CHAPTER 3 – VISUAL MONITORING RESULTS AND EVALUATIONS

CLIMATE AND WEATHER AT THE MONITORING SITE

During each monitoring event, monthly weather charts from the Refuge's weather station were collected. These monthly weather charts for the study period are held on file at CFLHD. The desert climate at Buenos Aires NWR is predominantly dry but experiences periods of heavy monsoon-type storms especially in July and August. The temperatures and precipitation for the 24-month monitoring period were typical of a semi-arid desert grassland with temperature reaching highs of 40^{o} C (103^{o} F) in July and lows of -7^{o} C (20^{o} F) in December. The precipitation was heaviest during July with as much a 150 mm (6 in) of rain. The driest months with no significant rain were April through June, and an average of 5 mm (0.2 in) was reported during the months of August through March.

The evaluation team thought that a tabulation of the daily weather data for the entire 24-months would not contribute to the conclusions as most days showed no precipitation. In the rare event when rainfall was recorded, it was on the order of 3 mm (0.1 in) per day. However, at least one monsoon event was noted at 43 mm (1.7 in) for that day.

What was deemed important, however, was the weather during each actual monitoring event and the days immediately prior. Primarily, the weather influenced the visual observations of dust. A relatively dry monitoring event period would allow for greater amounts of dust, whereas a moist or wet event would limit it. This was not considered an issue because the measures during each monitoring period were relative to each other and not an absolute measure.

Rainfall data was also needed to evaluate the level of each product's potential leaching from the stabilized roadway. The evaluation team concluded that rainfall levels of 3 mm (0.1 in) could not produce enough moisture to saturate the roadway into a state where leaching was possible. On the other hand, monsoon events of 75 mm (3 in) in a single day would wash any visible leachable product material far away from the source.

At the 6-month monitoring event on March 4-5, 2003, the weather was cold and windy with intermittent light sprinkles. Weather in the 3-weeks prior to this was also rainy, windy, and cold. At the 12-month monitoring event on August 11, 2003, the weather was very warm reaching a high of 120^{o}. There was a trace of rain as is typical this time of year. At the 18-month monitoring event on March 17, 2004 the weather was warm and in the eighties for the day. At the 24-month monitoring event on August 24, 2004 the day started out with a few sprinkles. By midday however, the weather was warm in the upper eighties, and a light breeze of 10 to 15 miles per hour lasted most of the day.

DUST ABATEMENT

Table 6 indicates the dust rating values for each of the monitoring periods. As discussed earlier, these values are the average of the three evaluators' ratings. The final column on the right is, for each of the test sections, an overall average value representing performance over the entire 24-

months. Since these values are based on a scale of 0 to 10, they represent a normalized scale and can be directly compared with the average values of the other subjective observations. The values for each product at each monitoring event and the overall average are plotted in Figure 9.

Table 6. Dust rating values.

Test Section	Product	6-Month Average Value	12-Month Average Value	18-Month Average Value	24-Month Average Value	Overall Average Value
I	**Mag/Lig**	6.3	6.7	7.7	7.3	7.0
II	**Caliber**	8.3	8.0	8.7	7.7	8.2
III	**Soil Sement**	5.0	5.3	7.7	5.3	5.8
IV	**Permazyme**	5.0	5.0	5.0	5.0	5.0
V	**Terrazyme**	5.7	5.0	6.3	5.0	5.5
VI	**Lignosulfonate**	6.3	5.7	7.0	5.0	6.0
VII	**Mag/Cl**	7.3	5.3	6.0	4.3	5.8

Note: These averaged scores are based on a 0 to 10 scale with 10 indicating the best performer and 0 the worst performer. The baseline product (Section IV) was the first product to be rated and was given a score of 5. All other products were compared to that product.

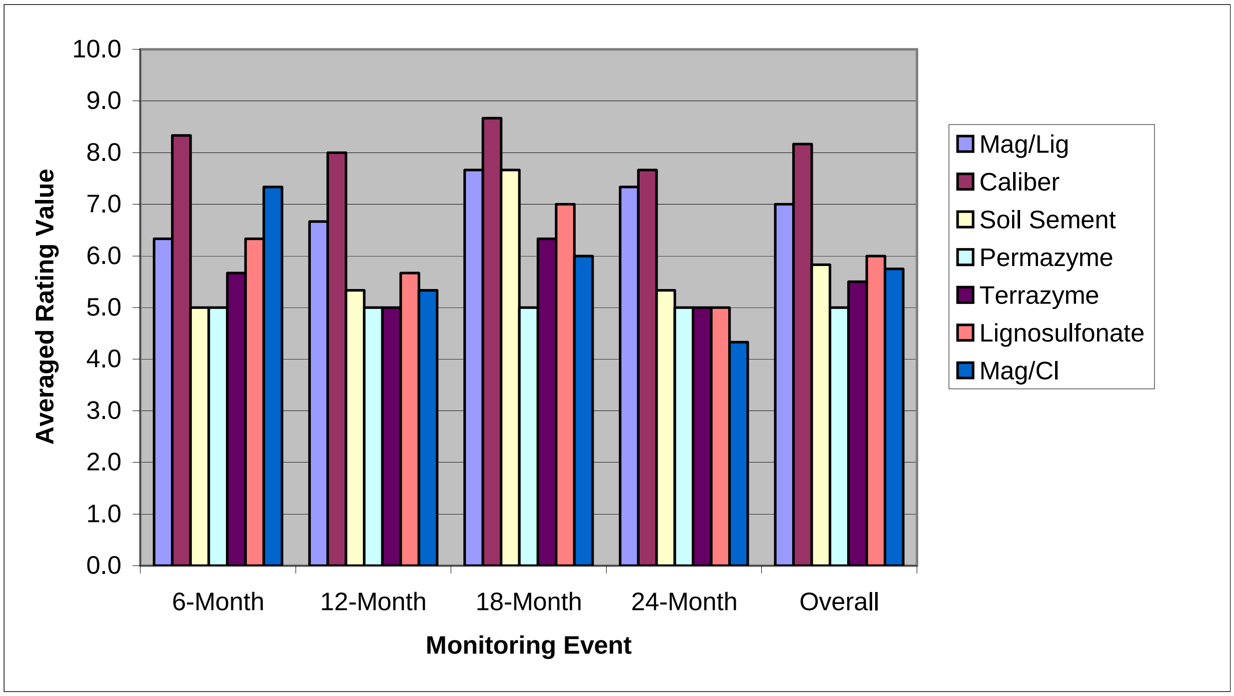

Figure 9. Plot. Dust values over time.

As indicated by the data in Table 6 and plotted in Figure 9, over time each product's relative standing in the group stayed pretty much the same. There were variations, for instance the improved relative values for Soil Sement at the 18-month event, but the relative standings remained substantially the same. The average over the four monitoring events best shows the overall relative performance of the products in dust abatement.

Looking at both the 24-month values and the overall average values, the products can be separated into two dust abatement groups. In the first group, the Caliber and the Mag/Lig sections allowed the least amount of airborne particles. In the second group, all of the other products also indicated acceptable performance, but with slightly more dust being generated relative to the first group. In the second group was the Mag/Cl in Section VII. This was a surface application only and not mixed to a depth of 150 mm (6 in) as were the other products, yet it initially performed similarly to the other sections. By the 24-month period, however, the values observed for this surface application of Mag/Cl were the lowest. This was not unexpected as a primary assumption of this project was that full depth stabilization would be more effective for a longer period than that of a surface application.

A similar observation is that these two groups may indicate some level of service life that could be expected from each of the products. It would appear from Figure 9 that even at the 18-month event all of the products were still relatively comparable. But by the 24-month event, a clear distinction is apparent between these two groups. One could also conclude that there may be a weather effect as the relative values for the 6 and 18-month events, both recorded in March, are similar. Just as the relative values for the 12 and 24-month events, both recorded in August, are similar.

Expanding on this thought, a key item to note is that for dust specifically, the best conditions to evaluate a product's performance would be when the climate is at its driest such as that recorded at the 12 and 24-month events. The relative average values for these two periods clearly support the observation that two groups exist with distinguishable differences in how they mitigated dust on this project.

Nevertheless, even though two groups were distinguished, all products performed acceptably throughout the 24-month period.

WASHBOARDING

Table 7 shows the washboarding rating values for each of the monitoring periods and the overall averages. These values for each product are plotted in Figure 10. As indicated by both the table and figure, over time each product's values generally corresponded in similar relative trends.

The products shown in Table 7 can be separated into three washboarding groups. In the first group, the Caliber and the Mag/Lig allowed the least amount of washboarding. In the second group were the Soil Sement, Terrazyme, and Lignosulfonate products. In the third group were the other products of Permazyme and Mag/Cl products whose sections had the highest levels of washboarding.

Section IV, treated with Permazyme, was noted to have the most washboarding. Figure 11 shows the washboarding typical on the Mag/Cl Section VII, which had value totals similar to Section IV. One explanation for this is that Section IV was the first section following a paved section of roadway and therefore experienced higher speed traffic than the other sections. However, it still exhibited a consistent level of washboarding throughout its length even where traffic would have slowed. The 6.0 km (3.7 mi) long Section VII actually does carry slightly more traffic than the other sections.

Table 7. Washboarding rating values.

Test Section	Product	6-Month Average Value	12-Month Average Value	18-Month Average Value	24-Month Average Value	Overall Average Value
I	**Mag/Lig**	7.3	6.7	7.7	7.3	7.3
II	**Caliber**	8.3	8.0	9.0	8.7	8.5
III	**Soil Sement**	5.3	6.0	5.3	6.3	5.8
IV	**Permazyme**	5.0	5.0	5.0	5.0	5.0
V	**Terrazyme**	5.0	6.0	6.7	6.3	6.0
VI	**Lignosulfonate**	5.0	5.3	6.3	6.7	5.8
VII	**Mag/Cl**	5.3	4.0	5.3	6.0	5.2

Note: These averaged scores are based on a 0 to 10 scale with 10 indicating the best performer and 0 the worst performer. The baseline product (Section IV) was the first product to be rated and was given a score of 5. All other products were compared to that product.

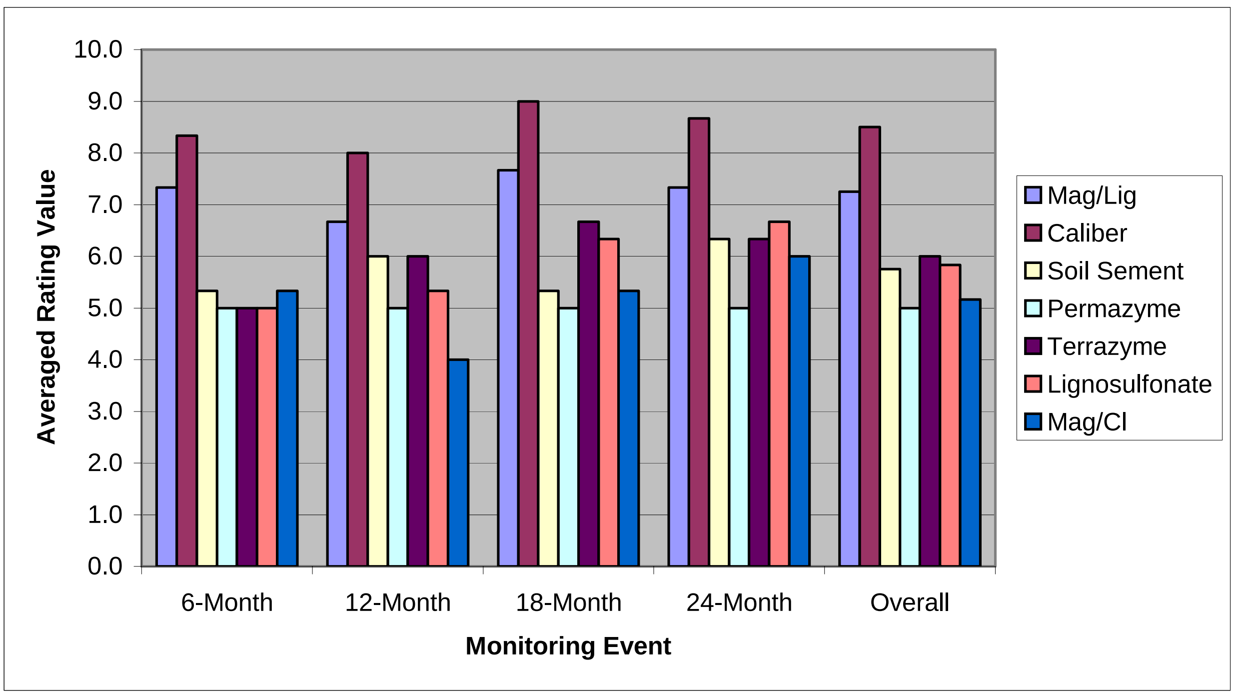

Figure 10. Plot. Washboarding values over time.

Figure 11. Photo. Washboarding, raveling, and dust.

An ideal study location would be one where all sections had identical geometry, grade, and composition. Unfortunately, the terrain varied throughout the project from relatively level or slightly rolling hills to some steeper sections as shown in Figure 12. The Mag/Lig, Terrazyme and Lignosulfonate roadway sections all had areas of rougher terrain, steeper grades, and curvilinear alignment. The evaluation team recognized that the effects of vehicles traveling on these steeper grades and curvilinear alignments would be greater than on the relatively flat and straight portions of each of these sections. Thus, difficult terrain areas were excluded from the rating process. Similarly, longitudinal water erosion "rivulets," which were evident in the Lignosulfonate Section VI shown in Figure 12 were a result of adverse weather on the steeper grades and curved alignment. These types of distress areas did not reflect on the affected product's evaluation of performance.

RAVELING

Table 8 shows the raveling rating values for each of the monitoring periods and the overall averages. These values for each product are plotted in Figure 13.

As indicated by the data in Table 8 and plotted in Figure 13, over time each product's relative standing in the group did not significantly change.

Figure 12. Photo. Water erosion rivulets.

Table 8. Raveling rating values.

Test Section	Product	6-Month Average Value	12-Month Average Value	18-Month Average Value	24-Month Average Value	Overall Average Value
I	Mag/Lig	6.7	7.0	7.7	7.3	7.2
II	Caliber	8.0	8.0	8.7	8.3	8.3
III	Soil Sement	5.0	5.3	4.7	6.3	5.3
IV	Permazyme	5.0	5.0	5.0	5.0	5.0
V	Terrazyme	5.0	5.7	6.7	5.7	5.8
VI	Lignosulfonate	5.3	5.7	5.7	6.7	5.8
VII	Mag/Cl	6.0	4.7	5.0	5.7	5.3

Note: These averaged scores are based on a 0 to 10 scale with 10 indicating the best performer and 0 the worst performer. The baseline product (Section IV) was the first product to be rated and was given a score of 5. All other products were compared to that product.

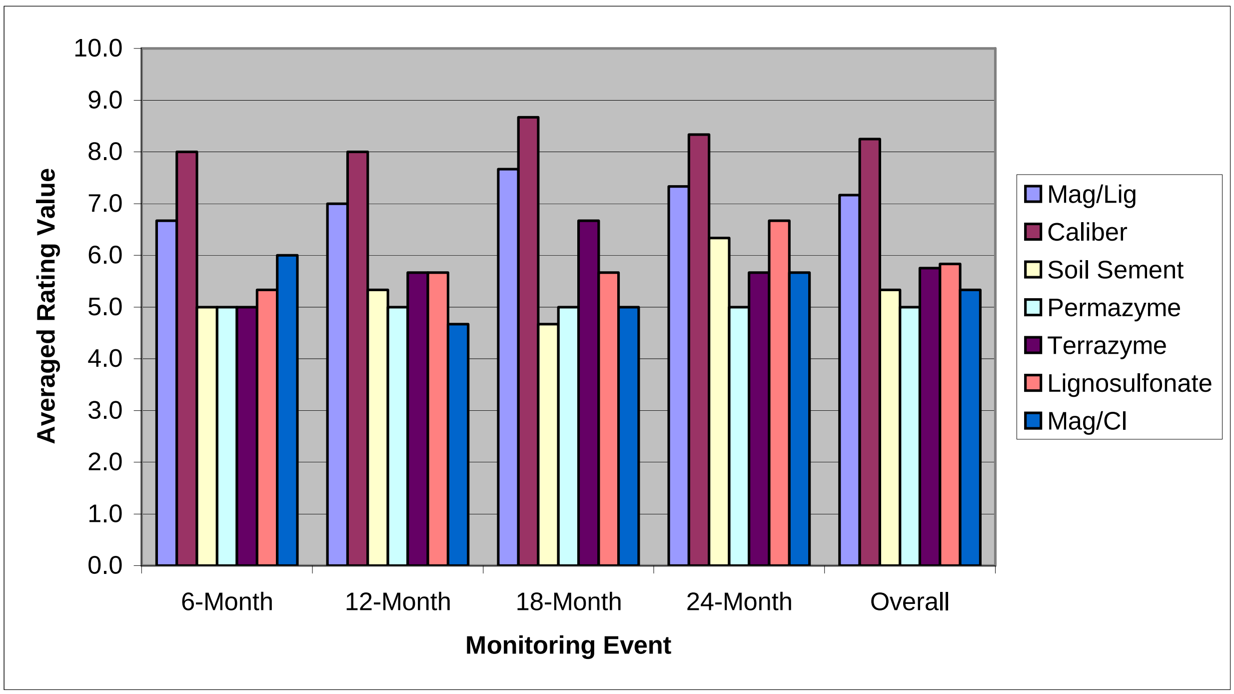

Figure 13. Plot. Raveling values over time.

The products shown in Table 8 can be separated into three raveling groups. In the first group was the Caliber section that appeared to have less loose particles at the roadway surface than other sections**.** It had a “tighter” surface appearance and little or no raveling. There was progressively more raveling in the Mag/Lig section in the second group. In the third group were all of the other products whose sections had higher but similar levels of raveling. Figure 11 shows the raveling on the Mag/Cl Section, typical of the sections in this third group.

Based on the request by the CFLHD at the start of this study, the Refuge did not perform any maintenance on this route from the initial placement of the borrow material with the stabilization and dust control products to the conclusion of the study. By the end of this 24-month study, all sections exhibited some roadway surface weathering. More raveled material was visible on the roadway surfaces of all sections during this monitoring event than on previous visits, and the roadway was clearly in need of maintenance grading.

RUTTING

Table 9 shows the rutting rating values for each of the monitoring periods and the overall averages. These values for each product are plotted in Figure 14.

Table 9. Rutting rating values.

Test Section	Product	6-Month Average Value	12-Month Average Value	18-Month Average Value	24-Month Average Value	Overall Average Value
I	**Mag/Lig**	6.7	5.0	6.0	6.7	6.1
II	**Caliber**	6.7	5.0	6.7	7.7	6.5
III	**Soil Sement**	7.0	4.7	5.0	5.3	5.5
IV	**Permazyme**	5.0	5.0	5.0	5.0	5.0
V	**Terrazyme**	6.0	4.7	5.7	5.0	5.3
VI	**Lignosulfonate**	5.7	4.7	5.3	6.0	5.4
VII	**Mag/Cl**	7.3	5.0	5.3	5.3	5.8

Note: These averaged scores are based on a 0 to 10 scale with 10 indicating the best performer and 0 the worst performer. The baseline product (Section IV) was the first product to be rated and was given a score of 5. All other products were compared to that product.

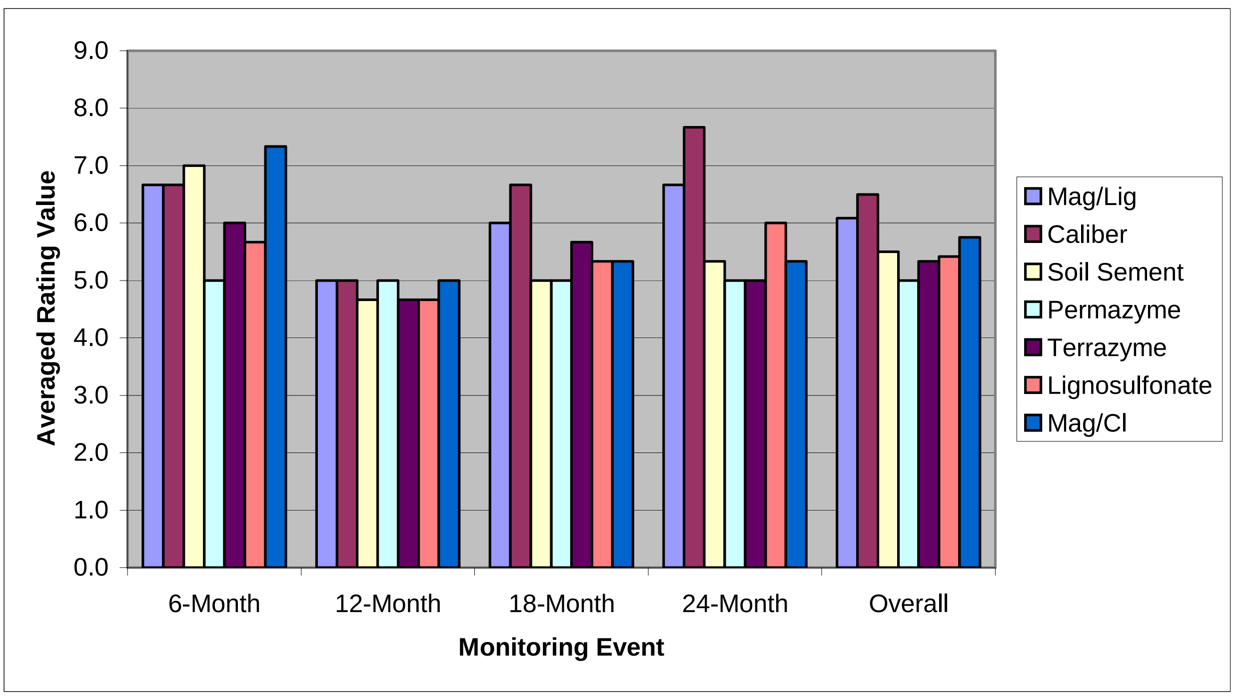

Figure 14. Plot. Rutting values over time.

As indicated by the data in Table 9 and plotted in Figure 14, over time each product's relative standing in the group remained pretty much the same. Although there were specific variations, for instance the improved rutting values for Lignosulfonate at the 24-month event, the relative standings remained quite consistent. The value totals at the end of the 24-month monitoring period best show the overall relative performance of the products with regard to rutting.

At the 6-month monitoring event, the Caliber product in Section II appeared to retain fines on the surface such that wheel tracks were clearly visible on the surface from traffic during a previous rain. The other sections did not have this appearance. Staff from the Refuge reported that this Section was "sloppy" and "slick" on February 10, 2003, when 25 mm (1 in) of rainfall occurred. These visible wheel tracks however did not constitute rutting to a depth to cause material deformation, nor was the "slippery and slick" surface condition observed on subsequent monitoring events.

While overall average values for each product in Table 9 show slight numerical differences for rutting, the evaluation team agreed that none of the sections exhibited any measurable rutting. Therefore, as all of the products performed on a relatively equal basis, they concluded that no single product could be separated out as having performed better or worse than the others.

POTHOLING

Potholing was included in the evaluation based on CFLHD's prior experience with surface applications of products, such as magnesium chloride, that tended to produce a thin hardened surface layer that would break up, or pothole, in areas of lesser compaction. Conceptually therefore, since in this project the roadway was stabilized to a depth of 150 mm (6 in), the extent of potholes that normally develop under these thin surface type of applications should not occur. The evaluation team, however, was unsure whether this full-depth stabilized roadway would form potholes out or not, so they monitored it.

Table 10 shows the rating values for each of the monitoring periods and the overall averages for potholing. These values for each product are plotted in Figure 15.

Table 10. Potholing rating values.

Test Section	Product	6-Month Average Value	12-Month Average Value	18-Month Average Value	24-Month Average Value	Overall Average Value
I	**Mag/Lig**	5.0	5.0	5.0	5.0	5.0
II	**Caliber**	5.0	5.0	5.0	5.0	5.0
III	**Soil Sement**	5.0	5.0	5.0	5.0	5.0
IV	**Permazyme**	5.0	5.0	5.0	5.0	5.0
V	**Terrazyme**	5.0	5.0	5.0	5.0	5.0
VI	**Lignosulfonate**	5.0	5.0	5.0	5.0	5.0
VII	**Mag/Cl**	5.0	5.0	5.0	5.0	5.0

Note: These averaged scores are based on a 0 to 10 scale with 10 indicating the best performer and 0 the worst performer. The baseline product (Section IV) was the first product to be rated and was given a score of 5. All other products were compared to that product.

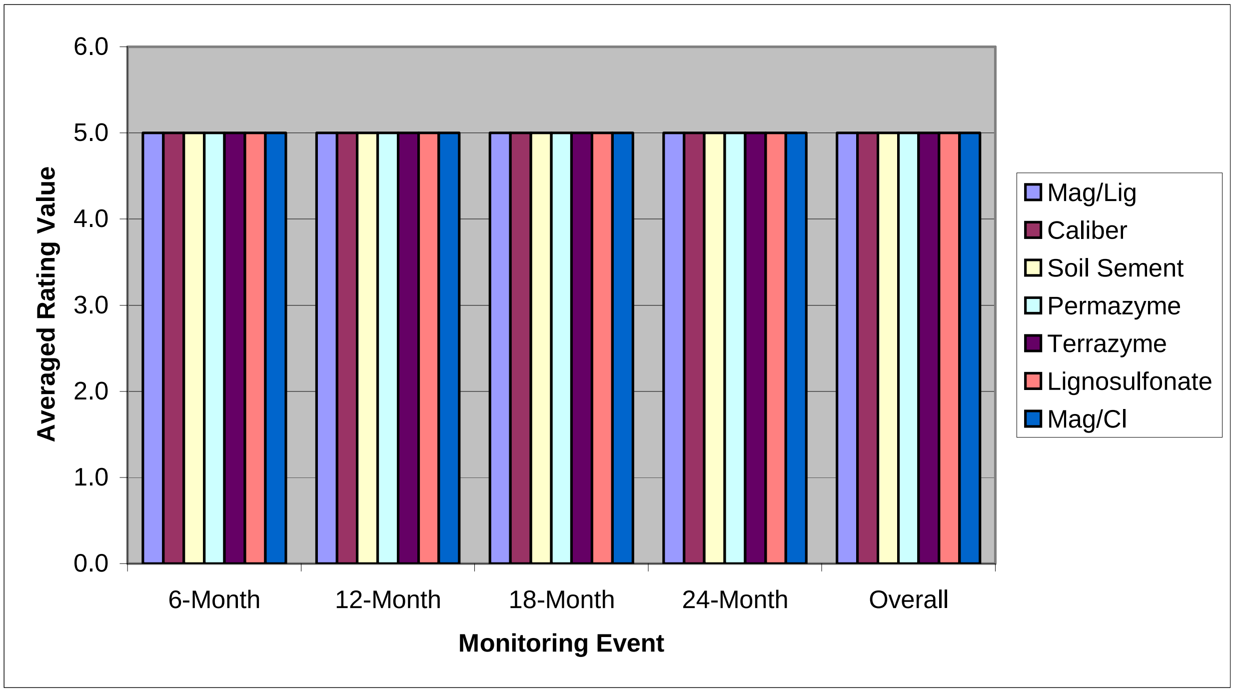

Figure 15. Plot. Potholing values over time.

As indicated by the data in Table 10 and plotted in Figure 15, no true potholing was observed. Therefore all products had similar relative performance over the entire 24-month monitoring period.

In the earlier monitoring events, the evaluation team observed what it thought were potholes in some sections, but it was unclear if these were truly potholes. For instance, there were three potholes noted in the Soil Sement Section III, two potholes in the Mag/Lig Section I, but none in any of the other sections. There was also no evidence that these few potholes were a result of the products' performance. It could even be speculated that the holes were due to large rocks pulled during the grading operation and the hole filled with poorly compacted material. By the end of the study, even though the Refuge had not performed any roadway maintenance, no evidence of potholes was apparent. As a result, no single product can be separated out as having performed better or worse than the others. In addition, the absence of potholing is significant because potholing is common on the Buenos Aires native material roadways.

LEACHING

Leaching of roadway stabilizing material was monitored, but it was not rated under the comparative evaluation method used for the dust, washboarding, raveling, rutting, and potholing parameters.

In the 6-month monitoring event, minor leaching of soluble stabilizing material was evident in the Caliber Section II as shown in Figure 16. Most of what appeared to be leaching occurred as crusting in some low-lying areas. Rather than leaching, this appeared to be the result of the product over-application during installation. In subsequent monitoring events, there was no

Figure 16. Photo. Minor surface crusting as a result of leaching.

visual evidence of leaching of soluble stabilizing material into the surrounding soils, nor did the earlier noted product appear to damage roadside vegetation.

VISUAL INSPECTION SUMMARY

A summary of the overall average values for each of the parameters and products is shown in Table 11. As an overall subjective measure of relative performance of each product, all of the overall parameter averages were averaged again to show a single average score for each product. These overall parameter average values as well as the average score for each product are plotted in Figure 17.

Table 11. Rating values summary.

Test Section	Product	Dust Overall Average Value	Washboard Overall Average Value	Raveling Overall Average Value	Rutting Overall Average Value	Potholing Overall Average Value	Visual Overall Average Score
I	**Mag/Lig**	7.0	7.3	7.2	6.1	5.0	6.5
II	**Caliber**	8.2	8.5	8.3	6.5	5.0	7.3
III	**Soil Sement**	5.8	5.8	5.3	5.5	5.0	5.5
IV	**Permazyme**	5.0	5.0	5.0	5.0	5.0	5.0
V	**Terrazyme**	5.5	6.0	5.8	5.3	5.0	5.5
VI	**Lignosulfonate**	6.0	5.8	5.8	5.4	5.0	5.6
VII	**Mag/Cl**	5.8	5.2	5.3	5.8	5.0	5.4

Note: These averaged scores are based on a 0 to 10 scale with 10 indicating the best performer and 0 the worst performer. The baseline product (Section IV) was the first product to be rated and was given a score of 5. All other products were compared to that product.

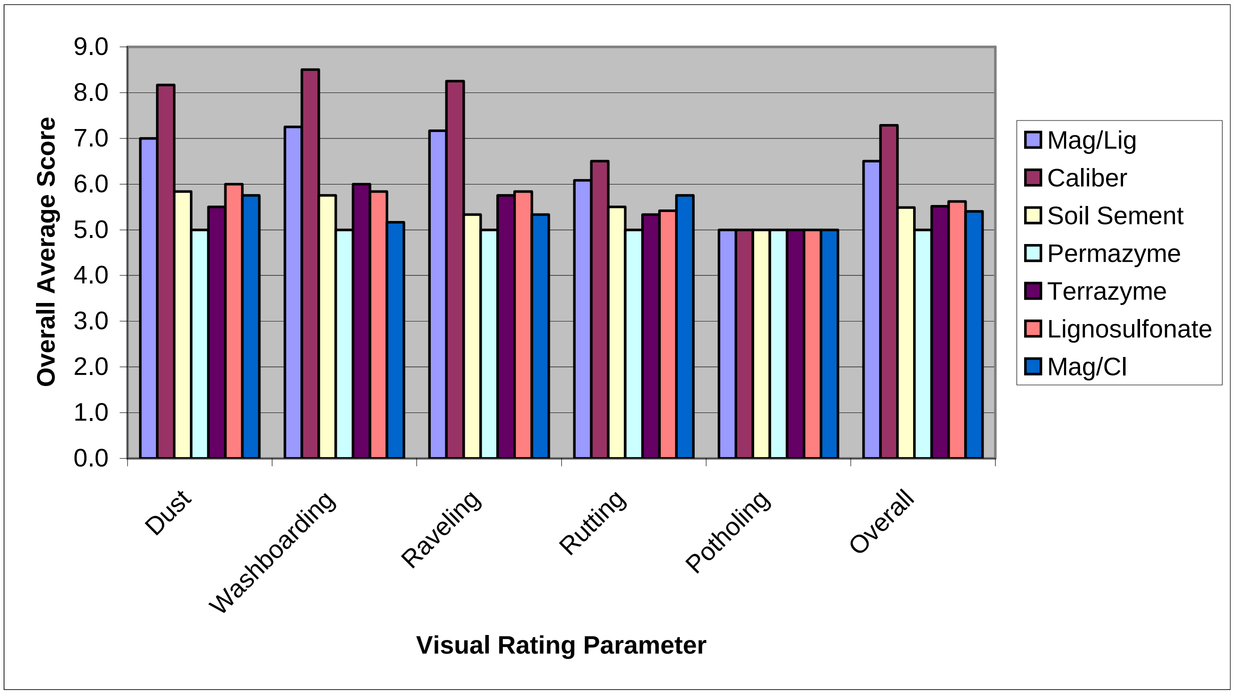

Figure 17. Plot. Overall average scores for each parameter.

From these average scores covering all parameters, three groups of product performance are evident. In the first group, one product, Caliber, performed the best overall. Second to this was the Mag/Lig product. The other products showed a fairly comparable relative performance and comprised the third group.

As stated earlier, all products performed acceptably throughout this study. Therefore the conclusion to be drawn here is not that some products performed well and the others poorly, but that some products exhibited better performance than some of the others. The objective physical evaluations in the next chapter provide additional information that corresponds to and confirms these subjective visual evaluations.