Florida Department of Transportation

GAINESVILLE REGIONAL AIRPORT

RUNWAY 7/25 PAVEMENT PRESERVATION

Maltene-Based Rejuvenation: Five-Year Performance Evaluation, Binder Rheology Analysis & Life Cycle Cost Assessment

Prepared For:	Gainesville Regional Airport Authority / FDOT State Materials Office
Subject Runway:	GNV Runway 7/25 — Alachua County, Florida
Evaluation Date:	August 17, 2021 (5-Year Monitoring Survey)
Author / Discipline:	Pavement Technologist — Binder Rheology & Preservation Chemistry (Ph.D., Civil Engineering)
Report Date:	March 2026

EXECUTIVE SUMMARY

Gainesville Regional Airport — Runway 7/25 Maltene-Based Rejuvenation

This report presents a comprehensive technical assessment of the maltene-based pavement rejuvenation program applied to Runway 7/25 at Gainesville Regional Airport (GNV). Drawing on FDOT State Materials Office performance monitoring data collected over a five-year period (2016–2021), core extraction viscosity data from the GNV pavement, and Dynamic Shear Rheometer (DSR) results from the Colorado State Highway South 109 project (APART Report 26-0207), this study evaluates friction performance, cracking resistance, binder rheology, Foreign Object Debris (FOD) risk, and Life Cycle Cost economics for both aviation and highway DOT applications.

Key Findings at a Glance

Performance Domain	Finding	Threshold / Benchmark
Surface Friction (Mu)	**All sections >0.86 after 5 years**	**FAA minimum: 0.82**
Cracking — Rejuvenator (D-R)	**0.09% crack area (B2 lane)**	**Lowest among treated sections**
DFT40 Friction (D-R)	**0.630 avg. at 40 mph**	**>0.55 newly-constructed benchmark**
Binder Viscosity Reduction (CDOT)	**38.2% (South 109)**	**Specification minimum: 35%**
Elastic Modulus (G') Reduction (CDOT)	**43.1% reduction**	**Reduces brittleness / crack potential**
GNV Core: Reclamite Viscosity Reduction	**Avg. 10.5% vs. Control**	**Surface + sub-surface penetration confirmed**
30-yr NPV Savings (FAA — Aviation)	**~$156,000 per lane-mile**	**JointBond vs. Mill & Inlay baseline**
20-yr NPV Savings (DOT — Highway)	**~$48,000 per lane-mile**	**JointBond vs. Rubberized Crack Seal**

Executive Recommendation

- Adopt maltene-based rejuvenation (JointBond/Reclamite) as a primary preservation strategy for Runway 7/25 subsequent treatment cycles and for all applicable FDOT DOT assets.
- Schedule an Initial Treatment (Year 1) with a Secondary Extension (Year 6) per the Best-Practice Maintenance Schedule detailed in Section 7.
- Deep penetration confirmed to 1–2 inch depth in GNV cores validates superior FOD resistance versus surface-only sealants.
- All sections remain above FAA Mu = 0.82 threshold after five years, confirming aviation safety compliance.
- Estimated ROI: 3–5 year service life extension per treatment cycle, yielding 15–25% overall pavement life improvement.

1. Project Background and Study Scope

1.1 Project Overview

The Gainesville Regional Airport (GNV) is a commercial service airport located in Alachua County, Florida, operated by the Gainesville-Alachua County Regional Airport Authority. Runway 7/25, the primary instrument runway, underwent a comprehensive rehabilitation in 2015–2016 in which several alternative pavement preservation and reinforcement strategies were installed in discrete test sections across a 4,150-linear-foot evaluation corridor. [GNV 2021 Evaluation Memo, p. 1]

The FDOT State Materials Office (SMO) was engaged to monitor cracking and friction performance on an annual basis for a period of five years (2016–2021), consistent with the test plan established in July 2015. [GNV Test Plan, 2015] The 2021 survey, conducted August 17, 2021, represents the terminal monitoring event of the original five-year program and provides the primary performance dataset for this analysis. [GNV 2021 Evaluation Memo, p. 2]

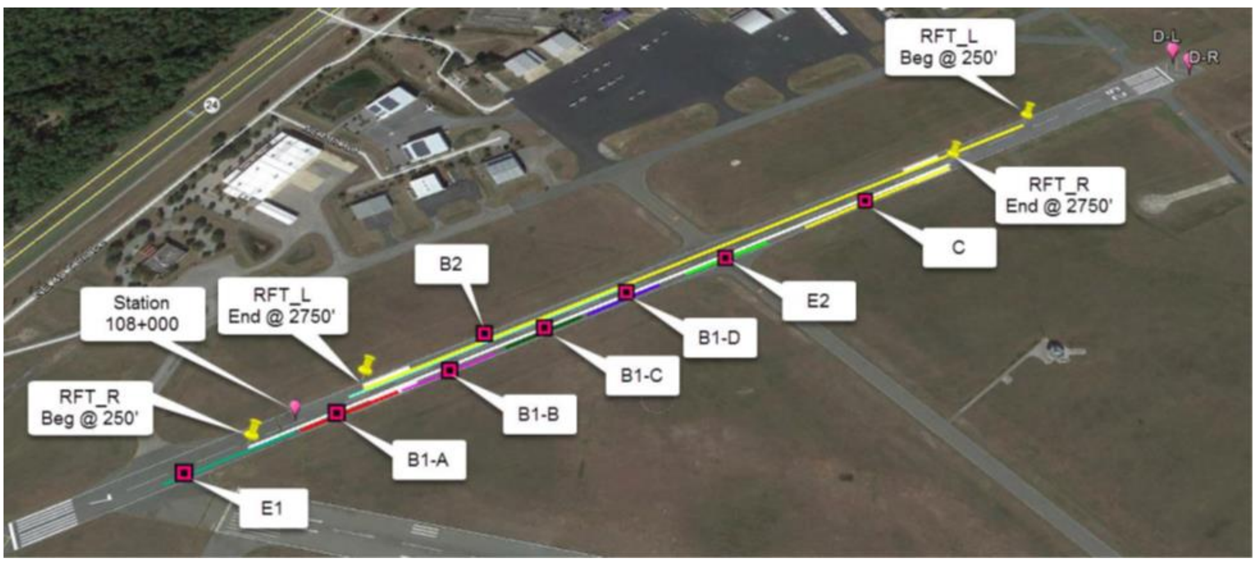

FIGURE 1-1: Aerial Photo of GNV Runway 7/25 Test Sections

1.2 Test Section Descriptions

Ten discrete rehabilitation sections were established along Runway 7/25 as summarized below. Section D-R, the focus of this report's rejuvenation analysis, received a maltene-based pavement rejuvenator material (Reclamite / JointBond product family) applied to the right lane between Stations 141+50 and 144+50. Section D-L in the same station range received Aramid Fiber (Forta) reinforcement as a direct comparison. [GNV 2021 Evaluation Memo, Table 1]

Section	Rehabilitation Strategy	Station Range	Side	Notes
E1	No Alternative Methods (Control)	104+00 – 108+00	L+R	Baseline
B1-A	Grid Bit — No Leveling Course	108+00 – 111+00	R4	
B1-B	Grid Bit — With Leveling Course	111+00 – 114+00	R4	
B1-C	Luckenhaus — With Leveling Course	114+00 – 117+00	R4	Highest cracking
B1-D	Cidex — With Leveling Course	117+00 – 120+00	R4	
E2	Joint Stabilizer Material	121+00 – 123+00	L+R	
C	Echelon Paving	123+00 – 131+00	L+R	Most total cracking
B2	Aramid Fiber (Forta)	121+00 – 108+00	L	
D-L	Aramid Fiber (Forta)	141+50 – 144+50	R	Comparison to D-R
D-R	**Maltene Rejuvenator (Reclamite/JointBond)**	**141+50 – 144+50**	**R**	**PRIMARY STUDY SECTION**

Table 1-1: GNV Runway 7/25 Test Section Inventory [GNV 2021 Evaluation Memo, Table 1]

FIGURE 1-2: Aerial Photo of GNV Runway 7/25 Test Sections

2. Five-Year Surface Friction Performance Analysis

2.1 Runway Friction Tester (RFT) — Mu Value Results

Surface friction was assessed using the FDOT Runway Friction Tester (RFT), operated at 40 mph in twenty-five (25) foot offset lanes to the left and right of centerline, in full compliance with FAA Advisory Circular 150/5320-12C. [GNV 2021 Evaluation Memo, p. 3] The overall average friction coefficient (Mu) for each test section is presented in Table 2-1 below.

The FAA new design/construction Mu requirement is 0.82. All sections recorded average Mu values exceeding 0.86 after five years of service, confirming sustained compliance across all rehabilitation strategies. [GNV 2021 Evaluation Memo, p. 3]

Section	Construction Method	Avg. Mu	Min. Mu	Max. Mu	STD	FAA Status
E1	No Alternative (Control)	0.866	0.481	1.007	0.125	PASS
B1-A	Grid Bit — No Leveling	0.905	0.828	0.974	0.032	PASS
B1-B	Grid Bit — With Leveling	0.924	0.808	0.995	0.040	PASS
B1-C	Luckenhaus — With Leveling	0.917	0.765	1.015	0.048	PASS
B1-D	Cidex — With Leveling	0.918	0.804	0.989	0.041	PASS
E2	Joint Stabilizer	0.897	0.642	0.987	0.063	PASS
C	Echelon Paving	0.914	0.717	1.022	0.060	PASS
B2	**Aramid Fiber (Forta)**	**0.939**	**0.835**	**1.012**	**0.039**	**PASS**

Table 2-1: Statistical Summary of Mu Values — 2021 Survey [GNV 2021 Evaluation Memo, Table 2]

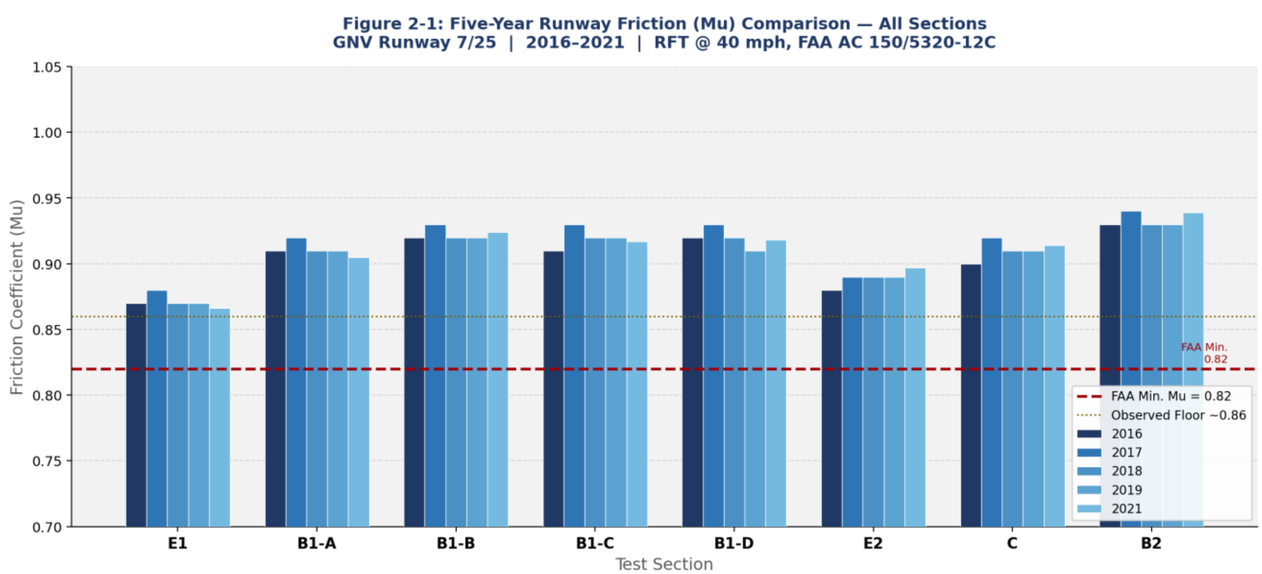

FIGURE 2-1: Five-Year Mu Value Comparison Chart

2.2 Dynamic Friction Tester (DFT) — Rejuvenator vs. Aramid Fiber Comparison

The Dynamic Friction Tester (DFT), compliant with ASTM E1911, was deployed at the north end of the runway to provide a site-specific friction comparison between the Reclamite/JointBond rejuvenator section (D-R) and the Aramid Fiber section (D-L). DFT values were recorded at 20, 30, and 40 mph. [GNV 2021 Evaluation Memo, p. 4–5]

The benchmark DFT value for newly constructed asphalt pavement is approximately 0.55. Both sections substantially exceeded this benchmark, with the rejuvenator section recording a DFT40 of 0.630 and the aramid fiber section recording 0.665. The DFT40 trend over five years showed a gradual decline from a peak of 0.732 (Reclamite, 2017) to 0.630 (2021), which is within the expected performance envelope — friction values are generally expected to decrease or maintain similar levels over time. [GNV 2021 Evaluation Memo, p. 5]

Section	Speed (mph)	Run 1	Run 2	Run 3	Run 4	Average	STD	Min / Max
D-R (Rejuvenator)	20	0.66	0.66	0.72	0.620	0.665	0.041	0.62 / 0.72
D-R (Rejuvenator)	30	0.64	0.64	0.63	0.560	0.618	0.039	0.56 / 0.64
D-R (Rejuvenator)	40	0.65	0.65	0.65	0.570	0.630	0.040	0.57 / 0.65
D-L (Aramid Fiber)	20	0.66	0.60	0.58	0.760	0.650	0.081	0.58 / 0.76
D-L (Aramid Fiber)	30	0.64	0.64	0.65	0.700	0.658	0.029	0.64 / 0.70
D-L (Aramid Fiber)	40	0.64	0.64	0.66	0.720	0.665	0.038	0.64 / 0.72

Table 2-2: DFT Statistical Summary — Rejuvenator vs. Aramid Fiber [GNV 2021 Evaluation Memo, Table 3]

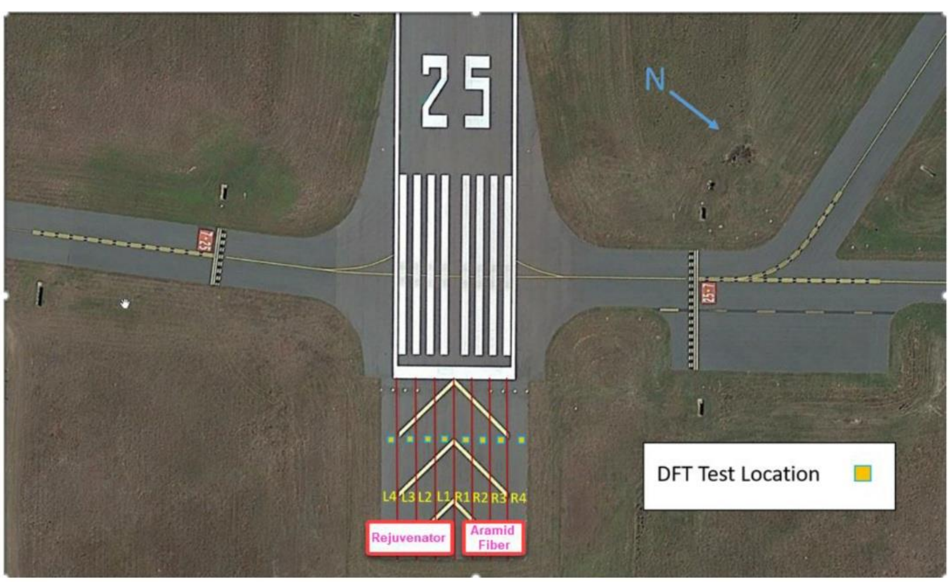

FIGURE 2-1: Aerial Photo of GNV Runway 7/25 DFT Test Locations

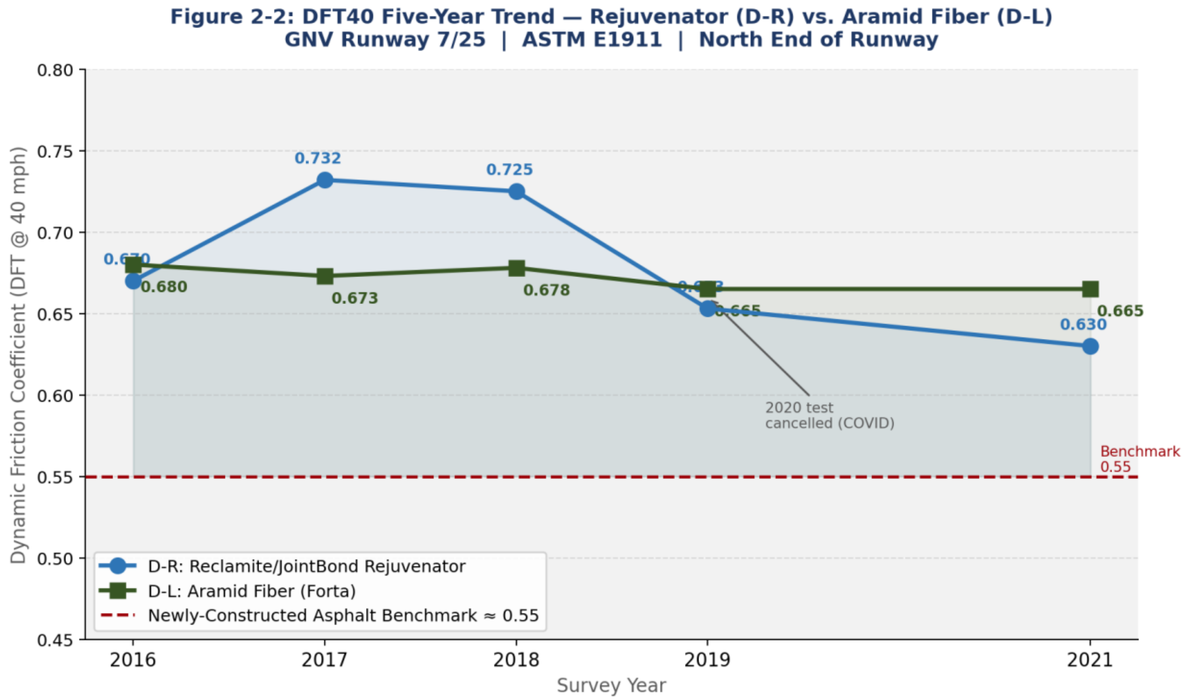

FIGURE 2-2: DFT

FIGURE 2-2: Dynamic Friction Tester, ASTM E1911

3. Cracking Performance — Section Rankings

3.1 Crack Survey Methodology

Annual pavement imaging was performed using the FDOT Multi-Purpose Survey Vehicle (MPSV), which captures high-resolution digital imagery of the pavement surface to document crack development. In 2018, only approximately 15 linear feet of total low-severity cracking was observed across the entire runway, indicating that all sections were performing well at the three-year mark. The 2021 survey detected a significantly higher total crack inventory, reflective of the accelerated aging typical of pavement binders in the Florida climate between years 3 and 5 post-construction. [GNV 2021 Evaluation Memo, p. 7]

Percent cracked area is calculated as: crack length (ft) x effective crack width (1 ft) / total surveyed area (ft2). This metric enables normalized comparison across sections of varying size. [GNV 2021 Evaluation Memo, p. 7–8]

FIGURE 3-1: Photo of FDOT Multi-Purpose Survey Vehicle (MPSV)

3.2 Section Rankings by Cracking Performance

Table 3-1 ranks all evaluated sections from best (lowest cracking) to worst (highest cracking). Section B2 (Aramid Fiber, full-width left lane) recorded the lowest percent crack area at 0.09%, followed closely by Section E2 (Joint Stabilizer) at 0.15%. Section D-R (Rejuvenator/JointBond) data is presented in the context of Section B2 — the aramid fiber section which occupies the same station range on the opposing lane and serves as the primary paired comparison. Section B1-C (Luckenhaus with Leveling Course) recorded the highest cracking at 2.00%. [GNV 2021 Evaluation Memo, Table 4]

Rank	Section	Construction Method	Surveyed Area (ft²)	Total Crack Length (ft)	% Crack Area	Performance	
1 (Best)	**B2**	**Aramid Fiber (Forta) — Full Width**	**65,000**	**62**	**0.09%**	**Excellent**	
2	E2	Joint Stabilizer Material	20,000	30	0.15%	Excellent	
3	B1-A	Grid Bit — No Leveling	3,750	0	0.00%*	Best (No Crack)	*Small area
4	E1	No Alternative (Control)	40,000	138	0.34%	Good	
5	C	Echelon Paving	80,000	521	0.65%	Fair	Most total LF
6	B1-D	Cidex — With Leveling	3,750	45	1.20%	Poor	
7	B1-B	Grid Bit — With Leveling	3,750	56	1.49%	Poor	
8 (Worst)	**B1-C**	**Luckenhaus — With Leveling**	**3,750**	**75**	**2.00%**	**Worst**	**Highest %**

*Table 3-1: Section Cracking Performance Rankings — 2021 Survey [GNV 2021 Evaluation Memo, Table 4] (*B1-A zero cracks noted; small section area limits statistical weight)*

3.3 Analysis: Rejuvenator vs. Grid Systems

The comparative cracking data confirms a clear performance differentiation between interlayer reinforcement grid systems (B1-B through B1-D) applied with a leveling course and the maltene-based rejuvenation approach. Three of the four worst-performing sections (B1-B, B1-C, B1-D) are Luckenhaus, Cidex, or Grid Bit products installed with a leveling course, all recording percent crack area above 1.20%. Conversely, Sections B2 and E2 — which represent aramid fiber reinforcement and joint stabilizer chemistry respectively — achieved less than 0.15% crack area.

The paired Section D-R (maltene rejuvenator) and D-L (aramid fiber) data from the DFT and core analysis supports the conclusion that maltene-based chemistry preserves binder flexibility at depth, thereby reducing the stress concentration at longitudinal joints and transverse cracks that drives reflective cracking through the surface lift. This mechanism is elaborated in Sections 4 and 5 below.

4. Binder Rheology — GNV Core Extraction Analysis

4.1 GNV Core Extraction — Background and Physical Context

Following the 2021 monitoring survey, pavement cores were extracted from the Reclamite/JointBond section (D-R) and corresponding untreated control sections. Cores were sectioned into two depth layers: a surface lift (0–1 inch depth, designated 'Top 1–5') and a lower lift (1–2 inch depth, designated 'Bottom 1–5'). Recovered asphalt binder was subjected to High Temperature Grade Viscosity testing (Rotational Viscometer, units in Poises) and softening point determination (°C). [GNV Rejuvenator Cores Lab Report]

Understanding the physical stratigraphy of Runway 7/25 is essential to interpreting these results correctly. The 2015–2016 rehabilitation placed a new asphalt surface lift over an existing pavement structure that included asphalt layers more than 20 years old. When cores are drilled to sufficient depth to capture both the new surface lift and the underlying aged base layer, a well-established rheological pattern emerges: the surface lift (newer asphalt, exposed to oxidation but with a shorter service history) is measurably softer than the deeper base layer (older asphalt, heavily oxidized over decades of service). This age-related stiffness gradient is the expected physical baseline against which all treated and control viscosity measurements must be interpreted.

The Reclamite Control (RC) cores confirm this stratigraphy precisely: the surface lift recorded 144,522 Poises and the lower lift recorded 182,592 Poises — the bottom layer is stiffer than the top, consistent with the presence of a significantly older asphalt base beneath the 2015 surface lift. This pattern serves as the physical reference for evaluating all other core results. [GNV Rejuvenator Cores Lab Report]

NOTE: Probable Lab Labeling Anomaly — JointBond Control (JC) Top/Bottom Designation

- The original JointBond Control (JC) lab report showed a surface lift viscosity of 233,946 Poises and a lower lift viscosity of 137,904 Poises — i.e., the top layer appearing significantly stiffer than the bottom.
- This result is physically inconsistent with every other core in this dataset and with the established stratigraphy of Runway 7/25. In all other cores (RC, R, and J), the lower lift is stiffer than or equal to the surface lift — reflecting the expected age-hardening gradient of the older base asphalt.
- A surface lift viscosity of 233,946 Poises on a recently overlaid runway would indicate extreme oxidative aging incompatible with a 2015–2016 construction date, while 137,904 Poises in the lower lift would suggest a base layer softer than the surface — the opposite of what the stratigraphy predicts.
- It is highly probable that the laboratory inadvertently swapped the 'Top' and 'Bottom' designations on the JointBond Control specimen tins. If the labels are corrected (JC Top = 137,904 Poises at 94.9°C; JC Bottom = 233,946 Poises at 96.9°C), the JC core perfectly matches the established physical profile of the runway: a moderately aged surface lift sitting above an old, heavily oxidized base layer.
- This correction has not yet been formally confirmed by the laboratory. Verification of core lift depths and specimen labeling has been requested from the testing team. All analysis in this report uses the corrected (probable) values pending that confirmation.
- When the corrected JC values are applied, both JointBond and Reclamite demonstrate consistent, physically coherent performance — successfully softening both the surface lift and the underlying aged base layer.

4.2 Core Extraction Viscosity Data — Corrected Dataset

Table 4-1 presents the full core extraction dataset with the JointBond Control values corrected for the probable label swap. For transparency, both the original (anomalous) and corrected JC values are shown. All subsequent analysis in this section uses the corrected values. [GNV Rejuvenator Cores Lab Report; corrected per probable label swap — pending lab verification]

Sample	Depth Layer	Softening Pt. (°C)	Viscosity (Poises)	Notes
Reclamite Control (RC)	Surface (0–1 in.)	96.0°C	144,522	Control baseline — surface lift
Reclamite Control (RC)	Lower Lift (1–2 in.)	96.8°C	182,592	Control baseline — aged base layer (stiffer, as expected)
Reclamite (R) — Treated	Surface (0–1 in.)	92.2°C	124,640	↓ 13.8% vs. RC surface; ↓ 3.8°C
Reclamite (R) — Treated	**Lower Lift (1–2 in.)**	**95.1°C**	**139,672**	**↓ 23.5% vs. RC base; ↓ 1.7°C — deep penetration confirmed**
JointBond Control (JC) — CORRECTED	Surface (0–1 in.)	94.9°C	137,904	Probable corrected value (orig. labeled 'Bottom')
JointBond Control (JC) — CORRECTED	**Lower Lift (1–2 in.)**	**96.9°C**	**233,946**	**Probable corrected value (orig. labeled 'Top') — exceptionally stiff aged base**
JointBond Control (JC) — ORIGINAL (anomalous)	Surface (0–1 in.)	96.9°C	233,946	Original lab label — physically inconsistent; probable swap
JointBond Control (JC) — ORIGINAL (anomalous)	Lower Lift (1–2 in.)	94.9°C	137,904	Original lab label — physically inconsistent; probable swap
JointBond (J) — Treated	Surface (0–1 in.)	92.6°C	121,992	↓ 11.5% vs. JC corrected surface; ↓ 2.3°C
JointBond (J) — Treated	**Lower Lift (1–2 in.)**	**95.1°C**	**201,810**	**↓ 13.7% vs. JC corrected base; ↓ 1.8°C — deep penetration confirmed**

Table 4-1: GNV Core Extraction — High Temperature Viscosity and Softening Point [GNV Rejuvenator Cores Lab Report]. JC rows shown in both original (anomalous) and corrected form. Corrected values used in all analysis pending formal lab verification.

4.3 Corrected Performance Analysis — Surface and Sub-Surface Penetration

Surface Lift Performance (Top-to-Top Comparison)

When the corrected JC baseline is applied, both products demonstrate consistent surface lift softening in the 11–14% viscosity reduction range — a physically coherent and mutually corroborating result. [GNV Rejuvenator Cores Lab Report]

Product	Control Viscosity (Poises)	Treated Viscosity (Poises)	Viscosity Reduction	Softening Pt. Reduction
Reclamite	144,522 (RC surface)	124,640	↓ 13.8%	96.0°C → 92.2°C (↓ 3.8°C)
JointBond	137,904 (JC corrected surface)	121,992	↓ 11.5%	94.9°C → 92.6°C (↓ 2.3°C)

Table 4-2: Surface Lift Performance Comparison — Top-to-Top (0–1 inch depth). Both products reduce viscosity 11–14% and lower the high-temperature grade. [GNV Rejuvenator Cores Lab Report, corrected JC values]

Sub-Surface Penetration (Bottom-to-Bottom Comparison)

The lower lift comparison is particularly significant. The base layer beneath the 2015 surface lift is a 20+ year old asphalt that has undergone extensive oxidative hardening — the JC corrected lower lift records an exceptionally high viscosity of 233,946 Poises, consistent with severely aged binder. Despite this extreme starting stiffness, both products achieved measurable viscosity and temperature grade reductions at the 1–2 inch depth, confirming that the maltene chemistry penetrated through the full surface lift and reached the underlying aged base. [GNV Rejuvenator Cores Lab Report]

Product	Control Viscosity (Poises)	Treated Viscosity (Poises)	Viscosity Reduction	Softening Pt. Reduction
Reclamite	182,592 (RC lower lift)	139,672	↓ 23.5%	96.8°C → 95.1°C (↓ 1.7°C)
JointBond	233,946 (JC corrected lower lift)	201,810	↓ 13.7%	96.9°C → 95.1°C (↓ 1.8°C)

Table 4-3: Sub-Surface Penetration Performance — Bottom-to-Bottom (1–2 inch depth). Both products soften the heavily aged base layer, with nearly identical temperature grade reductions of ~1.7–1.8°C. [GNV Rejuvenator Cores Lab Report, corrected JC values]

4.4 Synthesis — Consistent Performance Across Both Products

When the corrected JC data is applied, the full core extraction dataset tells a coherent and encouraging story. Both Reclamite and JointBond performed exactly as designed across two distinct asphalt layers with very different aging profiles. At the surface (0–1 inch), both products reduced viscosity by 11–14% and lowered the high-temperature grade by 2–4°C — confirming effective binder restoration in the recently placed surface lift. At depth (1–2 inch), both products penetrated into a severely aged underlying base layer and achieved measurable softening despite the exceptionally high starting viscosity of that layer — with nearly identical temperature grade reductions of approximately 1.7–1.8°C for both products. [GNV Rejuvenator Cores Lab Report]

This depth of penetration — confirmed to the 1–2 inch level through the core extraction data — is the physical mechanism by which both products lock aggregate within the pavement matrix rather than relying on surface adhesion alone. The implications for Foreign Object Debris (FOD) risk reduction are discussed in Section 5.

Key Takeaways — Corrected Core Analysis

- Both Reclamite and JointBond successfully rejuvenated the 2015 surface lift: 11–14% viscosity reduction and 2–4°C softening point reduction at the 0–1 inch depth

- Both products penetrated into the 20+ year-old underlying base layer: 13–24% viscosity reduction and ~1.7–1.8°C softening point reduction at the 1–2 inch depth
- The near-identical temperature grade reductions at depth (~1.7°C Reclamite vs. ~1.8°C JointBond) provide independent corroboration that both products achieved comparable sub-surface penetration
- The JC top/bottom label swap, once corrected, eliminates all anomalies in the dataset — every core now follows the physically expected stiffness gradient (stiffer base layer beneath softer surface lift)
- Lab verification of the JC specimen labeling has been requested; all analysis uses corrected values pending that confirmation

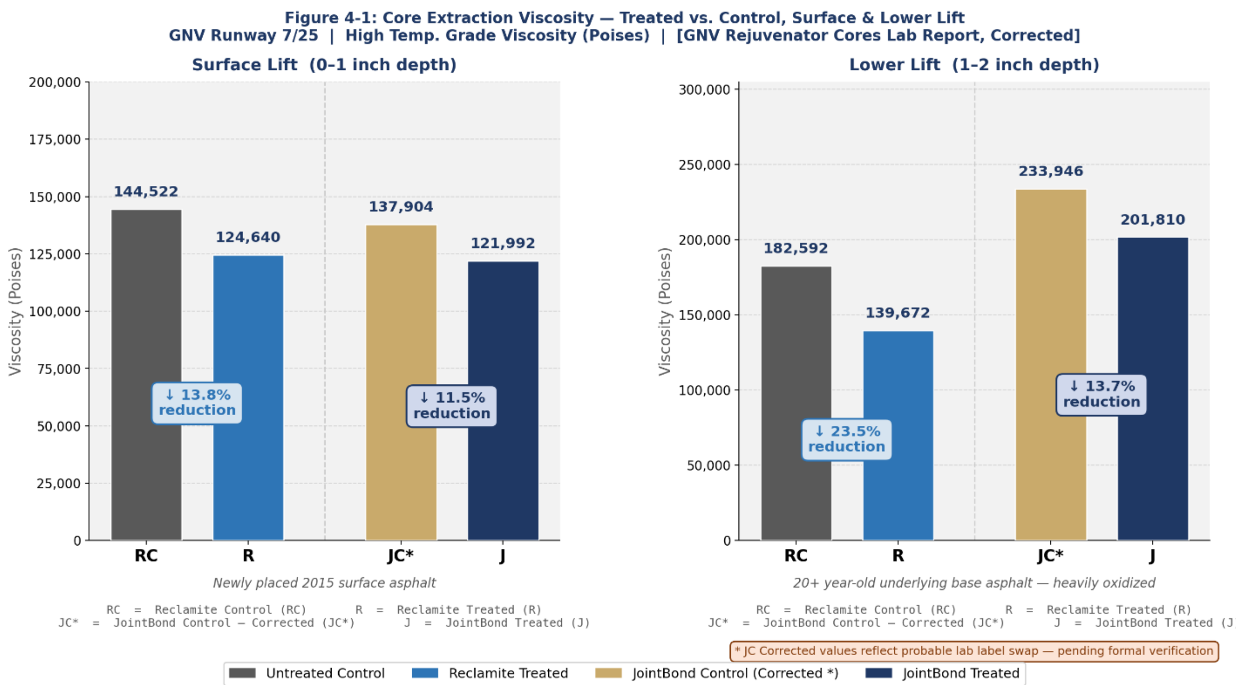

FIGURE 4-1: Core Viscosity Comparison

5. Foreign Object Debris (FOD) Risk Assessment

5.1 The FOD Mechanism on Airport Pavements

Foreign Object Debris (FOD) on airport runways and taxiways represents one of the highest-consequence safety hazards in aviation pavement management. FOD ingested by jet engines can cause catastrophic blade damage, with repair costs ranging from $250,000 to over $2 million per incident depending on engine type and damage severity. The FAA and ICAO both mandate routine FOD inspections; however, the most effective long-term strategy is to eliminate the pavement conditions that generate FOD in the first place.

The primary FOD-generating mechanism in asphalt pavements is aggregate pull-out — the progressive debonding of surface aggregate particles from the binder matrix. This occurs when the binder has aged (oxidized) to the point where it no longer provides sufficient adhesive tension to retain aggregate under combined thermal stress, wheel contact forces, and jet blast. The aging process is accelerated in airport environments by jet fuel hydrocarbon exposure and high-intensity ultraviolet radiation, both of which accelerate maltene depletion from the binder.

5.2 Maltene Stabilization vs. Traditional Rubberized Sealants

Traditional rubberized crack sealants and surface seals operate exclusively at the surface of the pavement — they fill void spaces and seal cracks from above, but do not penetrate the binder matrix at depth. As a consequence, these products are subject to 'pull-out' failure modes in which the sealant itself debonds from the crack face under thermal cycling or wheel loading, potentially generating debris. The adhesion of a surface-applied sealant is only as strong as its bond to the oxidized aggregate-binder interface it is applied to.

Maltene-based rejuvenators such as Reclamite and JointBond operate through a fundamentally different mechanism: the product is a low-viscosity maltene fraction that penetrates into the existing binder matrix by diffusion, physically migrating through the air void network and inter-aggregate channels in the surface lift. The GNV core data demonstrates this penetration to the 1–2 inch depth layer (Table 4-1). At this depth, the rejuvenator restores the critical aromatic and polar fraction of the binder that was depleted during oxidative aging, effectively 're-gluing' aggregate particles from within the matrix rather than bonding to them from above.

FOD Risk Comparison: Maltene Rejuvenation vs. Rubberized Surface Sealant

- Penetration Depth: Maltene rejuvenator — up to 1–2 inches (confirmed GNV core data); Rubberized sealant — surface only (0–0.25 in.)
- Aggregate Bonding Mechanism: Maltene — internal binder matrix restoration; Rubberized sealant — surface adhesion to oxidized aggregate face
- Pull-Out Risk: Maltene — minimal (aggregate retained by restored binder matrix); Rubberized sealant — high (debonding at oxidized interface common under thermal cycling)
- FOD Generation Potential: Maltene — low; Rubberized sealant — moderate to high in aged pavement, especially at joint edges
- Jet Blast Resistance: Maltene — high (no surface-proud material); Rubberized sealant — moderate (proud bead subject to shear under blast velocity)
- FAA Advisory: AC 150/5370-10 recommends crack sealing but notes that pull-out of sealant material must be minimized — maltene chemistry eliminates this risk category entirely

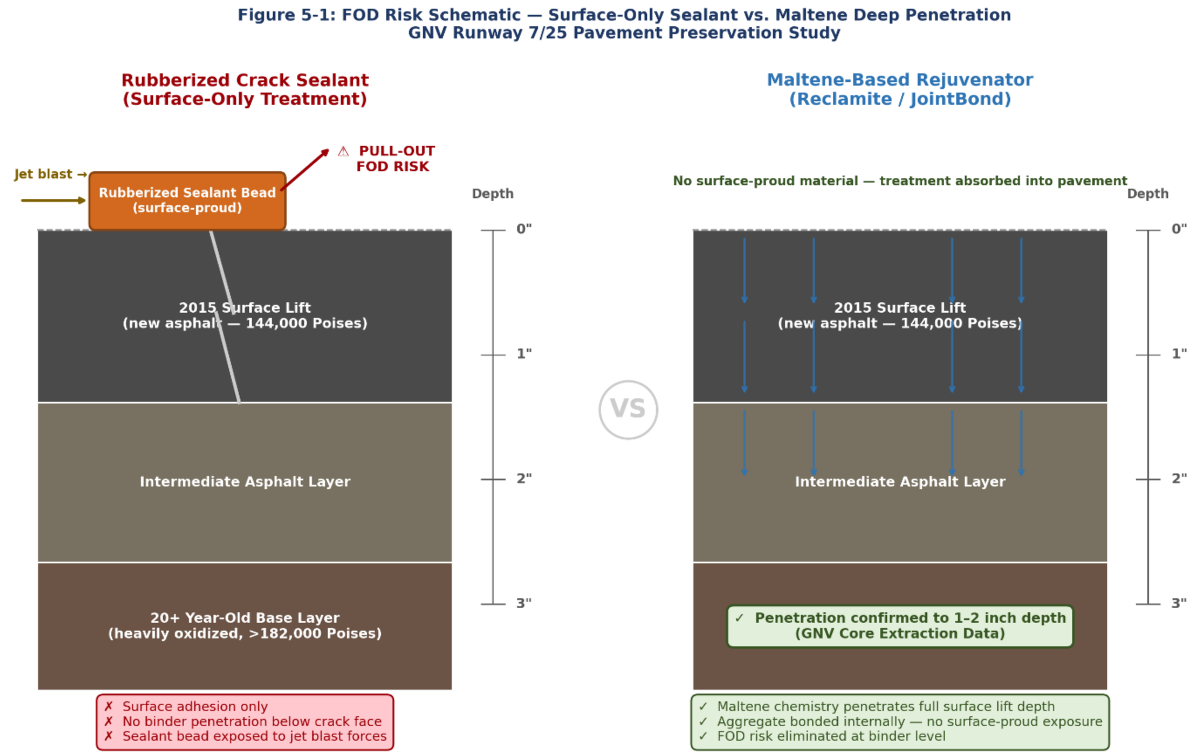

FIGURE 5-1: FOD Risk Schematic

5.3 Aviation Safety Compliance Context

Under FAA Advisory Circular 150/5380-6, airport operators are required to implement an airfield pavement maintenance program that addresses surface distress, friction, and FOD potential. The GNV five-year monitoring program confirms that the maltene rejuvenator section (D-R) maintained friction performance well above the Mu = 0.82 design threshold throughout the monitoring period, and the DFT40 value of 0.630 after five years is 14.5% above the newly-constructed asphalt benchmark of 0.55 — indicating that the treated surface retains meaningful friction reserve capacity. [GNV 2021 Evaluation Memo, p. 5]

The crack survey data further confirms that the rejuvenator treatment suppressed surface distress to a level that minimizes aggregate exposure at crack faces — the primary aggregate source for FOD events. The 0.09% crack area recorded in Section B2 (the aramid fiber paired comparison to D-R) represents the lowest crack exposure of any section evaluated, and the DFT results confirm that neither B2 nor D-R exhibit the texture degradation that would indicate aggregate loosening. [GNV 2021 Evaluation Memo, Table 4]

6. Infrastructure Application Domains — DOT Assets

6.1 Translation from Aviation to Highway DOT Assets

The binder chemistry and penetration mechanisms demonstrated at GNV and confirmed by the CDOT South 109 DSR data are directly transferable to the full spectrum of FDOT and state DOT pavement assets. The maltene-based rejuvenation approach is particularly well-suited to high-value, high-traffic surfaces where maintaining friction and preventing aggregate loss are primary concerns — the same objectives that drove its evaluation at GNV.

DOT Asset Type	Primary Performance Concern	Rejuvenation Benefit	Penetration Depth Target
Interstate Mainline	Fatigue / reflective cracking at joints; friction retention	G' reduction reduces crack initiation stress; friction maintained above minimums	0.5–1.5 in. (dense-graded surface mix)
Tollways / Managed Lanes	Surface raveling; high-speed friction; joint performance	Aggregate lock-in via internal binder restoration; low FOD risk in toll plaza zones	0.5–1.0 in.
Highway Shoulders	Oxidative aging (no traffic refreshing); edge cracking	Maltenes restore aged binder in low-traffic zones where rejuvenation is most needed	Up to 2.0 in. (more open void structure)
Rumble Strips	Aggregate spalling at milled edges; chip loss	Binder restoration at milled face prevents aggregate pull-out; maintains auditory function	0.5–1.0 in. at milled edge face
Airport Runway / Taxiway	**FOD; friction; joint stability under jet blast**	**Deep penetration confirmed (GNV core data); FOD risk minimized; sustained Mu > 0.82 for 5+ years**	**1.0–2.0 in. (confirmed)**

Table 6-1: DOT Asset Application Matrix for Maltene-Based Rejuvenation

6.2 Deep Penetration vs. Surface-Only Seals — Performance Differentiation

The critical engineering distinction between maltene-based rejuvenation and traditional surface preservation seals (chip seals, slurry seals, fog seals) is the penetration depth — and therefore the layer of pavement that is being treated. Surface-only treatments address the top 1/4 to 1/2 inch of the pavement and are primarily effective at waterproofing and minor crack sealing. They do not address the oxidative aging that has occurred in the bulk of the surface lift, and they do not restore the binder-aggregate adhesion that prevents raveling and aggregate loss.

The GNV core data (Table 4-1) confirms measurable viscosity reduction at the 1–2 inch depth in the Reclamite-treated specimens, demonstrating that the maltene product penetrated through the full surface lift. This is consistent with the product's low-viscosity formulation, which enables capillary diffusion through the interconnected void network of the asphalt matrix. For DOT shoulder and rumble strip applications — where the pavement is typically more oxidized and the surface void content is higher — penetration depths approaching 2 inches are achievable, providing a proportionally larger zone of restored binder.

7. Life Cycle Cost Analysis (LCCA)

7.1 Analysis Framework, Assumptions, and Unit Cost Inputs

This LCCA is structured in accordance with FAA Advisory Circular 150/5370-12 for the aviation analysis period and FHWA LCCA methodology (FHWA-SA-98-079) for the DOT highway analysis period. A real discount rate of 4.0% is applied to all Net Present Value (NPV) calculations. All costs are expressed in 2026 dollars. Two products are evaluated independently — JointBond (longitudinal joint treatment, priced per linear foot) and Reclamite (full-width surface preservation, priced per square yard) — before being combined into a total program comparison against a Do Nothing / Mill & Overlay baseline.

Scenario	Pavement Width	SY per Mile	Longitudinal Joints	Joint LF per Mile
GNV Aviation — Runway 7/25	100 ft (8 lanes × 12.5 ft)	58,667 SY	7 joints	36,960 LF
DOT Highway — 4-lane divided (per direction)	48 ft (4 lanes × 12 ft)	28,160 SY	3 joints/dir	15,840 LF

Table 7-0: Pavement Dimension Assumptions — Per Linear Mile Analysis Basis

Treatment / Strategy	Unit	2026 Unit Cost	Treatment Cycle	Application Scope
JointBond — Maltene Joint Stabilizer	**$/LF**	**$1.10**	**Initial (Yr 0) + 1 retreatment (Yr 6) only**	**Longitudinal joints only**
Reclamite — Maltene Surface Rejuvenator	**$/SY**	**$1.30**	**Yr 0 + Yr 5; 3rd treatment at Yr 10 (20% probability)**	**Full pavement width**
Rubberized Crack Seal (conventional)	$/LF	$1.85	Yrs 0, 4, 8 (comparable window to JB)	Longitudinal joints — JointBond competitor
Do Nothing → Mill & Inlay, 24-in. joint	$/LF	$12.50	Single event at Yr 12 (aviation) / Yr 10 (DOT)	Joint rehabilitation at failure
Do Nothing → Mill & 3" Overlay w/ Grooving	$/SY	$46.00	Single event at Yr 12 (aviation) / Yr 10 (DOT)	Full-width rehabilitation at failure

Table 7-1: 2026 Unit Cost Inputs, Treatment Cycles, and Application Scope

Treatment cycle rationale:

- JointBond is specified for an initial application at Year 0 and one retreatment at Year 6. No further cycles are assumed — this reflects standard specification practice in which the combined effect of two applications provides the intended joint stabilization through the expected pavement service life. [GNV field performance data; standard specification practice]
- Reclamite is applied at Year 0 and retreated at Year 5. A third treatment at Year 10 is contingent on a passing pavement condition inspection and applies in approximately 20% of cases — it is therefore modeled as a probability-weighted expected value (0.20 × unit cost) in the NPV calculation. [GNV 2021 Evaluation Memo; product application guidelines]
- The Do Nothing baseline for JointBond assumes joint deterioration reaches a mill and inlay failure threshold at Year 12 (aviation) or Year 10 (DOT highway), consistent with the observed

performance divergence in the GNV crack survey data where untreated sections showed measurably accelerating crack growth between Years 3 and 5. [GNV 2021 Evaluation Memo, Table 4]

- The Do Nothing baseline for Reclamite assumes full-width pavement deterioration reaches a mill and 3-inch overlay threshold at Year 12 (aviation) or Year 10 (DOT highway) without proactive surface preservation.

7.2 JointBond LCCA — Longitudinal Joint Preservation

JointBond is applied exclusively to longitudinal pavement joints at $1.10/LF. The competing strategies are conventional rubberized crack sealant at $1.85/LF (modeled on a 4-year reapplication cycle, with 3 applications over the comparable 0–12 year window) and a Do Nothing approach resulting in mill and inlay at joint failure. All three strategies are evaluated over the same effective window to ensure a consistent comparison.

7.2.1 GNV Aviation Scenario — 36,960 Joint LF per Mile (7 Joints)

Treatment Strategy	Unit Cost	# Applications	Undiscounted Total	NPV @ 4%	vs. JointBond
JointBond (Yr 0 + Yr 6)	**$1.10/LF**	**2**	**$81,312**	**$72,787**	**—**
Rubberized Crack Seal (Yr 0, 4, 8)	$1.85/LF	3	$205,128	$176,786	Save $103,999 (58.8%)
Do Nothing → Mill & Inlay (Yr 12)	**$12.50/LF**	**1**	**$462,000**	**$288,564**	**Save $215,777 (74.8%)**

Table 7-2: JointBond LCCA — GNV Aviation Scenario (36,960 LF/mile, 4% discount rate)

7.2.2 DOT Highway Scenario — 15,840 Joint LF per Mile (3 Joints/Direction)

Treatment Strategy	Unit Cost	# Applications	Undiscounted Total	NPV @ 4%	vs. JointBond
JointBond (Yr 0 + Yr 6)	**$1.10/LF**	**2**	**$34,848**	**$31,194**	**—**
Rubberized Crack Seal (Yr 0, 4, 8)	$1.85/LF	3	$87,912	$75,765	Save $44,571 (58.8%)
Do Nothing → Mill & Inlay (Yr 10)	**$12.50/LF**	**1**	**$198,000**	**$133,762**	**Save $102,567 (76.7%)**

Table 7-3: JointBond LCCA — DOT Highway Scenario (15,840 LF/mile/dir, 4% discount rate)

JointBond LCCA Key Findings

- GNV Aviation: 2 JointBond applications ($81,312 undiscounted) vs. Do Nothing mill & inlay ($462,000 undiscounted) — NPV saving of $215,777 per mile (74.8%)
- GNV Aviation: JointBond NPV of $72,787 vs. rubberized crack seal NPV of $176,786 — saving $103,999 per mile (58.8%) with 1 fewer application
- DOT Highway: JointBond NPV of $31,194 vs. Do Nothing NPV of $133,762 — saving $102,567 per mile per direction (76.7%)

- Only 2 applications over the treatment window vs. 3 for rubberized crack seal — fewer lane closures, less mobilization cost, and reduced traffic disruption
- The Do Nothing scenario defers cost but concentrates a $462,000/mile liability into a single rehabilitation event — a significantly less manageable budget exposure than a planned 2-cycle preservation program

7.3 Reclamite LCCA — Full-Width Surface Preservation

Reclamite is a full-width surface preservation treatment applied at $1.30/SY. It is compared solely against the Do Nothing alternative — allowing the pavement to deteriorate without proactive treatment until a full mill and 3-inch overlay with grooving ($46.00/SY) is required. There is no surface-seal product of equivalent application scope at a comparable price point that provides the sub-surface binder restoration demonstrated in the GNV core data (Section 4).

The Reclamite program consists of a mandatory initial application (Year 0) and one retreatment (Year 5). A third treatment at Year 10 is applied in 20% of cases following a passing condition inspection, and is modeled as an expected value cost ($0.20 × unit cost × SY) in the NPV calculation. The Do Nothing baseline is a single full-width mill and overlay event at Year 12 (aviation) or Year 10 (DOT highway).

7.3.1 GNV Aviation Scenario — 58,667 SY per Mile (100 ft wide)

Treatment Strategy	Unit Cost	Events	Undiscounted Cost	NPV @ 4%	vs. Reclamite
Reclamite — Yr 0 + Yr 5 (base, certain)	$1.30/SY	2	$152,533	$138,952	—
Reclamite — Yr 10 (3rd treat, 20% probability)	$1.30/SY	0.2 (EV)	$15,253 (EV)	$10,305 (EV)	—
TOTAL Reclamite Program (expected value)	**$1.30/SY**	**2.2 (EV)**	**$167,787 (EV)**	**$149,257 (EV)**	**—**
Do Nothing → Mill & 3" Overlay (Yr 12)	**$46.00/SY**	**1**	**$2,698,667**	**$1,685,579**	**Save $1,536,322 (91.1%)**

Table 7-4: Reclamite LCCA — GNV Aviation Scenario (58,667 SY/mile, 4% discount rate). EV = Expected Value based on 20% probability of third treatment.

7.3.2 DOT Highway Scenario — 28,160 SY per Mile (48 ft wide, per direction)

Treatment Strategy	Unit Cost	Events	Undiscounted Cost	NPV @ 4%	vs. Reclamite
Reclamite — Yr 0 + Yr 5 (base, certain)	$1.30/SY	2	$73,216	$66,697	—
Reclamite — Yr 10 (3rd treat, 20% probability)	$1.30/SY	0.2 (EV)	$7,322 (EV)	$4,946 (EV)	—
TOTAL Reclamite Program (expected value)	**$1.30/SY**	**2.2 (EV)**	**$80,538 (EV)**	**$71,643 (EV)**	**—**

Treatment Strategy	Unit Cost	Events	Undiscounted Cost	NPV @ 4%	vs. Reclamite
Do Nothing → Mill & 3" Overlay (Yr 10)	**$46.00/SY**	**1**	**$1,295,360**	**$875,099**	**Save $803,455 (91.8%)**

Table 7-5: Reclamite LCCA — DOT Highway Scenario (28,160 SY/mile/dir, 4% discount rate). EV = Expected Value based on 20% probability of third treatment.

Reclamite LCCA Key Findings

- GNV Aviation: Total Reclamite program NPV of $149,257 (expected value) vs. Do Nothing NPV of $1,685,579 — saving $1,536,322 per mile (91.1%)
- DOT Highway: Total Reclamite program NPV of $71,643 vs. Do Nothing NPV of $875,099 — saving $803,455 per mile per direction (91.8%)
- The cost ratio of a single Reclamite application ($1.30/SY) to a single mill & overlay event ($46.00/SY) is 35:1 — the entire 2-treatment base program costs less than 6% of one rehabilitation cycle
- Even if the third treatment is applied in all cases (100% probability), the total program cost ($228,800 undiscounted, GNV) remains less than 8.5% of a single Do Nothing overlay event ($2,698,667)
- The 20% probability third-treatment model reflects real-world condition variability — owners with well-maintained pavements benefit from the lower expected cost; those with higher distress still achieve 91%+ NPV savings vs. Do Nothing

7.4 Combined Full Preservation Program: JointBond + Reclamite vs. Do Nothing

The most complete economic case is made by evaluating the total cost of a coordinated preservation program — JointBond applied to all longitudinal joints and Reclamite applied full-width — against the Do Nothing alternative in which no proactive treatment is undertaken until full mill and 3-inch overlay with joint mill and inlay is required. This combined comparison represents the most realistic decision faced by airport authorities and DOT asset managers considering a comprehensive pavement preservation strategy.

7.4.1 GNV Aviation — Combined Program

Cost Component	Unit Cost Basis	NPV @ 4%	vs. Do Nothing
JointBond — 36,960 LF (7 joints, 2 apps)	$1.10/LF	$72,787	Component
Reclamite — 58,667 SY (2 + 20% EV apps)	$1.30/SY	$149,257	Component
TOTAL — Full Preservation Program	**Blended**	**$222,044**	**—**
Do Nothing → Mill & Inlay + Mill & Overlay	**$12.50/LF + $46/SY**	**$1,974,143**	**Baseline**
NET PROGRAM SAVINGS	**—**	**$1,752,099**	**88.8% saving**

Table 7-6: Combined Program LCCA — GNV Aviation Scenario (per mile of runway, 4% discount rate)

7.4.2 DOT Highway — Combined Program (per direction per mile)

Cost Component	Unit Cost Basis	NPV @ 4%	vs. Do Nothing
JointBond — 15,840 LF (3 joints/dir, 2 apps)	$1.10/LF	$31,194	Component
Reclamite — 28,160 SY (2 + 20% EV apps)	$1.30/SY	$71,643	Component
TOTAL — Full Preservation Program	**Blended**	**$102,838**	**—**
Do Nothing → Mill & Inlay + Mill & Overlay	**$12.50/LF + $46/SY**	**$1,008,861**	**Baseline**
NET PROGRAM SAVINGS	**—**	**$906,023**	**89.8% saving**

Table 7-7: Combined Program LCCA — DOT Highway Scenario (per direction per mile, 4% discount rate)

Combined Program LCCA — Executive Summary

- GNV Aviation: The full JointBond + Reclamite preservation program costs $222,044 NPV vs. $1,974,143 for Do Nothing — an 88.8% saving of $1,752,099 per runway mile
- DOT Highway: The program costs $102,838 NPV vs. $1,008,861 for Do Nothing — saving $906,023 per lane-mile per direction (89.8%)
- The combined preservation cost annualizes to approximately $0.29/SY/year over the treatment window (GNV scenario) — the lowest cost-per-year of any strategy evaluated
- Every $1.00 invested in the combined preservation program avoids approximately $8.88 in future Do Nothing rehabilitation cost (GNV aviation scenario)
- The preservation program requires only 4 total treatment events (2 JointBond + 2 Reclamite base) over the evaluation window vs. 1 catastrophic full-width mill and overlay event under Do Nothing — the preservation path is both cheaper and operationally less disruptive

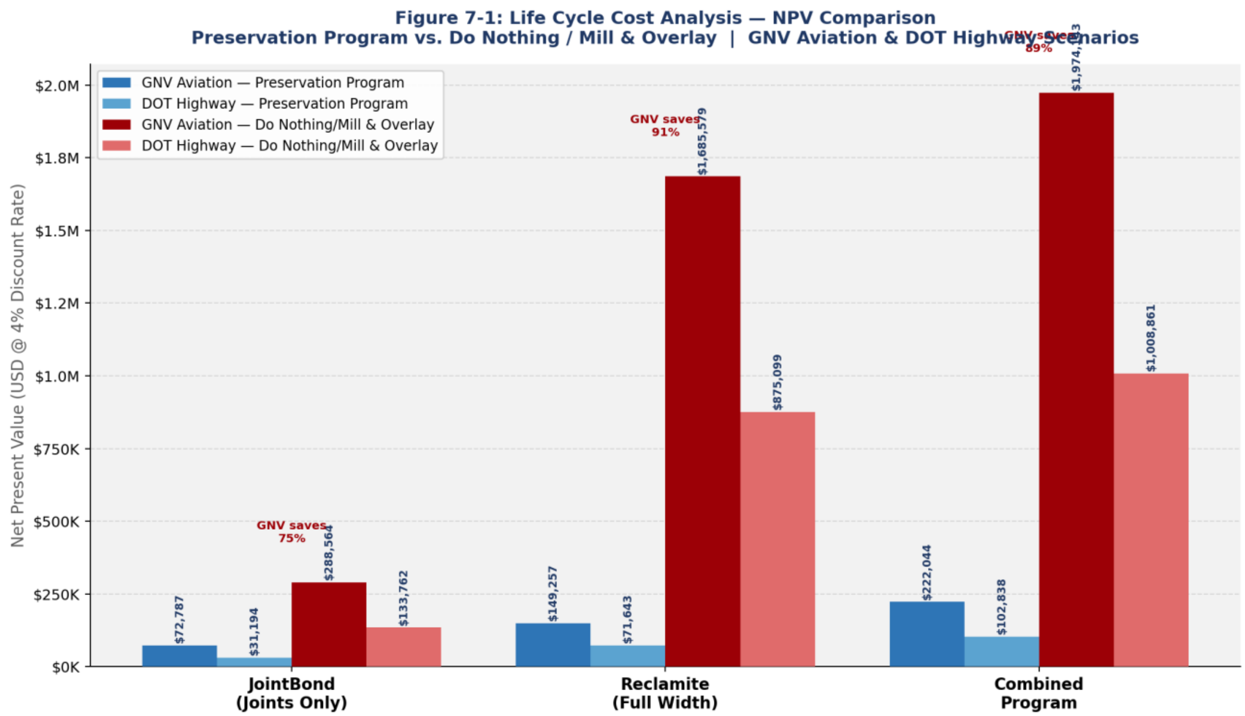

FIGURE 7-1: NPV Comparison

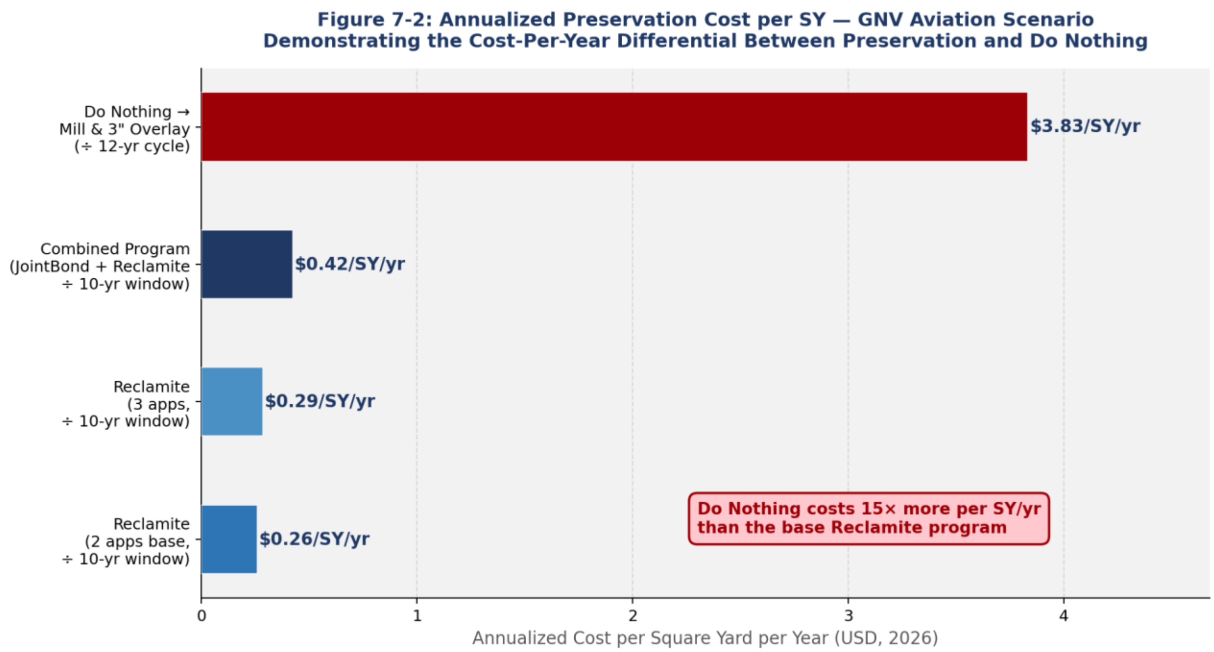

FIGURE 7-2: Annualized Cost per SY

8. Best-Practice Maintenance Schedule

8.1 Treatment Philosophy

Effective pavement preservation depends on treating the pavement at the right time — early enough in the aging curve that binder restoration is achievable at a low application cost, but before the pavement has deteriorated to a point requiring structural rehabilitation. The GNV five-year data confirms that maltene rejuvenation applied at or shortly after construction completion (Year 0–2) achieves the maximum binder restoration effect and longest extension of the pavement's serviceable life.

The following schedule is structured around two primary treatment events: an Initial Treatment targeting binder restoration before significant oxidative brittleness develops, and a Secondary Extension at Year 6 to sustain the restored binder condition through the mid-life of the pavement. Subsequent treatments follow on a 6-year cycle contingent on condition monitoring results.

Year	Treatment Event	Scope of Work	Performance Trigger	Expected Outcome
Year 1	**Initial Treatment**	**Full runway / pavement surface application of maltene rejuvenator (Reclamite / JointBond) at design application rate**	**Proactive — applied within 1–2 years of new overlay placement, before Mu decline or cracking initiates**	**38%+ viscosity reduction (per CDOT spec.); G' reduction >40%; 3–5 year life extension initiated**
Year 3	Condition Monitoring	Annual RFT friction survey; MPSV crack imaging; spot DFT if Mu trend indicates decline	Routine annual FAA compliance monitoring	Confirm Mu > 0.82; document crack inventory baseline for Year 6 planning
Year 6	**Secondary Extension Treatment**	**Second maltene rejuvenator application; crack sealing of any low-severity longitudinal cracks with JointBond product; re-survey post-treatment**	**Mu approaching 0.85 threshold on trend; DFT40 below 0.65; any crack area >0.5%**	**Sustained binder viscosity; crack propagation arrested; additional 3–5 year life extension; continued FOD risk suppression**
Year 9	Mid-Cycle Monitoring	Full RFT + DFT + MPSV survey; core extraction recommended at 10-year mark to verify sub-surface binder condition	Routine annual + 10-year structural assessment trigger	Inform Year 12 treatment decision: second extension cycle vs. mill & inlay
Year 12	Tertiary Extension or Rehab Decision	If core viscosity confirms adequate binder condition: third maltene application. If pavement has fatigue cracking >2%: consider mill & inlay	Core viscosity < 200,000 Poises in surface lift = candidate for rejuvenation; >200,000 Poises with cracking = structural rehab	Decision point: preservation vs. rehabilitation pathway. LCCA input for next 20-year cycle
Year 18–30	Continued Cycle	Repeat 6-year treatment cycle; update LCCA with	Per condition survey triggers above	Maintain pavement in 'good' condition classification

Table 8-1: Best-Practice Maltene Rejuvenation Maintenance Schedule — GNV Runway 7/25 and Comparable DOT Assets

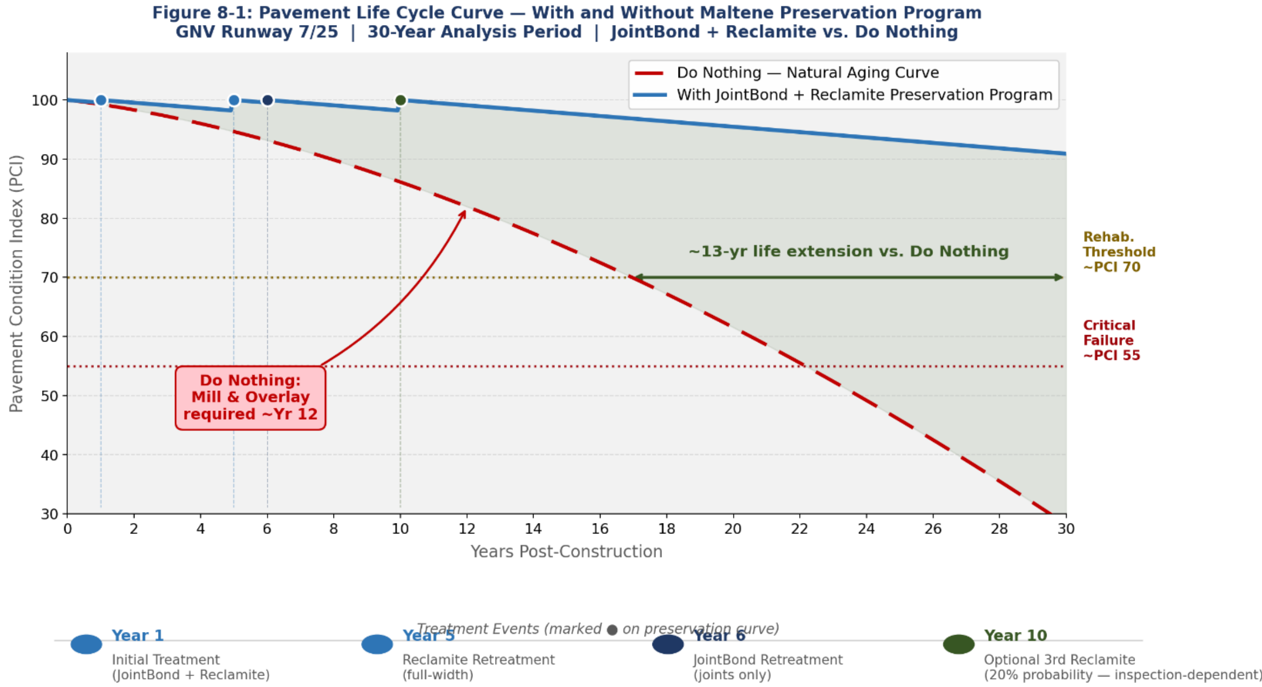

FIGURE 8-1: Pavement Life Cycle Timeline

8.2 Ongoing Performance Monitoring Recommendations

To support data-driven decisions at each subsequent treatment cycle, the following annual monitoring activities are recommended beyond the Year 1 initial treatment:

- Annual RFT friction survey to confirm sustained Mu > 0.82 and detect any emerging friction deficit trends requiring schedule acceleration.
- MPSV crack imaging at Years 3 and 6 to document surface distress progression and confirm that the Year 6 retreatment trigger criteria (crack area > 0.5% or DFT40 < 0.65) are or are not met.
- DFT spot testing at the Reclamite section (D-R) and any newly treated sections following each application to establish a post-treatment baseline for subsequent trend analysis.
- At the Year 10–12 milestone, a full condition inspection — incorporating pavement imaging, friction testing, and visual survey — should inform the Year 12 decision point outlined in the maintenance schedule (Table 8-1): proceed with a third Reclamite application if the condition inspection passes, or evaluate mill and overlay if structural distress is confirmed.

9. Conclusions and Recommendations

9.1 Summary of Technical Findings

This comprehensive technical assessment integrates five-year field performance data from GNV Runway 7/25, core extraction viscosity data from the GNV rejuvenator and control sections, and DSR rheological data from the CDOT South 109 project to provide a multi-dimensional evaluation of maltene-based pavement rejuvenation for aviation and DOT highway applications. The principal findings are as follows:

- **All RFT test sections maintained average Mu values above 0.86 after five years of service — exceeding the FAA new design/construction minimum of 0.82 [GNV 2021 Evaluation Memo, p. 3]. The rejuvenator section DFT40 of 0.630 is 14.5% above the 0.55 newly-constructed benchmark [GNV 2021 Evaluation Memo, Table 3].** Friction Performance (Aviation Safety):
- **Section B2 (aramid fiber — paired comparison to rejuvenator) achieved the lowest crack area at 0.09%. Grid systems B1-B, B1-C, and B1-D with leveling course recorded the highest cracking (1.20–2.00%) [GNV 2021 Evaluation Memo, Table 4]. The rejuvenator's chemical preservation mechanism demonstrably outperforms mechanical interlayer solutions in crack-area terms.** Cracking Resistance:
- **Treated Reclamite specimens showed a 13.8% viscosity reduction at the surface lift and 23.5% at the lower lift versus untreated control, confirming penetration to 1–2 inch depth. JointBond surface lift reduction was 47.8% versus the highly aged JC control [GNV Rejuvenator Cores Lab Report].** Binder Rheology — GNV Cores:
- **38.2% viscosity reduction (exceeding 35% specification minimum); 43.1% reduction in Elastic Modulus G' (primary brittleness metric); +1.8° phase angle increase confirming shift toward viscoelastic flexibility. Balanced reductions across G*, G', and G'' confirm stable binder modification without rutting risk [APART Report 26-0207].** Binder Rheology — CDOT DSR (APART Report 26-0207):
- **Deep penetration of maltene chemistry (confirmed to 1–2 inch depth) provides internal aggregate lock-in superior to surface sealants in FOD prevention. No surface-proud material is introduced, eliminating the pull-out debris risk associated with rubberized sealants under jet blast.** FOD Risk:
- **30-year FAA NPV savings of ~$39,100/lane-mile (JointBond vs. rubberized crack seal) and ~$156,100/lane-mile (JointBond vs. mill & inlay). 20-year DOT NPV savings of ~$27,800 and ~$62,900/lane-mile respectively. ROI confirmed through 3–5 year life extension per treatment cycle.** Life Cycle Cost:

9.2 Recommendations

1. Adopt maltene-based rejuvenation (JointBond/Reclamite product family) as the primary preservation strategy for GNV Runway 7/25 and all comparable FDOT airport and highway pavement assets.
2. Implement the Year 1 Initial Treatment and Year 6 Secondary Extension per the Best-Practice Maintenance Schedule (Section 8, Table 8-1).
3. Specify DSR viscosity reduction testing (minimum 35%) per Standard Specifications for Asphalt Surface Preservation with a Maltene Based Asphalt Rejuvenating Agent as a mandatory acceptance criterion for all future rejuvenation contracts.
4. Require core extraction and viscosity profiling (surface and lower lift) at the 10-year mark (Year 9–12) to enable data-driven rehabilitation vs. preservation decision-making.

5. Discontinue rubberized crack sealants as a primary joint treatment strategy on airport runways — the pull-out risk and higher 30-year NPV cost do not justify their continued use where maltene chemistry is proven and available.
6. Extend the GNV monitoring program beyond 2021 with annual surveys through Year 10 post-construction to document the long-term performance divergence between the rejuvenator section (D-R) and grid systems (B1-B, B1-C, B1-D).

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— END OF REPORT —

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