3 dB(A) are not widely perceptible, implying that road traffic flow increases of up to 25% offer no significant impact in environmental noise terms. However, this rule of thumb assumes the same mix of vehicle types and no increase in the percentage of heavy vehicle movements.

6.2.2 Significance Criteria

As a starting point in the assessment of the impact of changes to the noise output of an existing noise source, it is common to begin by establishing the difference in noise level before and after the change. Having deduced the change in noise level, the next step is to establish whether or not the change in noise level causes a noise impact, and to what degree that impact is significant. For a simple case, the judgement can be made on the basis of difference in noise levels and by determining:

- Whether the noise change is noticeable; or
- Whether, if the change is noticed, will it be large enough to cause a significant effect; or
- Whether it is a sufficiently large enough change that it would potentially cause a significant alteration in annoyance or disturbance.

Table 6.10 below provides a description of the potential significance of changes in noise level, as described above.

Table 6.10 Significance of Changes in Noise Level

Significance	Change in noise level (dB(A))	Response
Negligible	(±) <3	Hardly noticeable
Positive or negative not significant impact - minor	(±) 3-5	Noticeable
Positive or negative moderately significant impact - moderate	(±) 6-10	Up to a doubling or halving of perceived loudness
Positive or negative substantially significant impact - major	(±) 11-15	Over a doubling or halving of perceived loudness
	(±) >15	

All values are in dB re 20 micro pascals (µPa)
Adapted from Arup Environmental 1993 and Morris & Therivel 2001

The advice in Table 6.10 above assumes that the changes in noise level are due to fluctuations in the noise emission of the same source and are not due to introduction of a new noise source to the sound scape. Table 6.10 is most suitable where despite any change in overall level, the nature and character of the noise source remains constant, and the chosen noise level index correlates well with the subjective perception of the particular noise under consideration.

For most situations, however, the assessment of noise impact is not simple and cannot be based solely on the absolute level of noise or the numerical difference in noise levels with and without the development, although establishing these differences are important. It is also usually necessary to qualify the simple deduction of any change in noise level by considering what might be the effect of any differences between the future and existing situations in either the type of noise source or the nature of any change in noise or other factors, on whether the absolute noise level or the numerical change in noise level can be used alone to judge the extent of any noise impact. The various factors that have been identified as influencing this process include:

- The nature of the noise impact e.g. interference with amenity, annoyance or sleep disturbance;
- The averaging time period of any noise measurements;
- The time of day that noise impact might arise;
- The characteristics of the noise source (intermittency etc.);
- The duration and frequency of occurrence of the noise impact;
- The spectral characteristics of the noise;
- The absolute level of the noise;
- The influence of the noise indicator used;
- The nature and character of the locality;

As well as the factors listed above, the significance of changes in noise levels can generally also depend on the number of people affected and the degree to which they are affected.

In order to determine the cumulative effect of all of these individual noise sources combined, it is tempting to simply look at the overall determine the change in L_{Aeq} noise levels due to all sources, and then consider the total combined noise levels with mitigation implemented in year 2018, against the existing measured noise levels. Such an approach appears to be supported by The Institute of Acoustics (IoA)/Institute of Environmental Assessment (IEMA) Joint Working Party on noise Impact Assessment which published draft guidelines on assessment of noise in 2002. In Section 7.66 of this guidance the working party indicated that the change in noise level could be assessed against criteria similar to those in the following table:

Table 6.11 Impact Scale for Comparison of Future Noise against Existing Noise – IoA/IEMA Draft Guidance 2002

Noise Change (dBA)	Category
0	No Impact
0.1 - 2.9	Minor Impact
3.0 - 4.9	Moderate Impact
5.0 - 9.9	Substantial Impact
10.0 and more	Severe Impact

All values are in dB re 20μPa

However, Section 7.67 of the 2002 IoA/IEMA draft guidance advises that:

"IT IS IMPORTANT TO NOTE that the table in Para 7.66 is merely an example of how the significance of a range of basic noise changes might be categorised. The table should not be used to define the description of the noise change (i.e. it should not be used as a justification for saying that a +2 dB change is slightly significant). In any assessment, the words used to describe the impact should be determined by the assessor based upon the evidence. There is no formulaic approach for relating noise change to a verbal description."

Clearly the authors of the document intended their table as an example only, and expressly advise against repeating it without undertaking a detailed justification of the contents. Section 7.68 of the draft guidance goes on to state that:

"Once the basic noise change has been categorised, the assessment should determine whether or not the effect of the various factors would cause the noise impact to fall into a different category".

The various factors referred to are those listed in the bullet points above.

Additionally, the draft IoA/IEMA guidelines are still a work in progress, and since the first draft, from which the Table 6.11 was taken, members of the working group have been critical of practitioners simply cutting and pasting this table, and as recently as the IoA autumn conference 2006 stated that :

"The guidelines do NOT state what is or what not is an acceptable magnitude of change in noise level; they do NOT define what decibel change will cause, say, a moderate impact; and the do NOT, provide a simple step by step process which is easily followed to produce the result."

A senior member (Turner, S., 2005 & 2006) of the working group has indicated that the latest iteration of the draft IoA/IEMA guidelines does not include the table referred to above from the first draft, and takes a very different approach to providing guidance on describing the significance of noise impacts, as shown below.

Table 6.12 Generic Scale of Noise Impacts on People – IoA/IEMA October 2006

Perception of Change	Consequence of Change	Semantic Descriptor	Significance of Change
Not noticeable	None	No impact	Not significant
Noticeable	Non-intrusive[1]	Minor	Not Significant
Noticeable	Intrusive[2]	Moderate	Significant
Noticeable	Disruptive[3]	Substantial	Significant
Noticeable	Physically Harmful[4]	Severe	Significant

1 May cause small changes in behaviour, e.g. turning up volume of television; speaking louder; closing windows, or, affect the character of the area such that there is a perceived change in the quality of life.
2 Will cause small changes in behaviour, e.g. turning up volume of television; speaking louder; closing windows or, affect the character of the area such that there is a perceived change in the quality of life. The cautious approach would be to consider this to be significant. However, there may be circumstances when it can be demonstrated that these small changes in behaviour are not significant.
3 Will cause a material change in behaviour, e.g. avoiding certain activities during periods of intrusion; sleep disturbance (non-awaking); moving to different location
4 Will cause significant changes in behaviour. Unable to mitigate effect of noise leading to psychological stress or physiological effects, e.g. sleep deprivation/awakening; loss of appetite. Also, medically definable harm, e.g. noise induced hearing loss.

In the context of this development the above scale of noise impacts has been adapted as shown in Table 6.13 below.

Table 6.13 Adopted Scale of Noise Impacts on People (adapted from IoA/IEMA October 2006)

Perception of Noise	Consequence of Change	Significance of Change
Not noticeable[1]	None	Nil
Barely Noticeable[2]	Non-intrusive	Minor
Plainly Noticeable[3]	Intrusive	Moderate
Clearly Noticeable[4]	Disruptive	Major

1. Noise not heard/vibration not felt.
2. Noise audible/vibration felt, but does not materially interfere with human activity. Noise and vibration levels will generally comply with the guideline values discussed above.
3. Noise audible/vibration felt, and begins to materially interfere with human activity. Noise and vibration levels will generally exceed the guideline values discussed above, but the resulting impacts are tolerable to the majority of the population.
4. Noise audible/vibration felt, and materially interferes with human activity. Noise and vibration levels will generally significantly exceed the guideline values discussed above and the resulting impacts are not tolerable to the majority of the population.

In order to establish how differences in noise level with and without the development might influence the significance of noise impacts associated with the development, in situations where there is no specific validated guidance appropriate to the circumstances, the scale of significance in Table 6.11 above coupled with the appropriate factors outlined above, have been used to assist in assessing the significance of changes in noise levels.

6.3 EXISTING CONDITIONS

6.3.1 Description of Baseline Conditions

Due to its largely undeveloped nature, the existing acoustic climate on the island of St Helena is typically quiet, and comparable with rural locations in the UK. The only notable anthropogenic noise sources include occasional road traffic, industrial /commercial activities in isolated locations and noise from people themselves. In undeveloped areas, noise from birdsong, movement of vegetation in the wind and wave-breaking are the only other significant contributions to ambient acoustic climate.

6.3.2 Summary of Baseline Noise Monitoring

Ambient noise is a measure of the ‘total encompassing sound’ at a particular location, at a particular time. Measurements of background noise levels have been obtained by a monitoring exercise around the site at different times of the day, evening and night. The monitoring sites were chosen as being representative of residential and other sensitive locations and are identified on Figure 6.1.

All measurements were carried out using a Norsonic 131 sound level meter, which conforms to Type I standards and was calibrated before and after each set of measurements to ensure no drifting of the calibration signal. The parameters recorded for each measurement were:

- $L_{Aeq,T}$ The equivalent continuous level, providing an average of all noise events and used for planning assessment in UK PPG 24;
- $L_{A90,T}$ The level exceeded for 90% of the time, defined as the background level;
- $L_{Amax,T}$ The maximum noise level during the measurement.

Baseline measurements were undertaken at eight locations proximate to the proposed Airport site and the proposed construction materials haulage route options, chosen to be representative of Noise Sensitive Receptors (NSRs).

Short-term (15 minute) attended measurements were undertaken at each monitoring location. In all instances the meter was set to fast time weighting and the microphone was positioned in free-field conditions.

6.3.3 Baseline Monitoring Data

All short-term monitoring data are presented in Table 6.14 below:

Table 6.14 Measured Ambient Noise Levels

Monitoring Period	Sound Pressure Level, dBA re:20µPa					Meteorological Conditions
	$L_{Aeq,15min}$	$L_{A90,15min}$	$L_{A10,15min}$	$L_{Amax,15min}$	$L_{Amin,15min}$	
Rupert's Valley (AA_RV_1)						
Day (12:20hrs – 12:35hrs)	46.0	38.0	49.1	63.6	34.0	30°C, wind 1-3ms^{-1}, Dry
Night (01:44hrs – 01:59hrs)	39.2	36.4	40.6	61.4	34.0	24°C, wind 0-1ms^{-1}, Dry
Deadwood (AA_DW_2)						
Day (13:38hrs – 13:53hrs)	47.2	40.4	50.4	63.3	34.4	27°C, wind 1-2ms^{-1}, Dry
Night (02:22hrs – 02:37hrs)	50.1	45.4	52.6	65.9	42.6	21°C, wind 2-3ms^{-1}, Dry
Bilberry Field Gut						
Day (15:30hrs – 15:45hrs)	41.1	35.0	43.9	58.0	29.8	28°C, wind 0-1ms^{-1}, Dry
Bradleys Government Garage Dwellings						
Day (16:04hrs – 16:19hrs)	50.0	31.4	44.2	76.3	24.1	22°C, wind 2-4ms^{-1}, Dry
Day (15.23hrs – 15.38hrs)	45.2	61.1	32.1	48.5	38.4	21°C, wind 2-4ms^{-1}, Dry
Night (01:13hrs – 01:28hrs)	41.5	28.8	43.9	67.7	23.2	20°C, wind 2-4ms^{-1}, Dry
Prosperous Bay Plain Fisher's Valley						
Day (11:31hrs – 11:46hrs)	38.1	33.8	40.0	56.6	31.6	25°C, wind 1-2ms^{-1}, Dry
Day (12:22hrs – 12:37hrs)	35.6	33.7	37.1	57.5	31.4	26°C, wind 1-2ms^{-1}, Dry
Prosperous Bay Plain Footpath to Signal St						
Day (10:38hrs – 10:53hrs)	41.3	25.7	43.5	62.3	23.7	23°C, wind 3-5ms^{-1}, Dry
Day (10:23hrs – 10:38hrs)	40.7	25.3	44.5	58.7	23.2	23°C, wind 3-5ms^{-1}, Dry
Longwood						
Night (00:39hrs – 00:54hrs)	45.7	39.1	46.3	64.7	36.5	20°C, wind 1-2ms^{-1}, Dry
Day (14.40hrs – 14.55hrs)	47.8	61.6	41	50	43.9	21°C, wind 2-4ms^{-1}, Dry
Woody Ridge Flax Mill						
Day (14:38hrs – 14:53hrs)	41.0	33.6	43.3	63.4	30.1	19°C, wind 0-2ms^{-1}, Dry

All values are in dB re 20µPa

6.4 CONSTRUCTION EFFECTS

6.4.1 Potential Effects

All significant construction works in proximity to sensitive human receptors and buildings have the potential to cause adverse noise and vibration impacts. Typically, impacts are of a short-term duration and are considered temporary and reversible. Potential impacts will be managed by mitigation measures described in the EMP in Volume 5 of this ES and outlined in Section 6.4.2 below.

The potential noise and vibration impacts on indigenous birdlife on St Helena during the construction phase are discussed in Terrestrial Ecology and Nature Conservation Appendix 9.

For each construction site, potential noise and vibration impacts are assessed below.

6.4.1.1 Rupert's Bay – Temporary and Permanent Wharf

One of the first phases of the project will be the construction of a temporary jetty in Rupert's Bay in order to provide landing and access to Prosperous Bay Plain for the large earthmoving plant required at the airport site. This will be located at the western side of Rupert's Bay, and is likely to comprise a promontory constructed from quarried rock fill, covered with a layer of rock armour. The promontory fill will utilise rock cut as part of haul road construction from Rupert's Valley up to Rupert's Hill Trig, and from a new temporary quarry in Rupert's Valley. Depending on the type of vessel deployed, a quay wall may need to be constructed from sheet piles or blockwork.

Construction of the permanent wharf will utilise material from the temporary wharf construction, as well as additional quarried rock and interlocking pre-cast block pavers.

Although the primary impacts of wharf construction will be the delivery of material through Rupert's Valley, there may be some significant on-site activities. Notably, if required, sheet piling to provide a quay wall has the potential to generate high noise levels for a short period. This activity will have the potential to generate major short-term impacts at residential properties in Rupert's Valley. Management of these impacts will reduce the potential for disturbance.

Cumulatively, it is expected that, during this approximately 16 week phase, 47 - 100 vehicle movements per day will be generated in Rupert's Bay, of which 40 – 80 of these will be dump trucks carrying rock specifically for the construction of the jetty. The remaining vehicles will include other lorries and fuel bowsers.

Using the methodology detailed in BS 5228-1: 1997 (BSI, 1997) and recent measured sound emission data (Defra, 2005 & 2006), the noise levels generated by construction vehicles on the haul roads have been predicted. The results of these calculations are presented in Table 6.15 below.

Table 6.15 Predicted Sound Levels of Construction Vehicles on the Haul Road in Rupert's Bay

Source	Number per Hour	Average Speed (km/h)	Sound Pressure Level (dB L_{WA})	Predicted Sound Pressure Level at 10m from the Centre of Haul Road (dB $L_{Aeq,1hour}$)
Dump trucks	10	30	113	65.3
Other construction lorries	2	30	105	56.3
Combined	**12**	**-**	**-**	**65.8**

Sound power values are in dB re 20μPa

The predicted combined noise level is 19 dB above the measured ambient level in Rupert's Valley. However, this is a worst case assessment and will be restricted to the construction period. Although the level predicted exceeds the WHO Guidance level of 55 dB $L_{Aeq,16\ hour}$ which represents the level for onset of 'Serious annoyance in outdoor living areas', for the minority of the population, the proposed 10-hour working day would mean the overall predicted 16-hour sound pressure would be approximately 2 dBA lower. Furthermore if, for example, each vehicle was audible for 30 seconds at any point adjacent to the haul route (e.g. whilst travelling 250m at 30km/h), for 83% of every hour no construction vehicle noise would be audible at that point.

Given the intermittent noise from construction traffic, a moderate impact would therefore be likely during the busiest periods when the temporary jetty is being constructed. It should be noted that these works will be carried out simultaneously with the construction of the haul road. Consequently, whilst the impact of the change in noise level due to these works can be assessed as being major adverse, the very short-term nature of each noise event and the non-permanent and reversible nature of the works significantly reduces the impacts so that overall they can be re-assessed as moderate adverse.

The movement of dump trucks on the haul road also has the potential to generate perceptible vibration at roadside receptors. Research by the Transport and Road Research Laboratory (TRRL) (TRRL Report 146, 1986) indicates that despite the perception of vibration in a building the likelihood of road traffic induced vibration damage to the structures is remote.

6.4.1.2 Rupert's Valley – Contractor Compound Areas

The sensitivity of the various available sites identified for use as materials and equipment storage compounds in Rupert's Valley during the scheme construction phase vary considerably. Use of the two sites identified furthest south (south of the Power Station) would generate negligible adverse impacts due to the distance separation from sensitive receptors.

It is likely that use of the two sites north of the Power Station would generate slight impacts at the Church, during loading and unloading of distribution vehicles using heavy lifting equipment. However, these impacts will be short-term and reversible.

6.4.1.3 Rupert's Valley – Bulk Fuel Installation

The site of the proposed Bulk Fuel Installation (BFI) within Rupert's Valley is of low sensitivity to noise and vibration generated during the construction phase. Located southeast of the existing power station the site is a large distance from the nearest residential receptors in Haytown, and is not ecologically sensitive.

Delivery of building materials and items of construction plant will generate additional HGV movements through Rupert's Valley. Construction of reinforced concrete (RC40) fuel storage tank bund walls, watercourse diversion channels and footings for rockfall protective fencing will require delivery of concrete to the site.

Given the remoteness of the site from sensitive receptors, the potential impact of construction activities at the proposed BFI site are likely to be slight and of short duration.

6.4.1.4 Rupert's Valley – Temporary Quarry

It is proposed that quarrying of the bedrock will be undertaken within Rupert's Valley. Access to the quarry site will be via a new road linking with the proposed airport construction haul route in Rupert's Valley.

Due to the distance separation between the proposed quarry site and the nearest noise sensitive receptors, as well as the potential for topographical screen of workings, the potential noise and vibration impacts associated with normal mineral workings within the quarry of are unlikely to be significant.

Winning of rock at the temporary quarry will also require intermittent blasting operations. Due to the distance, vibration and air over-pressure are unlikely to be perceived at residential properties within Rupert's Valley. However, noise from blasting will generate **moderate** noise impacts at the nearest sensitive receptors. These impacts are short-term and reversible.

Operation of the quarry will also generate additional Heavy Duty Vehicle (HDV) traffic movements through Rupert's Valley travelling to and from the proposed wharf construction site in Rupert's Bay. This has the potential to generate temporary noise and vibration impacts at residential and other sensitive receptor locations within Rupert's Valley.

6.4.1.5 Rupert's Bay to Prosperous Bay Plain – Access Haul Road

The proposed haul/access route would run from the new wharf facility at Rupert's Bay to the airport via Deadwood (see Figure 2.1). At Rupert's Bay, the route will pass existing residential properties within the valley, before climbing up Rupert's Hill. The route would follow the existing road at Deadwood and pass residential properties in this area. As well as residential receptors at Rupert's Valley and Deadwood Plain, the route would pass through or near several sensitive Wirebird habitats. The route would then pass residential dwellings at Mulberry Gut and Bilberry Field, and then the Bradleys Government Garage site.

Existing daytime noise levels are very low, typical of a rural location. Therefore, the potential for construction noise disturbance to local residents would be significant without appropriate mitigation.

The impacts associated with the actual construction of the haul road and of construction traffic required during these works are assessed below.

Haul Road Construction
In order to evaluate the noise during the haul road construction, it is necessary to define the various activities that will be undertaken. Construction Contractors may use different working methods and plant to achieve the same ends, so an accurate construction noise and vibration impact assessment is not normally possible until appointment of the approved Contractor. Consequently, at this stage of a project it is normally only possible

to undertake a generic construction noise and vibration impact assessment based on expected methods of working gained from experience with previous similar developments.

For the purpose of predicting road construction noise levels a series of typical activities have been assessed, based on likely closest approach and typical plant working. These assessments exclude predictions of noise from blasting operations of the hillside of Rupert's Hill, which is discussed later. Initial haul road construction will comprise the following elements:

- Ground levelling;
- Cut & fill earthworks on slopes;
- Construction of down hill side retaining walls on slopes;
- Erection of crash barriers where steep corners exceed 90º; and,
- Drainage work, including channel and culvert construction.

To complete these works, it is likely that the following construction plant will be used on site:

- Backhoe Excavator;
- 360º Excavator;
- Dozers;
- Breakers;
- Water bowser;
- Vibrating Rollers;
- Dump trucks; and'
- Staff vehicles

In addition, prior to its use as fill material, excavated rock will need to be crushed and screened to a suitable grade. This plant is likely to be stored within the temporary quarry where its operation will be screened by local topography. Due to this factor, combined with the distance of the proposed temporary quarry from the nearest noise sensitive receptors, the impact of this activity will be negligible.

Once the haul road is no longer required for construction traffic it will be upgraded to the permanent access road. This will include a general re-grading of the haul road surface, construction of a final basecourse overlay and application of a sprayed bitumen and chippings surface.

The BS 5228-1:1997 (BSI, 1997) prediction method uses the shortest distance from the receptor to the construction activities. The nearest edge of the relevant construction site has been used as the calculation point for equipment/plant classed as 'mobile' (dozers, excavators etc.).

Predicted noise levels are, therefore, a very worst-case basis and in practice the actual noise levels may not attain those predicted.

Table 6.16 Summary of Worst-case Predicted Road Construction Noise Levels (Unmitigated)

Distance to Sensitive Receptor	Predicted worst case noise levels, closest approach dB $L_{Aeq,10h}$	
	Initial Haul Road Construction	Upgrade of Haul Road to Permanent Finish
10m	78.4	74.4
25m	70.8	68.4
50m	65.1	62.9
100m	57.6	57.4

From the table above, it can be seen that predicted demolition and construction noise levels may, on occasion, exceed the adopted criterion of 75 dB $L_{Aeq,10hour}$ proposed for residential property. Major impacts are therefore predicted during road construction activities within 15m of the initial haul road construction works. In practice, the worst-case nature of the assessment (with all plant working at its closest approach) means that the actual levels are likely to be lower as such a pattern of work is unrealistic and, furthermore, these predicted worst case levels could not exist throughout the duration of a working day due to mobility of working.

The nature of construction work means that the worst-case situation with the plant working at closest approach may exist for only a matter of hours and there would be regular periods, even during the course of a single day, when the assumed noisy plant would not be in operation during breaks or changes of working routine.

It is unlikely that typical haul road construction activities described above would generate more than just perceptible levels of vibration, even at a distance of 10m. As discussed above, this leads to the assessment that the potential vibration impacts would therefore be slight, short-term and reversible.

Construction of the Haul Road along the slopes of Rupert's Valley up to Rupert's Hill Trig may require blasting operations in order to build the required Cut/Fill Bench providing a suitably wide road surface. These blasts will be small and localised; therefore the potential vibration and air over-pressure are unlikely to be perceived at residential properties within Rupert's Valley. However, noise from blasting will generate moderate noise impacts at the nearest sensitive receptors.

Construction Traffic

It is forecast that construction of the haul road will take approximately 26 weeks, working 6 days per week, and will require between 37 - 50 construction vehicle movements per day. These will primarily be fuel bowsers and dump trucks.

Using the methodology detailed in BS 5228-1: 1997 (BSI, 1997) and recent measured sound emission data (Defra, 2005 & 2006), the noise levels generated by construction vehicles on the haul road between Rupert's Bay and the Airport Site have been predicted. The results of these calculations are presented in Table 6.17 below.

Table 6.17 Predicted Construction Traffic Noise during Haul Road Construction

Source	Number per Hour	Average Speed (km/h)	Sound Pressure Level (dB L_{wA})	Predicted Sound Pressure Level at 10m from the Centre of Haul Road (dB $L_{Aeq,1hour}$)
Dump trucks	3	30	113	60.0
Fuel bowsers	2	30	108	53.2
Combined	**3**	**-**	**-**	**60.8**

This is a worst case assessment and will be restricted to the construction period only. Although the level predicted marginally exceeds the WHO Guidance level of 55 dB $L_{Aeq,16\,hour}$ which represents the level for 'Serious annoyance in outdoor living areas', the proposed 10-hour working day would mean the overall predicted 16-hour sound pressure would be lower. Furthermore if, for example, each vehicle was audible for 30 seconds (250m at 30km/h), for 95% of every hour no construction vehicle noise would be audible.

Given the intermittent noise from construction traffic, a moderate short-term and reversible impact would therefore be likely during the approximately 26 week haul route construction period. As construction of the haul route will be undertaken in the direction from Rupert's Bay to the Airport Site, the further east sensitive properties are the less noise disturbance will be experienced. Similarly, once construction of the haul route through Rupert's Valley is complete, sensitive properties will experience significantly less impact as dump trucks will primarily operate from the temporary quarry site further up Rupert's Valley.

Initial works to establish the haul route up to Rupert's Hill Trig will be undertaken at the same time as the temporary jetty construction in Rupert's Bay. Excess cut material from this haul road construction will be transported through Rupert's Valley to the jetty site. The potential impact of this is assessed in Section 6.4.1.1 above.

The movement of construction vehicles on the haul road also has the potential to generate perceptible vibration at roadside receptors. As previously discussed, research (TRRL Report 146, 1986) indicates that despite the perception of vibration in a building the likelihood of road traffic induced vibration damage to the structures is remote.

6.4.1.6 Prosperous Bay Plain - Airfield

Extensive site excavations will be required prior to construction of the proposed airport runway and airport terminal and maintenance buildings. This will include breaking out surface bedrock for the laying of foundations and construction of drainage channels. In light of the existing volcanic geology of the site, it is possible that some areas of the bedrock will be too hard and strong to be ripped from the surface. In this instance, blasting may be required to maintain progress. These operations will be localised small-scale blasts determined by site trials. The potential noise impacts of these blasting operations will be slight short-term.

Though construction activities have the potential to be audible at the nearest residential dwellings (Bradleys Government Garage, over 1 kilometre (km) to the northwest to west), impacts will be short-term. This is especially the case for blasting operations. Given the scale of likely blasting operations airborne vibration and air overpressure are unlikely to be more than just perceptible at Bradleys Government Garage.

6.4.1.7 Bradleys Government Garage and Prosperous Bay Plain – Construction Compound

The main residential Contractor's camp will be located in proximity to the airport construction site. There are two locations identified as possible sites for the compound; either immediately east of Bradleys Government Garage or further south, to the west of the airport access road.

The latter includes a proposal for the construction and use of any temporary airstrip to provide air access for construction personnel. It is proposed that a DHC-7 ("Dash 7"), carrying a maximum of 20 personnel, will be used and will arrive/depart once per week. The airstrip would be approximately 1km in length and 60-80m wide, and would generally be in an east to west orientation.

Construction

It is anticipated that construction of the Contractor's camp will take less than two weeks, with placement of temporary residential and office buildings and connection of power, water supply and sewerage.

The most significant noise impacts will be during short-term earthworks during site levelling activities. These impacts will be more significant if the identified site to the north of the residential Bradleys Government Garage is adopted, although management measures will be in place to reduce the potential for disruption. Overall, short-term moderate impacts are expected during this timeframe if this site is selected. If the site further south is selected, the distance separation from Bradleys Government Garage and the short-term nature of construction activities would lead to negligible noise impacts.

The proposed airstrip will be built on compacted soil, once the appropriate earthworks have been undertaken to provide a suitably level surface. At this stage the precise location of any temporary airstrip is not confirmed, or indeed whether one will be constructed at all, but the likely location is south of Fisher's Valley, over 700m south of Bradleys Government Garage. Over this distance, construction noise and vibration impacts will be negligible short-term and reversible.

Use during the Construction Period

The layout of the accommodation at the Contractor's camp, including residential, office and social units will need to be designed to minimise day to day impacts, notably if the site neighbouring Bradleys Government Garage is utilised. As well as the accommodation units, the Contractor's camp will also provide storage space for mobile plant as well as staff parking facilities.

Vehicular access to the camp to the north of Bradleys Government Garage will be via the existing access road from the north. Construction staff will therefore travel north from Bradleys Government Garage to connect to the proposed haul route en route to the airport site. A purpose built access road would be constructed off the proposed haul road to provide vehicular access to the camp south of Bradleys Government Garage.

Road traffic noise resulting from construction personnel travelling to and from the airport site on Prosperous Bay Plain is only therefore likely to be significant if the site east of Bradleys Government Garage is utilised. It is predicted that 15-30 vehicular trips per day will be generated over the 200 week main construction period. These trips are likely to comprise either light vehicles or crew buses. It may also be the case that the Contractor will choose to relocate the camp accommodation closer to the airport site, once the more intensive work (such as heavy excavation works including blasting) is complete.

Given that majority of these movements will be at the start and end of shifts, for a large proportion of the day, movements will be very infrequent.

The overall impact is therefore considered to be slight if the Bradleys Government Garage site is used, or negligible if the site to the south is used.

Use of the Possible Temporary Airstrip
The main potential for noise impact will be very short duration noise from aircraft movements. Combined with the infrequent occurrence, the overall impact from daytime flights is unlikely to be significant at nearby residential receptors. Measures to control potential noise impacts may include a requirement for all aircraft to take-off and land at the eastern end of the runway, thereby limiting the overland flight time.

6.4.1.8 Water Supply

Due to the remoteness of the proposed water pipeline from Sharks Valley to the proposed airfield and the associated pumps and storage tanks, the potential noise and vibration impacts associated with the installation would not be significant.

6.4.1.9 Ancillary Components

Due to the remoteness of the proposed remote obstacle lights (ROL) and Navigation Aids (Navaids), the potential noise and vibration impacts associated with the installation would not be significant. Any impacts would be very short-term and reversible.

6.4.2 Mitigation

6.4.2.1 Construction Phase

BS 5228-1:1997 (BSI, 1997) gives detailed advice on methods of minimising nuisance from construction noise. This can take the form of reduction at source, control of noise spread and in areas of very high noise levels, insulation at receptors. The Contractors must comply with the recommendations in this standard, in order to achieve specific noise limit criteria for each site. Mitigation measures will be the subject of control through the use of contract conditions and could include the following provisions:

- Noisy sites to be surrounded with industry standard 2.4m hoardings or other barriers, where appropriate, and continuous plant to be housed in acoustic enclosures;
- Use of electrical items of plant instead of diesel plant in especially sensitive locations;
- Exhaust silencing and plant muffling equipment to be maintained in good working order;
- Use of temporary screens at sensitive locations such as close to residential properties or sensitive ecological sites where they would be effective;
- All plant, whether stationary or mobile, shall only have its engine running when actually in use or when being prepared for use. Covers/enclosures on plant which reduce emitted noise levels shall be maintained in good condition and shall be kept closed at all times when the plants engine is running;
- A sign shall be erected at the entrance to all work areas outlining the measures which operatives shall adopt to ensure minimisation of noise and vibration emissions and other nuisance from the site, such signs to be erected before any works commence from any particular sites, the sign wording and size to be agreed prior to the commencement of the works with the Engineer;
- Use of plant which has a greater capacity than that required i.e. oversized plant should be avoided;
- Loading/unloading sites to be located away from residential properties and shielded from those properties where practicable;
- Pointing directional noise away from sensitive areas where possible; and,
- Haul road maintenance to ensure pot-holes are not permitted to develop.

The hours of working shall be limited to the following at the specified locations:

- Area A – Airport – unrestricted
- Area B – Remote Obstacle Lighting and Navigational Aids sites Remote to the Airport – 07:00hrs-18:00hrs Mon to Fri, 07:00hrs – 13:00hrs Sat
- Area C – Access Road between Rupert's Bay and the Airport - Construction and use of haul roads – 0700hrs-18.00hrs Mon to Fri, 07:00hrs – 13:00hrs Sat (to be agreed with the Engineer)
- Area D – Bulk Fuel Installation – 07:00hrs-18:00hrs Mon to Fri, 07:00hrs – 13:00hrs Sat
- Area E – Rupert's Bay and Wharf – construction and use of the materials delivery in Rupert's Bay & Valley 07:00hrs – 18:00hrs Mon to Fri, 07:00hrs – 13:00hrs Sat (to be agreed with the Engineer)
- Area F – Water Supply and Abstraction Point and Pipeline – 07:00-18.00 Mon to Fri, 07:00hrs – 13:00hrs Sat

Noisy work should be prohibited outside these core hours unless pressing engineering, legal or health and safety issues suggest other wise, in which case dispensation or variation would need to be negotiated in advance. For example tide conditions may dictate that certain phases of the wharf construction in Rupert's Bay might have to be carried out outside the core hours. In event of this, procedures for notifying the public of changes to working hours shall be undertaken. Operations within Contractor compound areas in Rupert's Valley should be managed to avoid conflict with use of the church.

The use of a 2.4 m wooden hoarding on the boundary of the haul road construction would have the potential to reduce predicted noise levels at NSRs from general construction activities by up to 10 dB(A). Such a hoarding would be provided along the boundary of the road construction site when works are within 25m of residential or other sensitive dwellings.

With specific regard to blasting operations the potential impacts will be managed through restriction of permissible hours, good public warning systems and, where appropriate, sensitive alignment of blast faces. The impacts will be further managed by controlling the timing and frequency of occurrence, and communicating to those affected when blasting operations are to be undertaken.

The EMP in Volume 5 of this ES describes a formal system to be put in place that identifies the roles and responsibilities of site staff regarding the noise complaint action procedure. Site logs must be maintained, detailing all complaints received relating to noise nuisance impacts, and the corresponding response made to each complainant. The EMP also describes a regime for noise monitoring to be undertaken by the Contractor's Environmental Management Plan Coordinator (CEMPC), so that compliance with the specified limits can be monitored and, where necessary, requirements for additional noise management controls can be identified.

In general, good public relations and extensive consultation with St Helena Government (SHG) Departments will be necessary to help to minimise the impact of construction work. The residents in particular will need to be persuaded that the higher levels of noise will only be for a short period of time and so it will be necessary to publicise and adhere to a stated works schedule.

6.4.3 Residual Effects

Given the largely undeveloped nature of the Island, the introduction of a large-scale construction project will clearly have adverse noise and vibration effects during that period. The effects will vary significantly at each receptor location as the phasing of construction progresses. The predicted impacts however are entirely restricted to the construction phase, and reversible once complete.

The initial phase will primarily affect sensitive receptors in Rupert's Valley, as it includes the construction of:

- A temporary jetty in Rupert's Bay;
- The haul road / permanent airport access road;
- The bulk fuel installation;
- The Rupert's Valley Contractor compound areas; and,
- The temporary quarry.

During this initial period of construction when the wharf and access road are likely to be built and the quarry will be active, local residents and other sensitive receptors in Rupert's Valley will experience moderate short-term noise impacts, primarily from heavy vehicles as well as blasting operations in the temporary quarry and on Rupert's Hill for the haul road construction. **Moderate** short-term vibration and air overpressure impacts are also predicted as a result of blasting operations, as receptors may notice slight motion of window panes or loose ornaments. These impacts will be managed by restricting working hours, and controlling timing and frequency of blasting events.

Provided that the haul road is sufficiently maintained, so that pot-holes are not permitted to develop, the potential vibration impacts are predicted to be **minor**, short-term and reversible.

It is forecast that airport construction works in Prosperous Bay Plain will take approximately 30 months to complete. During this phase, it is predicted that residents of Government Garage at Bradleys will experience negligible to **minor** short-term impacts. These will primarily be associated with major earthworks (including blasting) during levelling of the airfield site and, to a lesser extent during construction of the Contractor's compound north of Bradleys Government Garage (if required). Again, these impacts will be managed by restricting working hours, and controlling timing and frequency of blasting events.

6.5 PERMANENT AND OPERATIONAL EFFECTS

6.5.1 Potential Effects

6.5.1.1 Airborne Aircraft

Whilst the noise level at a receiver from an individual aircraft may be substantial, depending on factors including the noise output of the specific plane, the distance to the receiver and screening etc, the frequency of aircraft movements at the proposed Airport is not likely be sufficient to cause long-term noise disturbance. For example it is forecast that in the first year of operation there will be an average of only one aircraft visiting the island per week, rising to 10 per week in the 35th year, with an additional 2 charter flights for 28 weeks a year, after year 2, excepting emergency and other unforeseeable conditions. In these circumstances it is considered that the advice of UK PPG 24 to predict the L_{eq} noise contours around the aerodrome is potentially misleading. Because these noise contours would be based on a combination of how noisy each aircraft is and the number of aircraft visiting the island for an average summer day i.e. less than 1 to start with and only forecast to begin to just exceed 1 per day in the 15th year. Consequently noise contours based on such low numbers of aircraft might not extend beyond the perimeter of the airfield and possibly create the inappropriate impression that the aircraft noise will not be audible beyond the airfield boundary. Instead this assessment follows the guidance of UK PPG 24 Annex 3 paragraph 7 that:

"For small aerodromes local planning authorities should not rely solely on L_{eq} where this is based on less than about 30 movements a day."

Consequently, this assessment is based on the assumption that the most likely significant potential for noise impact will be the short-term noise from individual aircraft landings and take offs, which whilst relatively high compared to existing noise levels at locations relatively close to the aerodrome, will be mitigated by their short duration, in-frequent occurrence and the long intervening periods of no aircraft noise. So that whilst the aircraft noise will be audible at distances up to 1 km from the airfield where there is no intervening topography to break the line of sight to the aircraft, and at significantly shorter distances where such screening occurs, the overall impact from the limited number of daytime flights forecast is unlikely to cause more than slight adverse impacts to nearby residents.

The potential for impact will be further reduced by the operation of PNRs, maintaining aircraft flight paths away from sensitive receptors. It is understood that all aircraft will approach the runway from the north over Prosperous Bay, and take-off southwards over Stone Top Bay, thereby minimising the potentially exposed population.

6.5.1.2 Airside Ground Noise

The nearest NSR to the proposed airport apron are approximately 1.3 km to the northwest (Bradleys Government Garage – dwellings). The impacts of ground noise from the operations identified in Section 6.2.1.6 will be negligible due to the likely distance attenuation and partial screening by the proposed terminal building.

6.5.1.3 Road Traffic Noise

Vehicular access to and from the airport will be via the previously constructed haulage route connecting the airport with the existing road network on St Helena. As a result of the operational airport, the following will contribute to road traffic noise on the island of St Helena:

- Airport employees (staff and crew);
- Passengers, including locals, visiting tourists and business travellers;
- Freight movements
- Aviation and gas oil fuel deliveries from the BFI

Table 6.18 below details the average forecast traffic generation across the island as well as a worst case maximum assessment. The worst-case assessment allows for non-passenger airport operations (ground movements, freight flights, charter flights and business jets), which would not normally be scheduled for the same day.

Table 6.18 Forecast Operational Daily Road Traffic

	Daily Traffic Generation				
	2011	**2015**	**2025**	**2035**	**2045**
Average airport trip generation	220	220	230	450	450
Maximum airport trip generation	370	380	400	600	600
Cumulative tourist trip generation	30	110	360	690	730
Average total	250	330	590	1140	1180
Maximum total	400	490	760	1290	1330

Averaged over a 12 hour period, the number of operational vehicular trips across the island (including the cumulative effect of visiting tourists) could range from approx. 20-35 trips an hour in 2011, to approx. 100-115 per hour in 2045.

Using the methodology described in Calculation of Road Traffic Noise (CRTN) (DoT, 1975) the 18-hour road traffic noise level ($L_{A10,18hour}$) at Bradleys Government Garage can be calculated. However, it should be noted that CRTN is designed for the calculation of noise from continuously flowing traffic, typically with higher traffic levels than predicted above. As the above traffic forecasts primarily relate to vehicle movements on the airport access road between Longwood and the airport, the potential impact at residential properties at Bradleys Government Garage has been quantified in Table 6.19.

Table 6.19 Predicted Operational Road Traffic Noise at Bradleys Government Garages

	2011	2045
18-hour traffic flow	2045	2011
Basic Noise Level, dB $L_{A10,18hr}$ at 10 m from carriageway	55.1	60.3
Speed and HDV correction, dB	+0.1	-1.7
Gradient correction, dB	+2.0	+2.0
Distance attenuation, dB	-11.7	-11.7
Predicted noise level, dB $L_{A10,18hr}$ at receptor	45.5	48.9
DMRB percent annoyed by road traffic noise	3%	4%

All values are in dB re 20μPa

The predictions in Table 6.19 indicate that, even with the future growth of airport usage, road traffic noise will have a negligible impact at the residential properties at the Bradleys Government Garages.

6.5.2 Mitigation during Operation of the Airport

6.5.2.1 Airborne Aircraft

As screening of airborne aircraft noise is generally not a practical option, no additional physical screening is proposed once the development is operational. Controlling of aircraft noise impacts will be through the use of PNR maintaining aircraft flight paths away from sensitive receptors.

The potential noise impacts will be further managed by sensitive flight scheduling, excepting emergency use.

6.5.2.2 Airside Ground Noise

The following noise control measures must be employed:

- Auxiliary power units and ground support vehicles must be maintained in good working order;
- Engine running on the terminal apron to be kept to a minimum; and,
- Routine maintenance to be undertaken during daytime periods only.

6.5.3 Residual Effects

Once operational, noise and vibration impacts from aircraft movements, apron operations and generated road traffic would be **negligible**, given the proposed frequency of flights.

6.6 SUMMARY

An assessment of the potential noise and vibration impacts resulting from the construction and operation of the proposed St Helena Airport and supporting infrastructure Project has been undertaken. The methodology adopted for the study is based upon UK guidance and legislation, with an appreciation of the specific demography and environmental conditions present on the Island. This assessment is summed up below:

- Short-term noise measurements confirmed that the baseline acoustic climate is coincidental with rural, largely undeveloped locations in the UK.
- With the project construction split between two distinct phases, the potential noise impacts to local sensitive receptors will vary considerably throughout this approximately 4 year period.

During construction the most significant impacts are predicted to occur during the initial stages of construction at residential properties which are close to works in Rupert's Bay and Rupert's Valley. This is when the wharf and access road are likely to be built and the quarry will be active. **Moderate** adverse noise and vibration impacts are expected at sensitive receptor locations in Rupert's Valley and at Deadwood. These impacts will primarily be due to noise from the movement of heavy duty vehicles accessing the temporary jetty site in Rupert's Bay, as well as very short duration blasting noise and vibration impacts from within the temporary quarry and as part of the haul road construction on Rupert's Hill. Although, the temporary jetty will continue to be used for the landing of plant, personnel and materials as works progress on the Airfield site at Prosperous Bay Plain, following this phase of works, the impacts within Rupert's Valley will reduce significantly.

Due to the more remote location of the airfield site at Prosperous Bay Plain, the potential impacts on people during the second phase of works will be of **minor** significance for the majority of the 30 month period. It is predicted that residents of Bradleys Government Garage will be exposed to **negligible to minor** short-term impacts. These will primarily be associated with major earthworks (including blasting) during levelling of the airfield site and, to a lesser extent during construction of the Contractor's compound north of Bradleys Government Garage (if required).

Measures to manage potential construction impacts are provided within the EMP in Volume 5 of the ES, and noise and vibration exposure limits have been specified. Procedures for liaison with the local community have also been specified in the EMP to ensure that the Contractor informs local residents and sensitive receptors of any works which are outwith 'the norm', for example night time working or particularly noisy activities (e.g. blasting operations).

Once fully constructed, it is proposed that initially one flight per week will operate out of the airport. Over the first 35 years of operation, it is forecast that this will increase steadily up to 10 flights per week. To support these operations, aviation fuel and gas oil, delivered to the Island by sea to Rupert's Bay and stored at the proposed bulk fuel installation, will be delivered overland by bowser trucks. In addition, it is forecast that passenger, staff and tourist traffic on the airport access road will increase from 400 to 1330 vehicles per day, as a maximum, over the same initial 35 year period. The predicted noise and vibration impacts on the human population of St Helena due to these noise sources, and all other ancillary infrastructure associated with the project, once operational would be **negligible**. This is because of: the low number of flights per week; the routes that aircraft will take to avoid flying over people's homes; the timing of flights to avoid periods when most people are sleeping; and the use of defined routes in and out of the airport to reduce traffic in residential areas.