



Drakelands Restoration Limited

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# HEMERDON MINE

Low Frequency Noise Mitigation Options  
Appraisal Report





Drakelands Restoration Limited

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## HEMERDON MINE

### Low Frequency Noise Mitigation Options Appraisal Report

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WSP

1 Capital Quarter

Tyndall Street

Cardiff

CF10 4BZ

Phone: +44 2920 769 200

WSP.com

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Signature				
Checked by	Keith Jefferson	Keith Jefferson	Keith Jefferson	
Signature			pp	
Authorised by	Keith Jefferson	Keith Jefferson	Keith Jefferson	
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APPENDIX A

REVIEW OF OPTIONS PRESENTED IN THE JANUARY 2018 REPORT

APPENDIX B

STRATEGIC OPTIONS SCORING SHEET



# EXECUTIVE SUMMARY

This options appraisal report has been prepared to assist Drakelands Restoration Limited (DRL) to determine the most suitable measures to mitigate low frequency noise (LFN) at the fundamental frequency and second harmonic of the 12 screens which are proposed to operate in the mineral processing facility (MPF) area of Hemerdon Mine and are known to be sources of LFN (see Section 1 of the Noise Impact Assessment<sup>1</sup> submitted with the application for details of the 12 screens).

This options appraisal report has assessed and ranked mitigation using an adapted version of the Kepner-Tregoe decision making process.

The 32 mitigation options presented in the Wolf Minerals' Options Evaluation Process<sup>2</sup> have been assessed and, of these, three have been included for further consideration.

A total of five mitigation options were then ranked. In accordance with the findings of the noise impact assessment the highest scoring option will be implemented as mitigation which is inherent in the design of the MPF. The options ranked second to fifth inclusive will be are included in the Noise Management Plan<sup>3</sup> and may be implemented, if proven to be required, once the MPF is operational. Note that underpan venting does not work in combination with deck venting so, should deck venting be employed as a mitigation measure, underpan venting should be discounted.

A summary of the options appraisal is tabulated below followed by details of the three highest ranked options. The analysis was undertaken in a series of meetings involving DRL, WSP, Eatec Dynamics (acoustic engineers) and Shann Pitts Consulting (environmental compliance specialist).

Rank	Option ID	Title	Weighted Aggregate Score
1	1	Acoustic enclosure for screen	385
2	5	Acoustic enclosure for screen with Kingspan cladding	330
3	2	Deck venting	301
4	4	Active noise control	229
5	3	Underpan venting	211

Three highest ranked options:

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<sup>1</sup> WSP report *Hemerdon Mine Low Frequency Noise Impact Assessment*, August 2023

<sup>2</sup> Wolf Minerals (UK) Ltd report *Low Frequency Noise options Evaluation Process*, January 2018

<sup>3</sup> WSP report *Hemerdon Mine Noise Management Plan for Minerals Processing Facility*, August 2023  
WSP report *Hemerdon Mine Noise Management Plan for Minerals Processing Facility*, October 2023



- Option 1 (Ranked 1): Acoustic enclosure with an open area for the material infeed and a chute for the discharge. The enclosure is designed to have a natural frequency of at least 20% above that of the screen which it encloses.
- Option 5 (Ranked 2): As Option 1 above and with the inclusion of Kingspan cladding to the external faces of the enclosure. The Kingspan cladding reduces noise at the second harmonic only.
- Option 2 (Ranked 3): Increasing the open area of the screen by including a diamond shaped “chimney”. This has the effect of reducing the acoustic efficiency of the screen which reduces its sound pressure level.

# 1 INTRODUCTION



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- 1.1.1. This options appraisal report is specific to low frequency noise (LFN) mitigation for the 12 MPF screens at the Hemerdon mine in south Devon (see Section 1 of the NIA for a list of the MPF screens). The overall aim of the exercise is to identify proven technologies which achieve a considerable reduction of LFN at its source and in the community whilst being aware of cost and any operational impacts. Options which reduce LFN at the fundamental frequency and second harmonic herein termed 'the relevant frequencies' are considered.
- 1.1.2. A number of LFN mitigation options have been considered in the past when the mine was operated by Wolf Minerals, and these are detailed in the report Low Frequency Noise Options Evaluation Process, dated January 2018. This report was submitted to the Environment Agency (EA) for consideration with the following response received via the Schedule 5 notice dated 1st March 2023:
- e. Include additional mitigation options within the NVIA.**  
*A previous Schedule 5 notification (dated 16/02/2022) requested a more comprehensive appraisal (including consideration of costs and benefits) of all available control options. You have stated that this written appraisal shall be included as part of the Noise Management Plan. We also require these options to be assessed within the NVIA to justify your selection of appropriate measures to prevent or where that is not practicable minimise emissions of infrasound/low frequency noise.*  
*It is noted that previously discussed mitigation measures such as antiphase speakers, enclosure of sources, and Innova J57 building cladding proposed under previous operation, have not yet been considered for the assessment, and the currently modelled insertion loss of the proposed double-layer concrete building cladding system is zero for sound frequencies in the 12.5 Hz, 16 Hz, and 25 Hz third octave bands.*
- 1.1.3. This appraisal assesses the mitigation options discussed in the January 2018 options appraisal report and identifies those which have been considered further in this appraisal. This exercise is presented in Appendix A.
- 1.1.4. Five options are then taken through to the final ranking exercise, three of which were identified in the 2018 options appraisal report. The options have been evaluated using an adapted version of the Kepner-Tregoe decision making process, as detailed in Section 3.

## 2 STRATEGIC OPTIONS


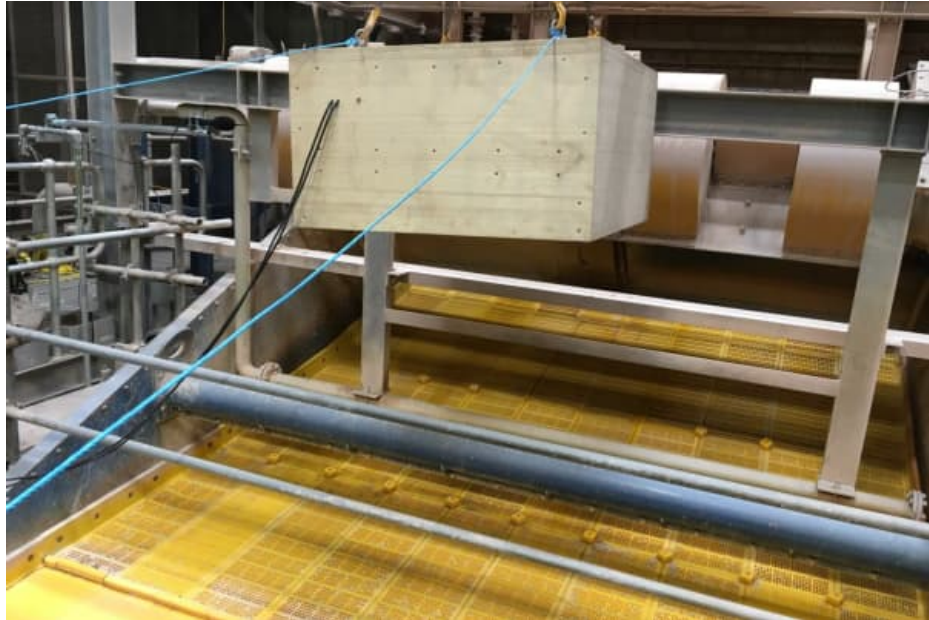
2.1.1. The following five LFN mitigation options are all deemed appropriate to consider in this assessment and are focused on reducing the levels at the fundamental frequency of the screens, unless otherwise stated.

**Table 2-1 – LFN Mitigation Options**

Option ID	Title	Detail of Mitigation Option*	Photograph of Mitigation Option
1	Acoustic enclosure for screen	<p>Acoustic enclosure with an open area for the material infeed and a chute for the discharge. The enclosure is designed to have a natural frequency of at least 20% above that of the screen which it encloses.</p> <p>Provides a proven reduction of 11dB at the fundamental frequency, in accordance with the results of a LFN trial undertaken in June and July 2023. However, a noticeably higher reduction is likely in practice as the infeed will also include a chute.</p>	
2	Deck venting	<p>Increasing the open area of the screen by including a number of diamond shaped “chimneys” to the screen. This has the effect of reducing the acoustic efficiency of the screen which reduces its sound pressure level.</p> <p>Provides a proven reduction of 6dB at the natural frequency, in accordance with the results of a trial undertaken in August 2020<sup>4</sup>.</p>	

<sup>4</sup> Eattec Dynamics report, *Low Frequency Noise mitigation tests on screen 150-SN-01*, dated August 2020



Option ID	Title	Detail of Mitigation Option*	Photograph of Mitigation Option
3	Underpan venting	<p>The screen deck generates pressures of opposite phase on either side. Underpan venting opens the transmission path between the upper and lower surfaces to create some cancellation which reduces the noise level.</p> <p>Provides a proven reduction of 1dB at the fundamental frequency in accordance with tests undertaken in July 2020<sup>5</sup>.</p>	
4	Active noise control	<p>An active system which generates a pressure waveform close to the screen deck that is of the same magnitude and in anti-phase with the pressure being generated from the screen. This option is also known as noise cancelling.</p> <p>Provides a proven reduction of 10dB at the fundamental frequency in accordance with tests undertaken in August 2020 (see Ref. 3 above).</p> <p>During the design stage, the technical detail of the active noise control system will be developed and will achieve a reduction of approximately 10dB</p>	
5	Acoustic enclosure for screen with Kingspan cladding	<p>As Option 1 above with the inclusion of Kingspan insulation on the outside of the enclosure. This option is targeted at reducing the 2nd harmonic and, through the site trials in June and July 2023, was shown to be ineffective in reducing noise at the fundamental frequency of the screens. The Kingspan product is the same as that identified in the BS 4142 assessment undertaken by SLR, dated November 2022. Item f of the Schedule 5 notice issued by the Environment Agency, dated 01.03.2023 requests further</p>	<p>Cladding shown in Option 1 photograph above</p>

<sup>5</sup> Eatec Dynamics report *The effect of underpan venting on transmitted low frequency sound pressure*, dated July 2020



Option ID	Title	Detail of Mitigation Option*	Photograph of Mitigation Option
		<p>information on the cladding system to ensure consistency between the low frequency NIA and the SLR report.</p> <p>Provides a proven reduction of 2.4 dB at the 2nd harmonic as shown in the site trials in June and July 2023. No reduction in noise level is achieved at the fundamental frequency.</p>	

\*Please see the NIA report for details of the trials/tests referred to above.

### 3 ASSESSMENT CRITERIA

#### 3.1 MUSTS

- 3.1.1. The “musts” refer to the must have criterion/criteria that apply. For this appraisal, there are two must criteria which are:
- the technology evaluated must be proven in its effectiveness to reduce LFN at the relevant frequencies; and
  - the technology reduces LFN.
- 3.1.2. A mitigation option has been discounted where it fails one or both of the criteria.

#### 3.2 WANTS

- 3.2.1. The “want” criteria are those which are considered desirable to the success of the project; i.e. those which DRL would like the final outcomes to support.
- 3.2.2. The appraisal methodology assigns a weighting to each of the want criteria, as tabulated below.

**Table 3-1 – Want Criteria and Weighting**

Want ID	Want Criteria	Description	Weighting (10 = highest, 1 = lowest)
W1	Most effective reduction	Achieves the highest reduction in noise level at the relevant frequencies on the site and in the local area.	10
W2	Easy to operate the mitigation	The mitigation is easy for the DRL personnel to operate	7
W3	Achieve Best Available Technique (BAT)	Mitigates and minimises the LFN at source	9
W4	Least risk of impact on H&S of personnel	Mitigation provides minimal risk to personnel on the site	7
W5	Least impact on operations	Option provides the least impact on the operating procedures and mineral processing at the mine.	5
W6	Lowest cost	Considers the cost of procuring the mitigation option.	3
W7	Easy to maintain	Maintenance requirements of the mitigation option to ensure it remains operating as intended.	2
W8	Easy to install	Installation of the mitigation option causes least disruption to the mine operations and its personnel.	1

## 4 SCORING

### 4.1 SCORING GUIDE

4.1.1. Table 4-1 below shows the scoring guidelines, as agreed with DRL. The want criteria will be scored from 1 to 10, with 10 being closest to achieving the want criterion.

**Table 4-1 – Want Criteria Scoring Guidelines**

Want ID	Want Criteria	1 out of 10	10 out of 10
W1	Most effective reduction	Low reduction in noise level at the fundamental frequency	High reduction in noise level at the relevant frequencies
W2	Easy to operate the mitigation	DRL personnel need to considerably amend their approach to operating the plant	DRL personnel can work unhindered by the mitigation
W3	Achieve Best Available Technique (BAT)	Mitigation being applied in the propagation path and/or at the receptor	Mitigates and minimises the noise levels at source
W4	Least risk of impact on H&S of personnel	High H&S risks to personnel on site	Lowest H&S risk to personnel on site
W5	Least impact on operations	Mitigation makes the mine less operationally efficient	The mine can operate unhindered by the mitigation
W6	Lowest cost	Highest overall cost	Lowest overall cost
W7	Easy to maintain	Requires least maintenance to continue operating with the specified noise reduction technique	Requires the most maintenance to continue operating with the specified noise reduction technique
W8	Easy to install	Onerous to install in terms of disruption to mine operations	Installation causes no disruption to mine operations

### 4.2 RAW SCORES AND RANKING

4.2.1. The scoring for each option is tabulated in Appendix B with the resulting and ranked options below.



**Table 4-2 – Option Ranking**

<b>Rank</b>	<b>Option ID</b>	<b>Title</b>	<b>Weighted Aggregate Score</b>
1	1	Acoustic enclosure for screen	385
2	5	Acoustic enclosure for screen with Kingspan cladding	330
3	2	Deck venting	301
4	4	Active noise control	229
5	3	Underpan venting*	211

\*Note that underpan venting is to be discounted if deck venting has been employed as a mitigation measure; they do not work in combination.

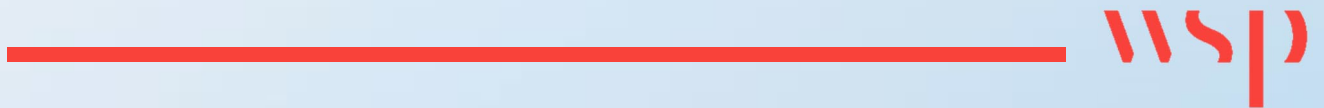
## 5 CONCLUSIONS

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- 5.1.1. Five mitigation options have been appraised by scoring them against the “must have” criteria and, those which meet the must criteria, were then scored against the “want to have” criteria.
- 5.1.2. The highest ranking option is the acoustic enclosure for screens (excluding the Kingspan cladding), primarily for its effectiveness in mitigating noise levels at the fundamental frequency.
- 5.1.3. Ranked second is the acoustic enclosure for screens including the Kingspan cladding. Note that this option reduces noise levels at the second harmonic only.
- 5.1.4. Ranked third is deck venting which provides a slightly lower reduction in noise levels at the fundamental frequency than the acoustic enclosure.
- 5.1.5. The fourth and fifth ranked options (active noise control and underpan venting respectively) are also worthy of ongoing consideration and have been considered in the Noise Management Plan submitted with the application.
- 5.1.6. The following are proposed to be adopted by DRL:
- Acoustic enclosures will be fitted to all 12 screens which are known to emit LFN.
  - Deck venting will also be installed on all screens to provide additional certainty regarding LFN at far field receptors.
  - ~~Options which were ranked second to fifth~~ Other options also provide considerable reductions in noise at the fundamental frequency and/or second harmonic and these will be included in the Noise Management Plan and Noise Impact Assessment as additional mitigation options, should they be required.

# Appendix A

REVIEW OF OPTIONS PRESENTED IN  
THE JANUARY 2018 REPORT



The Wolf Minerals Low Frequency Noise Options Evaluation Process (January 2018) started with 32 conceptual mitigation options to appraise. A screening exercise was undertaken on the 32 options which resulted in the 11 being progressed to a “sensitivity and cost benefit analysis” stage and four of these 11 options were identified as appropriate. These four options (including a description) are listed below with the first scoring the highest in the exercise and the bottom scoring the lowest. For clarity, E45 and J57 are references to cladding products produced by Innova and the ‘building’ refers to the mineral processing building.

■ **Retrofit existing cladding to Building E45 (Option SO3)**

*SO3 remedial option utilises the existing building frame structure and removes the current cladding replacing with new acoustic cladding treatment Innova E45 (Estimated transmission loss 13dB at 16Hz) on both the walls and roof. The existing building structure has been provisionally assessed to be capable of bearing the additional mass. Additional cost would be incurred to provide isolated structural stiffening. The noise transmission loss specification is significantly less than option SO1 and SO2. Acoustic treatments required for access points and revised ventilation control. Provisional Cost of SO3 approximately £4million.*

■ **Retrofit existing cladding to Building J57 (Option SO2)**

*SO2 remedial option utilises the existing building frame structure and removes the current cladding and replacing it with new acoustic cladding treatment Innova J57 (Estimated transmission loss is 22dB at 16Hz) on both the walls and roof. The existing building structure has been provisionally assessed to be capable of bearing the additional mass. Additional cost would be incurred for local stiffening of the existing structure. The noise transmission loss specification is the same as option SO1. Acoustic treatments required for access points and revised ventilation control. Provisional Cost of SO2 approximately £5million.*

■ **Building over a building with acoustic cladding – J57 (Option SO1)**

*SO1 remedial option includes building an isolated new building frame over the existing building structure with new acoustic cladding treatment Innova J57 (Estimated transmission loss is 22dB at 16Hz) on both the walls and roof. The increased complexity of the new building frame and removal of the existing cladding has a significant impact to the overall cost. The additional cost provides no additional acoustic benefit as the structural vibration of the existing building can be controlled with local stiffening of the existing structure. Acoustic treatments required for access points and revised ventilation control. Provisional Cost of SO1 approximately £10million.*

■ **Modular and/or spray-on acoustic treatment (options S25)**

*S25 remedial option utilises the existing building frame structure and cladding but increases mass with the application of a cement material bonded to the cladding (Estimated transmission loss 10dB at 16Hz). A new roof cladding arrangement will be installed. Additional cost would be incurred to provide isolated structural stiffening. The noise transmission loss specification is significantly less than option SO1, SO2 and SO3. Acoustic treatments required for access points and revised ventilation control. Provisional Cost of S33 approximately £2million.*

The 2018 assessment concluded that Option S02 “Retrofit existing cladding to Building J57” was most appropriate to implement.

It is important to note that the Wolf Minerals options were all based on the plant being able to remain operational during the work. All of the four options above have been discounted from this appraisal. This is due to the mine not currently operating and there being the opportunity to treat the noise closer to the source – i.e. at the screen itself.





Table A-1 overleaf provides a summary of the 2018 mitigation options and assesses them against the must criteria in Section 3 to determine whether any are worthy of ongoing consideration.



**Table A-1 – Review of Options from 2018 Report and Reasons for Including/Excluding from this Appraisal**

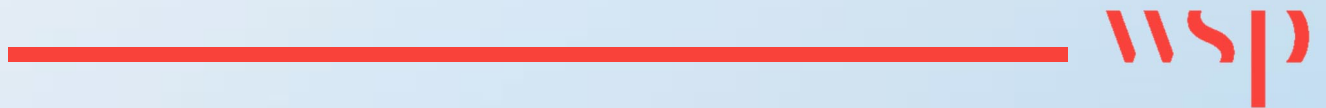
Option	ID	Title	Does Option Meet Must Criteria?		Comments
			Tested and Proven Solution	Reduces LFN	
1	SO1	Building over a building with acoustic cladding	No	Unknown	Do not meet one or both of the must criteria. Excluded from further consideration
2	SO2	Retrofit existing cladding (rubber sides)	No	Unknown	
3	SO3	Retrofit existing cladding (steel sides)	No	Unknown	
4	SO4	Replace existing cladding on specific facades/roof sections	No	Unknown	
5	SO5	Treatment of cladding 'hotspots'	No	Unknown	
6	SO6	Localised stiffening of existing steelwork	No	Unknown	
7	SO7	Screen synchronisation	No	No	
8	SO8	Remove cladding	No	No	
9	SO9	Add damping	No	Unknown	
10	S10	Do nothing	No	No	
11	S11	Container wall	No	Unknown	
12	S12	Sub-divide internal volume	No	Unknown	
13	S13	Alter internal building geometry	No	Unknown	
14	S14	Supplementary volumes	No	Unknown	
15	S15	Alter operating frequencies away from 16Hz	No	Unknown	
16	S16	Stiffen cladding	No	Unknown	
17	S17	Nearfield acoustic enclosure rubber sides	No	Unknown	
18	S18	Nearfield acoustic enclosure steel sides	Yes	Yes	Meet both of the must criteria and are taken forward to be considered against the want criteria – see Section 4
19	S19	Nearfield acoustic enclosure acoustic 'room'			
20	S20	Modify the gap between under pan and screen	Yes	Yes	



Option	ID	Title	Does Option Meet Must Criteria?		Comments
			Tested and Proven Solution	Reduces LFN	
21	S21	Active noise control (speaker system)	Yes	Yes	Do not meet one or both of the must criteria. Excluded from further consideration
21a	S21a	Active noise control (compressed air system)	No	Unknown	
22	S22	Fix residents' rattles	No	No	
23	S23	Close building openings	No	Unknown	
24	S24	Restrict the hours of operations	No	No	
25	S25	Modular and/or spray-on acoustic treatment	No	Unknown	
26	S26	Relocation and splitting of screens	No	Unknown	
27	S27	Under pan volume increase	No	Unknown	
28	S28	Bunding and noise attenuation measures	No	No	
29	S29	Separate operations	No	Unknown	
30	S30	Improve current isolation efficiencies	No	Unknown	
31	S31	Shift product screen operating frequencies into the 12.5Hz 3rd octave band 40Hz 3rd octave at 3x harmonic	No	No	

# Appendix B

## STRATEGIC OPTIONS SCORING SHEET





**Table B-1 – Strategic Options Scoring Sheet**

		Option 1	Option 2	Option 3	Option 4	Option 5						
<b>Must:</b>	Tested and proven solution	Y	Y	Y	Y	Y						
	Reduces LFN	Y	Y	Y	Y	Y						
<b>Want:</b>												
		Weighting	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted
W1	Most effective reduction	10	10	100	8	80	1	10	6	60	9	90
W2	Easy to operate the mitigation	7	8	56	9	63	10	70	1	7	8	56
W3	Achieves BAT	8	10	80	8	64	2	16	5	40	9	72
W4	Least risk of impact on H&S of personnel	8	10	80	5	40	1	8	7	56	9	45
W5	Least impact on operations	5	8	40	1	5	10	50	10	50	8	40
W6	Lowest cost	2	2	4	6	12	10	20	5	10	1	2
W7	Easy to maintain	3	8	24	9	27	10	30	3	1	8	24
W8	Easy to install	1	1	1	10	10	7	7	5	5	1	1
<b>Weighted Aggregate Score</b>			57	385	56	301	51	211	42	229	53	330

Option	Description
1	Acoustic enclosure for screen
2	Deck venting
3	Underpan venting
4	Active noise control
5	Acoustic enclosure for screen + Kingspan cladding



1 Capital Quarter  
Tyndall Street  
Cardiff  
CF10 4BZ

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