



## INNOVATIVE PAVEMENT PRESERVATION SOLUTIONS



## CM REAS PERFORMANCE TRACKING (CPT)

### INTRODUCTION

This CMREAS Performance Tracking (CPT) effort is a 10 year study that demonstrates the lifecycle performance of Central Mix Rubberized Emulsion Aggregate Slurry (CM REAS) to provide agencies with objective insight into pavement preservation solutions. The CM REAS Performance Tracking study, initiated in 2017, tracks the long-term performance and effectiveness of CM REAS on city streets. The study, which selects one street from 10 different projects each year, documents street conditions and preparation work before, during and after CM REAS treatment until the street is retreated or resurfaced. Thus far this longitudinal study has demonstrated the lower life cycle cost of maintaining and preserving asphalt-concrete streets using CM REAS as compared to conventional slurry seals. It will also provide PMI with critical insights on how to further optimize CM-REAS and its application processes in order to further improve performance for agencies.

# Table of Contents

Background.....	2
Objectives .....	2
Scope of Program– General .....	2
Program Procedures and Scope .....	2
Evaluation Elements.....	3
• Street Condition Rating.....	3
• Material Remaining.....	3
• Color .....	3
Evaluation Procedure – Field.....	3
• BEFORE.....	4
• DURING .....	4
• AFTER.....	4
• ANNUAL .....	4
Data Storage and Recordkeeping.....	4
SUMMARY OF RESULTS COLLECTED TO DATE .....	4
Before Condition Rating .....	4
Material Remaining Results .....	5
Color Monitoring Results .....	7
Summary of Findings .....	8
<b>APPENDIX A- ATTACHMENT I:</b> .....	<b>9</b>
<b>BEFORE - STREET ASSESSMENT RATING (B-SAR) GUIDE</b> .....	<b>9</b>
<b>APPENDIX B- ATTACHMENT II:</b> .....	<b>11</b>
<b>MATERIAL REMAINING RATING GUIDE</b> .....	<b>11</b>
<b>APPENDIX C - ATTACHMENT III:</b> .....	<b>13</b>
<b>COLOR RATING GUIDE</b> .....	<b>13</b>
<b>APPENDIX D - PROJECT REPORT FORMS</b> .....	<b>14</b>
Form #1: BEFORE REAS APPLICATION.....	14
Form #2: DURING APPLICATION .....	15
Form #3: AFTER REAS APPLICATION.....	16
Form #4: ANNUAL EVALUATION .....	17

# CMREAS PERFORMANCE TRACKING (CPT) PROGRAM ASSESSING STREET CONDITION AND PAVEMENT PRESERVATION PERFORMANCE

## Background

Petrochem Material Innovation's (PMI) initiated the "CMREAS Performance Tracking" (CPT) in order to measure the performance of Central Mix Rubberized Emulsion Aggregate Slurry (CM REAS) treated streets. Each year, PMI selects ten (10) streets to be treated with CM REAS and evaluates them in three phases: street condition and preparation work just prior to treatment (BEFORE), material related details and environmental conditions (DURING), and quality of the finished project (AFTER). PMI annually assesses all streets previously included in the study for ten years or until the street is re-slurried or resurfaced.

## Objectives

The CPT study will objectively demonstrate the superior long-term value and performance that agencies can expect from CM REAS. With the study's growing library of projects, PMI will document that CM REAS treated streets outperform conventional slurry seals in terms of quality, durability, and effective lifespan, resulting in the lower life cycle cost of maintaining and preserving asphalt-concrete streets with CM REAS. PMI will also use this study to monitor material quality during and after application, identifying variables and resulting effects, which will help optimize PMI practices and CM-REAS outcomes.

## Scope of Program– General

Every year, a random street from each of ten different projects scheduled for CM REAS treatment is added to the program to achieve a mix of street classifications, geography, time of year, and material applier. The BEFORE, DURING, and AFTER assessments are documented on report forms, along with Before and After pictures. The ANNUAL assessments are documented in an "Annual Evaluation" report form along with pictures. The four "**Forms**" are attached to this report.

All assessment work is done on a visual basis only. All reports, pictures and map reference are stored by PMI. Rating summaries are input and maintained in a digital database.

## Program Procedures and Scope

Slurry treatments are recognized as activities for pavement preservation, which is an essential part of any asphalt-concrete street maintenance program. Most public agencies budget for a regular pavement preservation cycle to keep their streets in good condition. To achieve this goal, it is imperative that the selected treatment provides sufficient protection from water infiltration, protects the existing asphalt mixture from oxidation, and yields sufficient texture and color for a safe ride. High quality and long-lasting CM REAS has been proven to provide these protections and helps extend the life of a street by delaying the cracking and/or raveling and eliminates the potholes usually observed on aging streets. These protections defer costly rehabilitation or reconstruction and allow

better ride quality for users of these streets. Lower quality conventional slurry seals, although less costly initially, can leave gaps in protection leading to premature failures and higher life cycle costs.

In addition to prevention of cracking and raveling, color of street surface is also a very important consideration of a pavement preservation treatment. A long lasting, dark street color presents a sharp contrast to pavement striping, markings, and warnings which enhance safety for vehicular traffic, bicyclists, and pedestrians. Enhanced street color is also aesthetically pleasing to residents and improves the “feel of the neighborhood” overall. In this performance tracking program (CPT), the common type of distresses and color change have been included in the evaluation procedure as discussed in the following sections.

### Evaluation Elements

Given these pavement preservation priorities, three key ratings are selected for this CPT Program after treatment. In addition to the three elements, street condition just prior to treatment is also an important factor needed to explain why a given project may be performing better or worse than expected over time. The following are the three elements that are rated with a score.

- **Street Condition Rating** – See **APPENDIX A - ATTACHMENT I: “Before - Street Assessment Rating Guide”**. This rating is only assigned in the BEFORE condition report. A score of 0 (worst) – 100 (best) is assigned based on factors including: 1. Cracking – Adequacy of crack fill and severity of unmitigated raised cracks affecting ride quality; 2. Potholes – Sufficiency of asphalt repairs; and 3. Evidence of raveling. Other preparation and environmental factors outside the normal expected range are noted in the “Other Comments” section but not scored. These may include inadequate street cleaning/sweeping, poor weed abatement, presence of water, excessive tree canopy shade, etc.
- **Material Remaining** – See **APPENDIX B - ATTACHMENT II: “Material Remaining Rating Guide”**. This rating is primarily assigned in the ANNUAL reports and is focused on cracking, potholes, and raveling. A rating is assigned in the AFTER reports but should be 100%, assuming no unexpected issues.
- **Color** – See **APPENDIX C - ATTACHMENT III: “Color Rating Guide”**. A color coded chart is used to determine the color rating of the street. This score is primarily assigned in the ANNUAL reports. The AFTER reports would typically note a 100 score.

### Evaluation Procedure – Field

As mentioned earlier, there are four forms used to evaluate and document the condition of the street before, during, after, and annually. To achieve the goal of evaluation, four forms were developed for the program.

- **BEFORE** – The form report (**APPENDIX D - Form #1: BEFORE**) is completed during a field assessment just prior to the scheduled REAS application when crack fill and other preparation work has been completed. The specific procedure for rating the street condition is included in **APPENDIX A – ATTACHMENT I**. 4-8 pictures (depending on length of street) are taken at this time. Picture angles are noted on a street map included in the upload. Pictures are numbered in conjunction with the map numbering. After and Annual pictures are taken at the same angles.
- **DURING** – This information is noted during the material application process. See **APPENDIX D - Form #2: DURING APPLICATION**.
- **AFTER** – This phase is evaluated a month or two after REAS application to allow for striping and pavement marking work to be completed. Pictures would then show the greatest contrast that can be compared in future annual evaluations. Specific procedures for rating material remaining and color are included in **APPENDICES B AND C**, respectively. **APPENDIX D - Form #3: AFTER** is attached. Pictures are required at the same angles as the Before pictures.
- **ANNUAL** – Each past project included in the study is assessed on an annual basis using the attached **APPENDIX D - Form #4: ANNUAL**. **APPENDICES B AND C** include the specific procedures for rating material remaining and color. Pictures are taken at the same angles as the Before and After pictures.

## Data Storage and Recordkeeping

All original reports, maps, and pictures are saved by PMI. Additionally, two-page Annual Reports, which summarize findings of projects assessed for the year and other information of interest, are also stored.

## SUMMARY OF RESULTS COLLECTED TO DATE

This section includes the results of evaluations divided in 3 sections including Before Condition Rating, Material Remaining, and Color Rating. In each section a brief summary of all streets showing average results and variation (standard deviations) for each rating are shown and a street by street analysis of the relative change with age of street.

### Before Condition Rating

Table 1 includes a list of selected streets that have been slurried between 2017 and 2020 with the three types of slurries produced by PMI. These include Type I, Type II, and Type III. The ratings shown are based on using Form #1 in Appendix D in conjunction with the Before – Street Assessment Rating Guide in Appendix A. As shown in the table, the estimated street condition BEFORE application varies between a low score of 40 and a high score of 75. Agencies have always attempted to keep the condition of the streets they manage at the best condition and thus a goal of the agencies is not to have any street with poor conditions.

Table 1. Example of BEFORE Condition of Streets included in the CPT program

STREET CLASSIFICATION	DATE OF APPLICATION	TYPE OF REAS	ID	EST. STREET CONDITION BEFORE
Residential	6/16/2017	I	1703	50
Residential	7/20/2017	I	1704	60
Collector	11/29/2017	I	1710	65
Residential	11/27/2018	I	1810	40
Collector	1/10/2019	I	1901	70
Residential	8/16/2019	I	1906	55
Residential	1/29/2020	I	2001	40
Residential	8/26/2020	I	2009	60
Residential	8/14/2017	II	1706	75
Residential	10/10/2018	II	1808	70
Residential	10/22/2018	II	1809	70
Arterial	5/7/2019	II	1903	55
Arterial	8/26/2019	II	1907	75
Arterial	9/13/2019	II	1908	75
Arterial	3/17/2020	II	2002	60
Residential	8/15/2020	II	2008	70
Residential	9/1/2020	II	2010	60
Ramp	8/15/2017	III	1707	70

### Material Remaining Results

Following the protocol described in Appendix B Attachment II, ratings of 29 street sections were collected. The ratings are based on amount and severity of cracking areas as well as raveling and potholes. The ratings are divided in 4 categories based on the score determined after deduction as follows:

- 90 - 100: Excellent Condition
- 75 - 90: Good Condition
- 60 - 75: Fair Condition
- Below 60: Consider additional maintenance and/or rehabilitation

The rating data is collected following a visual observation on an annual basis. The results collected to date (Sep 2020) include 29 sections that vary in age from 1 year to 10 years. The number of streets evaluated for each of the 10 years is not the same and varies between only 2 streets for age 10 and 29 streets with age of one year. Table 2 includes the summary for the material remaining for all 29 streets and also show the variation in ratings by listing the Standard Deviation for the specific year.

Table 2. Summary of Material Remaining Ratings for 29 Streets Surveyed to Date

Years of Service	Total Number of Streets Evaluated	Average Score for Material Remaining	Standard Deviation
1	29	89.5	4.6
2	20	85.3	7.2
3	12	78.3	9.2
4	6	76.7	8.0
5	6	75.0	9.6
6	6	76.7	4.7
7	4	68.8	2.2
8	4	63.8	6.5
9	3	60.0	7.1
10	2	60.0	0.0

Figure 1 depicts the average value as a function of years of service and also display the range in values as defined by one standard deviation higher and lower than the average (probability of 68%).

The results show that the average rating after 5 years remain at 75.0 with a standard deviation of +/- 9.6 units. This average rating indicates there are typically only moderate fine cracks throughout and a few wider cracks. Figure 2 shows photos of typical sections rated at 70-80 and at 60-70 to show the typical condition found after 5 years. Such condition is considered to be good to fair condition and does not require immediate mitigation.

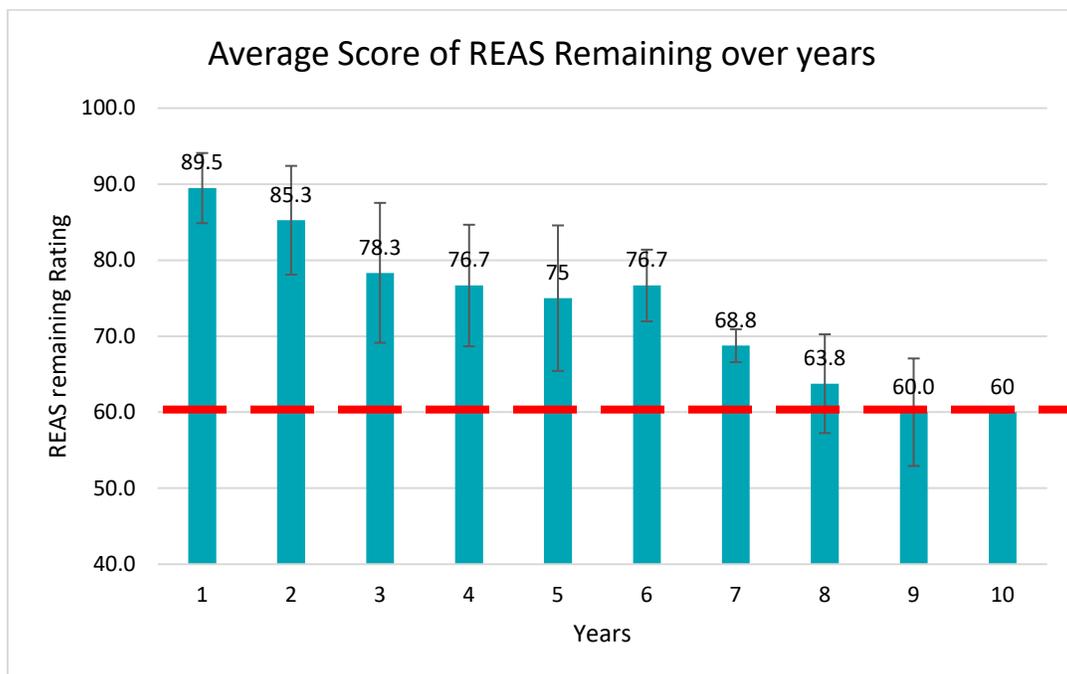


Figure 1. Results of the Material Remaining Score (REAS) as a function of age of service



Material Remaining = 60 (Type II Arterial – 8 yrs)

Material Remaining = 70-80 (Type I Local – 3 yrs)

Figure 2 Photos of Typical streets rated as 60 Material Remaining and 70-80 Material Remaining

If the rating of 60 is considered the end of service life of slurry, the results shown in Figure 1 indicate that on average life expectancy of 7-8 years is expected for the REAS application. This life expectancy is longer than that estimated for other conventional slurry applications commonly cited in technical literature as 4-5 years. This confirms the added value of the special quality of the REAS.

### Color Monitoring Results

Following the protocol described in Appendix C Attachment III, ratings of the same 29 street sections were collected. The ratings are based on color observed during the evaluation and matching with the color chart shown in Attachment III. The ratings are divided in 4 categories as follows:

90 - 100:	Excellent
70 - 80:	Good
60 - 70:	Fair
Below 60:	May not be adequate

Figure 3 depicts the average color rating value as a function of years of service and also displays the range in values as defined by one standard deviation higher and lower than the average (probability of 68%).

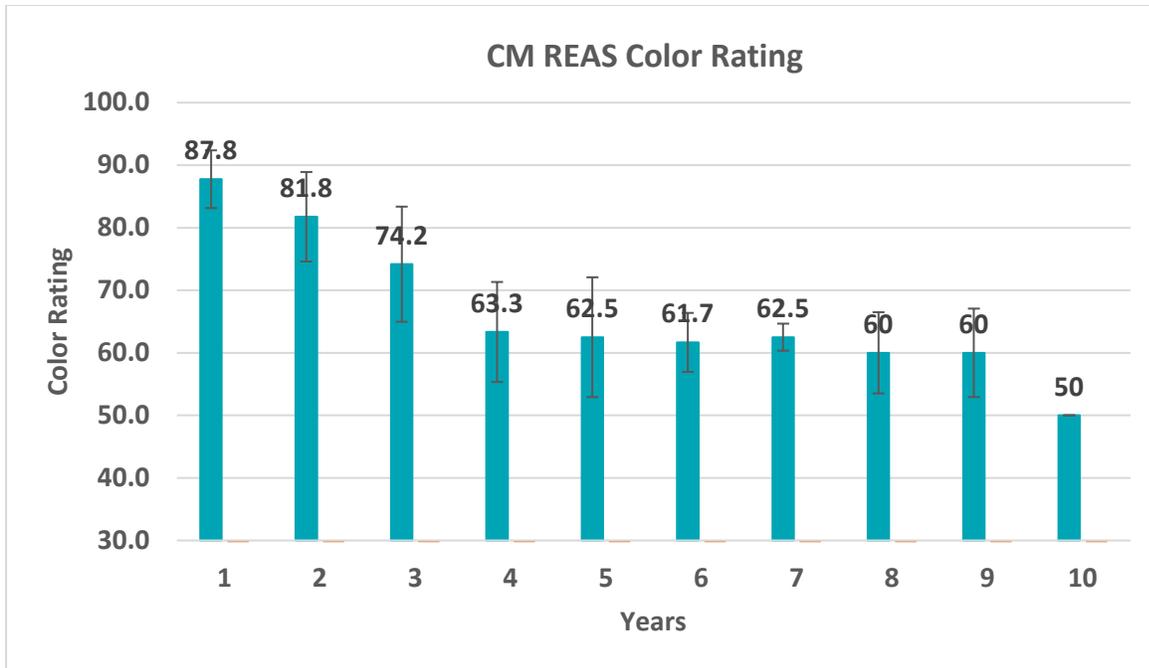


Figure 3. Results of the surface color of streets as a function of age of service

## Summary of Findings

In this report the condition of 29 streets on which PMI REAS slurry was applied has been evaluated and tracked to determine the life cycle performance of the slurry. The analysis of the results leads to the following findings:

1. The material remaining rating of 60-70 is reached on average after 7-8 years.
2. The color change rating of 60-70 is reached after 4 years and is maintained in that range for 4-5 more years.
3. Based on these results the life expectancy of the REAS slurry defined as rating equal or above 60% in all indicators of distresses and color ranges between 7 and 9 years.

# APPENDIX A- ATTACHMENT I:

## BEFORE - STREET ASSESSMENT RATING (B-SAR) GUIDE

### General

All projects in the study must be assessed just prior to REAS or slurry seal application. **APPENDIX D - Form #1: BEFORE** is included in this report. A “Before - Street Assessment Rating (B-SAR)” is to be determined and recorded on this Form.

### Rating Criteria

The three (3) areas to be assessed as part of the B-SAR score include:

- Cracking – Amount, quality of crack fill, effect on ride quality;
- Potholes and other Asphalt-Concrete Failures – Sufficiency and quality of repairs; and
- Raveling – Evidence of active raveling and/or rough surface with missing fines.

### Rating Procedure

A score of 0 (worst) – 100 (best) will be assigned. Starting at a “100”, points are deducted according to field observations and the following guidelines:

#### CRACKS

- ***Rough Ride due to lifted or sunken cracks:***  
No Deduction for good ride, (-10 points) for a fair ride, (-20 points) for a rough ride; AND
- ***Amount of cracking but mitigated well:***  
No Deduction for light, (-5 points) for moderate, (-10 points) for heavily cracked; OR
- ***No Crack Fill:***  
(-10 points) for fine and low number, (-20 points) for moderate, (-30 points) for many and/or some wider cracks; OR
- ***Poor Crack Fill (Sunken or Inadequately Filled):***  
(-5 points) for light to moderate, (-10 points) for more than a moderate amount.

#### POTHoles/AC FAILURES

- ***Number of locations:***  
None to minimal with ride quality ok and repairs done well: No Deduction

- ***Inadequate repair coverage:***
  - *Alligating:*  
(-10 points) for a few smaller areas with solid base, (-20 points) for more smaller areas and/or larger, (-30 points) for several areas not adequately repaired maybe with floaters and/or sunken areas; AND
  - *Utility Trenches and Vaults:*  
(-10 points) for localized smaller areas, (-20 points) for more and/or larger; AND
  - *Unfilled pot-sized and smaller holes:*  
(-10 points) for 1-2 locations, (-20 points) for more.

### RAVELING

- ***Active Raveling***  
Loose aggregate on surface or in gutter: (-5 points) for light, (-10 points) for moderate amount, (-20 points) for heavy raveling in several locations; OR
- ***Evidence of Past Raveling***  
Surface is open graded and rough: (-5 points) for slight to moderate, (-10 points) for no fines remaining.

### Overall Score

The overall final score translates to:

- 90 – 100: Excellent Condition
- 70 – 85: Good Condition
- 50 – 65: Fair Condition
- Below 50: Poor condition – More mitigation work should be done

## APPENDIX B- ATTACHMENT II:

### MATERIAL REMAINING RATING GUIDE

#### General

In addition to the BEFORE assessment, all projects in the study must be evaluated 1-2 months after REAS or slurry seal application (AFTER) and on an annual basis (ANNUAL) to rate how well the surface treatment is performing. Both Forms are included in **APPENDIX D** of this report. A “Material Remaining Rating” is to be determined and recorded on this Form.

#### Rating Criteria

The four (4) areas to be evaluated as part of the Material Remaining Rating score include:

- Cracking – Amount and severity of cracks opening, exposing the street to water infiltration;
- Potholes and other asphalt-concrete failures;
- Raveling – Premature surface wear and/or continuing active raveling; and
- Premature wearing areas – Typically hand-worked ends and driveways, parking lanes.

#### Rating Procedure

As with the B-SAR rating, points will be deducted from 100 based on the presence and severity of Cracking, Potholes, and Raveling plus an additional deduction for premature heavier wearing areas if applicable. Below are some example cases that can be used as guidelines:

##### CRACKS OPENING AT STREET SURFACE

- *Only “reflective cracking”, no cracks opening at surface:* **No Deduction**
- *Just a few fine cracks opening up:* **Deduct 5-10 points**
- *Moderate # of fine cracks throughout or few wider cracks:* **Deduct 10-20 points**
- *More than one alligatored area and moderate # others:* **Deduct 20-30 points**
- *Heavy # cracks opening throughout and/or multiple alligatored:* **Deduct 30+ points**

## POTHoles AND OTHER ASPHALT-CONCRETE FAILURES

- *None:* **No Deduction**
- *1 or 2 localized:* **Deduct 5-10 points**
- *3 or more localized:* **Deduct 10-20 points**
- *More than 3 predominantly in one area of the street:* **Deduct 20+ points**
- *Multiple failures in several different areas of the street:* **Deduct 30+ points**

## RAVELING

- *None to very little:* **No Deduction**
- *Only light raveling in 1-2 localized areas:* **Deduct 5-10 points**
- *Moderate raveling in multiple locations:* **Deduct 10-20 points**
- *Evidence of moderate raveling throughout and/or multiple heavy raveling locations:* **Deduct 20+ points**
- *Raveling over 25%+ of street with loss of "fines" and larger aggregate exposed:* **Deduct 30+ points**

## AREAS WEARING PREMATURELY

- *Deduct points for unusually heavy worn localized areas vs the entire street area:* **Typically 5% for only at ends, 10% with few driveways added, over 10% with heavy lane wear added.**

## Overall Score

The overall final score for "Percent Material Remaining" translates to:

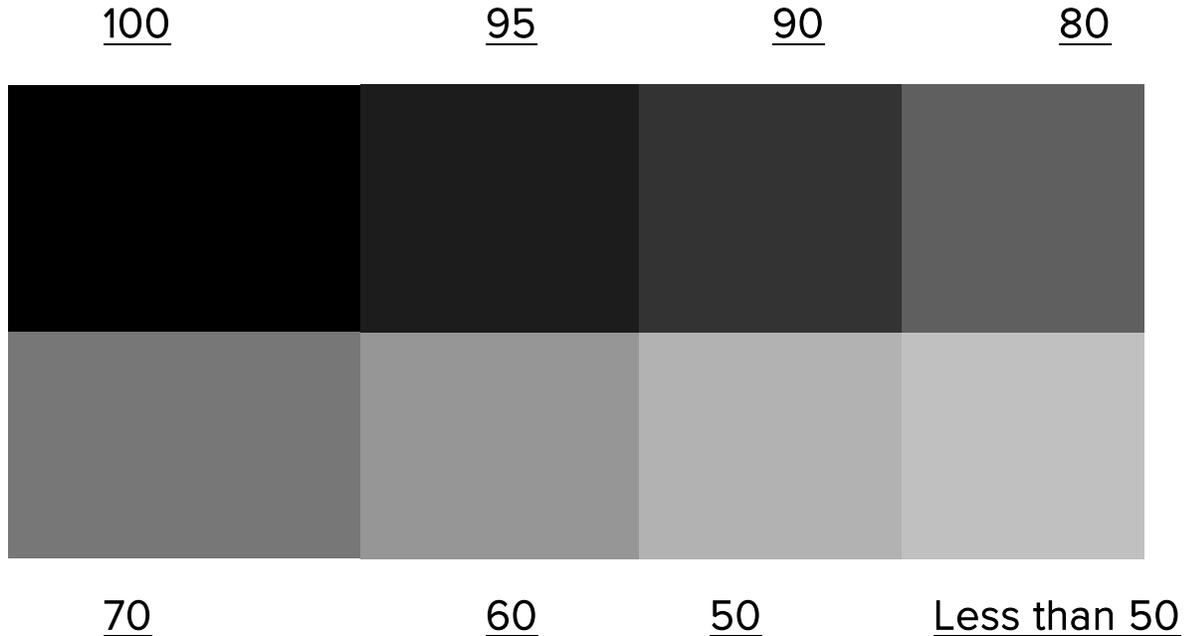
- 90 - 100%: Excellent Condition
- 75 - 90%: Good Condition
- 60 - 75%: Fair Condition
- Below 60%: Consider additional maintenance and/or rehabilitation

## APPENDIX C - ATTACHMENT III:

### COLOR RATING GUIDE

#### CM REAS PERFORMANCE TRACKING PROGRAM

### COLOR CHART



#### Rating Procedure

1. Use the Color Chart as a reference for all Annual Evaluation reports.
2. Rate streets from 100 to 50 or "Below 50" in increments of 10, except 95 - ok.
3. If color is uneven:
  - a. Less than 25% lighter color, rate darker color but subtract 10 points;
  - b. More than 25% lighter color, rate lighter color;
  - c. Note color inconsistency details in Annual Report under "11. Other Comments".
4. 90 - 100: Excellent  
70 - 80: Good  
60 - 70: Fair  
Below 60: May not be adequate

## APPENDIX D - PROJECT REPORT FORMS

### CM REAS PERFORMANCE TRACKING PROGRAM

#### Form #1: BEFORE REAS APPLICATION - STREET ASSESSMENT W/ PHOTOS

1. Date and Time of assessment; temperature and sky conditions
2. Customer and Project Title
3. Name of street being tracked (include cross street limits)
4. Street classification, posted speed limit, avg. traffic counts (from agency, if available)
5. Rate overall condition of street 0-100: Use Before - Street Assessment Rating Guide
6. Note general street condition concerns (examples: poor crack fill, potholes, sunken cracked areas, failed areas not repaired, excessively dirty, etc.)
7. Note concerns other than street condition (examples: excessive water, substantial shadows, low tree crowns, significant handwork required, etc.)
8. Describe specific issues of concern, note address, take pictures if needed
9. Other comments

[Name (who completed this form)]  
[Date Evaluated]

**CM REAS PERFORMANCE TRACKING PROGRAM**  
**Form #2: DURING APPLICATION – PROJECT DETAILS**

**General**

1. Customer and Project Title
2. Name of street being tracked (include cross street limits)
3. Who applied material (PMI, Agency, or which Contractor)

**Field Work** - if possible, take field sample for WTAT (#11 below)

4. Date(s) and Time(s) material was applied, temperatures, sky conditions
5. Applicator Truck Number(s) and Delivery Trailer Number(s), if available
6. Note any irregularities during application (poor preparation, drive or walk throughs, temperature extremes, overcast, heavy shaded areas, wind, etc.)
7. Material observations in field (look, workability, consistency, too dry?, too wet?)
8. Work description (excessive hand work, logistical challenges)
9. Other comments from the field

**Material**

10. Type of REAS material used
11. Wet Track Abrasion Test (WTAT) results
12. Any comments from the Plant

[Name – who completed this form]  
[Date - Noted]

**CM REAS PERFORMANCE TRACKING PROGRAM**  
**Form #3: AFTER REAS APPLICATION – EVALUATION W/ PHOTOS**

1. Date and Time of assessment; temperature and sky conditions
2. Customer and Project Title
3. Name of street being tracked (include cross street limits)
4. **Rate Color:** 50-100 or “Below 50” (100 blackest) - Use “Color Rating Guide”
5. Cracks: Deductions using “Material Remaining Rating Guide”
6. Potholes: Deductions using “Material Remaining Rating Guide”
7. Raveling: Deductions using “Material Remaining Rating Guide”
8. Heavy Wear Areas: Deductions using “Material Remaining Rating Guide”
9. **Rate Percent REAS Remaining:** #5 - #8 Deductions from a Base of 100 - Use “Material Remaining Rating Guide”
10. Comment on Street Ride Overall and Any Localized Rough Areas
11. Additional Comments  
(Examples: Color Inconsistencies, Unevenness in Material, etc.)

[Name (who completed this form)]  
[Date Evaluated]

**CM REAS PERFORMANCE TRACKING PROGRAM**  
**Form #4: ANNUAL EVALUATION – WITH PHOTOS**

1. Date and Time of assessment; temperature and sky conditions
2. REAS Application Date, How many years since REAS application
3. Customer and Project Title
4. Name of street being tracked (include cross street limits)
5. **Rate Color:** 50-100 or “Below 50” in increments of 10 (100 blackest) - Use “Color Rating Guide”
6. Cracks: Deductions using “Material Remaining Rating Guide”
7. Potholes: Deductions using “Material Remaining Rating Guide”
8. Raveling: Deductions using “Material Remaining Rating Guide”
9. Heavy Wear Areas: Deductions using “Material Remaining Rating Guide”
10. **Rate Percent REAS Remaining:** #6 - #9 Deductions from a Base of 100 - Use “Material Remaining Rating Guide”
11. Any utility or other street cuts, other damage (note specific locations)
12. Has street been re-slurry sealed or resurfaced? If so, include photos and close out file
13. Other Comments

[Name – Who completed this form]  
Date Evaluated