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BM515E / BM515M COMPARISON REPORT

UMK / SWARTKOPS TERMINAL

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1. Introduction.

UMK has been utilizing Benmarc BM515E chemical in their dust mitigation program whereby the ore is treated prior to being loaded into the rail cars for transport to Port Elisabeth.

Analysis of the characteristics of the wide grade-range of manganese ore from the Northern Cape region, revealed a porosity whereby the existing BM515E was absorbed into the lumpy ore. Although acceptable visible results were achieved with the base chemical, Benmarc researched an alternative for improved fines retention. The new chemical composition, designated BM515M, was developed with a component that would maintain extended surface activity, and thereby improve binding of fines to the lumps. BM515M was earmarked specifically for controlled treatment on UMK lumpy ore.

During the latter part of 2015 it was agreed that the comparison test on lumpy ore would commence in February to ascertain the improvement (if any) in dust retention and reduction of emissions at port.

At the same time it was also decided that the observation location would be moved from TPT to Swartkops Terminal. For this singular reason, the test focus was shifted from lumpy ore to fines. Therefore no historical data could be used for comparison in the test as all previous tests were conducted on lumpy ore.

2. Executive Summary.

- The analysis of the test data indicates that both BM515E and 515M achieved acceptable levels of dust control on manganese fines. This however, is a grade-specific result and relative to fines only. The comparison has not been done on lumpy ore for which the chemical was developed.
- BM515E appears to achieve lower dust emissions on manganese fines grade material.
- The BM515M was developed for improved dust control on lumpy grade manganese.
- Testing of both products needs to be conducted to determine whether acceptable performance can be achieved or additional formulation research is required.
- Given the inherent properties of each grade, it is quite possible a grade specific product would be applied to assure dust levels at Port Elizabeth are met.

3. Objective.

To determine the more effective of the two Benmarc chemicals, BM515E and BM515M, in sustaining surface activity and therefore fines retention on lumpy manganese.

4. Test Equipment.

Benmarc uses an industry accepted method to ascertain the effectiveness of its dust suppression installations by recording direct emissions at the locations most likely (or proven) to generate dust.

A single TSI Sidepak AM510 Aerosol Monitor was used as is the standard operating procedure within Benmarc. The certificate of calibration for the instrument (serial number 10710006) is attached to this report.

The equipment measures the total weight (in mg) of dust particles per cubic meter (mg/m^3) of sampled air, with constant sampling. Standard practice, as was employed at UMK, is to sample continuously at 1 second intervals.

5. Test Procedures.

Locomotive and rail car numbers were carefully recorded by the Benmarc technicians at the mine as the ore was being loaded. Therefore, although not correlated in this report, an accurate record was being held regarding the treatment of BM515E and BM515M.

Approximately 50% of each of the two control trains was treated with BM515E, and the remaining 50% was treated with BM515M.

The following procedure was followed:

- At least one Benmarc representative was present during the loading to verify the application system was functioning properly and moth moisture and chemical treatment targets were meet.
- For the test, no modification was done to the treatment system or its configuration in order to maintain comparable conditions.
- Two trains were selected for treatment. The initial thought was to treat both trains with BM515M. However, due to logistical/operational difficulties, the silo (on both occasions) had already been charged with BM515E-treated manganese before the arrival of the Benmarc team. This accounts for approximately 50% of the total requirement per train. Therefore :
- The first 50% (approximately 50 rail cars per train) of each train was loaded with BM515E treated manganese
- The remaining 50% (approximately 54 rail cars per train) was loaded with BM515M-treated manganese.
- All material was treated at the pre-set injection rate of 0.07 l/ton. At the projected loading rate of up to 900tph, this equates to 1050ml/minute
- The pre-loading calculated water consumption (according to pressure and nozzle configuration), was 6.18 l/ton (or 0.62% by weight) – at 900tph
- Train/loco/rail car numbers were recorded during loading.
- Dust monitoring and sampling at treatment points and at load out point was done with the system in operation.
- Pictures were taken during loading process as supporting verification.
- A Benmarc representative (JP Jonker) was present at Swartkops Terminal during the offloading process.
- Dust monitoring and sampling was conducted while the rail car was tipping into the receiving bin.
- Pictures were taken for visual verification.

6. Results

The resulting emission trends for both trains were grouped into BM515E, and BM515M data groups for ease of comparison (where each colour represents the emissions from an individual wagon):

Figure 6.1. Train 1 - BM515E

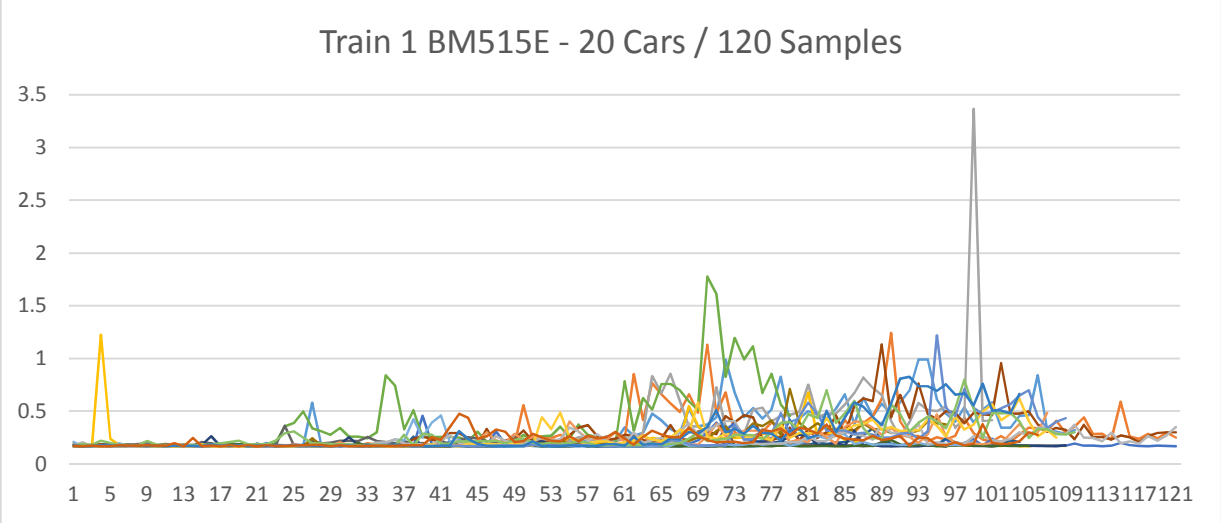


Figure 6.2. Train 1 - BM515M

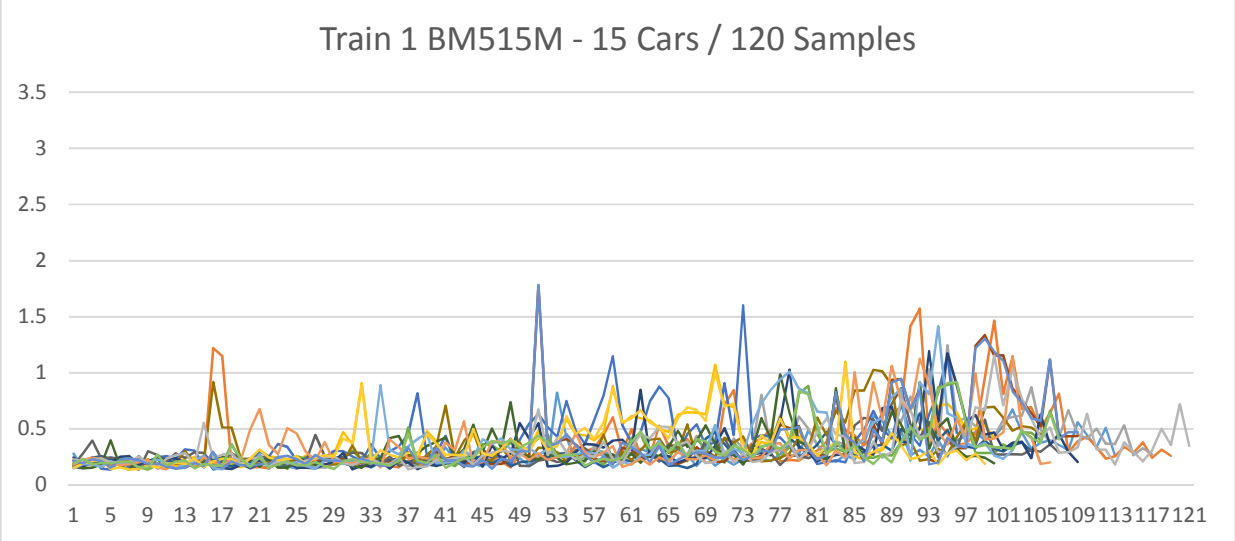


Figure 6.3. Train 1 – BM515E vs BM515M Performance Comparison

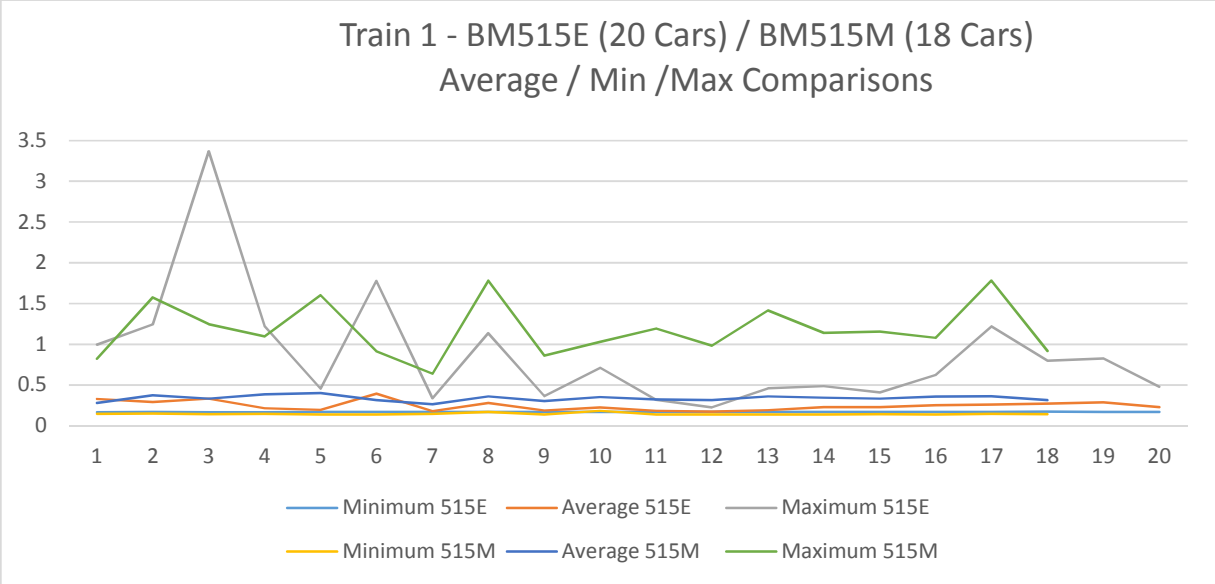


Figure 6.4. Train 2 – BM515E

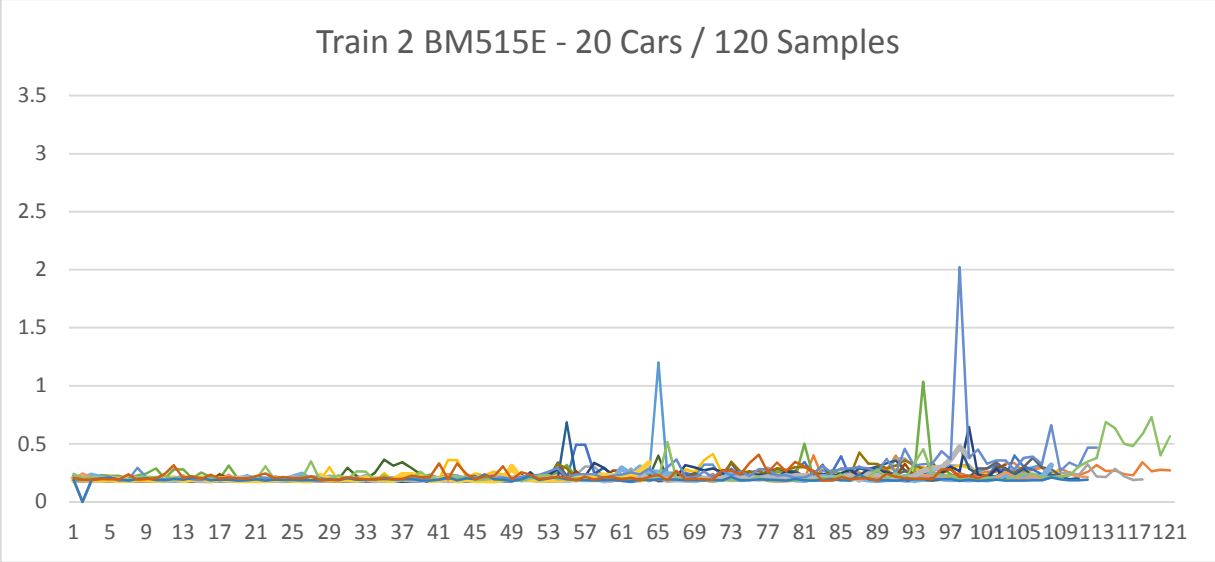


Figure 6.5. Train 2 – BM515M

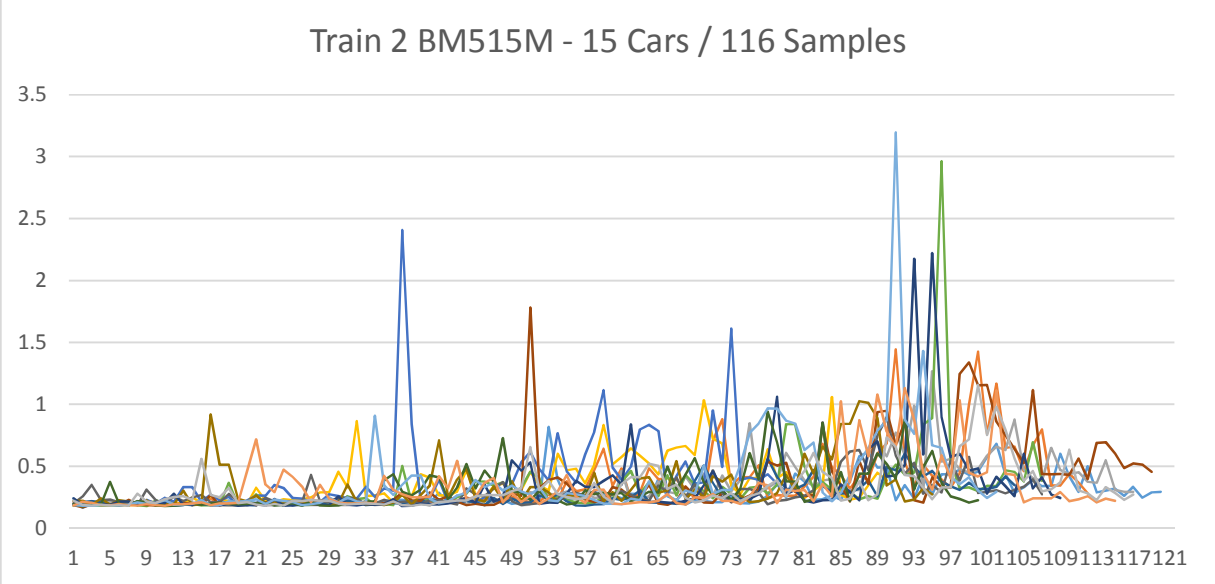


Figure 6.6. Train 2 – BM515E vs BM515M Performance Comparison

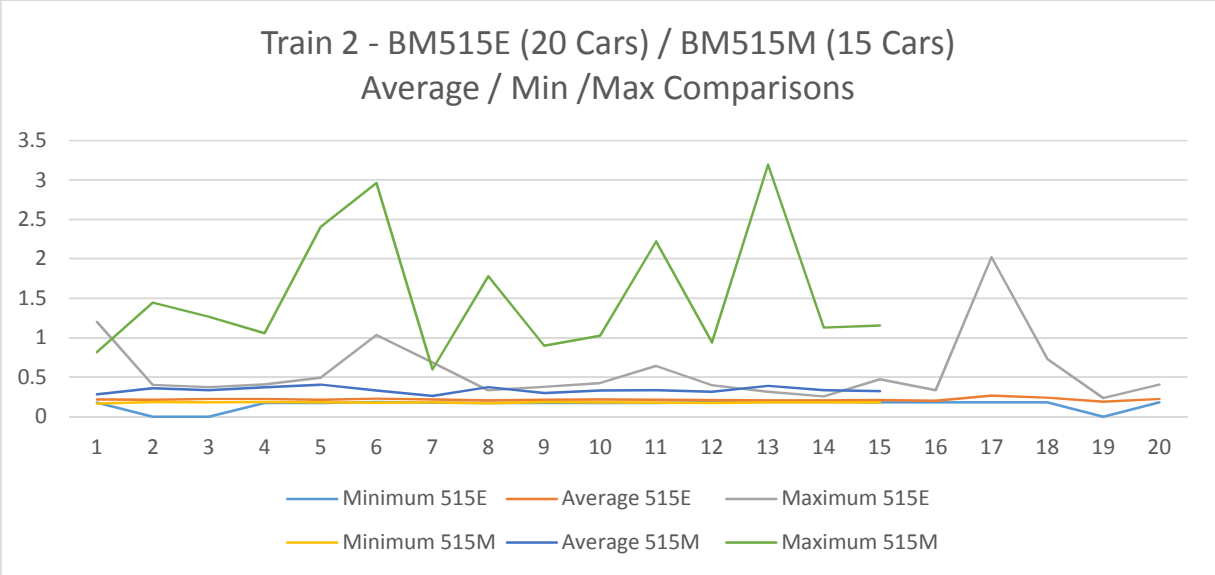


Figure 6.7. Train 1&2 - BM515E vs BM515M – Combined Performance Comparison

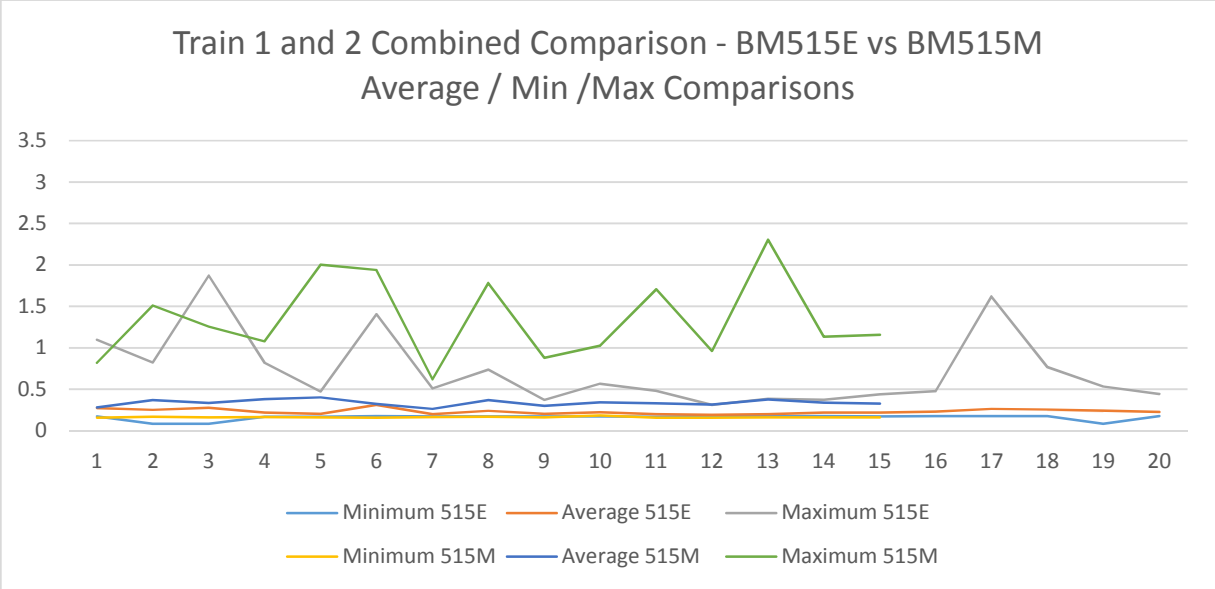
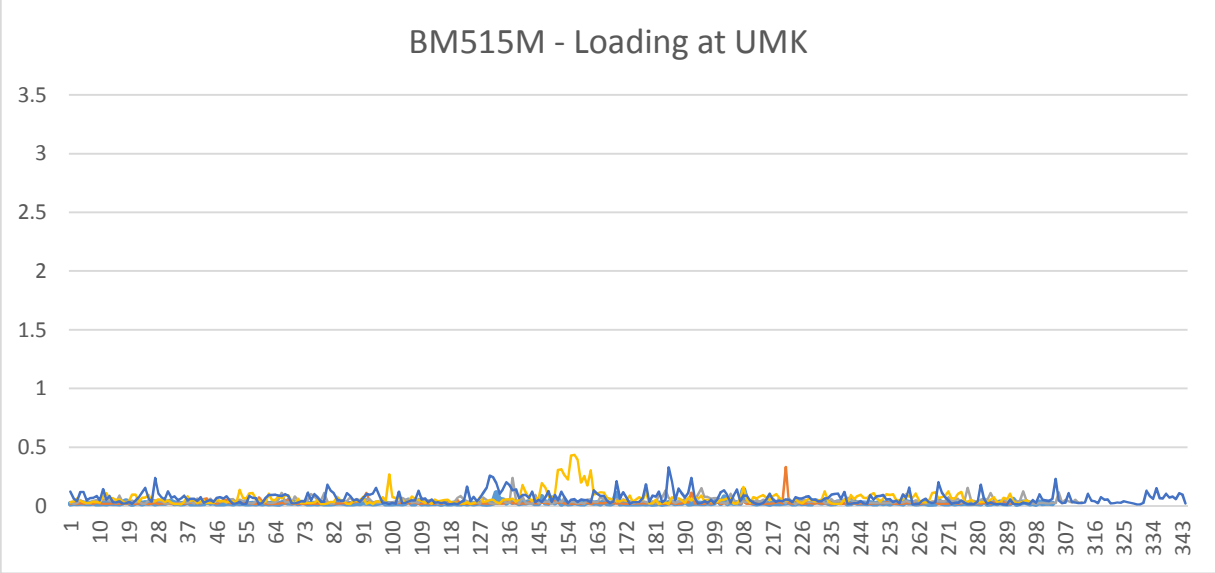


Figure 6.8. Train 1 - BM515M – Emissions while loading at UMK



7. Pictures During Loading at UMK and Offloading at Swartkops

Figure 7.1. Treatment Manifolds at UMK

Figure 7.2. Dust-free Loading at UMK

Figure 7.3. Calibration of Instrument at Swartkops

Figure 7.4. Instrument Placement at Swartkops – Downwind of Emissions

Figure 7.5. Dust-free Offloaded at Swartkops

Figure 7.6. Residual material due to rainfall

8. Weather Conditions

TFR reported that both trains assessed for emissions, were subjected to moderate rain – both en route, and at the Swartkops terminal on Sunday.

Although Swartkops reported 10mm on Sunday, TFR could not quantify the amount that the trains were exposed to on the way from UMK to PE.

The empty rail car in figure 7.6 above, gives an indication of the severity of the additional wetting caused by the rain, and it appears from this visual evidence that the amount of rainfall would have penetrated the material bulk to a depth where it would have an effect on the treated material and therefore the expected emission patterns.

Irrespective of the above, both BM515E and BM515M treated rail cars were exposed to the same amount of rain, although unquantified. Therefore the influence would have been the same on all rail cars.

9. Discussion of Results

The amount of data collected makes it impossible to present every sample in this report. However, all data was considered and analysed while only selected tangible information is presented. The analysis of the data was done mostly by comparisons of averaged emission levels. This approach gave the most consistent results and a general reflection of the emission patterns experienced.

All emission levels were extremely low throughout on all samples – BM515E and BM515M. This was prevalent during loading at the mine and during offloading at Swartkops. The maximum recorded spike was at 3.36mg/m^3 (train 1 – BM515E), and the overall average across all samples was a mere 0.28 mg/m^3. Therefore, as far as fines are concerned, either chemical composition would suffice.

Due to the very low level of all the emissions, the difference is not extreme in nature, but tangible in terms of the emission data recorded. Although the variance is marginal, it is evident from the graphs presented in figures 6.3, 6.6, and 6.7, that BM515E performed better than BM515M on the two sample trains.

However, Benmarc is of the opinion that the characteristics of the fines are not comparable to that of the lumps in terms of its reaction to the chemicals, as the results of

the controlled laboratory tests suggested a clear superiority of BM515M over BM515E on lumpy ore.

10. Conclusion

The emission levels for all treated material remained well within acceptable levels during the off loading of ore. In future, the treatment with either chemical on the fines, will ensure that emissions do not exceed acceptable levels.

The BM515M chemical was specifically developed and tested on lumpy ore, and although the evidence shows better performance of BM515E on fines, the objective of the test remain unconcluded and the potential dust mitigation capability on lumpy ore unknown.

11. Recommendations

Benmarc recommends continuation of testing specific to lumpy ore with a 50/50 train treatment of 515E/515M. It is our understanding that UMK will be sending two consignments of lumpy ore to Swartkops in the near future.

This will present an excellent opportunity for comparison and a path moving forward.