Notice of Request for More Information Response Document

Site name:	**Hemerdon Mine Mineral Processing Facility**
Site address:	**Hemerdon Mine, Plympton, Devon PL7 5BS**
Operator name:	**Drakelands Restoration Limited**
Application reference:	**EPR/AP3203ML/A001**

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Document Ref: SPC0124/Schedule5 Response/TWL October 2023

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Introduction

Overview

This document has been written by Shann Pitts Consulting Limited on behalf of and in conjunction with Drakelands Restoration Limited, drawing on additional technical knowledge from several sources, namely:

- Louise Beamish (WSP Acoustics Team)
- Brian Jarvis (Eatec Dynamics)
- Andrew Hodgson (Fairport Engineering Limited)

This document serves as a formal response document to the Environment Agency (EA) with respect to an outstanding 'Notice of request for more information' or 'Schedule 5 notice' relating to a new permit application for the operation of the minerals processing facility at Hemerdon mine (permit application reference: EPR/AP3203ML/A001).

Permitting Background

On 26 August 2021 Tungsten West Plc (Tungsten West) submitted a new bespoke environmental permit application to the EA for the operation of the Mineral Processing Facility at Hemerdon Mine.

On 17 September 2021 the EA permitting department deemed the permit application permit to be 'duly made'. Subsequently, the EA carried out a public consultation on the permit application which closed on 29 October 2021.

On 8 February 2022 the EA served Tungsten West with a Schedule 5 notice with respect to the permit application requiring updated supporting documents namely non-technical summary, BAT assessment, environmental risk assessment, BS4142 noise impact assessment, air quality impact assessment and site plan. This Schedule 5 notice is herein termed 'Notice 1a'.

On 16 February 2022 the EA issued Tungsten West with a second Schedule 5 notice requiring a revised Noise and Vibration Impact Assessment (NVIA) to address twelve individual queries relating to the assessment of low frequency noise (LFN). This Schedule 5 is herein termed 'Notice 1b'.

On 17 June 2022 the legal entity making the permit application was transferred from Tungsten West to Drakelands Restoration Limited (Drakelands Restoration).

In July 2022, due to the impact of the war in Ukraine, Drakelands Restoration revised some of the detail within the permit application to reflect proposed operational changes designed to reduce the CAPEX and OPEX of the project, termed internally as 'Project Trident'.

On 1 December 2022 Drakelands Restoration submitted to the EA individual responses and supporting documents with respect to Notices 1a and 1b including a substantially new Noise and Vibration Impact Assessment.

On 12 December 2022 the EA opened a new public consultation of the revised permit application documents, as a result of Project Trident. This consultation ended 31 January 2023.

On 3 February 2023 the EA issued Drakelands Restoration with a third Schedule 5 notice 'Notice 2a' requiring the production of a Noise Management Plan (NMP) incorporating audible noise and LFN.

Anecdotally, the EA had accepted the response to Notice 1a with respect to audible noise but require the NMP to also incorporate LFN. There was verbal confirmation that the development of an overarching NMP incorporating audible noise and LFN control would satisfy the remainder of the questions.

On 1 March 2023 the EA issued a fourth Schedule 5 notice 'Notice 2b' which follows on from the response to Notice 1b which did not satisfactorily address all the points raised in Notice 1b. Notice 2b requires the development of a revised noise impact assessment (NIA) with respect to LFN. The notes in Notice 2b confirm the closure of Notice 1b.

On 15 August 2023 Drakelands Restoration submitted to the EA a response document to the single outstanding issue in Notice 2a (the NMP) and the whole of Notice 2b including the following supporting documents:

- Hemerdon Mine Noise Management Plan for Minerals Processing Facility, WSP, August 2023 (V4)
- Hemerdon Mine Low Frequency Noise Impact Assessment, WSP, August 2023
- Low Frequency Noise Mitigation Options Appraisal, WSP, August 2023

On 5 October 2023 the EA issued a fifth Schedule 5 notice 'Notice 3' which raises questions in respect to the information submitted in response to Notice 2a and Notice 2b.

Structure of Document

The document has been written to detail the responses of Drakelands Restoration to Notice 3. Notice 3 is in three parts:

- Question 1 requires the response to 14 specific questions in relation to the August 2023 NIA. Depending upon the depth of information that is required to fully respond to the query, the response is either included in the main text of the document or is in a standalone report in the Appendices.
- Question 2 requires the submission of a verification plan for commissioning which is included as Appendix H to this document.
- Question 3 requires wording in relation to the NMP and has been included as a revised version of the NMP.

The following separate supporting documents accompany this response:

- Hemerdon Mine Noise Management Plan for Minerals Processing Facility, WSP, October 2023 (V6)
- Low Frequency Noise Mitigation Options Appraisal, WSP, October 2023 (V3)
- Appendices C & G are Excel spreadsheets and as such have been submitted as separate documents.

1. Noise Impact Assessment

The following questions relate to the Noise Impact Assessment (dated August 2023). Submission of the requested information can be provided in a separate addendum to the assessment.

Question 1a

Provide an explanation of how the screens and enclosures will be orientated to avoid directionality of the overall LFN emissions.

The Noise Impact Assessment report (dated August 2023) states that as 'there will be multiple screens operating at Hemerdon… they will not be oriented in the same direction' which will negate the issue of directionality.

Using a mean average to derive the stated 11 dB reduction for enclosures, would mean that the enclosures would be less effective than 11 dB in certain directions. For instance, the report showed that the 'enclosure and discharge chute' (Figure 5-15) had less than an 11 dB reduction compared to the 'open' scenarios, between 115 degrees and 286 degrees (Figure 5-4 and 5-5). One result appears to show that the 'enclosure and discharge chute' scenario had a higher level in one direction compared to the 'open' scenarios showed in Figure 5-4 and 5-5.

There is therefore a concern that directionality of emissions is unpredictable, and the enclosure's assumed 11 dB reduction is reliant on the correct collective orientation of all screens.

Question 1a Response

The directionality seen in the near field is more a result of local reflections than screen orientation. The enclosure with chute test, with the overall 11 dB reduction compared to the open test did have 13.6 dB higher levels at a compass angle of 250^o compared to that at 15^o showed no such directionality in the far field measurements for this test.

This phenomenon is explained in more detail in Appendix A - Screen Enclosure Tests – directionality.

Question 1b

Provide an explanation of how the chute design that has been tested, would be replicated on site for all relevant screens.

It is unclear that the chute design, as tested, could be practically replicated for all screens. This would include the distance between the end of the chute to a solid surface or processed material, and the dimensions of any open area at the end of the chute. If this scenario could not be replicated then there is concern that the estimated 6 dB additional reduction could not be achieved.

Question 1b Response

We can confirm that no alternative outlet chute configurations were trialled. The chute was not part of the original trial design but was added to assess the effect of different size openings in the enclosure. It became apparent as the trial progressed that the sizes of the openings in the enclosure had a significant effect on the transmitted noise. The early tests had openings of around 8.6 m^2. This had been reduced to 1.2 m^2 by the final test that included the chute. The actual chute design will ensure that the LFN emissions will be no greater than those measured during the trial. Appendix B shows the various possible configurations of chutes that are proposed.

Appendix C shows the near field monitoring results with respect to different sized screen openings and includes the dimensions of the openings associated with each test scenario.

Appendix D details enclosure design criterion for mitigating LFN and demonstrates the design principles that have been derived from the trial.

Question 1c

Provide the results of any tests which were carried out with alternative chute outlet configurations.

Question 1c Response

Please see the answer to Question 1b above.

Question 1d

Provide a full dataset (including excel spreadsheet) of results from testing the screen with and without various enclosure scenarios described at section 5.2.3 showing sound pressure levels at the fundamental frequency 12.5 Hz, the second harmonic frequency 25 Hz, and the third harmonic frequency 37.5 Hz, recorded at each nearfield monitoring point for each test scenario.

Question 1d Response

The tables of results and resulting charts in the format requested are provided in Appendix C - Near Field Results Values for all Test Scenarios including Opening Sizes.

Note that Test 1 and Test 2 are repeats of the same test and this was carried out at the start of the trial to assess repeatability of the results in the near field, which was satisfactorily demonstrated.

Question 1e

Provide separate graph plots for each frequency of sound level vs compass angle (like Figure 5-9) showing the results of all the tests carried out on the screen without enclosure, and with all the various enclosure combinations which shall indicate directionality of source at the different frequencies. Provide a full explanation of results.

Question 1e Response

The data requested is provided in Appendix C. An assessment of the impact of directionality is included in Appendix A.

Question 1f

Provide an explanation of why the enclosure appears to have resulted in an increase in average near field sound pressure levels in one test scenario, and why another test scenario resulted in almost no reduction in average near field sound pressure levels, at the fundamental frequency 12.5 Hz, (Figures 5-10, 5-13, 5-16) and any impact this has on uncertainty of conclusions.

Question 1f Response

The objective of the trial was to determine the most effective design for the enclosure. Acoustic theory predicted that if the enclosing surfaces were made stiff enough, the vibration response would be low so that the indirect transmission through the walls would be significantly attenuated. The direct paths through openings in the enclosure would also provide a transmission path so that the overall emissions would be a combination of the two. What was unknown at the start of the trial was the proportions that would take each of these paths.

It became apparent as the planned test proceeded that the openings had a much greater effect on the total than the transmission through the walls. For the maximum open area of the enclosure, the near field sound pressure average was greater than for the open screen (i.e., the unmitigated noise level). This behaviour was also seen in the far field and so cannot be attributed to local reflections.

This finding was recognised during the trial, and it became clear that to achieve a good sound reduction, the opening sizes would have to be kept as small as possible. This led to the chute being tested in combination with the enclosure. There was only time to add a chute to the discharge opening, and of all the test scenarios it gave the most promising results. There was no time to add a chute to the inlet opening which remained large on the roof of the enclosure. It would be expected that with the inlet chute, further reductions could be achieved.

It remains an interesting academic question as to why there should be an increase in sound pressure level with an enclosure and large openings compared to an open screen. To be certain of the mechanisms that gave this result would require a new set of trials although the results would have no influence on the enclosure design.

The likely mechanism that explains this effect is linked to the location of the openings in the enclosure. With an open screen, positive pressure is generated above the screen deck while negative pressure is generated below. Both the volumes above the deck and below the deck are open to the environment without an enclosure and there will be some pressure cancelling that will take place. With the enclosure around the screen, the openings were only to the volume above the deck and so the cancelling effect would be less.

Without further trials, this theory is impossible to prove, but it is the basis for deck venting and there is a large body of evidence to show that the pressure cancelling effect is significant.

Question 1g

Show how data presented in Table 5-3 has been derived for each result. Provide an explanation of why the enclosure appears to have resulted in an increase in far field sound pressure levels at the fundamental frequency 12.5 Hz in multiple test scenarios (Table 5-3) and any impact this has on the uncertainty of conclusions. What results were obtained for the test scenario with outlet chute which is absent from Table 5-3 and explain how that data has been derived?

Question 1g Response

The responses to the subsections of this question have been broken down for ease of assessment.

- **Show how data presented in Table 5-3 has been derived for each result.**
- **What results were obtained for the test scenario with outlet chute which is absent from Table 5-3 and explain how that data has been derived?**

The data in Table 5-3 (Sound Pressure Levels at Fundamental Frequency at Far Field Location during Enclosed Test Scenarios (no Cladding), dBZ) are the predicted sound pressure levels for the screen at the fundamental frequency for various trial scenarios. To obtain the screen levels, the contribution from the background noise needs to be estimated and removed.

Analysing the far field results from the enclosure trial was not easy because the sound levels from the screen were very close to the background levels. An attempt has been made to remove the influence of the background, but with the screen at such low levels of sound pressure, this process was prone to error. This reduces the accuracy of the estimate of the sound pressure from the screen, although it is clear that the absolute levels from the screen are extremely low.

When the far field contribution from the screen drops to background levels, obtaining an accurate estimation of the values becomes difficult and, in attempting to do so, various methods can be used. Appendix E *Estimating the screen contribution from background levels* provides an example of using different methods for obtaining a value for screen contribution for the enclosure with chute scenario at Windwhistle Farm.

Any method does introduce a high level of uncertainty if the contribution from the screen is relatively small because it relies on the background values changing in an insignificant way between the narrow bands. In some cases (screen fully enclosed with measurements at Windwhistle Farm), the bands next to that containing the screen frequency varied from 46.5 dBZ to 49.0 dBZ whereas the band with the screen frequency was 48.2 dBZ. The difference between using one band or the other for removing the background is either the screen is contributing 42.6 dBZ of sound pressure or removing 41.3 dBZ from the environment. This technique is therefore subject to significant uncertainty in the absolute values of screen contribution and comparison between tests should be treated with caution when the levels in the bands representing "background" and "screen + background" are so close. What can be stated with certainty is that if the level in the "screen + background" is acceptably low, the screen cannot be contributing any higher level.

The analysis of the data extracted the sound pressure in a narrow band around the fundamental frequency (which included the contribution from the screen) and also in a narrow band of the same width adjacent to the first band (to give the background level). For all test scenarios (except for the 'enclosure with chute' scenario as reported in Table 5-5 of the NIA), the band width was 0.148 Hz. With the enclosure with chute scenario, the band width was 0.5 Hz.

The difference in approach with respect to the narrowband analysis (0.148 Hz and 0.5 Hz) is because the far field measurements for the enclosure with chute scenario (Table 5-5 of the NIA) were taken by roving measurements of length 10 minutes rather than from the permanent far field monitors used for other tests (Table 5-3 of the NIA) where longer periods allowed for finer frequency resolution. By the time the 'enclosure with chute' scenario was tested the three permanent far field monitors had been removed.

In all cases presented in this Schedule 5 response, the background noise level was consistently derived using the adjacent band on the upper side of the fundamental frequency band. The noise levels in Table 5-5 of the NIA included a hybrid approach, where the background was derived from either of the adjacent frequency bands which was, in part, based on a subjective approach. However, the approach used for the values in the revised Table 5-3 is a consistent and robust approach and, therefore, allows for the levels in Table 5-5 to now be directly compared to those in Table 5-3 of the NIA. Please see Table 1 which includes the data presented in Table 5-3 of the NIA with the addition of the updated levels for the 'Enclosure with chute' scenario all derived in a consistent manner.

Table 1 below shows the values of sound pressure in the two narrow bands, labelled 'Background' and 'Screen + background' plus the difference when the background band is subtracted from the band with the screen. For clarity, the values in Table 1 (excluding the 'Enclosed with chute' scenario) have been calculated using 0.148 Hz narrow band analysis. The 'Enclosed with chute' scenario has been calculated using 0.5 Hz narrowband analysis.

Table 1 – Far field results at three monitoring locations including background, background and screen readings and the calculated result for the screen alone, Fundamental Frequency, dBZ

	Open Area (m^2)	Portworthy (dBZ)			Dartmoor Zoo (dBZ)			Windwhistle (dBZ)		
		Background	Screen + background	Screen alone	Background	Screen + background	Screen alone	Background	Screen + background	Screen alone
Open full ply test 1	-	24.7	28.6	26.3	26.6	40.8	40.6	44.8	45.6	37.9
Open full ply test 2	-	32.9	43.5	43.1	26.8	40.3	40.1	33.7	44.4	44.0
Fully enclosed	0	27.4	28.5	22.0	44.4	44.8	34.2	45.9	49.3	46.6
Lower end panel removed	3.17	40.6	42.4	37.7	36.6	41.3	39.5	42.4	43.8	38.2
Lower end and top panels removed	5.45	46.4	49.7	47.0	33.6	42.1	41.4	39.6	42.6	39.6
Lower and upper end and top panels removed	8.62	41.0	50.6	50.1	34.4	43.2	42.6	34.8	50.6	50.5
Enclosed with slots	0.08	27.2	31.0	28.7	34.7	36.9	32.9	43.5	45.0	39.7
Enclosed with single deck openings	1.18	34.4	41.1	40.1	39.8	40.0	26.5	40.0	43.6	41.1
Enclosed with twin deck openings	1.6	41.0	43.2	39.2	34.4	36.3	31.8	37.9	41.8	39.5
Enclosed with chute	1.18	41.9	42.1	28.6	35.3	39.2	36.9	46.8	48.2	42.6

Provide an explanation of why the enclosure appears to have resulted in an increase in far field sound pressure levels at the fundamental frequency 12.5 Hz in multiple test scenarios (Table 5-3) and any impact this has on the uncertainty of conclusions.

It is recognised that in multiple test scenarios the enclosure appears to have resulted in an increase in far field sound pressure levels at the fundamental frequency. There are two possible reasons for this observation:

- High background noise levels making it difficult to extract a screen only noise level ; and / or
- The location of the enclosure openings in relation to the screen deck.

Each of these possible reasons is addressed below.

The effect of high background noise levels during the screen measurements is demonstrated in Appendix E which provides an example of levels at Windwhistle for the "fully enclosed" scenario. . In summary, the screen noise level is so hidden within the background that the attempt to extract it has resulted in a result with a high level of uncertainty.

The effect of the location of the enclosure openings in relation to the screen deck is explained in the response to Question 1f.

Whilst there is uncertainty associated with the derivation of screen only noise levels, as explained above, there is no uncertainty in the conclusions of the NIA – i.e., that the LFN from the screen sits predominantly within the background.

Question 1h

Are the results in Table 5-5 for the scenario with outlet chute directly comparable to the results in Table 5-3 (noting the commentary at section 5.3.19) for other test scenarios for the three common locations? Provide an explanation of the results of far field monitoring in the test scenario with outlet chute in place (section 5.3.23 and Table 5-5) in comparison with results of far field monitoring for other test scenarios for the common locations (section 5.3.19 and Table 5-3).

Question 1h Response

As stated in the response to Question 1g above, when the tests with the chute in place were carried out, the three permanent far field monitors had been removed. To obtain far field readings, sound pressure measurements were carried out over 10 minute periods in various far field locations. The contribution to the sound levels from the screen were very low, masked by the background noise.

Using the same 0.5 Hz narrow band analysis to compare adjacent bands with and without the screen frequency, the measurements shown in Table 2 below were obtained. The submission shows an attempt to estimate the contribution from the screen by subtracting the background (see Table 5-5 of the NIA). The missing data in Table 5-5 of the NIA indicates that the background band was higher than the screen band.

Table 2 – Far field monitoring results for the trial scenario with enclosure with chute, Fundamental Frequency, dBZ

Receptor Location	Background (dBZ)	Screen + background (dBZ)	Screen alone (dBZ)
Portworthy	41.9	42.1	28.6
Windwhistle	46.8	48.2	42.6
Dartmoor Zoo	35.3	39.2	36.9
Gorah Cottages	32.6	35.9	33.2
Yondertown	54.1	51.3	
Lutton	34.7	35.5	27.8
Cornwood Inn	37.9	37.1	
East of Lee Moor	61.8	61.9	45.5
Broadoaks Cottages	58.7	59.8	53.3
Wotter	54.7	54.7	
Elfordleigh Hotel	59.5	57.8	
Colebrook	61.0	59.5	
Road Junction	57.2	55.7	

The results in Table 5-5 are broadly comparable to those in Table 5-3 of the NIA. However, the headings for Dartmoor Zoo and Windwhistle Farm in Table 5-3 of the NIA previously submitted had been accidently switched. The revised Table 5-3 below (to also include the values for the enclosure with the discharge chute) now includes the correct headings and is replicated below. The revised Table 5-3 below includes the values for the chute scenario shown in Table 1 above, rather than those directly from Table 5-5 of the NIA. As explained above in the response to Question 1g, the revised values present a consistency in the way the background levels for all scenarios have been derived. The levels in the revised Table 5-3 below are, therefore, directly comparable, albeit with the limitations set out in the response to Question 1g with respect to the screen levels being low and not easily distinguishable from the background.

Table 5-3 (Revised) – Sound Pressure Levels at Fundamental Frequency at Far Field Location during Enclosed Test Scenarios (no Cladding), dBZ

Scenario	Open area m^2	Date/Time	Portworthy Farmhouse	Windwhistle Farm	Dartmoor Zoo
Open full ply test 1	-	12/6 13:25	22.4	37.9	40.6
Open full ply test 2	-	13/6 11:21	43.1	44.0	40.1
Fully enclosed	0	19/6 11:53	22.0	46.6	34.2
Lower end panel removed	3.17	19/6 12:36	37.7	38.2	39.5
Lower end and top panels removed	5.45	19/6 13:10	47.0	39.6	41.4
Lower and upper end and top panels removed	8.62	19/6 14:11	50.1	50.5	42.6
Enclosed with slots	0.08	20/6 13:37	28.7	39.7	32.9

Scenario	Open area m^2	Date/Time	Portworthy Farmhouse	Windwhistle Farm	Dartmoor Zoo
Enclosed with single deck openings	1.18	20/6 14:26	40.1	41.1	26.5
Enclosed with twin deck openings	1.6	20/6 15:05	39.2	39.5	31.8
Enclosed with discharge chute and open area for infeed	1.18	13/7 11:13 to 12:20	28.6	42.6	36.9

Comparing values in this table should be carried out with some caution for the reasons discussed in the other responses. To illustrate this, it is known that "Test 1" and "Test 2", both with no enclosure, gave virtually identical results in the near field. These tests were intentionally carried out on two separate days to check for repeatability, and they concluded that the sound power at source did not change.

In the far field, for example at Portworthy, the estimated sound level from the open screen was 22.4 dBZ (Test 1) and 43.1 dBZ (Test 2). The background levels for Test 2 were higher than for Test 1 and less equal between bands making it appear that the screen was contributing more noise. The same was true at Windwhistle Farm, but the difference was less extreme. At Dartmoor Zoo, the difference was negligible.

In the cases where the open area was large (8.62 m^2 and 5.45 m^2),which have been highlighted in blue in the table above, the contribution from the screen was clear in the narrow band containing the running frequency. This meant that the variation in background levels between the bands was less important and the highlighted values in the table above are more certain. At the time of the trial, this was noted and the importance of reducing open area influenced the remainder of the testing and indeed the proposed inherent mitigation measure of minimising opening sizes in the screen enclosures.

Question 1i

Provide an explanation of why the enclosure appears to have resulted in an increase in near field sound pressure levels at the second harmonic frequency 25 Hz in multiple test scenarios, including (marginally) the scenario with outlet chute (section 5.3.18 and Figure 5-17). What results were obtained for measurements in the far field at this frequency? Provide an explanation of any impact this has on uncertainty of conclusions. What results were obtained for sound pressure levels at the third harmonic 37.5 Hz? Provide an appropriate explanation of these results.

A complete set of results from the near field and far field measurements during tests of different enclosure scenarios has not been presented. Results appear to have been presented selectively, and in a way which makes direct comparison of different scenarios difficult.

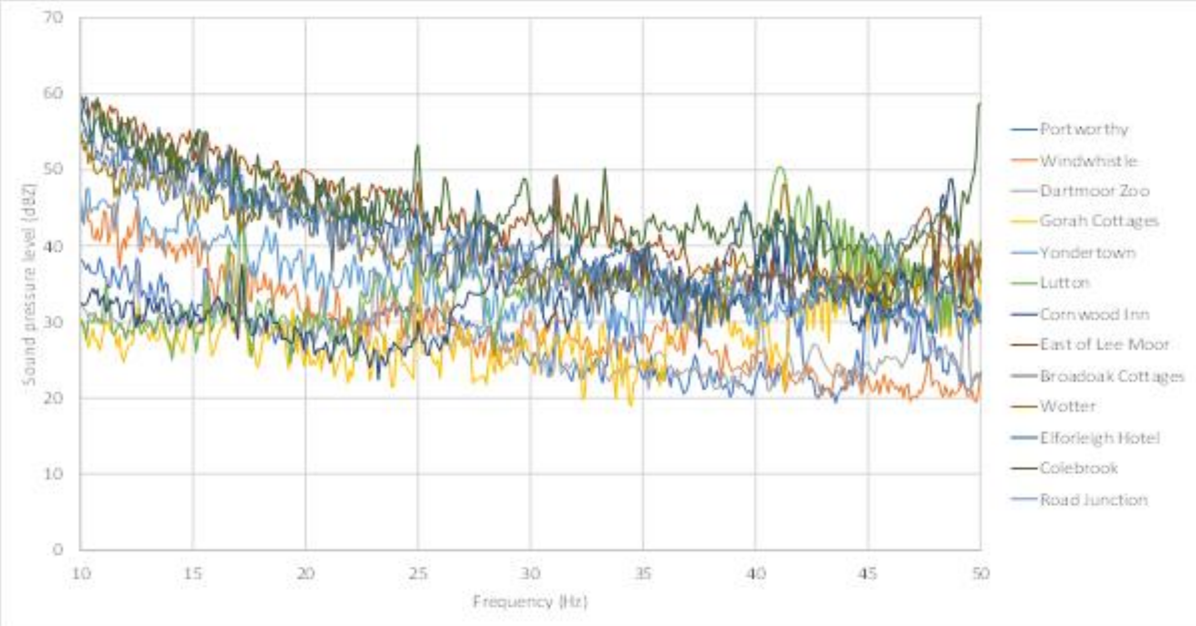
There is an incomplete explanation of how content of the various results Tables has been calculated/derived. The test results which have been presented for different enclosure scenarios raise material questions over the effectiveness of the intended technique of steel enclosure at reducing emissions of low frequency noise; some test scenarios appear to have resulted in increased sound pressure levels measured in the near field and in the far field compared with the scenario of no enclosure.

Discussion of the test results is selective and incomplete, and ignores and fails to explain some results which indicate the possibility of enclosure scenarios increasing sound pressure levels measured in the near field and in the far field. Incomplete presentation and discussion and explanation of test results significantly limits confidence in the conclusions presented.

Question 1i Response

The spectra for the range up to the second harmonic for all the far field measurements with the chute in place are shown in Figure 1 below. There is little evidence that the second harmonic makes a significant contribution, but the first harmonic is contributing. The highest level was measured at Colebrook with a value of 53.3 dBZ. This frequency is just inside the audible range, although the weighted level is low (8.6 dBA). When the spectrum at Colebrook is examined over a wider frequency range, it becomes apparent that there was a strong source at 50 Hz. This had harmonics at 50 Hz with a sub-harmonic at 25 Hz. It is therefore probable that the contribution from the screen at 25 Hz was much lower than the measured value. The monitoring location at Colebrook was in an industrial estate with machinery operating all around, so this result was not surprising.

Figure 1 – Far field measurements for the chute scenario for 10-50Hz



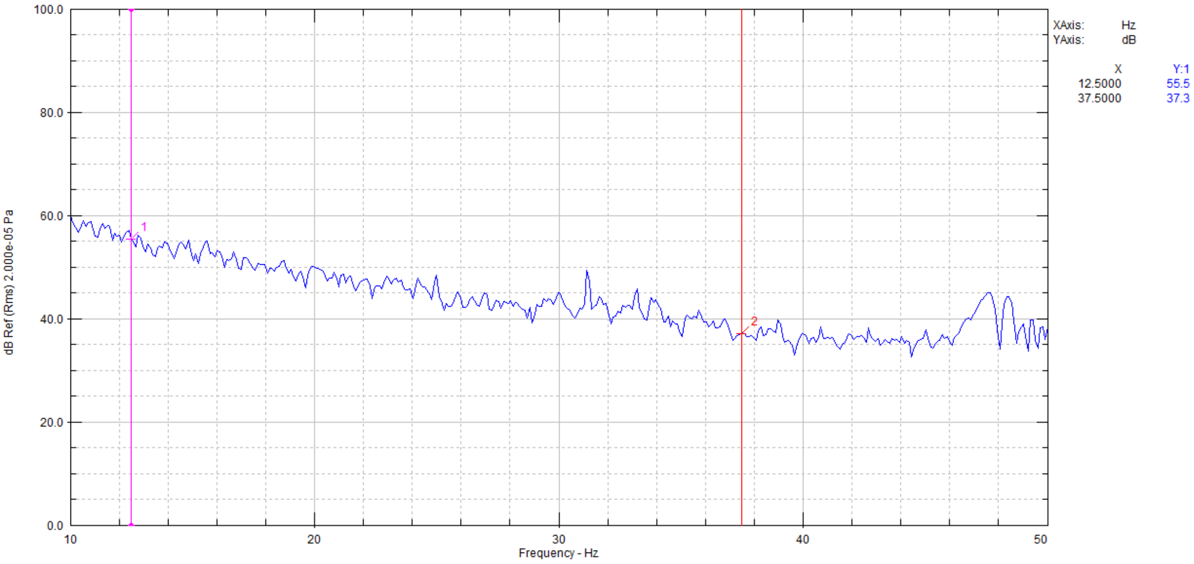
The source of the low frequency sound is the vibrating surface of the screen deck. The screen is driven by rotating offset masses that generate a centrifugal force that is reacted mainly by inertia forces of the screen body. If the rotating masses are held at a constant speed, the motion will be purely sinusoidal. Acoustic theory states that the air pressure generated at a surface will be directly proportional to the normal velocity of that surface. This means that the air pressure will be purely sinusoidal. In practice, the waveform of the velocity will not be purely sinusoidal because of the mechanical connections in the drive mechanism. Additionally, any reflected air pressure will feedback into the screen deck motion to change the waveform. Because the rotational speed is constant, the resulting motion and air pressure is constrained to be periodic with the fundamental frequency being the rotational frequency. This is manifest in the shape of the waveform which changes from a pure sinusoid to some other shape. Under these conditions, the spectrum of the waveform must be the fundamental frequency plus the harmonics. The number and relative magnitude of the harmonics depends on how far the waveform is from a pure sinusoid.

Adding enclosures and varying the openings will change the internal reflections and this will have an effect on the waveform shape and hence on the higher harmonics. An increase in those harmonics is entirely possible with changes to enclosure designs.

If the higher harmonics became large enough, there is a possibility that they could cause a noise nuisance. In the case with the enclosure and discharge chute, but with an open top inlet, the second harmonic was the most significant and its averaged near field sound pressure level was 60 dBZ, which at this frequency is equivalent to 25 dBA. At these levels, the far-field effects will be well below background noise levels.

To illustrate this, Figure 2 below shows the spectrum of sound pressure measured at the location known as East of Lee Moor when the test with the chute was in progress. The two vertical coloured lines show the levels at the fundamental and the second harmonic. Neither level is distinguishable from the background, but at 37.5 Hz, the absolute levels are around 37 dBZ and would be undetectable by the human ear.

Figure 2 - The spectrum of sound pressure measured at 'East of Lee Moor' under the chute scenario



The text above describes why there is confidence that the first and second harmonics could not cause a disturbance in the far field and therefore the conclusions in the NIA remain valid.

Question 1j

Provide justification for the 6 dB reduction by deck venting.

We could not identify where the 6 dB reduction for deck venting derived from. It was not clear in the referenced Appendix O.

Question 1j Response

Attenuation expected from deck venting is explained in Appendix O of the NIA. This contains the results from a series of trials with the objective of working out the best arrangement for venting a deck surface. As the trial progressed, it became clear that distributed venting gave the best performance, although any deck venting was a benefit.

The final set of tests explored distributed venting in a screen deck initially covered in plywood. The base case was with no openings in the plywood and then a series of tests were carried out, increasing the vented area up to 6.6%. The arrangement is shown in the Figure 3 below:

Figure 3 – Extract from NIA showing Tested Distributed Vent Locations

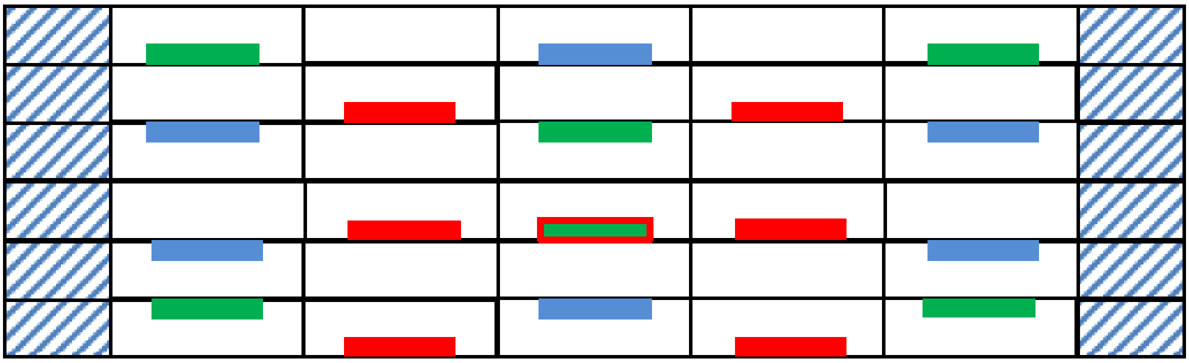


Figure 14.1 Distributed vent locations

Test	Vents	Vented area
Ph 0	None	0%
Ph 1	Green	2.2%
Ph 2	Green + blue	4.4%
Ph 3	Green + blue + red	6.6%
Ph 4	Green + blue + red (one vent with cut mat)	6.6%

The sound pressure levels from these five tests are presented in Appendix O of the NIA, but the attenuation from Phases 1-4 was not explicitly calculated. Table 3 below gives these values for the nearfield measurements above the screen and the far field measurements made at Sparkwell:

Table 3 – Pressure & Attenuation above the Screen and at Sparkwell under Deck Venting Phases 1-4

Test	**Pressure above the screen (Pa rms)**	**Attenuation above the screen (dB)**	**Pressure at Sparkwell (Pa rms)**	**Attenuation at Sparkwell (dB)**
Ph 0	27.2		0.0114	
Ph 1	24.0	1.1	0.0076	3.4
Ph 2	19.1	3.1	0.0038	9.6
Ph 3	12.8	6.5	0.0033	10.8
Ph 4	11.3	7.6	0.0026	12.6

The attenuation has been calculated in dB. This uses the values from the unvented screen divided by a vented case and expressed logarithmically. So, for example, the attenuation above the screen, unvented is 27.2 Pa and in Ph 1 it is 24.0 Pa. The calculation is as follows:

$$attenuation = 20 \times \log\left(\frac{27.2}{24.0}\right) = 1.1\ dB$$

These results show that over 12 dB attenuation was achieved in the far field if the vented area could be distributed and 6.6% of the total deck area.

The claim that deck venting could provide 6 dB attenuation is being cautious.

Question 1k

Provide justification that the different control measures (steel enclosure, deck venting and active noise control) would work in-combination.

There is concern that the different control measures may not lead to linear improvement, but may have a more complicated effect on results.

Question 1k Response

The final sound emission from a screen can be considered in three parts:

i) The strength of the source
ii) Mitigation of the source strength
iii) Transmission attenuation

The strength of the source depends on the screen deck velocity, its area and its acoustic efficiency. Deck venting has the effect of reducing the acoustic efficiency so that the resulting air pressure immediately above the deck is reduced. By placing active noise control above this surface, some of the reduced air pressure will be cancelled so that the overall levels that reach the enclosure walls will be lower. The presence of the enclosure will introduce reflections that will affect the optimum phase lag between the loudspeaker diaphragm and the screen deck. The amplifier has a continuously adjustable phase lag option, and each loudspeaker installation would have to set this value for maximum cancellation.

The enclosure walls then provide the extra attenuation for overall sound emissions.

There is an important difference between the reductions offered by active noise control and enclosure walls. The loudspeaker works by noise cancelling, which is by subtracting air pressure. In theory if one loudspeaker halved the air pressure (a reduction of 6 dB), then two loudspeakers would eliminate it completely. Clearly, in practice, it could not be so precise, but this illustrates the principle. With an enclosure, the transmission is factored, so if an enclosure provides a 6 dB reduction, two enclosures would only achieve 12 dB.

The design principles underpinning the working of active noise control are given in Appendix O of the Noise Impact Assessment document. In summary, energy in the air outside the loudspeaker enclosure is converted to heat within the enclosure and dissipated from the surfaces.

In summary, deck venting reduces the strength of the source. The enclosure, in particular the stiffness of the walls, mitigates the transmission of the sound pressure from the screen. In other words, the enclosure reduces any residual sound pressure that has not been reduced by deck venting. Should a further LFN mitigation option be required, i.e., active noise control, this will aid the reduction of the source strength through a different means i.e., by subtracting air pressure before it reaches the enclosure.

In summary, the physics described above demonstrates how the different control mitigation measures (two inherent and one additional) will work in combination with each other.

An updated version of the Low Frequency Noise Mitigation Options Appraisal Report (V3) is included as a supporting document. The update includes reference to the technical detail of the active noise system being developed during the design stage to achieve a reduction of approximately 10dB.

Question 1l

Confirm if the active noise control would be located within the enclosure, if it was installed, and provide an assessment of any likely directional effects

Active noise control has previously been tested with an operational screen without an enclosure, and its performance assessed with a single microphone location. Operation of coherent sound sources in close proximity results in directional effects (and constructive and destructive interference patterns), demonstrated by previous operation of phase-matched adjacent screens.

Question 1l Response

The ultimate source of the low frequency noise is the vibrating screen deck. It can be considered as a mechanism for generating oscillating air pressure. If a device can be installed directly above the deck (inside any enclosure) such that when positive pressure is being generated by the screen, the device generates negative pressure, then there will be a cancelling effect. To do this, the motion of this device (loudspeaker diaphragm) must be frequency locked to the screen motion. Additionally, a phase lag must be introduced to allow for the separation distance and the speed of sound. The trial device uses an accelerometer on the screen to provide the control signal for frequency locking, and the amplifier has an adjustable phase lag to optimize the cancelling performance.

It is important that the active noise control device is placed directly over the screen deck. If it were to be situated some horizontal distance away, there would be constructive and destructive interference depending on the difference in distance between a receiver and the two sources (screen and loudspeaker). This arrangement creates what is called a phased array and is used in technologies such as radar to create beams of energy which can be directed dependent on the source phasing. This beaming effect cannot occur if one source is placed facing the other. The enclosures will be designed and manufactured to accommodate any active noise control measures, should they be required.

Question 1m

Please provide full derivation and justification for the sound pressure levels for each screen quoted in Table 6-1.

You have stated that the assessment is based on manufacturer source data for some screens. For some screens, a comparison of measured versus manufacturer data has been undertaken and measured levels are lower. We need to know clearly where the assumptions for each screen have come from.

Question 1m Response

The calculation for source strength is shown in Appendix F.

Table 6-1 of the Noise Impact Assessment (NIA) has been updated (as below) to include all information required to justify the quoted sound pressure levels for each screen. Furthermore, the data have been provided in an Excel spreadsheet (see Appendix G) including the formulae used to derive the sound pressure level for each screen.

Note that paragraph 6.4 of the NIA states the sound pressure levels in Table 6-1 of the NIA are those for the scenario including screen enclosures and deck venting. The sound pressure levels quoted exclude the inherent mitigation.

Table Error! No text of specified style in document.**-1 (Revised) – LFN Sources Included in the Noise Model (Excluding Inherent Mitigation)**

Screen Detail	Location	Easting	Northing	Screen RPM	Stroke Normal to Deck in mm	Vibrating Area (A) in m^2	Acoustic Efficiency (r)	rms Velocity (v) in m/s	Characteristic Pressure (P_{sc}) (Pa rms)	Sound Pressure Level (P_{sc}), dBZ*
140-SN-01 DMS feed prep screen	Area 140 (DMS)	56899.9	58963.9	936.12	6.98	11.52	0.30	0.242	27.61	122.8
140-SN-06 secondary DMS screen	Within Area 150 (DMS)	56912.2	58956.7	1000.8	3.96	8.64	0.30	0.147	12.56	116.0
140-SN-07 scavenger DMS screen	Within Area 150 (DMS)	56914.9	58958.6	990.96	3.76	8.64	0.30	0.138	11.81	115.4
150-SN-01 primary mill sizing screen	Area 150 (Primary Milling)	56920.3	58955.8	948.54	6.57	9	0.30	0.231	20.57	120.2
115-SN-02 Secondary Crushing Scalping Screen	Area 115	57124.2	59103.8	738	8.5	18	0.30	0.232	41.42	131.3
125-SN-11 Ore Sorter Sizing Screen	Area 125A	57058.3	58979.4	738	8.5	14	0.30	0.232	32.21	129.1
125-SN-01 Pebble Ore Sorter 1 Dewatering Screen	Area 125B	57040.6	59019.9	960	5.7	3.6	0.30	0.203	7.23	116.0

Screen Detail	Location	Easting	Northing	Screen RPM	Stroke Normal to Deck in mm	Vibrating Area (A) in m^2	Acoustic Efficiency (r)	rms Velocity (v) in m/s	Characteristic Pressure (P_{sc}) (Pa rms)	Sound Pressure Level (P_{sc}), dBZ*
125-SN-02 Pebble Ore Sorter 2 Dewatering Screen	Area 125B	57036.6	59017.9	960	5.7	3.6	0.30	0.203	7.23	116.0
125-SN-03 Cobble Ore Sorter 1 Dewatering Screen	Area 125B	57033.5	59016.6	960	5.7	3.6	0.30	0.203	7.23	116.0
125-SN-04 Cobble Ore Sorter 2 Dewatering Screen	Area 125B	57029.1	59014.7	960	5.7	3.6	0.30	0.203	7.23	116.0
130-SN-12 Tertiary Crusher Sizing Screen	Area 130B	56958	58926.4	740	8.5	18	0.30	0.233	41.53	131.3
130-SN-13 Tertiary Crusher Dewatering Screen	Area 130A	57013.5	58965.7	740	8.5	18	0.30	0.233	41.53	126.3

*Please refer to Appendix F which includes the method for deriving the sound pressure level of the screen for use in the noise model. The equation below has been used to derive the sound pressure levels in this table:

$$p_{sc} = \frac{\rho A z v}{4\pi}$$

where:

z = 415 Rayls for air

Question 1n

Provide an explanation of why you consider the proposed enclosure will be effective for screens operating at 16 Hz as well as screens operating at 12.5 Hz, considering the precautions taken in design and construction for the test enclosure.

The screen and enclosure have been tested with a screen running at 12.5 Hz. The Application includes some screens running at around 16 Hz, a scenario which has not been tested. Precautions taken in constructing the test enclosure for the screen running at 12.5 Hz included appropriate specification of panel natural frequency.

Question 1n Response

The effectiveness of the enclosure depends on the size of the inlet and outlet openings and the vibration response of the enclosure walls. The size of openings has already been discussed. For the enclosure walls, the total sound power that they can transmit will depend on the sum of powers from each surface. These individual powers will depend on the vibration level in the wall and its area. To achieve the performance of the tested enclosure, any new enclosure must not generate any additional power. The trials included measurements of the vibration response of each surface and so the power level can be calculated for each tested enclosure option, including the option with the chute. This value gives a target for a new design and would be applicable to 16 Hz as much as 12.5 Hz. In practice, an enclosure to meet this sound power target at 16 Hz would need to be stiffer than one for 12.5 Hz. The stiffness of the enclosure is an element of the design principles of the screen enclosures.

The design procedure is outlined in Appendix D - Enclosure design criterion for mitigating LFN.

2 Verification Testing

Question 2a

Submit a written plan, stating how you would test the low frequency noise emitting screens, and control measures, once they have been installed in order to demonstrate emissions do not exceed sound pressure levels specified in the Application e.g., those set out at Table 6-1 of the Low Frequency Noise Impact Assessment and Table 3-1 of the Noise Management Plan. The plan must include details of:

- the experience or qualifications of those carrying out the testing;
- the monitoring standards being worked to;
- the approach to testing of near field and far field;
- how directionality of emissions will be considered;
- monitoring of background levels and any identifying in-combination effects;
- the effectiveness of the abatement on all screens;
- how the impact of wind conditions shall be considered;
- the timescales required for monitoring and reporting;
- how beating effects would be captured; and,
- how this information will be reported to the Environment Agency.

We would require verification testing of the screens and control measures stated in the Noise Impact Assessment (dated August 2023). The plan would be to verify the emissions of low frequency noise, and confirm they are aligned with the assumptions and results in the Noise Impact Assessment.

Question 2a Response

The proposed Verification Plan for LFN is Appendix H.

Question 3a

Within your Noise Management Plan, provide a procedure for consideration of reducing or stopping operations to avoid serious noise pollution.

Our guidance on noise and vibration management: environmental permits states that ….'all noise management plans should, as a minimum, include…. confirmation of the procedures in place to consider reducing or stopping operations to avoid serious noise pollution'.

Our guidance further states that 'appropriate measures to reduce or control noise should include…reducing, altering or stopping noisy activities until circumstances have changed, or you have put other appropriate measures in place, so operations can re-start without preventable, or significant adverse, noise impact'.

Question 3a Response

If a source or sources of serious noise pollution are identified as arising from the Mineral Processing Facility at Hemerdon Mine, then appropriate measures will be employed to reduce noise pollution as identified in Section 4 of the Noise Management Plan (V6) in particular Table 4-1 Actions and procedures to Achieve Appropriate Measures/BAT and Table 4-2 – Additional Mitigation Options. If, following the deployment of all appropriate measures, there is still preventable, or significant adverse, noise impact which has been substantiated, then the Operator will consider reducing, altering or stopping noisy activities until circumstances have changed or other appropriate measures are in place. The statement above has been added to the revised Noise Management Plan (V6) which has been submitted as a supporting document to this response.

Conclusion

This document and the supporting documents address all the queries and request for information contained within Schedule 5 Notice issued on 5 October 2023 with respect to the permit application for the MPF at Hemerdon Mine (Permit reference: EPR/AP3203ML/A001).

Appendix A - Screen Enclosure Tests – directionality

Screen Enclosure Tests – Noise emission directionality

Near-field noise measurements show a variation of sound level with compass direction at the screen running frequency. This is not unexpected and is influenced to only an insignificant extent by the way in which the screen is oriented.

With an enclosed screen, there are only two transmission paths for the sound to be emitted. Any openings in the enclosure will form a direct airborne transmission path from the sound source (the screen) to the outside environment. These openings will be restricted by inlet and outlet chutes, and these will have a vertical orientation. No direct airborne path will have a horizontal component and so no directionality at the openings.

The other transmission path is indirect. This will come from the surfaces of the enclosure. Dynamic air pressure inside the enclosure causes these surfaces to vibrate and thus re-radiate sound on the outside. The sound power from each surface will depend on the magnitude of vibration and the area of the surface. The design criterion for the enclosures is based on stiffness so that the magnitude of vibration can be limited so that the sum of power from all surfaces does not exceed the levels established in the screen trials. A poor design might make one surface unusually flexible so that this surface dominated the power output, but this condition is understood and would be avoided in the design.

The trial results show different levels around the near-field measurements, and this should be expected. Consider testing a large diesel engine. ISO 3746 gives a survey method for determining the sound power from the engine. The interest here is in audible frequencies, but the principle is the same. First, an array of microphone positions is defined on an imaginary enveloping surface, either hemispherical or a parallelepiped. Measurements are made at each position and could vary considerably. An overall sound pressure level needs to be calculated, but before this can occur, two corrections need to be made in the data. The first is for background noise and the second is for reflections from the test cell walls. The closer a reflecting surface is to the test item, the more influence it will have on the results, and it becomes more difficult to make the correction. Closeness depends on the number of wavelengths. In the case of ISO 3746, where the frequency range is up to 8 kHz, the minimum distance in the mid frequency range is defined to be 1.7 wavelengths. In the screen trial, the nearest reflecting surfaces are 0.5 wavelengths from the source. This means that the near-field measurements are significantly affected by reflections and this will be the dominating effect on the variation.

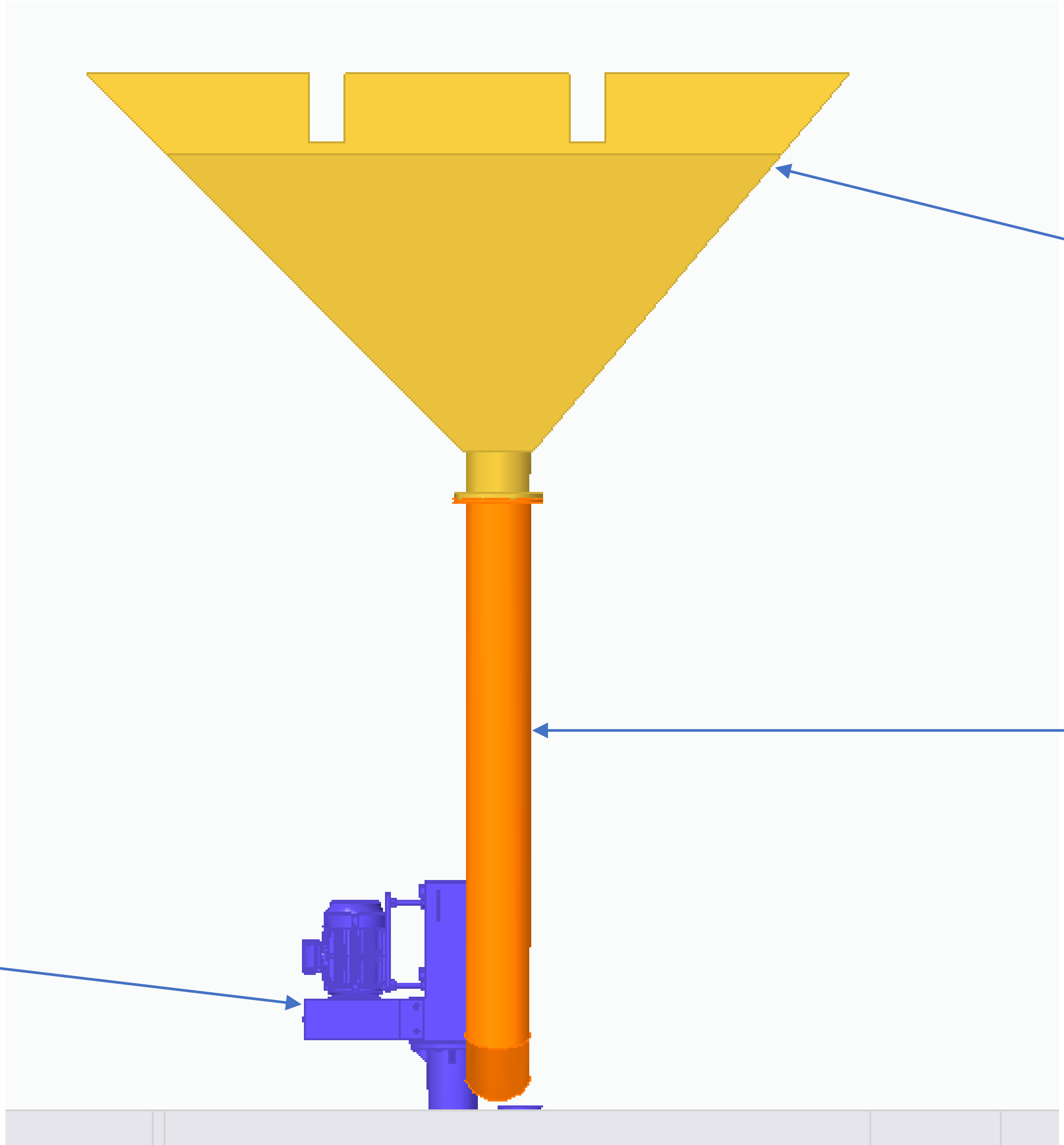
Continuing with the engine test analogy, the variation in the near-field measurements in the microphone array will be large. Close to the turbo-chargers, the levels might be 20 dB above those at the other end of the engine. ISO 3746 is not concerned with this difference and prescribes that an average is computed to obtain the sound power. The reason for this is that in the far-field, this variation is unimportant, and the engine can be treated as a point sound power source.

The tests that were carried out will have reflected energy in the near-field measurements and this has an effect on the variation around the compass directions and it also over-estimates the total sound power from the source. The results are therefore a worst case condition, but making corrections would be computationally difficult and hard to verify without further experimentation.

The far field measurements also had directionality which bore no relation to the directionality in the near field. This is also unsurprising because the far field levels are known to be affected by wind and the highest values were measured in the down-wind direction.

Appendix B – Examples of Chute Configurations

Typical Chute Configuration – Screen to Ground

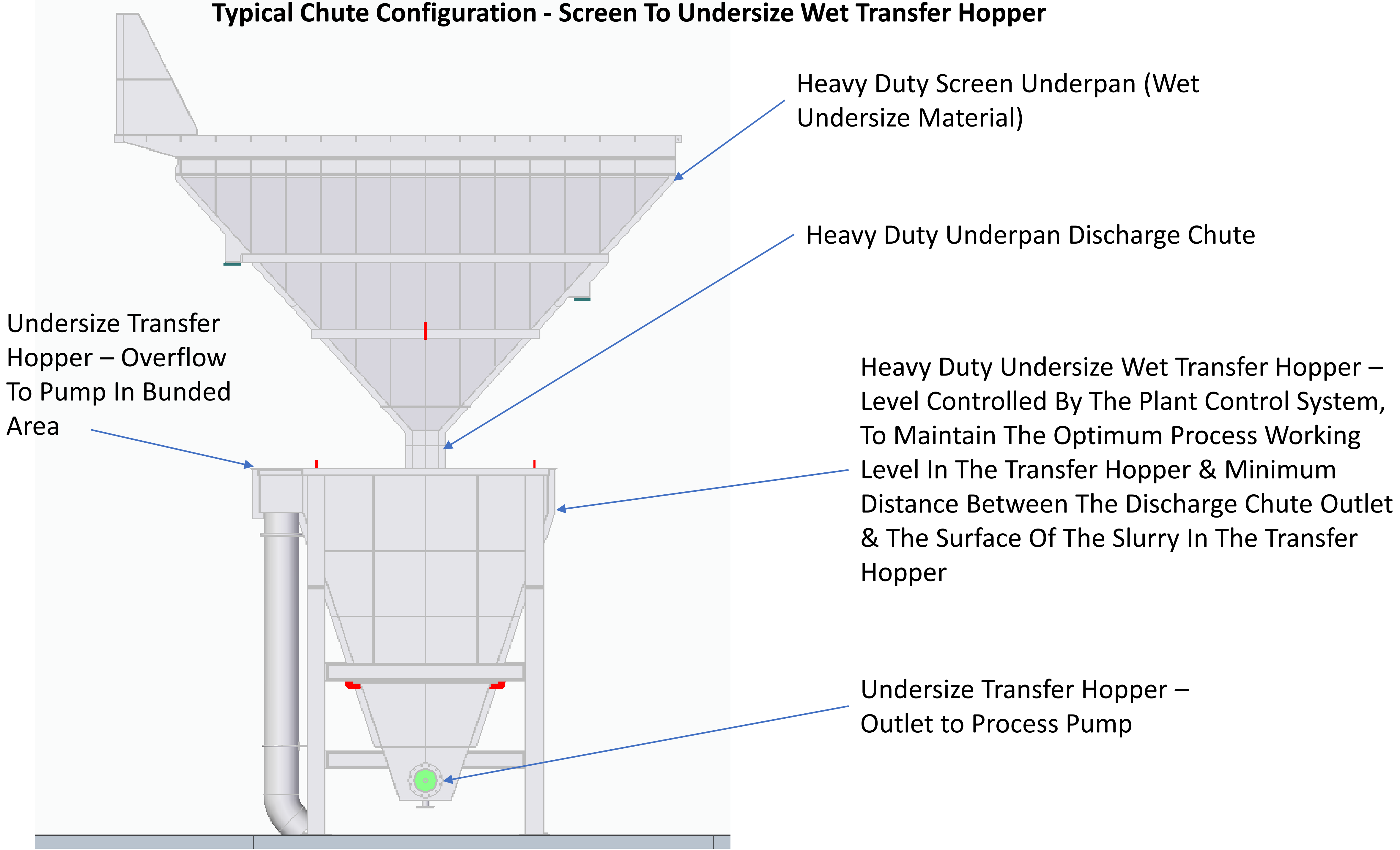


Heavy Duty Screen Underpan (Wet Undersize Material)

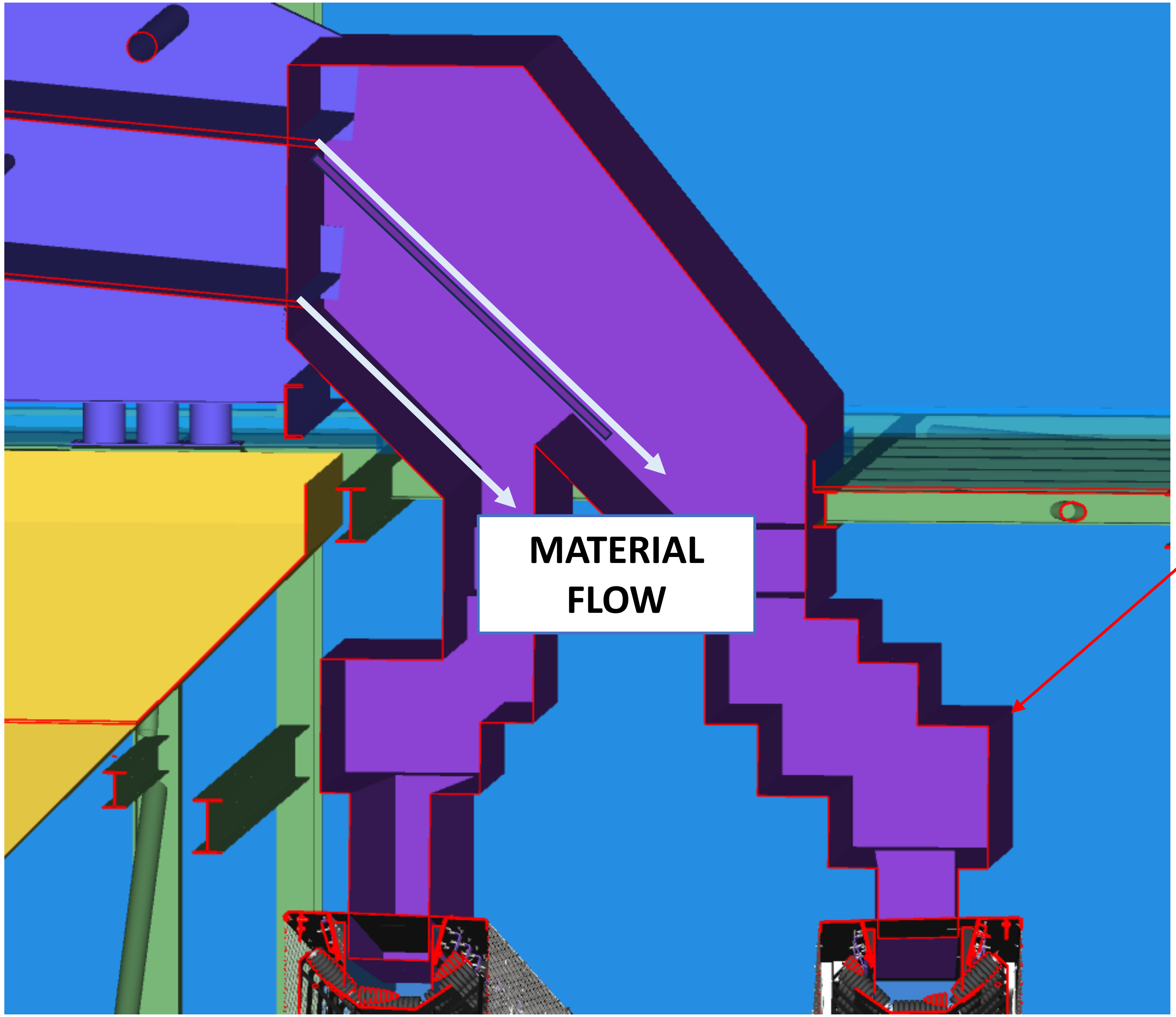
Heavy Duty Discharge Pipe To Bunded Building Floor Slab With Falls To Process / Sump Pump

Process / Sump Pump

Typical Chute Configuration - Screen To Undersize Wet Transfer Hopper

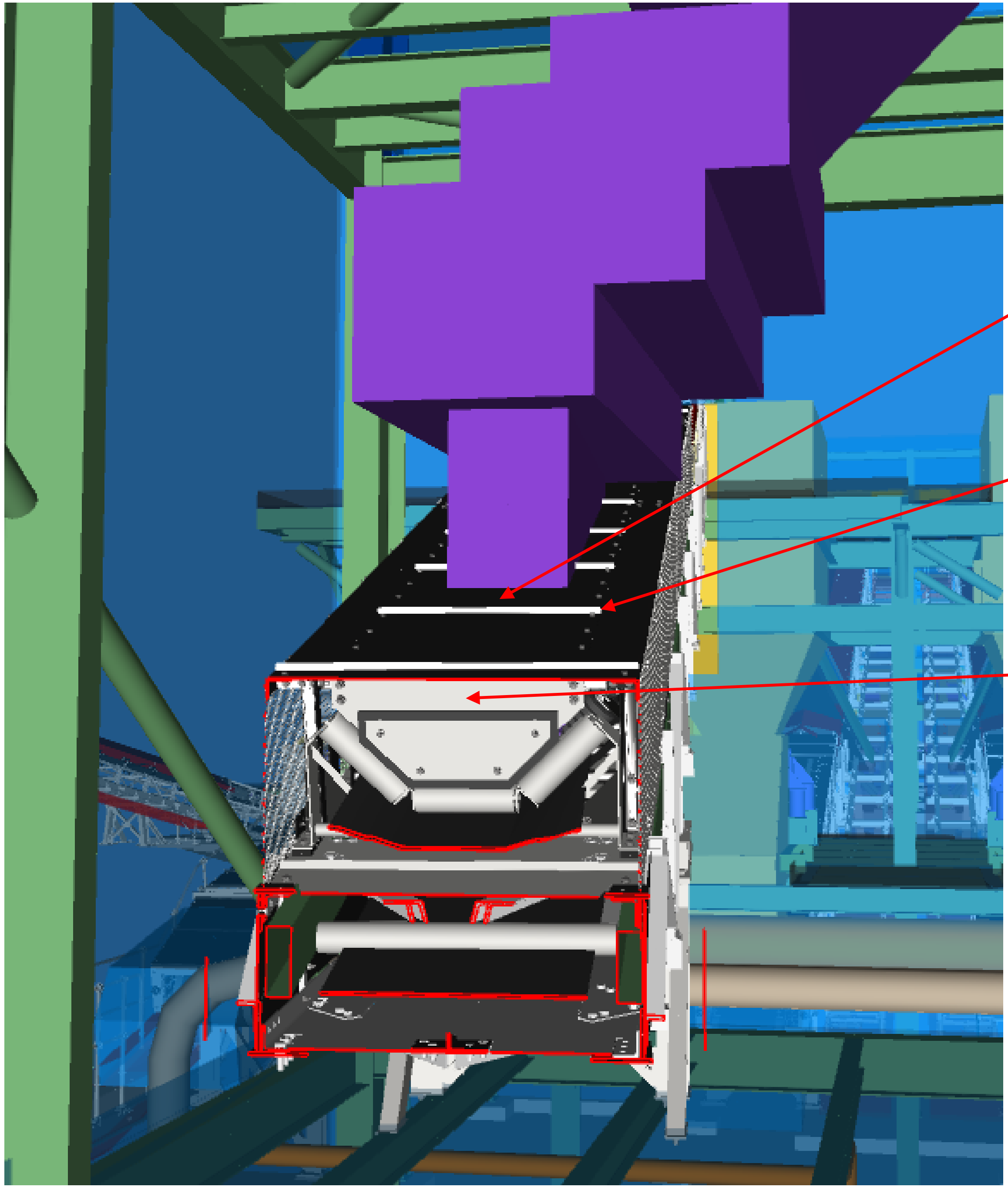


Typical Chute Configuration – Screen to Belt Conveyor Discharge Chute 1 of 4



CHUTES WILL BE DESIGNED IN ACCORDANCE WITH THE OPTIMUM BASIS OF DESIGN PRINCIPLES THAT HAVE BEEN DERIVED FROM THE LFN TRIAL OFFERING THE BEST ENVIRONMENTAL PROTECTION FROM LOW FREQUENCY NOISE WHILST MAINTAINING THE OPTIMUM PROCESS DESIGN REQUIREMENTS. MINIMISATION OF DROP HEIGHTS / OPEN AREAS USING CRASH / ROCK BOXES WHERE REQUIRED WILL BE INCORPORATED THROUGH THE CHUTE DESIGN PROCESS.

Typical Chute Configuration – Screen to Belt Conveyor Discharge Chute 2 of 4



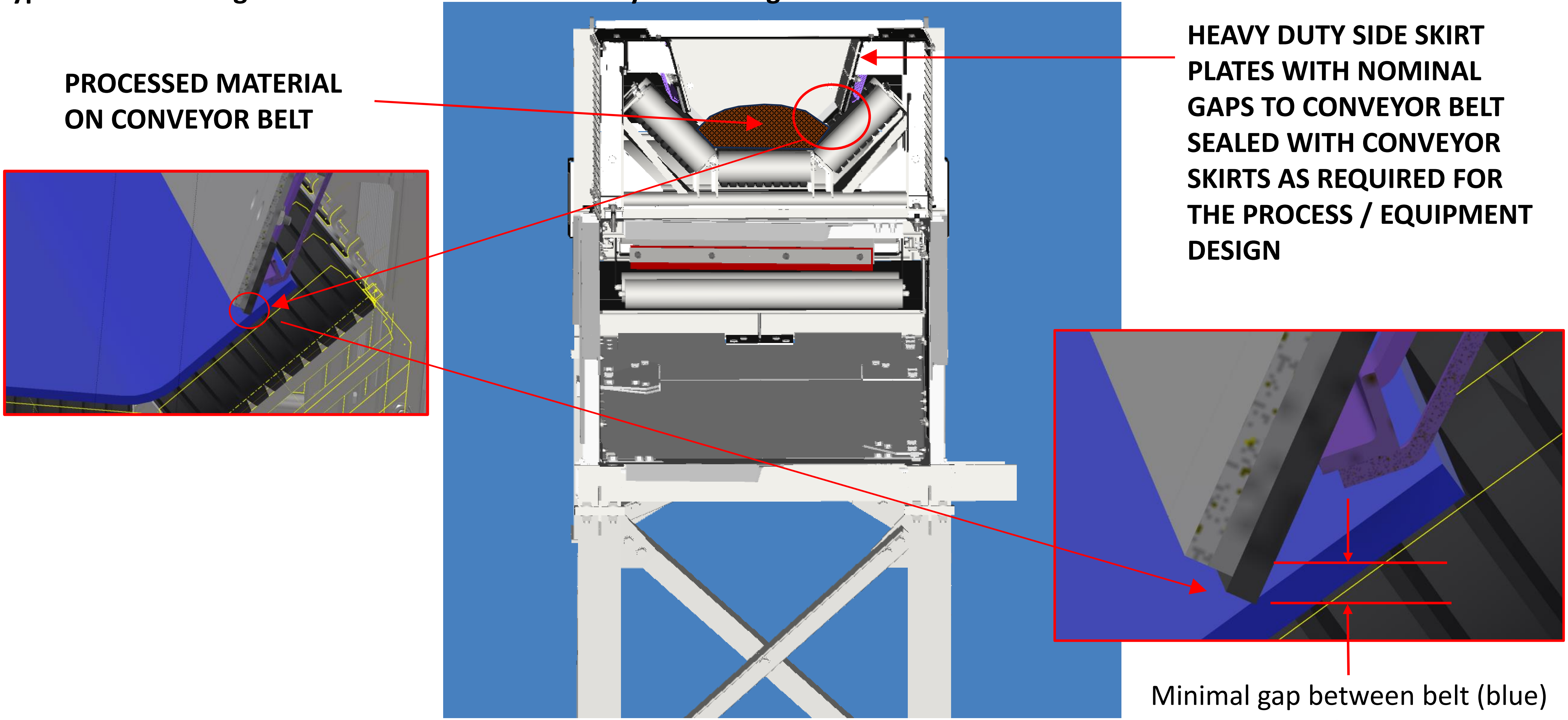
SCREEN DISCHARGE CHUTE OUTLET PROTRUDES INTO BELT CONVEYOR INLET SIDE SKIRTS

HEAVY DUTY CONVEYOR COVER PLATES

HEAVY DUTY BACK PLATE WITH NOMINAL GAPS TO CONVEYOR BELT SEALED WITH SKIRTS AS REQUIRED FOR THE PROCESS / EQUIPMENT DESIGN

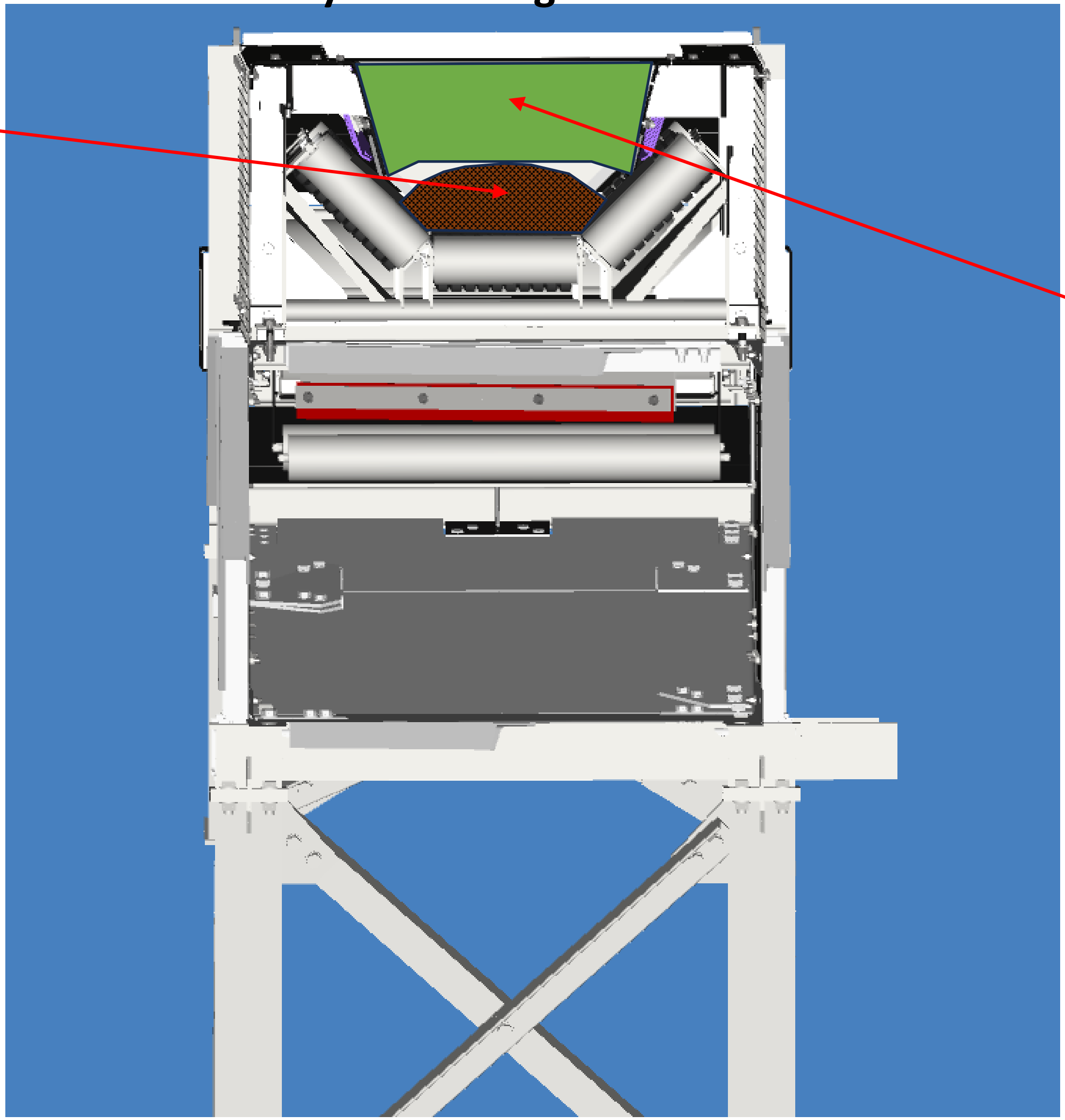
TAIL END OF CONVEYOR INLET CROSS SECTIONAL VIEW

Typical Chute Configuration – Screen to Belt Conveyor Discharge Chute 3 of 4



MID POINT OF CONVEYOR INLET CROSS SECTIONAL VIEW

PROCESSED MATERIAL ON CONVEYOR BELT



ADJUSTABLE HEAVY DUTY PROFILED BAFFLE ARRANGEMENT ON THE LOADING SECTION OUTLET TO CLOSE THE AIR GAP / PATH UP TO THE PROCESSED MATERIAL FLOW AS FAR AS IS REASONABLY PRACTICABLE

DISCHARGE END OF CONVEYOR INLET CROSS SECTIONAL VIEW

Appendix C - Near Field Results Values for all Test Scenarios including Opening Sizes

See separate document

Appendix D - Enclosure Design Criterion for Mitigating LFN

Enclosure design criterion for mitigating LFN

There are two paths for transmitting LFN from an enclosed screen. The openings, which are necessary, form one path and the other is through the enclosure walls. Dynamic air pressure acting on the walls causes a vibration response, and it is this surface vibration that generates LFN outside the enclosure. The objective of an enclosure to mitigate LFN is to respond to the dynamic internal air pressure with a minimum vibration, and this can be achieved by making the enclosure stiff or heavy. A heavy weight surround is not an option and so high stiffness will be required.

To gauge how stiff the enclosure needs to be can be based on the trials that took place at Tungsten West in July 2023. These investigated an enclosure that was designed on the criterion of a minimum natural frequency. The running speed of the screen is 12.5 Hz and most of the sound produced is at that frequency. There are also smaller components at x2 and x3 and the enclosure was intended to have a first natural frequency 20% above the x2 harmonic.

Now that the trial has been completed, surface velocity values have been measured on the sides and top of the enclosure which gives a measure of the sound power transmitted out into the environment. Since it is known that this level of transmitted power represents an 11 dB reduction in sound pressure level from the screen, a new criterion based on that power can be developed.

The vibration levels were measured at the centres of the 5 faces as shown in Figure 1.

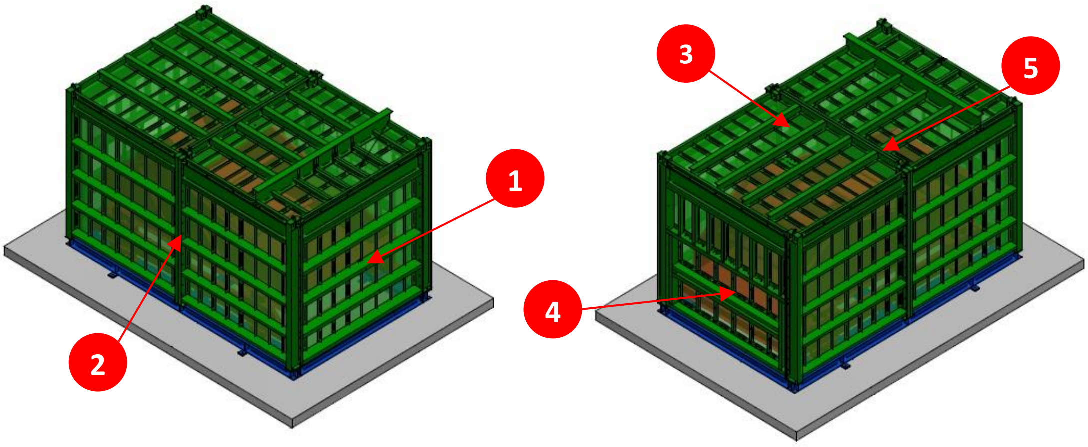


Figure 1 Velocity measurement positions

The sound power from each face is proportional to the face area and the velocity squared.

Taking the measurements and the enclosure dimensions, the values in Table 1 can be calculated:

Panel	Velocity (mm/s) rms	Velocity^2 (mm^2/s^2)	Dimensions (m x m)		Area (m^2)	Area x velocity^2 (m^4/s^2)
1	0.32	0.1024	4.52	3.611	16.32	1.671E-06
2	0.19	0.0361	7.54	3.611	27.23	9.829E-07
3	0.84	0.7056	7.54	3.611	27.23	1.921E-05
4	2.00	4.000	4.52	3.611	16.32	6.529E-05
5	1.10	1.2100	7.54	4.52	34.08	4.124E-05
Totals					121.18	1.284E-04

Table 1 Sound power from enclosure surfaces

The sound power generated depends on the dynamic pressure applied to the inside surfaces of the enclosure. For the particular enclosure that was tested, the pressure was around 130 dBZ. This equates to 63 Pa rms or an amplitude of 89 Pa at a frequency of 12.5 Hz.

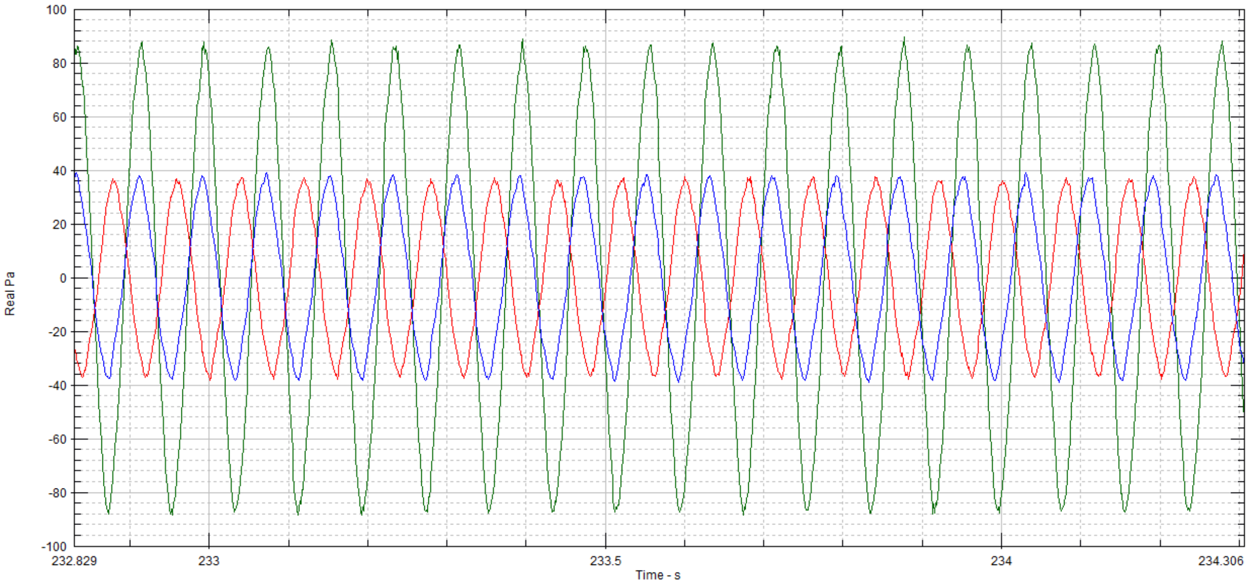
Sound intensity decreases with area so sound pressure decreases with the square root of area. This means that if a new enclosure has a total surface area of A m^2, the amplitude of pressure to be used in a calculation, P, should be given by:

$$P = 89 \times \sqrt{\frac{121}{A}} Pa$$

With this value of pressure applied, the rms velocity response at the centre of each face should be calculated and values entered in a version of Table 1 above. The target value for the total Area x velocity^2 should be 1.3×10^{-4} m^4/s^2.

The pressure amplitude to be used in the enclosure response calculations can come from measurement or theory. The value of 89 Pa came from direct measurement 1 m above a screen with a full surrounding enclosure. The presence of an enclosure will increase the pressure by a factor of 2 due to reflections and the theory which has been developed for an open screen must account for this factor to be useful for enclosure design.

The following figure shows a short period in the pressure time histories for 3 tests. The red and blue signals are from tests with the screen unenclosed and with plywood decking. The green signal is from the same configuration, but with the screen enclosed. This shows the effect of the sound reflections.



Pressure measurements 1 m above the screen deck with no enclosure (red and blue) and with enclosure (green)

The pressure calculated for this particular screen without an enclosure is given by:

$$p_{sc} = \frac{\rho Azv}{4\pi}$$

Where A is the screen area (18 m^2), ρ is the Acoustic Efficiency (0.3), z is the specific acoustic impedance (415 Rayls) and v is the velocity amplitude (0.329 m/s).

Using these values, $p_{sc} = 58.7\ Pa$. This value is higher than that measured because the assumed figure of 0.3 for the Acoustic Efficiency has been taken as a worst case for all screens in the submission to the Environment Agency. In practice, a more accurate value for AE for this screen would be 0.2.

Assuming the worst case of 0.3 for all screens, the values of internal pressure for an enclosure of 121 m^2 surface area are given in Table 2. It should be recognised that if the values in Table 2 are used for the enclosure design, it would impose the "worst case" condition on the values and a future decision might have to be made on whether this should be relaxed.

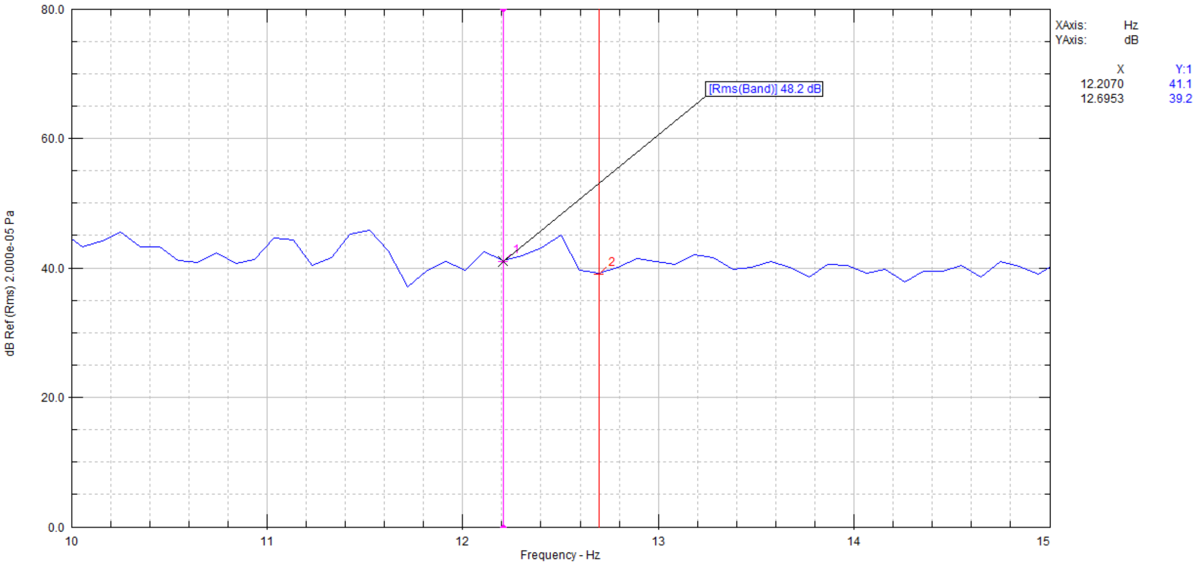
Screen	Characteristic pressure amplitude (Pa)	
	No enclosure	With enclosure
140-SN-01 DMS Feed Preparation Screen	39.0	78.1
140-SN-06 Secondary DMS Screen	17.8	35.5
140-SN-07 Scavenger DMS Screen	16.7	33.4
150-SN-01 Primary Mill Sizing Screen	29.1	58.2
110-SN-01 Secondary Crusher Scalping Screen	58.6	117.1
120-SN-11 Ore Sorter Sizing Screen	45.6	91.1
125-SN-01 Pebble Ore Sorter 1 Dewatering Screen	10.2	20.4
125-SN-02 Pebble Ore Sorter 2 Dewatering Screen	10.2	20.4
125-SN-03 Pebble Ore Sorter 3 Dewatering Screen	10.2	20.4
125-SN-04 Pebble Ore Sorter 4 Dewatering Screen	10.2	20.4
130-SN-12 Tertiary Crusher Sizing Screen	58.7	117.5
130-SN-13 Tertiary Crusher Dewatering Screen	58.7	117.5

Table 2 Pressure values to be used in enclosure design

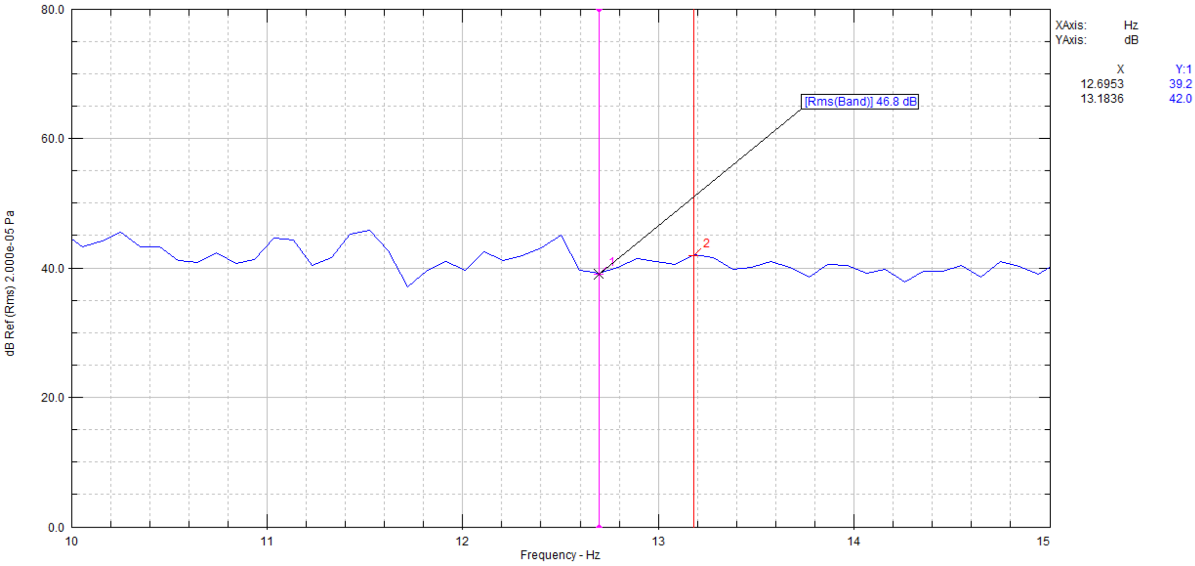
Appendix E - Estimating the screen contribution from background levels

Estimating the screen contribution from background levels

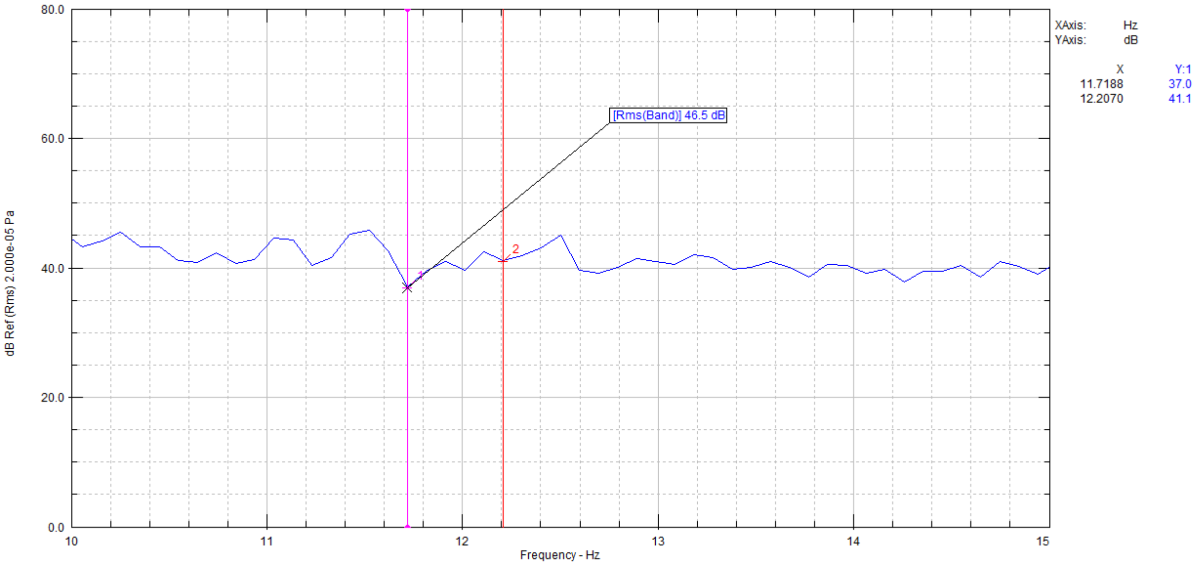
The chart below shows the sound pressure level around the fundamental frequency at Windwhistle Farm during the trial with the chute. A 0.5 Hz band around the running speed of 12.5 Hz gives a 48.2 dBZ value of sound pressure. This value is a combination of a contribution from the screen and general background noises in the environment. Without a clear peak, it is not possible to separate the two inputs.



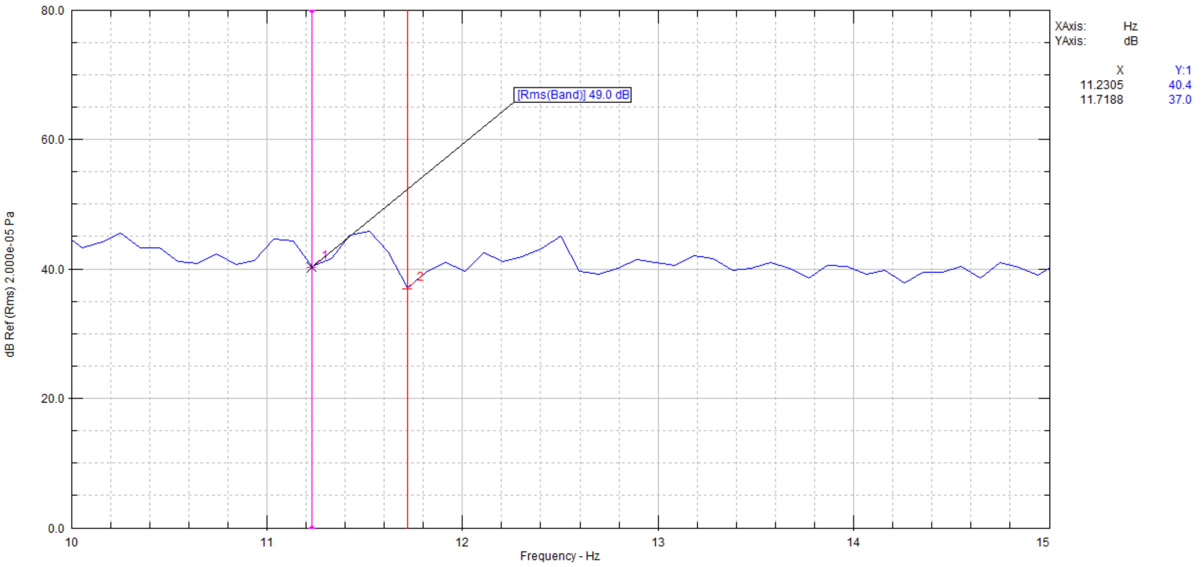
Consider the same width band immediately adjacent on the higher frequency side. This has a level of 46.8 dBZ. If the assumption was made that the background level in these two bands was the same, the screen must be contributing the difference, which is 42.6 dBZ.



Taking the adjacent band on the lower frequency side, the level is 46.5 dBZ, and this would mean the contribution from the screen would be 43.3 dBZ



Taking the next band down, the background level is 49.0 dBZ. Using the same methodology to separate the background from the screen would imply that the screen is **removing** 41.3 dBZ from the environment, which is clearly impossible.



This illustrates the problems of estimating the contribution of a source when it is so close to the background level.

Appendix F - Source Strength Calculations

Appendix E – Source Strength Calculations

For most sources of noise, the strength of the source is provided by the sound power and there are internationally recognised procedures for measurement. The method would be difficult to use for a screen and so a different strength term has been developed for this application.

Screen decks oscillate sinusoidally with a surface velocity of $v \times sin(2\pi f t)$ m/s where f is the screen running frequency in Hz. If the deck surface was solid, the pressure generated is given by the fundamental acoustic relationship

$$p(t) = zv(t)$$

Where $p(t)$ is the air pressure as a function of time in Pa and z is the specific acoustic impedance of air in Rayls. This has a value of 415 rayls at room temperature and 1 atmosphere of pressure.

A processing screen has a porous surface and there will be other leaks so that the generated pressure will be lower. This can be incorporated using the factor ρ (the acoustic efficiency) in the equation:

$$p(t) = \rho z v(t)$$

The far-field pressure will depend on the total area of the vibrating surface (A m^2). For each doubling of distance away from the source, the pressure drops by 6 dB. To characterise a specific source, the pressure at a hypothetical distance of 1 m from a point source can be calculated by applying the factor $\frac{A}{4\pi \times 1}$. The characteristic pressure will be denoted as $p_{sc}(t)$

$$p_{sc}(t) = \frac{\rho A z v(t)}{4\pi}$$

To determine this value by experiment, the pressure close to the screen deck will be measured. It is not practicable to have the microphone at the deck surface, so for all tests, a standard distance of 1 m above the centre of the deck will be used. A simultaneous measurement of surface velocity will be made using an accelerometer. This allows the acoustic efficiency term, ρ, to be calculated and using the deck area, the characteristic pressure can be determined. The characteristic pressure allows the ranking of different screens in terms of infrasound output.

Appendix G – Calculations of Sound Pressure Levels for each Screen

See separate document.

Appendix H – Proposed Verification Plan for LFN

TUNGSTEN WEST

Proposal for Verification Testing for Mineral Processing Facility

Site name:	**Hemerdon Mine Mineral Processing Facility**
Site address:	**Hemerdon Mine, Plympton, Devon PL7 5BS**
Operator name:	**Drakelands Restoration Limited**
Application reference:	**EPR/AP3203ML/A001**

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1. Introduction

Overview

This Verification Plan has been developed in response to the following question posed within the Schedule 5 Notice requiring further information served by the Environment Agency (EA) on 5 October 2023 with respect to the environmental permit application for the operation of the Minerals Processing Facility (MPF) at Hemerdon Mine (permit application reference: EPR/AP3203ML/A001).

Submit a written plan, stating how you would test the low frequency noise emitting screens, and control measures, once they have been installed in order to demonstrate emissions do not exceed sound pressure levels specified in the Application e.g., those set out at Table 6-1 of the Low Frequency Noise Impact Assessment and Table 3-1 of the Noise Management Plan. The plan must include details of:

- *the experience or qualifications of those carrying out the testing;*
- *the monitoring standards being worked to;*
- *the approach to testing of near field and far field;*
- *how directionality of emissions will be considered;*
- *monitoring of background levels and any identifying in-combination effects;*
- *the effectiveness of the abatement on all screens;*
- *how the impact of wind conditions shall be considered;*
- *the timescales required for monitoring and reporting;*
- *how beating effects would be captured; and,*
- *how this information will be reported to the Environment Agency.*

We would require verification testing of the screens and control measures stated in the Noise Impact Assessment (dated August 2023). The plan would be to verify the emissions of low frequency noise, and confirm they are aligned with the assumptions and results in the Noise Impact Assessment.

This Verification Plan has been written to detail the monitoring that will be carried out during the commissioning and ramp up of the MPF. There are a multitude of tests that will be carried out to ensure that the equipment upon installation is operating correctly. The scope of this document is specifically the monitoring that will be carried out in relation to Low Frequency Noise (LFN) to assess compliance with predictions that were made prior to operations commencing.

The verification testing methodology report is therefore intricately linked with the Noise Management Plan (NMP)[1] and Noise Impact Assessment (NIA)[2] reports and should be read and considered in conjunction with those reports.

[1] Hemerdon Mine Low Frequency Noise Impact Assessment, WSP, August 2023 & Schedule 5 Response (October 2023)

[2] Hemerdon Mine Noise Management Plan for Minerals Processing Facility, WSP, October 2023 (V6)

Objectives

The objectives of the verification testing are:

- To measure and quantify the sound pressure levels experienced at identified far field receptor locations in the vicinity of Hemerdon mine, recorded during operation of the MPF screens. The sound pressure levels are to be measured and quantified in terms of the absolute sound pressure levels, the temporal variation of sound pressure levels (for example due to beating effects or time of day) and the frequency content of the sound pressure levels.
- To compare the measured sound pressure levels during operation of the MPF screens with the background levels in the absence of operations at the MPF. Note that the background levels may include an element of low frequency noise arising from other sources that are not associated with Hemerdon mine. This might include low frequency noise from other industrial, commercial or minerals processing sites.
- To quantify the contribution of the operating MPF screens at Hemerdon to the low frequency noise climate at the identified receptor locations, via comparison of the measured sound pressure levels during operation of the MPF screens with the measured background levels.
- To compare the measured far field sound pressure levels in combination with the environmental conditions at the time of monitoring with those predicted through noise modelling.
- To determine the effectiveness of the low frequency noise control measures applied to the screens at Hemerdon mine. The effectiveness of the control measures is to be quantified in terms of the reduction in sound pressure levels compared to the unmitigated situation (using the best available data for the unmitigated situation), namely the sound pressure levels provided in Table 6-1 of the NIA.
- To obtain information on the character of low frequency sound experienced at the identified receptor locations; e.g. any observed beating effects (including the magnitude and periodicity of any beating effects).
- To obtain information relating to other factors that may affect the levels and perception of low frequency sound at the identified receptor locations; e.g. the effects of meteorological conditions such as wind speed and direction.

The results of the above will be used to inform updates of the Noise Management Plan, as described in Section 1.3 of the NMP.

Monitoring Strategy

It is proposed to carry out verification testing in two phases:

- The first phase is to carry out verification testing on all screens individually with plywood prior to ore commissioning and full operations, this has been termed 'Construction Verification'. This will allow any adjustments to be made to the screens and the LFN mitigation techniques to ensure alignment with the NIA.
- Only once all screens have been verified through the Construction Verification process will ore commissioning commence. During ore commissioning and subsequent full operations screens will be monitored in combination with mineral material, termed below as 'Ore Commissioning

Verification'. It is anticipated that this phase will last at least 6 months from the time that the first ore is processed until the entire MPF is fully operational.

Ongoing monitoring for LFN will be determined in consultation with the EA and in accordance with permit requirements.

The proposed monitoring is detailed in Section 5 Monitoring Plan.

2. Monitoring Personnel

The person(s) conducting the verification tests will be required to demonstrate that they have the necessary qualifications and experience to undertake the testing. This will be demonstrated by either:

- The person being a corporate member of the Institute of Acoustics (MIOA, FIOA or HonFIOA); or
- The person having the same level of academic qualifications and length of experience as would be required to achieve corporate membership of the Institute of Acoustics.

Note that the general requirements for entry to corporate membership of the IOA are that the person:

- Holds and acceptable educational qualification such as a degree in acoustics, the IOA Diploma in Acoustics or some other degree level qualification where the course included a significant element or module in acoustics; and
- Has had experience for at least three years of responsible work which demands a knowledge of acoustics or its application. The minimum period of professional experience must all have been undertaken after completion of the appropriate qualification in acoustics.

3. Monitoring Standards

The verification testing will, *where applicable*, take into account the guidance contained within the following technical standards and guidance documents:

- BS 4142: 2014+A1:2019: Methods for rating and assessing industrial and commercial sound (2019)
- Association of Noise Consultants BS 4142: 2014+A1:2019: Technical Note (2020)
- EA: Method Implementation Document (MID) for BS 4142 (2023)
- NANR45 Procedure for the assessment of low frequency noise disturbance, University of Salford (2005)
- Other standards and guidance referenced in the above documents, such as those relating to measurement instrumentation.

It is noted that BS 4142 is not directly applicable to the measurement and assessment of low frequency noise and this is discussed in more detail in Section 2.2 of the NIA. However, some of the guidance within BS 4142 and the associated guidance documents, such as that relating to measurement instrumentation and dealing with meteorological effects, is relevant to the situation at Hemerdon.

4. Monitoring Equipment

Construction Verification

During the construction verification phase, far field sound pressure levels for each screen running individually will be measured at accessible locations detailed in Section 5 far field monitoring locations.

For each location, the sound pressure levels would be captured for a period of 10 minutes at a frequency of at least 100 Hz. This is to provide sufficient frequency resolution to separate the output from the screen under test from any other equipment that might be emitting low frequency noise. An estimate of the screen contribution will be made by determining the sound energy in a 0.5 Hz band centred on the screen running frequency, and subtracting the sound energy in the adjacent 0.5 Hz band above. Spectrograms from each measurement would be calculated so that any time dependence in the measurements can be assessed.

Meteorological records from the Hemerdon mine weather station would be recorded at the times of testing to assess the effect of wind on the recordings.

The equipment used will be a laptop computer running the M+P Analyzer software with the sound pressure signal acquired using a National Instruments 9234 cDAQ module. The microphone will be a Class 1 device with a frequency range down to 4 Hz. This will be calibrated to National Standards before the verification exercise and field calibrated before each set of measurements.

Ore Commissioning Verification

Eatec Dynamics has developed remote monitors that can be configured to continuously monitor LFN. They can be set up to simultaneously record and process low frequency air pressure down to 5 Hz, audible sound up to 26 kHz, vibration at any meaningful frequency as well as other environmental parameters such as wind speed and direction, temperature, humidity, etc.

For LFN, the time history of air pressure is recorded and processed into summary information for each set period (usually one hour). These data are sent by mobile broadband to nominated recipients. All time history data can also be transmitted if required, or the information can be held locally and selectively transmitted on request.

The time histories will show the extent of beating which has been specifically identified by the EA.

With air pressure records of one hour duration, very fine resolution spectra can be calculated. The standard processing tools developed by Eatec Dynamics will generate this information as Fast Fourier Transforms (FFTs) or spectrograms. These tools could be extended to extract from an FFT the precise contribution of each individual screen at the MPF to determine the relative contribution and total output from the site. This would allow any changes with time to be tracked.

5. Monitoring Locations

Near field

Near field monitoring is not proposed due to the uncertainty of this data and the fact that any detected noise levels in the near field are going to be influenced by reflections due to the proximity and variability of structures in the MPF area. Therefore, verification testing will be based purely on data gathered at far field monitoring locations.

Far field Monitoring Locations

The far field measurement locations will be selected from the nearest noise sensitive receptors, as detailed in the NIA and NMP, and identified in Table 1 below.

Table 1 - Nearest Noise Sensitive Receptors and Potential Measurement Locations

Receptor Reference	Land Use	Compass Direction from the Site	Approximate Distance to Closest Site Boundary (m)	Approximate Distance to the Existing Processing Plant (m)
A: Birchland Farm	Residential	South-east	300	1,100
B: Galva House	Residential	South-west	480	950
C: Newnham House	Residential	South-west	1,000	1,475
D: Boringdon Hall	Hotel and spa	South-west	760	3,000
E: Mumford Cottage	Residential	North-east	820	2,000
F: Portworthy Farmhouse	Residential	North-west	200	1,900
G: Windwhistle Farm	Residential and hotel	South-west	950	1,400
H: Dartmoor Zoo	Zoo	South-east	320	1,250
I: Wotter	Residential	North-west	1,640	3,245
J: Broadoaks Cottages	Residential	North	990	2,390
K: East of Lee Moor*	Public land	North-east	1,520	2,900
L: Lutton	Residential	East	2,120	2,930
M: Cornwood Inn	Pub and restaurant	East	3,050	3,820
N: Gorah Cottages	Residential	East	1,150	1,950
O: Yondertown	Residential	East	1,680	2,490
P: Road Junction^	Public land	South-west	1,530	2,070
Q: Colebrook**	Public land	South-west	1,150	2,480
R: Elfordleigh Hotel	Hotel	West	1,070	2,340

*Representative of residential receptors in Lee Moor ^Representative of residential receptors in the area of Highglen Drive ** Representative of residential receptors in the north of Plympton in the area of Elford Crescent

The noise-sensitive receptors listed above can, for the purpose of describing them, be grouped into the following:

- Receptors to the east and south-east of the processing area, including Cornwood Inn (Receptor M), Lutton (Receptor L), Yondertown (Receptor O), Gorah Cottages (Receptor N) and Dartmoor Zoo (Receptor H) and Birchland Farm (Receptor A).
- Receptors to the south-west and west of the processing area, including Galva House (Receptor B), Windwhistle Farm (Receptor G), road junction (Receptor P), Colebrook (Receptor Q), Boringdon Hall (Receptor D), Elfordleigh Hotel (Receptor R) and Newnham House (Receptor C)
- Receptors to the north-west, north and north-east of the processing area, including Mumford Cottage (receptor E), Portworthy Farmhouse (Receptor F), Wotter (Receptor I), Broadoak Cottages (Receptor J) and East of Lee Moor (Receptor K).

The receptors to the east and south-east are generally visually screened from the mine by intervening topography. With the exception of Dartmoor Zoo, they are rural residential areas.

The receptors to the south and south-west are, with the exception of the road junction, a mix of residential and commercial properties. The mine is at a higher elevation than these receptors. All, except Colebrook are in a rural location.

The receptors to the north-west, north and north-east are generally at a higher elevation than the mine, some with intervening topography which visually screens the mine. With the exception of East of Lee Moor, they are all residential and in a rural setting.

Whist the intervening topography between the site and some of the receptors visually screens the site, there are considered to be no structures or topography in the areas which is capable of screening LFN from the mine at the receptors.

As the noise sensitive receptors and potential monitoring locations can be grouped into various community areas located at different compass directions from the site, with each identified community area being subject to similar intervening topography affecting sound propagation, validation measurements need not be undertaken at each and every receptor location identified in Table 1 above. Instead, in some situations, measurements undertaken at a specific receptor location can be considered to be representative of the noise climate at other locations within the immediate vicinity.

The choice of measurement locations will, of course, depend on the cooperation of residents and land owners to allow installation of automated measurement equipment or allow attended measurements to be undertaken on private property.

6. Monitoring Plan

Construction Verification

1. During the general construction works, each screen will be placed, aligned and enclosure installed along with associated chute work and discharge points.
2. Discharge points will be installed to suit the operating conditions, inclusive of the installation of conveyor belting and skirting.
3. Deck vents and associated screen panels will be installed along with a plywood covering that will represent the level of material coverage that will be present on the screen in operations.
4. Screens will be tested individually, as available, utilising a temporary power supply and associated services.
5. The screen will be operated at its design condition, in the presence of the Vendors Representative.
6. Standard mechanical and electrical inspections will be completed and further work carried out as necessary until the screen is approved as healthy.
7. LFN readings will be taken at far-field prior to operating under test conditions over an appropriate period after which the screen will be operated and LFN readings taken at designated locations.
8. If far field measurements exceed expected levels (these being derived considering modelled noise levels for the screen, environmental conditions and background noise levels, amongst other things), then adjustments to the screen and / or mitigation measures will be carried out. The test will be repeated and the associated results tabulated.
9. The temporary power supply and services will be disconnected, the plywood removed and the area returned to general construction activities.
10. Design modifications and / or adjustments will be formalised and incorporated into the screen/enclosure documentation including design drawings and operational parameters and manuals.
11. The completed Construction Verification report for each screen will be submitted to the EA for sign off.
12. The Noise Management Plan will be amended as required.

Ore Commissioning Verification

1. All screens and enclosures will be set to the construction certified conditions determined as per Construction Verification process.
2. Background LFN monitoring will be undertaken at the far field locations used during Construction Verification process.
3. General commissioning with ore will commence. All screens will be operated simultaneously.
4. During the first six months of operations as ore throughput increases, LFN readings will be continuously taken at the far field and throughput rates and environmental conditions will be monitored and recorded.
5. If far field measurements exceed expected levels (these being derived considering modelled noise levels for the screen, environmental conditions and background noise levels, amongst other things), then the dominant source(s) of LFN will be identified and any minor adjustments to the screen and / or mitigation measures will be carried out, as operationally feasible and required. This work will be carried out in consultation with the Environment Agency.
6. The Noise Management Plan will be amended as required.

Assessment of directionality

As detailed in the NIA, directionality in the far field is dominated by wind speed and wind direction and, for the purpose of verification testing, the assessment of directionality is limited to these effects. Further information is provided in the Wind conditions section below.

Wind conditions

There is a permanent and operational meteorological station within the mineral processing area of the mine (grid co-ordinates SX 56773 58841) which measures and records wind speed and wind direction, amongst other things. The data from the meteorological station which corresponds to the noise measurement periods will be analysed to determine the conditions during any noise monitoring.

In addition, the remote far field monitors which will be used during ore commissioning, ramp up and ongoing operations provide real time wind data.

Background effects

Background effects will be accounted for by:

- Carrying out background LFN monitoring in the far field immediately prior to any verification testing; or
- By using noise levels at adjacent narrow bands obtained during the measurement of the screen.

The chosen methodology and justification will be detailed in the reporting to the EA.

In-combination effects

In-combination effects will be determined via the Ore Commissioning Verification testing during which all screens will be operating.

Beating effects

The time histories of the remote monitors will show the extent of beating. Time history graphs will be included in the verification report submitted to the EA.

7. Reporting of Data

A Construction Verification report will be submitted to the EA within 2 weeks of completion of each screen test with plywood.

During the ore commissioning phase and during ramp up of the process, the continuous monitoring results will be submitted to the EA on a monthly basis within 5 working days of the end of the month. Any other monitoring data will be provided upon request at any reasonable time.

In both cases a spreadsheet of measured data including meteorological data and a full analysis of the results will also be provided to the EA.

Ongoing reporting of data will be carried out in accordance with the permit requirements.