

CORRECTIVE ASPHALT MATERIALS

Solutions for Long-Term Pavement Performance

2024 Minnesota Long-Term Study Research

Executive Summary

LONG-TERM MUNICIPAL STUDY DEMONSTRATES RECLAMITE® PERFORMANCE

In 2024, the Minnesota cities of Woodbury, Eden Prairie, and Richfield completed a long-term field study of the Maltene Based Rejuvenator, Reclamite, spanning up to eight years of pavement life. The study was conducted with Corrective Asphalt Materials (CAM). All three cities were early adopters of an MRT asphalt preservation program.

The goals were to document the long-term effects Reclamite has on asphalt and to determine whether subsequent applications add value. Below, we explain the background, the process, the testing data, and the results.

The findings are consistent across all three test methods: the earlier Reclamite is applied after paving, the longer the pavement holds its original asphaltene-to-maltene balance – the balance that keeps asphalt durable rather than merely flexible. Woodbury, which treated within twelve months of paving, still held a 40% viscosity reduction six years later and kept every treated roadway above 90 on the PCI scale eight years after paving. The economics follow the chemistry. Resurfacing costs 12 to 15 times what rejuvenation costs.

Every year an agency delays the first application is a year of that multiplier moving closer.



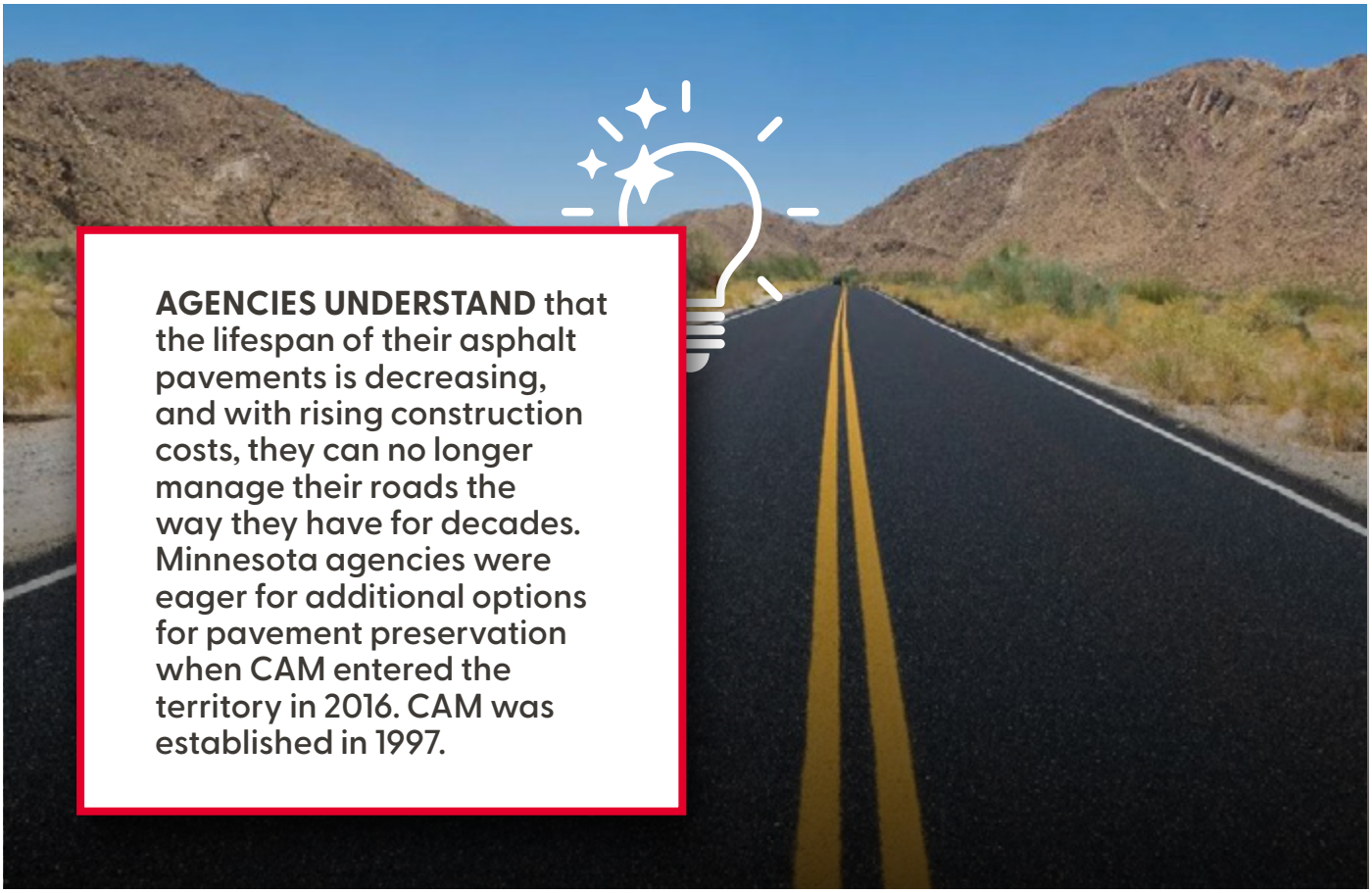
Background

A BREAKTHROUGH IN ASPHALT PRESERVATION

Reclamite is the original Maltene Replacement Technology (MRT) for restoring and preserving the durability of asphalt and is classified as an asphalt rejuvenator. Back in the early 1960s, Dr. Fritz Rostler, while working for the Golden Bear Oil Company, discovered the origin of asphalt pavement degeneration.

By separating the components of asphalt in laboratory conditions, Dr. Rostler determined that asphalt's soluble, more reactive components, known as maltenes, degrade when exposed to the heat used in processing asphalt-based formulations, and then further degrade as asphalt is exposed to the oxidizing effects of UV in field installations.

In collaboration with Golden Bear's Richard White, Dr. Rostler set about developing a technology that would restore the petroleum maltenes to aging asphalt, rejuvenating its pliability and resilience, thereby significantly improving pavement durability and extending the pavement's lifespan. Based on Rostler's research, Reclamite was developed.



AGENCIES UNDERSTAND that the lifespan of their asphalt pavements is decreasing, and with rising construction costs, they can no longer manage their roads the way they have for decades. Minnesota agencies were eager for additional options for pavement preservation when CAM entered the territory in 2016. CAM was established in 1997.

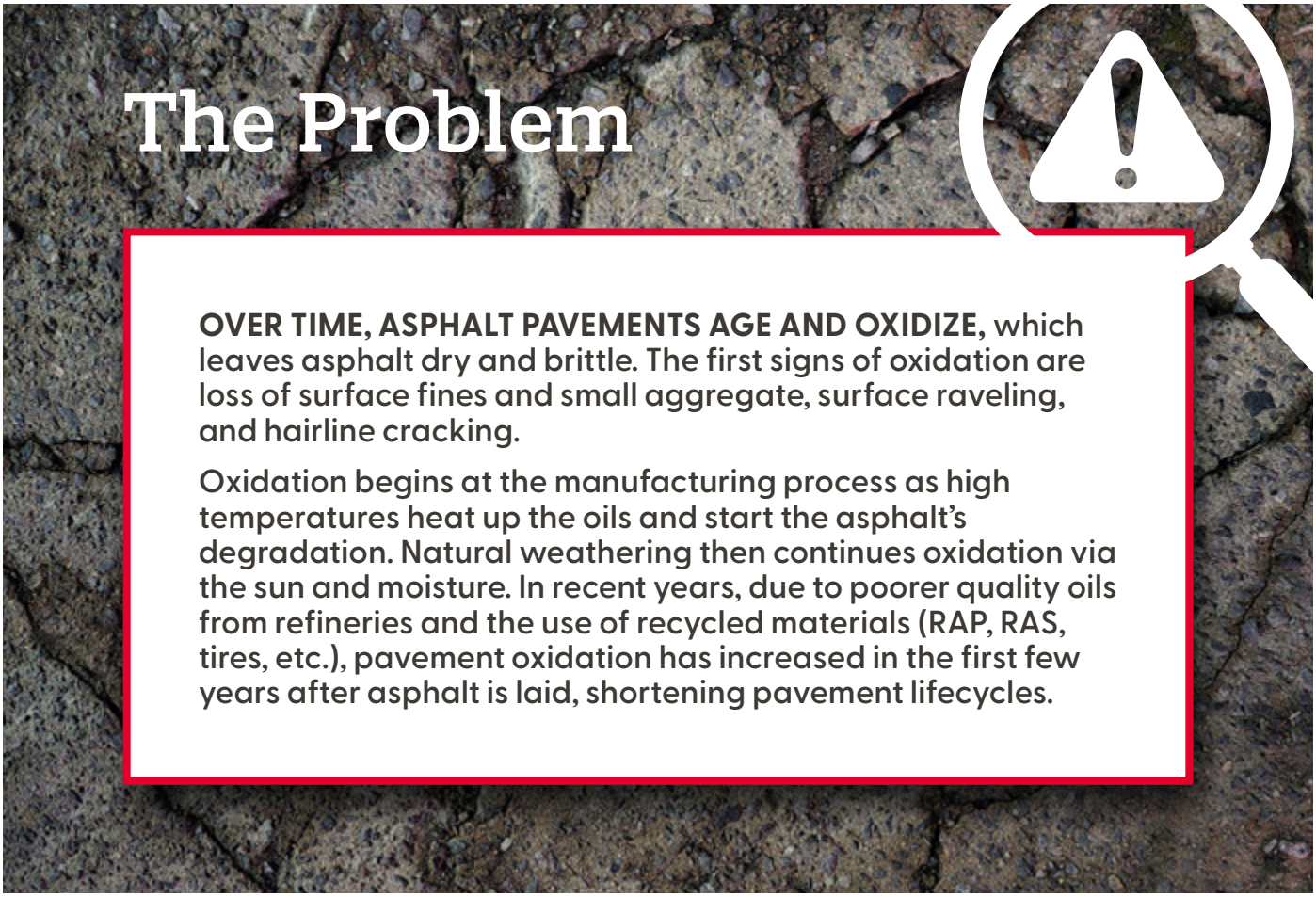
Background *(continued from p. 3)*

Uniquely, the Reclamite rejuvenator restores the reactive maltene components that asphalt pavements lose due to hot-plant operations and the subsequent field aging process. Reclamite deeply penetrates the surface to protect against air and water intrusion. CAM helped commercialize this technology in the Midwest and South. Its application in real-world conditions began in the early 1960s.

Unlike topical sealing products, Reclamite Maltene Replacement Technology chemically adjusts the asphalt's long term binder's rheology, increasing penetration values while decreasing viscosity and corresponding DSR (Dynamic Shear Rheometer) values.

Another distinction of Reclamite is the base oil, which is naphthenic (wax-free). The base oil is the vehicle that brings the maltenes to the asphalt. Paraffinic oils carry wax and additional solvents, which are added to help the waxy oil penetrate asphalt, resulting in lower viscosity and the sacrificing of the short-term with long-term damage and shorter roadway lifecycles. Paraffins can increase the colloidal instability of the asphalt binder resulting in the precipitation of the asphalt; in other words, the binder crystalizes and causes a phase separation that accelerates maltene oxidation.

Reclamite rejuvenator is the ideal solution for government agencies and private communities looking for a preservation solution, a partner with 50+ years of proven performance, and the highest lifecycle return on their road preservation investment.



The Problem

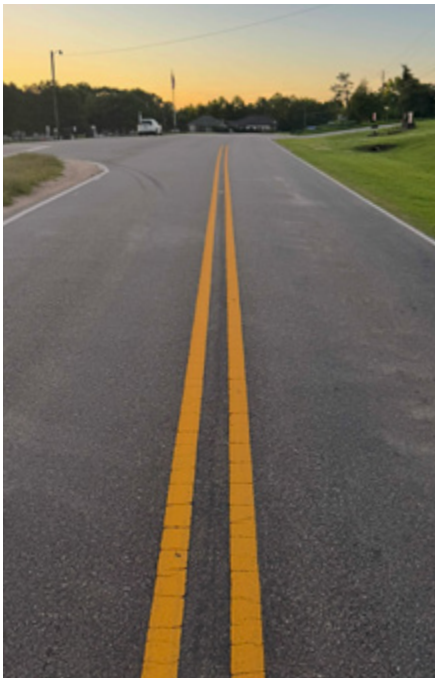
OVER TIME, ASPHALT PAVEMENTS AGE AND OXIDIZE, which leaves asphalt dry and brittle. The first signs of oxidation are loss of surface fines and small aggregate, surface raveling, and hairline cracking.

Oxidation begins at the manufacturing process as high temperatures heat up the oils and start the asphalt's degradation. Natural weathering then continues oxidation via the sun and moisture. In recent years, due to poorer quality oils from refineries and the use of recycled materials (RAP, RAS, tires, etc.), pavement oxidation has increased in the first few years after asphalt is laid, shortening pavement lifecycles.

The Hypothesis

RESTORING THE BALANCE THAT KEEPS ASPHALT DURABLE

New pavement has a specific proportion of asphaltenes to maltenes; the goal of rejuvenation is to maintain the asphaltene/maltene balance in the "new" condition for as long as possible by slowing natural oxidation. Many pavement restoration products reduce viscosity temporarily but do nothing to prevent oxidation because they are only addressing short-term flexibility. As the proportion of asphaltenes increases in untreated pavement, the binder ages and will become stiff and prone to surface cracking, decreasing durability. When treated with Reclamite, which adds maltenes back into the asphalt, the pavement exhibits slowed oxidation, chemically and visually. Adding maltenes is how durability is restored. Flexibility and durability are two different measurements; flexibility can be added without adding durability.



The Science

SLOWING OXIDATION BY RESTORING MALTENES

Reclamite uses Maltene Replacement Technology (MRT) to slow oxidation and the aging process. The asphalt binder is comprised of two components, asphaltenes and maltenes. Asphaltenes are the "bodying agent" and maltenes are the reactive components that keep the oil flexible and durable. Asphalt oxidizes as the percentage of maltene in the oil decreases over time; as the ratio of asphaltenes to maltenes in the oil grows, asphalt begins to age.

Oxidation is merely a chemical reaction in asphalt. Oxidation and the aging process can be significantly slowed by adding maltenes to the surface of the pavement, restoring the asphalt closer to its original state. MRT helps keep the surface of the pavement flexible and durable, significantly slowing the aging process.



Testing Standards & Explanation

THIRD-PARTY TESTING ACROSS THREE CITIES

Sections of pavement in the three Minnesota cities were treated with Reclamite and were tested for three industry-accepted criteria to evaluate the product's long-term effectiveness. All testing was completed by the same third-party laboratory: APART Asphalt Pavement & Recycling Technologies. These are the three criteria: All viscosity and chemical composition percentages reported in this paper represent change

Long-term Visual Performance	Long-term Relative Viscosity Change Using MRT (AASHTO T-315)	Long-term Chemical Composition of the Asphalt Binder (ASTM D-2006-70)

All figures reported in the tables that follow are long-term readings taken four to seven years after application, not the 60-day compliance measurement described above.

LOWER VISCOSITY ISN'T ALWAYS REJUVENATION

A rejuvenator should lower the viscosity of the asphalt binder. This suggests that the material has penetrated and combined with the existing binder to restore flexibility. Specifications typically state a minimum 30% decrease in viscosity within 60 days of the rejuvenator's application. The goal of an effective rejuvenator is to keep viscosities above the minimum level change for as long as possible.

It is imperative to increase the flexibility and durability of asphalt as it ages to slow the aging process; however, the product must do so without stripping the asphalt of its valuable oil components. Although viscosity is an important measure of a rejuvenator's effectiveness, a lower viscosity does not necessarily indicate that rejuvenation has occurred. Other materials like solvents and degreasers can dissolve the binder and reduce viscosity without replacing maltenes. A lower viscosity may indicate that the binder has improved flexibility, but does not address durability.

Chemicals such as diesel fuel, D-limonene, and linseed-based biodiesels will chemically separate and dissolve the asphalt binder and will show lower viscosities. These solvents create a short-term viscosity change and a visual difference, but do not address pavement oxidation. The visual difference is usually a surface appearance lighter in color than the untreated pavement, due to the material's dissolving the asphalt off the aggregate's surface.

Over time, some self-classified rejuvenators will age pavements at a faster rate than natural pavement oxidation; their chemical makeup causes phase separation and crystallization of the binder, which dries and dissolves, accelerating aging.

The binder is extracted and separated into its constituent components, asphaltenes and maltenes. Asphaltenes are comprised of the bodying (thickening) agent of the binder and typically do not degrade over time. Maltenes, the more reactive component, oxidize and become asphaltenes. The goal is to see a decrease in the percentage of asphaltenes: If asphaltenes increase, it suggests that the binder is aging.

Testing Standards & Explanation *(continued from p. 6)*

THREE WAYS TO PROVE LONG-TERM REJUVENATION

1

Long-term Visual Performance:

Visual performance evaluates how treated and untreated sections of pavement look at different time intervals, such as 6 months, 1 year, 5 years, 10 years and so on. The treated surface should show fewer visual signs of raveling, hairline cracking and aggregate loss, and may appear "tighter" relative to untreated sections. Raveling is defined as a wearing away of the pavement surface in high-quality hot-mix asphalt, caused by the dislodging of aggregate particles and loss of asphalt binder. Raveling and fine aggregate loss are the first visual signs of asphalt aging. Visual performance is important because testing binder properties alone for rejuvenators can occasionally show "false positive" results.

2

Long Term Viscosity or Rheology Change:

Viscosities of asphalt binders are measured with the AASHTO T-315, which uses a Dynamic Shear Rheometer (DSR). This method, also known as rheology, measures the linear viscoelastic properties (viscosity) of the asphalt binder using the DSR. Rheology testing can incorporate several different parameters and should be examined. For the purposes of this white paper, we kept the parameters simple, using only viscosity measurements.

Viscosity is measured in poises. Poises measure resistance to being bent or moved, as well as the resilience (elasticity) of the asphalt binder; a lower poise number reflects an increase in flexibility and movement of the asphalt. A stiff asphalt binder will have a higher poise number: As asphalt ages, it hardens – stiffens – so the poise increases. Keeping the oils flexible is crucial for slowing the asphalt aging process.

3

Long-term Chemical Composition:

While viscosity measurements focus on flexibility, ASTM D-2006-70 results relate to durability. The purpose of this test is to measure the composition of asphalt to assess the ratio of key components using the procedure described by ASTM D-2006-70.

Testing Data

FINDING THE RIGHT TIME FOR A SECOND APPLICATION

The agency and CAM visually examined the testing areas and found a clear difference between the treated and untreated sections on site; evidence of raveling, surface fine loss and aggregate loss were more visible in the untreated sections. Between years 6 and 7, the viscosity and the maltene/asphaltene ratios both dropped substantially in Woodbury, as did the loss of surface aggregate and fines. Loss of fines and aggregate was much more prevalent visually in Summer 2023 than in years past, suggesting that year 6-7 is the right time for the second application.

In 2020, Woodbury allowed CAM to apply a test spot of a second application over the original roadway, four years after the initial Reclamite Application in 2016. The original application was applied one year after paving occurred in 2015. In 2022, the parties decided to core these locations as Woodbury was trying to determine when to begin a second application of Reclamite. These coring results are what led CAM to reach out to Richfield and Eden Prairie to gather additional information.

In 2022, Woodbury's first MRT application was still holding a viscosity decrease of 40% six years after application. The second application, applied in 2020, 4 years after the first application, decreased viscosity by 46%. The minimal amount of change between the first and second applications showed us in the 2022 coring that if Reclamite is applied within a year of paving, four years is too early for a second application, which can be postponed until later in the pavement's lifecycle and long-term pavement management plan.

Woodbury actively uses the Pavement Condition Index (PCI), a third-party rating system from Goodpointe Technology. Because this data brings another objective evaluation of Woodbury's roadways, it is included in this analysis. The chart below indicates that untreated roads had a delta of 7-19 PCI points, while the treated roads' delta was 0-3 PCI points.

The PCI ratings alone show the importance of pavement preservation, especially when done early. Eight years after paving, all of Woodbury's treated roadways still have a rating above 90 on the PCI scale – a clear indication of success.



Testing Data *(continued from p. 8)*

WOODBURY PCI RATINGS IN 2019 AND 2023

This chart illustrates the PCI data.

TREATMENT TYPE	STREET	CONSTRUCTION TYPE	YEAR	FUNC CLASS	PREVIOUS CI OCTOBER 2019	CURRENT CI JULY 2023	DELTA CI
No Treatment	Spinaker Circle	Edgemill & Overlay	2016	Local	92	83	-9
No Treatment	Spinaker Drive	Edgemill & Overlay	2016	Local	94	88	-7
No Treatment	Spinaker Drive	Edgemill & Overlay	2016	Local	97	84	-13
No Treatment	Spinaker Drive	Edgemill & Overlay	2016	Local	94	75	-19
No Treatment	Spinaker Lane	Edgemill & Overlay	2016	Local	93	84	-9
No Treatment	Sunrise Drive	Edgemill & Overlay	2016	Local	94	85	-9
No Treatment	Sunrise Drive	Edgemill & Overlay	2016	Local	94	85	-9
Reclamite	Corral Alcove	Edgemill & Overlay	2015	Local	93	93	0
Reclamite	Corral Lane	Edgemill & Overlay	2015	Local	98	95	-3
Reclamite	Corral Lane	Edgemill & Overlay	2015	Local	97	95	-2
Reclamite	Corral Lane	Edgemill & Overlay	2015	Local	95	92	-3
Reclamite	Pheasant Run Road	Edgemill & Overlay	2015	Local	100	99	-1
Reclamite	Pheasant Run Circle	Edgemill & Overlay	2015	Local	92	91	-1
Reclamite	Pheasant Run Road	Edgemill & Overlay	2015	Local	97	97	0

Testing Data *(continued from p. 9)*

LONG TERM VISCOSITY- AASHTO T-315
WOODBURY, EDEN PRAIRIE, & RICHFIELD MINNESOTA

This table illustrates the long-term viscosity data.

AGENCY	EDEN PRAIRIE	RICHFIELD	WOODBURY YEAR 6 SECTION	WOODBURY YEAR 7 SECTION
Location of Applications	Waterford	Thomas Ave S.	Pheasant Run Rd	Pheasant Run Rd
Year Paved	2017	2015	2015	2015
When App. #1 Applied	2019	2018	2016	2016
When App. #2 Applied	2023	2023	2020	2023
Yrs between Paving & 1st App.	2	3	1	1
Year Core Taken	2023	2023	2022	2023
Yrs Between Core & 1st App.	4	5	6	7
Yrs Between Core & 2nd App.	2 Months	1 Month	2 Years	2 Months
1 App. Viscosity Change	37%	16%	40%	17%
2 App. Viscosity Change	53%	48%	46%	44%

The table above shows the viscosity, measured in poises, of the three Minneapolis area agencies over a period of 0-7 years. Each city chose to treat their pavements at different intervals (from 1-3 years) after paving; Woodbury chose to treat their pavements one year after the initial paving.

Eden Prairie chose to treat their pavements 2 years after paving; Richfield chose 3 years. The poise results show that treating a pavement earlier (Woodbury) was the most beneficial for slowing the aging of the pavement and the most cost-effective long-term pavement management program.

Testing Data *(continued from p. 10)*

EDEN PRAIRIE DATA

Eden Prairie's viscosity changes landed between Richfield's and Woodbury's. This data aligns with application timeframes and coring data.

The coring data shows that to slow the aging process of asphalt, the earlier you apply Reclamite, the more beneficial it is. It also shows that you can postpone the second application of Reclamite to 6 or 7 years if the first application is done within 1 year of paving.

The earlier you apply a first application of Reclamite with MRT technology, the further you can stretch your pavement management plan – and therefore agency dollars.

Treating pavements at year 0-1 will extend the pavement's lifecycle more than waiting until year 2 or 3; this is evident in the coring results.



Testing Data *(continued from p. 11)*

RICHFIELD DATA

Richfield's paving occurred in 2015, the same year as Woodbury's. Three years after the initial paving, they chose to apply the first application of Reclamite. Coring was completed in the summer of 2023, five years after that first application.

The coring data shows a 16% viscosity reduction still holding from the first application, and a 48% reduction following the second. Richfield's first-application number is the lowest of the three cities, and the reason is timing, not product performance: three years of unprotected oxidation had already occurred before the maltenes were restored. The second application recovered the pavement to a level comparable with the other two cities – but it took a second treatment to get there.



VISUAL TEST RESULTS
Richfield (Spring 2024)

- ➔ 2nd Application
- ➔ 1 Year Post-Treatment

Testing Data *(continued from p. 12)*

ASPHALTENES TABLE FOR THE THREE AGENCIES

The table below shows the decrease in asphaltenes in the roadways when treated with Reclamite. Specifications currently do not have a minimum decrease percentage; the goal is to keep asphaltenes as low as possible for as long as possible and to maintain the asphaltene to maltene ratio in alignment with their original chemical state as new asphalt.

By applying Reclamite early, Woodbury was able to hold the asphaltene percentage decrease with one application longer and better at 5.9% over Richfield's 4.4% change. The second application also showed a significant change versus Richfield: Woodbury's second application at year 7 decreased the asphaltene content by 16.2%, whereas in Richfield, the second application only decreased the asphaltene content by 11.5%. This shows that applying MRT technology early keeps the pavement in "like new" condition longer and allows the city to extend the second application to later in the pavement's lifecycle.

This table illustrates the long-term viscosity data.

AGENCY	EDEN PRAIRIE	RICHFIELD	WOODBURY	WOODBURY
Location of Applications	Waterford	Thomas Ave S.	Pheasant Run Rd.	Pheasant Run Rd.
Year Paved	2017	2015	2015	2015
When App. #1 Applied	2019	2018	2016	2016
When App. #2 Applied	2023	2023	2020	2023
Yrs between Paving & 1st App.	2	3	1	1
Year Core Taken	2023	2023	2022	2023
Yrs Between Core & 1st App.	4	5	6	7
Yrs Between Core & 2nd App.	2 Months	1 Month	2 Years	2 Months
Decrease in Asphaltenes with 1 Treatment	7.10%	4.40%	12.90%	5.90%
Decrease in Asphaltenes with 2 Treatments	13.60%	11.50%	15.40%	16.20%

Testing Data *(continued from p. 13)*

ASPHALTENES TABLE FOR THE THREE AGENCIES

Woodbury's core was taken two years later than Eden Prairie's and one year later than Richfield's — and still outperformed both. Viscosity and chemical composition are independent measurements, yet they rank the three cities identically. That agreement is what separates rejuvenation from a temporary softening of the binder.

Timing drives results — all three test methods agree.

AGENCY	YEARS FROM PAVING TO 1ST APPLICATION	CORE AGE	VISCOSITY REDUCTION, 1 TREATMENT	ASPHALTENE DECREASE, 1 TREATMENT
Woodbury	1	6 Years	40%	12.9%
Eden Prairie	2	4 Years	37%	7.1%
Richfield	3	5 Years	16%	4.4%

THE RECLAMITE TIMING RULE

First application: within 12 months of paving. Treating at year 0–1 extends the pavement's lifecycle further than waiting until year 2 or 3.

Second application: year 6 to 7. If the first application was made within a year of paving, four years is too early — the second treatment can be deferred and budgeted later in the pavement management plan.

The trigger is measurable. In Woodbury, the first application's viscosity reduction fell from 40% at year 6 to 17% at year 7, and the asphaltene decrease fell from 12.9% to 5.9% over the same twelve months. That falloff is the signal to reapply.

Reclamite Performance Conclusion

EARLY PRESERVATION DELAYS COSTLY RECONSTRUCTION

Long-term coring, visual results, and PCI ratings together establish the most beneficial time for local agencies to apply and reapply Reclamite. The sooner MRT technology is applied, the longer the roadway can wait for a second application – and the second application is well worth the cost-benefit ratio.

Woodbury applied Reclamite within the first twelve months of paving and still held a 40% viscosity reduction at year six. Between year six and year seven, that reduction fell to 17% and the asphaltene decrease fell from 12.9% to 5.9%. The first application did not fail; it reached the end of its service window. That twelve-month falloff is precisely why year 6–7 is the right time to reapply, and Woodbury's second application restored a 44% viscosity reduction and a 16.2% asphaltene decrease.

The PCI ratings show the same pattern from a different direction. Woodbury's untreated sections were paved in 2016 – a full year newer than the treated sections – and still lost 7 to 19 PCI points between 2019 and 2023. The treated sections, older pavement, lost 0 to 3.

Onsite visuals remain consistent with the laboratory data. In Woodbury, a clear line between treated and untreated pavement is still visible at the 2016 pilot project intersection where a treated road crossed an untreated roadway. MRT remains a powerful cost reduction tool for agencies, particularly since resurfacing costs 12 to 15 times the cost of rejuvenation, disrupts the community, and consumes budget that preservation would have protected.

