

Curraghinalt Project County Tyrone

Prepared for Dalradian Gold Limited

Environmental Statement - Volume 3

C20 Vibration Impact Assessment

November 2017

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GOLD



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PROJECT: Curraghinalt Gold Mine Project

Vibration Impact Assessment.

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Table of Contents

1	INTRODUCTION.....	1
2	FUNDAMENTALS OF VIBRATION	2
3	LEGISLATION AND STANDARDS	2
4	EXISTING ENVIRONMENT	7
5	VIBRATION IMPACT ASSESSMENT	9
6	VIBRATION MITIGATION MEASURES	16
7	CONCLUSIONS	17
APPENDIX I	The maximum instantaneous vibration level recorded during each blast from December 2014 to August 2016	

1 Introduction

Envest was commissioned by SRK (UK) Consulting Ltd. (SRK) on behalf of Dalradian Gold Ltd. (DGL) to complete a Vibration Impact Assessment for the proposed Curraghinalt Project in County Tyrone, Northern Ireland.

The Curraghinalt deposit and associated infrastructure are located within an area comprising a topographic ridge that forms the drainage divide between the Owenkillew River and the Owenreagh River. It is understood that the project has the following components:

- An underground mine;
- A decline, a sloping shaft/ tunnel that will be developed as the main access to the mineral deposit, it will extend from a portal at surface and near to the mineral process plant;
- An existing adit, a horizontal passage that provides access to the mineral deposit, originally developed for exploration of the deposit that will be retained to provide initial access for mine development and secondary/safety access to the mine workings in the operational phase;
- Three ventilation raises that will be used to ventilate the mine workings, one of these exists having been developed as part of the underground exploration programme;
- A mineral processing plant;
- A Dry Stack Facility (DSF) for storage of dry stack tailings and uneconomic rock – this facility will contain some of the flotation tailings from the plant, after they have been dewatered (85% of water removed) by means of a filtration process, and uneconomic rock from development of the mine workings;
- Paste backfill placed in the mine workings, this cement bound material will provide support in the workings and will be derived from tailings from the plant, specifically some of tailings from the flotation process and all of the tailings from the cyanide leaching process, mixed with binders;
- Ancillary infrastructure and services required to support the activities (administrative buildings, mobile maintenance shop, warehouse facilities, chemical and explosive stores, a mine dry, parking, site roads, water supply, water treatment and telecommunications);
- Connections, to offsite infrastructure including the Northern Ireland road network and the electrical grid;
- Passing bays on the Camcosy Road developed for the underground exploration programme and to be retained for the mine development.

A detailed Project Description has been prepared by SRK Consulting.

2 Fundamentals of Vibration

2.1 What is Vibration?

Vibration standards deal with both human comfort and with cosmetic or structural damage to buildings. The magnitude of vibration is defined in terms of Peak Particle Velocity (PPV). PPV is defined in BS 5228+A1 (2014): Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration as the: *'instantaneous maximum velocity reached by a vibrating element as it oscillates about its rest position.'* The unit of measurement of PPV is most commonly millimetres per second (mm/s). However, when dealing with human perception to vibration and the tolerances of sensitive equipment the unit of measurement of micrometers per second ($\mu\text{m/s}$) may be used.

It is also important to take account of the frequency at which the vibration occurs, which similar to sound is expressed in Hertz (Hz). Buildings are sensitive to vibration at very low frequencies, i.e. less than 10Hz, and are more resistant to vibration at higher frequencies, i.e. above 50Hz. It is acknowledged, however, that humans are sensitive to vibration stimuli at much lower magnitudes than those likely to cause damage to buildings. Vibration typically becomes perceptible at around 150 to 300 $\mu\text{m/s}$ PPV and may become disturbing or annoying at higher magnitudes. However, higher levels of vibration are typically tolerated for single events or events of short term duration, particularly during construction projects and when the origin of vibration is known.

3 Legislation and Standards

3.1 Planning Policy, Standards and Guidelines Applicable to the Vibration Impact Assessment

The policy documents, standards, and guidelines considered in development of the approach to the noise impact assessment are as follows;

- British Standard 5228-2:2009+A1: 2014 Noise and Vibration Control on Construction and Open Sites Part 2: Vibration
- British Standard 6472-1: 2008: Guide to Evaluation of Exposure to Vibration in Buildings. Vibration Sources Other than Blasting
- British Standard 6472-2: 2008: Guide to Evaluation of Human Exposure to Vibration in Buildings Part 2: Blast induced Vibration

- British Standard 7385: Evaluation and measurement for vibration in buildings. Part 1: Guide for measurement of vibration and evaluation of their effects on buildings. 1990.
- British Standard 7385: Evaluation and measurement for vibration in buildings. Part 2: Guide for damage levels from ground borne vibration. 1993.

British Standard 5228-1:2009 + A1:2014 'Code of practice for noise and vibration control on construction and open sites'

BS 5228-2:2009 outlines that human perception and disturbance caused by instantaneous levels of vibration can be assessed in terms of peak particle velocity (PPV). Criteria and guidance for evaluation can be found in BS 5228-2:2009: Code of practice for noise and vibration control on construction and open sites Part 2. The relevant criteria is reproduced in Table 1.

Table 1: Guidance on effects of vibration levels in terms of peak particle velocity (PPV) (reproduced from BS 5228-2:2009, Table B.1)

Vibration level	Effect
0.14 mm·s ⁻¹	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm·s ⁻¹	Vibration might be just perceptible in residential environments.
1 mm·s ⁻¹	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm·s ⁻¹	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

BS 5228-2:2009 suggests the following example of a planning condition and vibration limits for blasting;

"Annex A of Minerals Planning Guidance Note MPG 9 [12] and Scottish Government Circular 26/1992 [58] give illustrative guides to the planning conditions on vibration limits. These state that: "ground vibration as a result of blasting operations shall not exceed a peak particle velocity of [6 mm/sec] [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/sec] 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. Further information is given in BRE Digest 403 [55]"

British Standard 6472: 2008: Guide to Evaluation of Exposure to Vibration in Buildings.

BS 6472 is a document providing an assessment methodology for assessing the impact of vibration on people in buildings. The standard is split in to two parts;

Part 1 deals with vibration from sources other than blasting and provides a methodology for predicting human response to vibration in buildings over the frequency range 0.5 to 80 Hz. The standard provides guidance on measuring vibration, and assessing the vibration dose value from the measured results. The standard provides guidance on the likelihood of adverse comment on vibration levels during day and night time periods, for different vibration dose values.

The assessment is made by evaluating human response in relation to a measured vibration dose value ("VDV"), as shown in Table 2.

Table 2: Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings (Reproduced from BS 6472-1:2008, Table 1) (1) Below these ranges adverse comment is not expected. (2) Above these ranges adverse comment is very likely.

Place and time	Low probability of adverse comment, $m s^{-1.75}$ (1)	Adverse comment possible, $m s^{-1.75}$	Adverse comment probable, $m s^{-1.75}$ (2)
Residential buildings 16 hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hour night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Part 2 of the standard deals with blast induced vibration. Guidance is given on vibration measurement procedures. Guidance is provided on acceptable vibration levels for residential, office and workshop uses. The guidance is given on levels that are likely to give a low probability of adverse comment.

British Standard 7385: Evaluation and measurement for vibration in buildings.

BS 7285 considers the potential effects of vibration upon buildings. This standard defines criteria for two different types of building structure, brick built residential and more heavily built industrial. BS 7285 advises that there is a minimal risk of cosmetic damage (i.e. the formation of hairline cracks on drywalls, plaster or in mortar joints) at specific guidance levels.

For residential buildings, the limit for cosmetic damage varies with frequency; 14 mm/s at 4 Hz rising to 20 mm/s at 15 Hz and 50mm/s above 40 Hz. These limits apply to all three orthogonal directions individually.

Table 3: Transient vibration guide values for cosmetic damage (reproduced from BS 7385, Table 1)

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
1 Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2 Unreinforced 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 1 Values referred to are at the base of the building

NOTE 2 For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

It is highly likely that occupants would complain long before vibration levels reached this order of magnitude. It is common for a conservative approach to be taken when setting criteria for cosmetic damage and a lower vibration limit is often specified. Transport Infrastructure Ireland guidelines identify limits which provide for protection against vibration nuisance and is comfortably within BS 7385 limits for potential cosmetic damage, as follows;

- 8 mm/s (vibration frequency <10Hz)
- 12.5 mm/s (vibration frequency 10 to 50Hz)
- 20 mm/s (vibration frequency >50 Hz).

To assess the potential impact in terms of vibration on the existing sensitive receptors in proximity to the application site there are two key aspects that require consideration:

- vibration impact on people or equipment within buildings; and
- vibration impact on buildings.

3.2 Summary of Relevant Vibration Impact Assessment Standards & Guidelines

Following BS 5228, and as is generally accepted, the threshold of vibration perception for humans in residential environments is typically in the PPV range 0.15 to 0.3 mm/s at frequencies between 8 Hertz (Hz) and 80Hz with complaints likely at greater than 1 mm/s if prior warning and

explanation has not been given to residents. Table 4 outlines a summary of the relevant vibration impact assessment standards and guidelines.

Table 4: Relevant significance criteria used for the assessment of potential vibration impact.

Vibration Level – Peak Particle Velocity (mm/s)	Effect / Likely Subjective Response (BS 5228 – 2)	Significance
<0.14 mm/s	Vibration unlikely to be perceptible - The impact is not of concern.	None
0.14 mm/s to 0.3 mm/s	Vibration might just be perceptible - The impact is not of concern.	Negligible
0.3 mm/s to 1 mm/s	Vibration might just be perceptible in residential environments - The impact is of limited concern.	Minor
1 mm/s to 10 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.	Moderate
>10 mm/s	Vibration is likely to be intolerable for any more than a brief exposure to this level in most building environments	Substantial
15 mm/s at 4Hz rising to 20 mm/s at 15Hz	Guide value for cosmetic damage of residential or light commercial buildings	Severe
50 mm/s	Guide value for cosmetic damage of residential or industrial and heavy commercial buildings	Severe

4 Existing Environment

4.1 Baseline Vibration Monitoring

Vibration measurements have been carried out since the first underground blast in the underground exploration workings on 22nd December 2014. Since this date the main vibration measurement location has been located at the south-west corner of the household at 45 Camcosy Road, the nearest residential property to the existing underground blasting areas in the existing adit. On 27th May 2016, the vibration measurement location was moved to beside the security hut on the existing exploration site, across the road from 45 Camcosy Road.

The vibration measurements have been undertaken continuously and typically, a blast occurred daily within the exploration adit during the afternoon between the times of approximately 5 – 6 PM. The maximum instantaneous vibration level recorded during each blast from 22nd December 2014 to August 2016 are presented in Appendix I. The summarised results of the vibration measurements are documented in Graph 1, which represents the highest recorded peak component particle velocity measured at each location from individual daily blasts. The vibration monitor is set up to take approximately 1,024 readings per second. Each data point presented in the spread sheet is the highest peak recorded over a 10 second interval (or the maximum value over the 1,024 readings).

The existing planning condition for the exploration license states the following with regard to blast induced vibration limits;

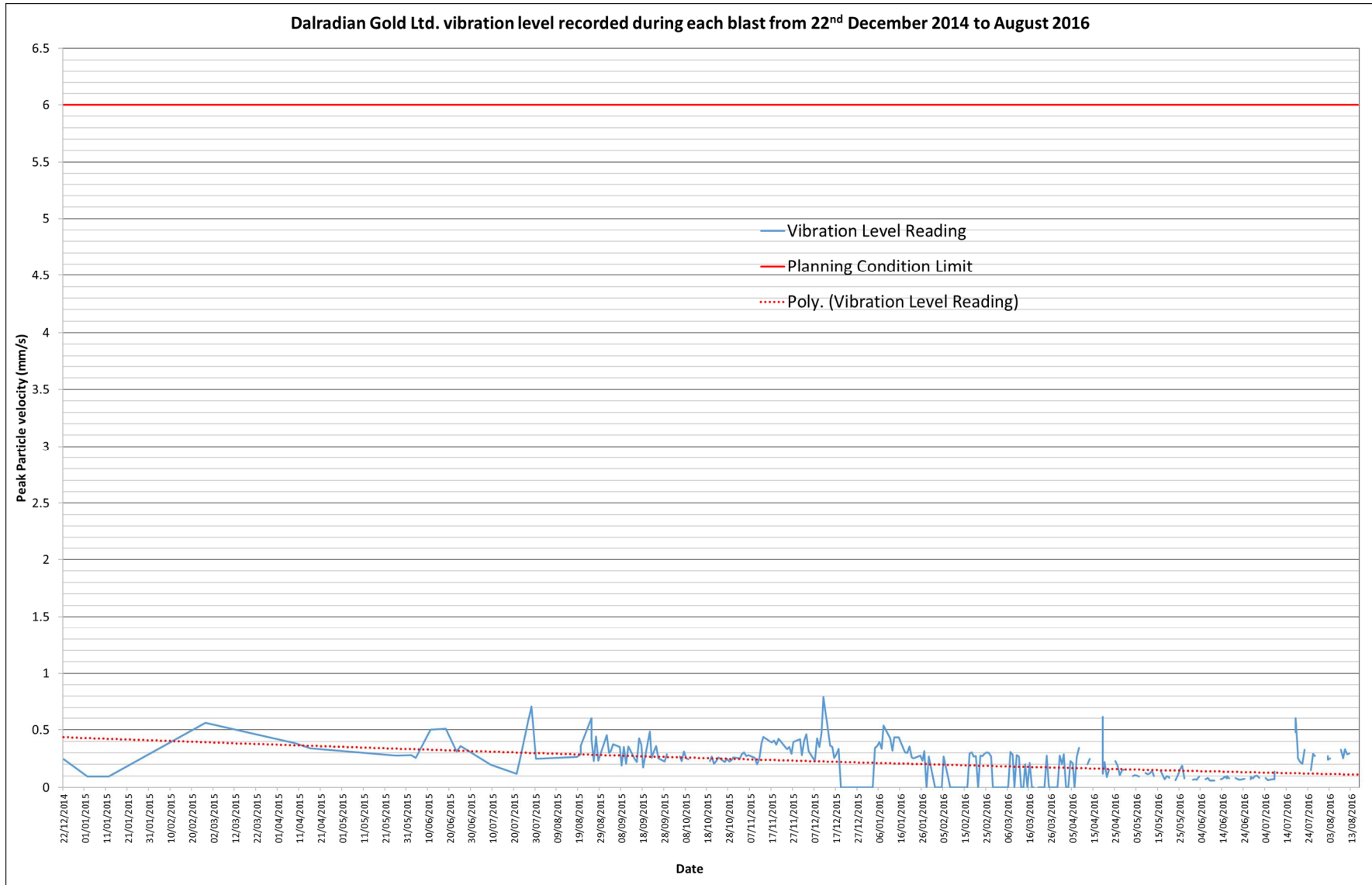
Blasting conducted within the mine itself shall not exceed a peak particle velocity (as measured at any occupied dwelling) of

<i>Place</i>	<i>Time</i>	<i>Magnitude</i>
<i>Residential</i>	<i>0800 – 1800 (Monday to Friday)</i>	<i>6 mm/s</i>
	<i>0800 – 1300 (Saturday)</i>	<i>6 mm/s</i>
	<i>2300 – 0700 (Night)</i>	<i>2 mm/s</i>
	<i>Other time outside above</i>	<i>4.5 mm/s</i>
<i>Office / Workshop</i>	<i>Anytime</i>	<i>14 mm/s</i>

For the purpose of this condition a 'blast' is defined as one which is greater than 0.5 mm/s.

During the period of monitoring from 22nd December 2014 to August 2016 no maximum instantaneous vibration level recorded during each blast exceeded the planning condition limit of 6 mm/s with a highest vibration level recorded of 0.794 mm/s (See Graph 1).

Graph 1: Maximum instantaneous vibration level recorded during each blast from December 2014 to August 2016.



5 Vibration Impact Assessment

5.1 Construction Vibration

BS6472-2:2008 'Blast induced vibration' states that in order to predict the likely vibration magnitude, a series of measurements at several locations should be taken from one or more trial blasts. With experience and knowledge of the factors which influence ground vibration, such as blast type and design, site geology and receiving structure, the magnitude and significance of these waves can be accurately predicted through calculation at any location.

The accepted method of predicting peak particle velocity for any given situation is to use a site-specific scaling approach utilising separation distances and instantaneous charge weights. This method allows the derivation of the site-specific relationship between ground vibration level and separation distance from a blast. A scaled distance value for any location may be calculated as follows:

$$\text{Scaled Distance, } SD = DW^{0.5} \text{ in mkg}^{0.5}$$

where D = Separation distance (blast to receiver) in metres

W = Maximum Instantaneous Charge (MIC) in kg i.e. maximum weight of explosive per delay interval in kg

For each measurement location the maximum peak particle velocity from either the longitudinal, vertical or transverse axis is plotted against its respective scaled distance value on logarithmic graph paper.

An empirical relationship derived by the United States Bureau of Mines relates ground vibration level to scaled distance as follows:

$$PV = a(SD)^b$$

where PV = Maximum Peak Particle Velocity in mm/s

SD = Scaled Distance in $\text{mkg}^{0.5}$

a, b = Dimensionless Site Factors

The site factors a and b allow for the influence of local geology upon vibration attenuation as well as geometrical spreading. The values of a and b are derived for a specific site from least squares regression analysis of the logarithmic plot of peak particle velocity against scaled distance which results in the mathematical best fit straight line where a is the peak particle velocity intercept at unity scaled distance and b is the slope of the regression line. In almost all cases, a certain amount of data scatter will be evident, and as such statistical confidence levels are also calculated and plotted.

The statistical method adopted in assessing the vibration data is that used by Lucole and Dowding. The data is presented in the form of a graph showing the attenuation of ground vibration with scaled distance and results from log - normal modelling of the velocity distribution at any given scaled distance. The best fit or mean (50%) line as well as the upper 95% confidence level are plotted.

The process for calculating the best fit line is the least squares analysis method. The upper 95% confidence level is found by multiplying the mean line value by 1.645 times 10 raised to the power of the standard deviation of the data above the mean line. A log - normal distribution of vibration data will mean that the peak particle velocity at any scaled distance tends to group at lower values.

From the logarithmic plot of peak particle velocity against scaled distance, for any required vibration level it is possible to relate the maximum instantaneous charge and separation distance as follows:

$$\text{Maximum Instantaneous Charge (MIC)} = (D/SD)^2$$

Where D = Separation distance (blast to receiver) in metres

SD = Scaled Distance in $\text{mkg}^{0.5}$ corresponding to the vibration level required.

The scaled distance approach assumes that blast design remains similar between those shots used to determine the scaling relationship between vibration level and separation distance and those for which prediction is required. For prediction purposes, the scaling relationship will be most accurate when calculations are derived from similar charge weight and distance values.

The main factors in blast design that can affect the scaling relationship are the maximum instantaneous charge weight, blast ratio, free face reflection, delay interval, initiation direction and blast geometry associated with burden, spacing, stemming and subdrill.

Although the instantaneous explosive charge weight has perhaps the greatest effect upon vibration level, it cannot be considered alone, and is connected to most aspects of blast design through the parameter blast ratio.

The blast ratio is a measure of the amount of work expected per unit of explosive, measured for example in tonnes of rock per kilogramme of explosive detonated (tonnes/kg), and results from virtually all aspects of a blast design, i.e. hole diameter, depth, burden, spacing, loading density and initiation technique.

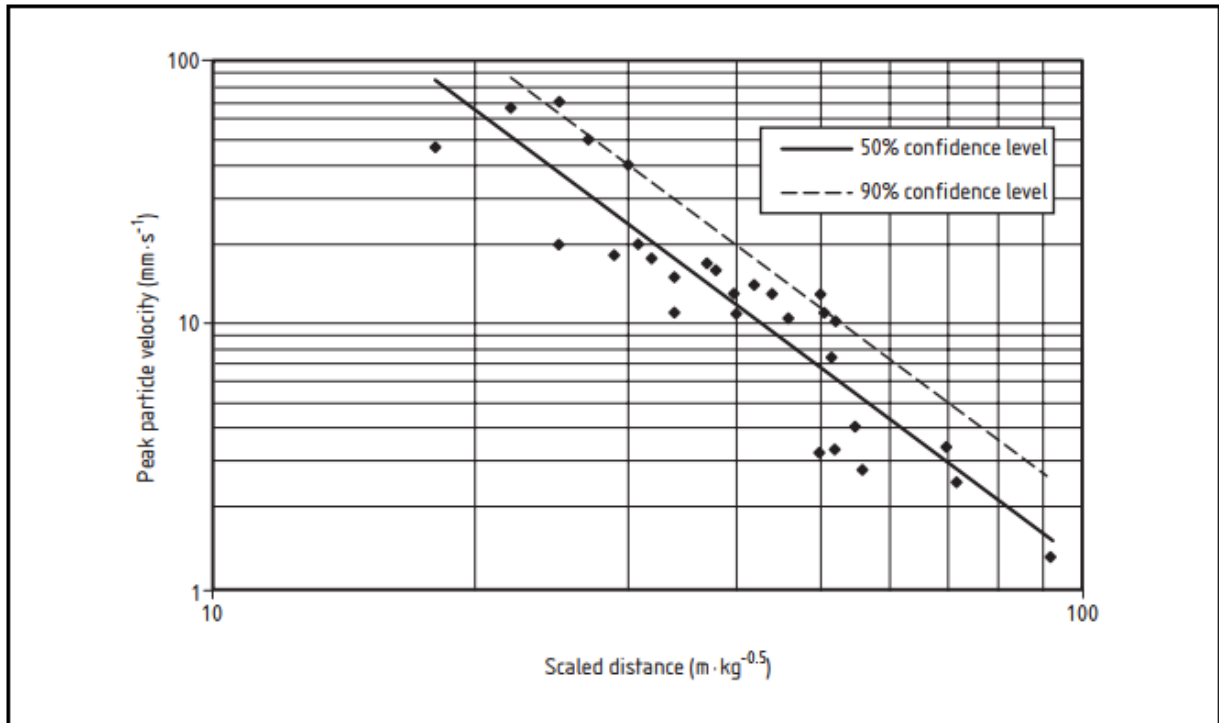
The scaled distance approach is also strictly valid only for the specific geology in the direction monitored. This is evident when considering the main mechanisms which contribute to ground motion dissipation:

- (i) Damping of ground vibrations, causing lower ground vibration frequencies with increasing distance.

- (ii) Discontinuities causing reflection, refraction and diffraction.
- (iii) Internal friction causing frequency dependent attenuation, which is greater for coarser grained rocks.
- (iv) Geometrical spreading.

In practice, similar rates of vibration attenuation may occur in different directions, however, where necessary these factors should be routinely checked by monitoring, especially on sites where geology is known to alter.

Graph 2: Sample site-specific scaled distance graph.



Where it is predicted that the received levels of vibration will exceed the relevant criteria, the operator will have to reduce the maximum instantaneous explosive charge weight. One method of achieving such a reduction is to deck the explosives within the borehole. This technique splits the column of explosives in two, separated by inert material. If blasting is required at closer distances than that where double decking would be a successful strategy, other charge reduction methods would have to be employed. These could be more complex decking strategies or changes to the blast geometry and / or the use of smaller diameter boreholes.

The empirical equations for predicting construction-related vibrations provide estimates in terms of PPV and therefore, the consequences of predicted levels in terms of human perception and disturbance can be established through direct comparison with the BS 5228-2:2009+A1:2014 guidance vibration levels. Hence, it is only through the use of trial blasts at the early stages of the blasting program that accurate construction-related vibrations can be predicted.

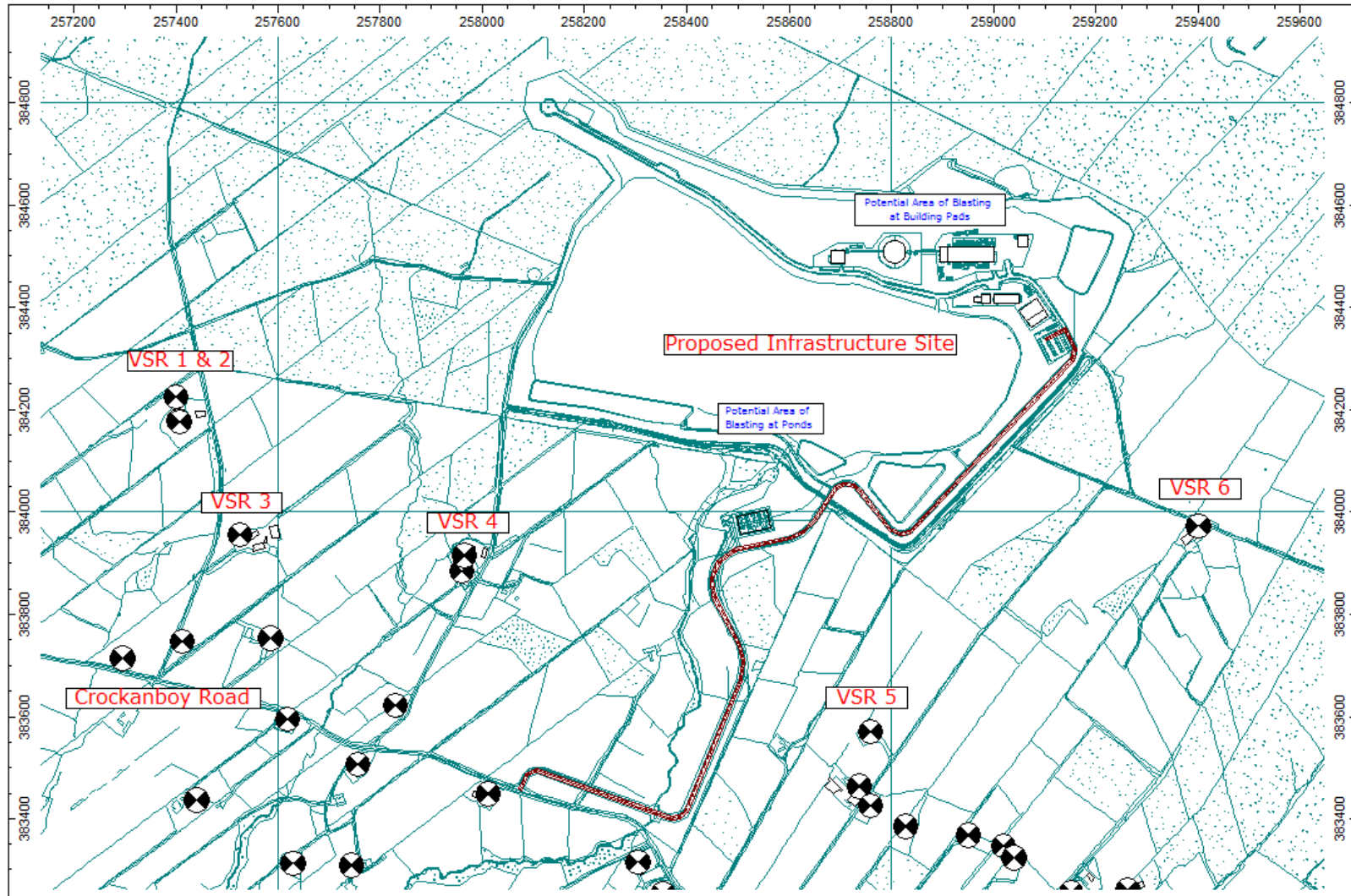
On account of the significant distance between the areas of the proposed blasting activities on the proposed infrastructure site and the nearest vibration sensitive receptors as outlined in Table 5, it is considered that a significant blasting vibration impact is unlikely. As stated above, an accurate prediction of such vibrations using the above-mentioned predictive methods is not possible until trial blast stage. However, the blasting contractor will employ such a trial blasting approach to ensure no significant impact will occur.

Table 5: Vibration sensitive receptors (VSR) in proximity to the proposed infrastructure site where surface blasting may occur during the construction phase (See Figure 1).

Ref No.	Address	Receptor ID	X Grid Coordinate (m)	Y Grid Coordinate (m)	Distance to Nearest Water Pond (m)	Distance to nearest Building Pad (m)
VSR 1	184 Crockanboy Road	D-R-0048	257408	384176	695	1325
VSR 2	K/2012/0141/RM Adjacent to 208 Crockanboy Road	D-Prop-0031	257400	384225	690	1320
VSR 3	204 Crockanboy Road	D-R-0010	257526	383955	625	1285
VSR 4	216 Crockanboy Road	D-R-0030	257965	383915	340	935
VSR 5	234 Crockanboy Road	D-R-0054	258760	383569	405	930
VSR 6	56 Mullydoo Road	D-R-0133	259402	383973	495	690

Note: Blasting may not be necessary to construct the water ponds to the south of the Dry Stack Facility. These may be constructed using excavators.

Figure 1: Vibration sensitive receptors (VSR) in proximity to the proposed infrastructure site where surface blasting may occur during the construction phase.



5.2 Operational Vibration

The only potential source of vibration during the operation of the Curraghinalt Project will be from underground blasting. This will be of a similar nature to the blasting that has been ongoing under the existing exploration license since December 2014, which as outlined in Section 4.1 and Graph 1 above, has not resulted in a significant vibration impact at any of the vibration monitoring locations. The proposed blasting methodology will involve the following approach; At the end of each shift the mine will be cleared of all personnel. Mine supervision will ensure that all personnel are on surface using the tag-in, tag-out board before initiating the central blasting system. The central blasting system initiates multiple development and production blasts throughout the mine. These blasts are set off in a sequence in order to minimise the disturbance to the mine and surrounding rock mass. Sequencing the blasts spreads out the explosive energy entering surrounding rock mass which thereby reduces the ground vibrations.

As outlined in the Project Description, variations of longhole stoping will be used in all geotechnical domains with the exception of one particular domain (known as the red domain), where cut-and-fill mining is required to limit the excavation span (See Figure 1).

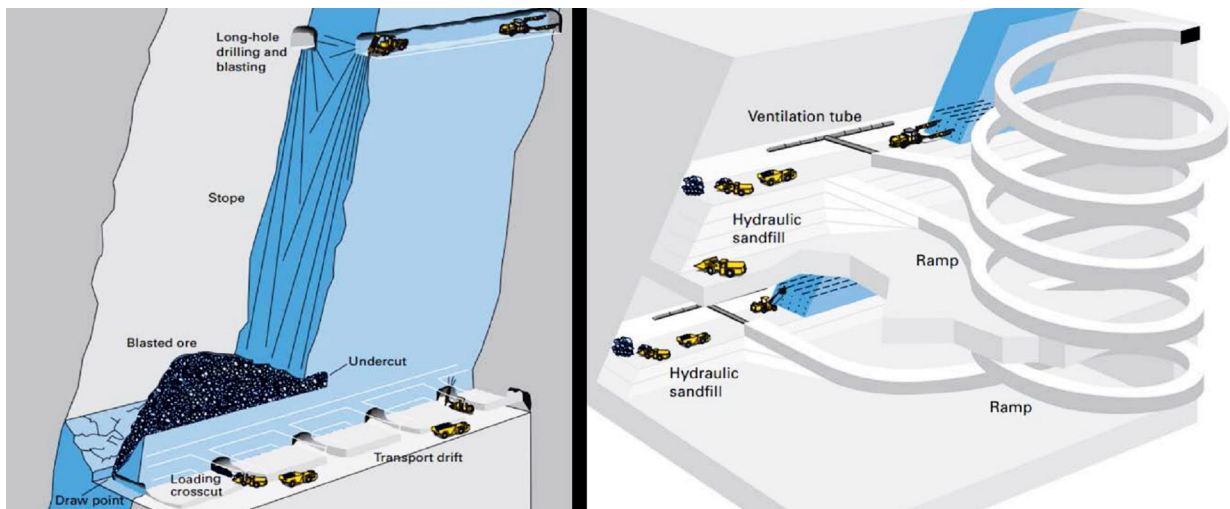


Figure 1: Longhole open stoping (left) and cut and fill mining (right) methods (Atlas Copco website. www.atlascopco.com. 2016)

Various drills (electric-hydraulic drills and pneumatic drills) will be used to develop the underground workings and mine the veins. Bulk emulsion explosives will be used for the majority of development and production mining activities. The blasts in the mine workings will be designed to minimise vibrations on surface. Due to the narrow veins being mined, blasts will be relatively small by underground mining standards. Blasting frequency is dependent on development and production rates and will normally occur at the end of each shift or twice per

day i.e. at 05:30 and 17:30. The explosives used will be bulk and packaged emulsions with electronic detonators.

Numerical modelling has been undertaken by the geotechnical specialists on the mine design team to assess the potential for subsidence (see the subsidence and seismicity memo from SRK Canada Inc, which is appended to the Environmental Statement for the Curraghinalt Project). From the modelling, it was concluded that significant surface subsidence is not expected to occur above the proposed mine extraction area. This finding is based on the initial mine design and can be attributed to the narrow mining widths, the mining methods used and the extensive placement of backfill. Further geotechnical information will be collected as the mine develops to refine the subsidence model. The potential for subsidence will be monitored as advised by geotechnical specialists (see the subsidence memo appended to the Environmental Statement). The monitoring will include surface monitoring systems capable of detecting the onset of any subsidence. These are common practice and well tested.

In terms of mine induced seismicity, given the rock mass conditions and the depth of mining in the proposed exploitation area, the occurrence of mining induced seismicity is expected to be limited. Numerical modelling based on the initial mine design shows micro seismic events are expected to occur along open excavations in the deeper sections of the mine but large seismic events are unlikely to occur. These are unlikely to impact on the integrity of surface structures and be experienced on properties adjacent to the extraction area (see the subsidence and seismicity memo from SRK Canada Inc, which is appended to the Environmental Statement for the Curraghinalt Project). A micro-seismic network will be installed to monitor, measure and locate any micro-seismicity. From this information, tactical strategies can be developed to ameliorate the occurrence and mitigate any impacts. This strategy could include changes in mining extraction sequences, the retaining of unmined pillars, and changes in excavation support regimes.

6 Vibration Mitigation Measures

6.1 Construction Vibration Mitigation Measures

Best management practice for vibration impact abatement will be implemented to minimise vibration impacts, including;

- choosing alternative, lower impact equipment or methods where necessary and / or possible;
- scheduling the use of vibration-causing equipment during the least sensitive time of day, i.e. not early morning and late afternoon;
- routing, operating or locating high vibration sources as far away from sensitive areas as possible;
- sequencing operations so that vibration-causing activities do not occur simultaneously;
- isolating the equipment causing vibration on resilient mounts; and
- keeping equipment well maintained.

6.2 Operational Vibration Mitigation Measures

Best management practice for vibration impact abatement will be implemented to minimise vibration impacts.

Continuous monitoring of vibration in proximity to the nearest residential properties will ensure that the recommended vibration thresholds as outlined in BS 5228 are not exceeded and to ensure that PPV levels are acceptable in terms of preventing disturbance and damage. This will be achieved by continuing the maximum instantaneous vibration level recordings during each blast as has been undertaken from 22nd December 2014 to date and presented in Graph 1 and Appendix I. Daily monitoring of the maximum instantaneous vibration level recordings during each blast will allow for the progress of the mine to be monitored closely. If maximum instantaneous vibration level recordings are found to be in excess of the recommended vibration thresholds as outlined in BS 5228 and the existing exploration planning condition limit of 6 mm/s then amendments to control the impact of the blasts can be instigated and enacted.

7 Conclusions

The construction contractor will develop and implement a site-specific Construction Management Plan including a specific Vibration Mitigation Strategy covering blasting, excavation and construction activities. This will ensure that best practicable means are used to mitigate construction vibration impacts.

No significant residual adverse vibration impacts will occur during operation of the Curraghinalt Project. Continuous monitoring of vibration in proximity to the nearest residential properties will ensure that the recommended vibration thresholds as outlined in BS 5228 and the relevant Planning Condition vibration limits are not exceeded.

APPENDIX I

The maximum instantaneous vibration level recorded during
each blast from December 2014 to August 2016

Date	Vibration Level Reading (mm/s)	Planning Condition Limit (mm/s)
18/08/2016	0	6
17/08/2016	0	6
16/08/2016	0	6
15/08/2016	0	6
14/08/2016	0	6
13/08/2016	0	6
12/08/2016	0.298	6
11/08/2016	0.289	6
10/08/2016	0.332	6
09/08/2016	0.253	6
08/08/2016	0.33	6
07/08/2016	0	6
06/08/2016	0	6
05/08/2016	0.288	6
04/08/2016		6
03/08/2016	0.252	6
02/08/2016	0.274	6
02/08/2016	0.242	6
01/08/2016	0	6
31/07/2016	0	6
30/07/2016	0	6
29/07/2016	0	6
28/07/2016	0	6
27/07/2016	0.272	6
26/07/2016	0.291	6
25/07/2016	0.151	6
24/07/2016	0	6
23/07/2016	0	6
22/07/2016	0.327	6
21/07/2016	0.205	6
20/07/2016	0.221	6
19/07/2016	0.296	6
19/07/2016	0.257	6
18/07/2016	0.479	6
18/07/2016	0.604	6
17/07/2016	0	6
16/07/2016	0	6
15/07/2016	0	6
14/07/2016	0	6
13/07/2016	0	6
12/07/2016	0	6
11/07/2016	0	6
10/07/2016	0	6

09/07/2016	0	6
08/07/2016	0.071	6
08/07/2016	0.14	6
07/07/2016	0.072	6
06/07/2016	0.067	6
05/07/2016	0.064	6
05/07/2016	0.065	6
04/07/2016	0.085	6
03/07/2016	0	6
02/07/2016	0	6
01/07/2016	0.084	6
30/06/2016	0.103	6
29/06/2016	0.1	6
28/06/2016	0.079	6
27/06/2016	0.071	6
27/06/2016	0.091	6
26/06/2016	0	6
25/06/2016	0	6
24/06/2016	0.074	6
23/06/2016	0.07	6
22/06/2016	0.069	6
21/06/2016	0.071	6
20/06/2016	0.084	6
19/06/2016	0	6
18/06/2016	0	6
17/06/2016	0.078	6
16/06/2016	0.078	6
16/06/2016	0.101	6
15/06/2016	0.096	6
14/06/2016	0.078	6
13/06/2016	0.071	6
12/06/2016	0	6
11/06/2016	0	6
10/06/2016	0.06	6
09/06/2016	0.06	6
08/06/2016	0.06	6
07/06/2016	0.083	6
06/06/2016	0.07	6
05/06/2016	0	6
04/06/2016	0	6
03/06/2016	0.097	6
02/06/2016	0.069	6
02/06/2016	0.073	6
01/06/2016	0.073	6
31/05/2016	0.068	6
30/05/2016	0	6

29/05/2016	0	6
28/05/2016	0	6
27/05/2016	0.079	6
26/05/2016	0.19	6
25/05/2016	0.156	6
24/05/2016	0.105	6
23/05/2016	0.065	6
22/05/2016	0	6
21/05/2016	0	6
20/05/2016	0.09	6
20/05/2016	0.085	6
19/05/2016	0.099	6
18/05/2016	0.07	6
17/05/2016	0.104	6
16/05/2016	0.146	6
15/05/2016	0	6
14/05/2016	0	6
13/05/2016	0.098	6
12/05/2016	0.146	6
11/05/2016	0.122	6
10/05/2016	0.117	6
09/05/2016	0.128	6
08/05/2016	0	6
07/05/2016	0	6
06/05/2016	0.094	6
05/05/2016	0.104	6
04/05/2016	0.107	6
03/05/2016	0.098	6
02/05/2016	0	6
01/05/2016	0	6
30/04/2016	0	6
29/04/2016	0.153	6
28/04/2016	0.149	6
27/04/2016	0.109	6
26/04/2016	0.192	6
25/04/2016	0.229	6
24/04/2016	0	6
23/04/2016	0	6
22/04/2016	0.155	6
21/04/2016	0.091	6
20/04/2016	0.22	6
19/04/2016	0.621	6
19/04/2016	0.119	6
18/04/2016	0	6
17/04/2016	0	6
16/04/2016	0	6

15/04/2016	0	6
14/04/2016	0	6
13/04/2016	0.249	6
12/04/2016	0.201	6
11/04/2016	0	6
10/04/2016	0	6
09/04/2016	0	6
08/04/2016	0.343	6
07/04/2016	0.265	6
06/04/2016	0	6
05/04/2016	0.211	6
04/04/2016	0.229	6
03/04/2016	0	6
02/04/2016	0	6
01/04/2016	0.288	6
31/03/2016	0.2	6
30/03/2016	0.278	6
29/03/2016	0	6
28/03/2016	0	6
27/03/2016	0	6
26/03/2016	0	6
25/03/2016	0	6
24/03/2016	0.276	6
23/03/2016	0	6
22/03/2016	0	6
21/03/2016	0	6
20/03/2016	0	6
19/03/2016		6
18/03/2016	0	6
17/03/2016	0	6
16/03/2016	0.215	6
15/03/2016	0	6
14/03/2016	0.201	6
13/03/2016	0	6
12/03/2016	0	6
11/03/2016	0.27	6
10/03/2016	0.279	6
09/03/2016	0	6
08/03/2016	0.283	6
07/03/2016	0.307	6
06/03/2016	0	6
05/03/2016	0	6
04/03/2016	0	6
03/03/2016	0	6
02/03/2016	0	6
01/03/2016	0	6

29/02/2016	0	6
28/02/2016	0	6
27/02/2016	0.268	6
26/02/2016	0.299	6
25/02/2016	0.304	6
24/02/2016	0.291	6
23/02/2016	0.272	6
22/02/2016	0.276	6
21/02/2016	0	6
20/02/2016	0.273	6
19/02/2016	0.268	6
18/02/2016	0.304	6
17/02/2016	0.298	6
16/02/2016	0	6
15/02/2016	0	6
14/02/2016	0	6
13/02/2016	0	6
12/02/2016	0	6
11/02/2016	0	6
10/02/2016	0	6
09/02/2016	0	6
08/02/2016	0	6
05/02/2016	0.269	6
04/02/2016	0	6
03/02/2016	0	6
02/02/2016	0	6
01/02/2016	0	6
29/01/2016	0.268	6
28/01/2016	0	6
27/01/2016	0.316	6
26/01/2016	0.233	6
25/01/2016	0.276	6
22/01/2016	0.254	6
21/01/2016	0.262	6
20/01/2016	0.355	6
19/01/2016	0.301	6
18/01/2016	0.303	6
15/01/2016	0.436	6
14/01/2016	0.436	6
13/01/2016	0.436	6
12/01/2016	0.322	6
11/01/2016	0.428	6
08/01/2016	0.538	6
07/01/2016	0.336	6
06/01/2016	0.396	6
05/01/2016	0.359	6

04/01/2016	0.344	6
03/01/2016	0	6
02/01/2016	0	6
01/01/2016	0	6
31/12/2015	0	6
30/12/2015	0	6
29/12/2015	0	6
28/12/2015	0	6
27/12/2015	0	6
26/12/2015	0	6
25/12/2015	0	6
24/12/2015	0	6
23/12/2015	0	6
22/12/2015	0	6
21/12/2015	0	6
20/12/2015	0	6
19/12/2015	0	6
18/12/2015	0.338	6
17/12/2015	0.29	6
16/12/2015	0.257	6
15/12/2015	0.353	6
14/12/2015	0.362	6
11/12/2015	0.794	6
10/12/2015	0.477	6
09/12/2015	0.351	6
08/12/2015	0.428	6
07/12/2015	0.231	6
04/12/2015	0.315	6
03/12/2015	0.464	6
02/12/2015	0.402	6
01/12/2015	0.281	6
30/11/2015	0.417	6
27/11/2015	0.395	6
26/11/2015	0.293	6
25/11/2015	0.35	6
24/11/2015	0.334	6
23/11/2015	0.356	6
20/11/2015	0.424	6
19/11/2015	0.371	6
18/11/2015	0.409	6
17/11/2015	0.393	6
16/11/2015	0.401	6
13/11/2015	0.438	6
12/11/2015	0.384	6
11/11/2015	0.246	6
10/11/2015	0.2	6

09/11/2015	0.256	6
06/11/2015	0.281	6
05/11/2015	0.271	6
04/11/2015	0.303	6
03/11/2015	0.289	6
02/11/2015	0.255	6
30/10/2015	0.261	6
29/10/2015	0.239	6
28/10/2015	0.224	6
27/10/2015	0.251	6
26/10/2015	0.222	6
23/10/2015	0.26	6
22/10/2015	0.231	6
21/10/2015	0.206	6
20/10/2015	0.268	6
19/10/2015	0.23	6
12/10/2015	0	6
09/10/2015	0.245	6
08/10/2015	0.254	6
07/10/2015	0.313	6
06/10/2015	0.23	6
05/10/2015	0.27	6
02/10/2015	0	6
01/10/2015	0	6
30/09/2015	0	6
29/09/2015	0.287	6
28/09/2015	0.225	6
25/09/2015	0.259	6
25/09/2015	0.254	6
24/09/2015	0.358	6
23/09/2015	0.313	6
22/09/2015	0.256	6
21/09/2015	0.485	6
18/09/2015	0.176	6
17/09/2015	0.371	6
16/09/2015	0.427	6
15/09/2015	0.221	6
14/09/2015	0.25	6
11/09/2015	0.356	6
10/09/2015	0.205	6
09/09/2015	0.351	6
08/09/2015	0.192	6
07/09/2015	0.353	6
04/09/2015	0.376	6
03/09/2015	0.317	6
02/09/2015	0.3	6

01/09/2015	0.453	6
28/08/2015	0.234	6
27/08/2015	0.441	6
26/08/2015	0.23	6
25/08/2015	0.603	6
25/08/2015	0.416	6
20/08/2015	0.288	6
20/08/2015	0.362	6
18/08/2015	0.264	6
30/07/2015	0.249	6
28/07/2015	0.71	6
23/07/2015	0.273	6
21/07/2015	0.121	6
09/07/2015	0.199	6
25/06/2015	0.359	6
23/06/2015	0.311	6
18/06/2015	0.51	6
11/06/2015	0.501	6
04/06/2015	0.256	6
02/06/2015	0.279	6
26/05/2015	0.277	6
16/04/2015	0.339	6
09/04/2015	0.382	6
26/02/2015	0.562	6
12/01/2015	0.097	6
02/01/2015	0.097	6
22/12/2014	0.247	6