



**SOILS &
STRUCTURES**

-Geotechnical Case Studies-

Cold in Place Recycling and Full Depth
Reclamation

Don R. Dunkin, PE

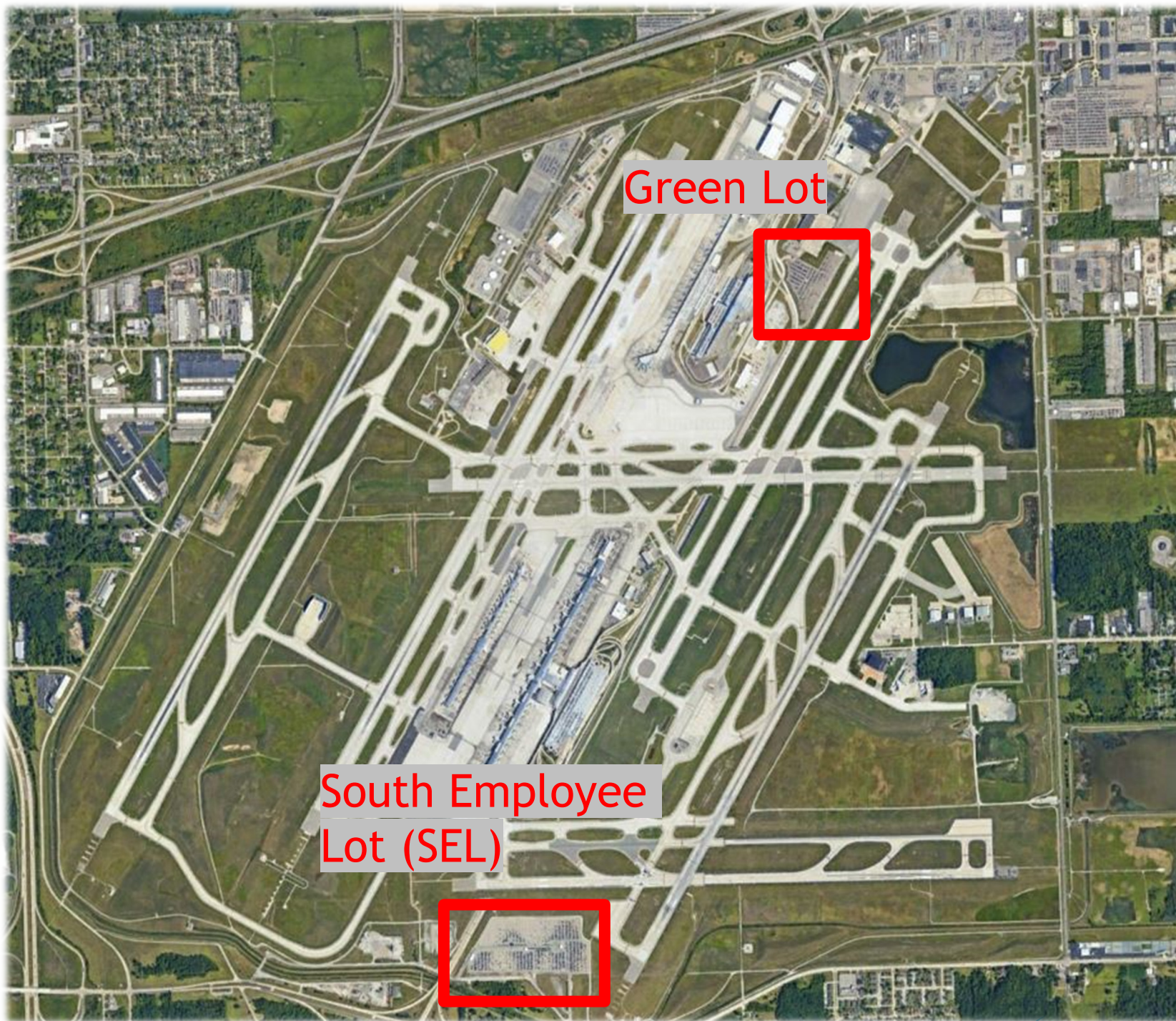
Outline

- ▶ DTW Case Study
- ▶ 2014 Through 2023 - Reclaimed Pavements by County
- ▶ Market Influences and Perspective on Future

Detroit Metro Airport

2013 - 2015 Full Depth Reclamation Case Studies

South Employee Lot & Green Lot



Hypothesis:

**Pretreating High
Clay Content
Stabilized Base
Course with Lime
Kiln Dust (LKD) Prior
to Cement
Stabilizing Will
Increase
Freeze/Thaw
Durability**



SEL
Image Date
04/24/2000



Image Date
07/14/2022

Reconstructed
Summer 2013

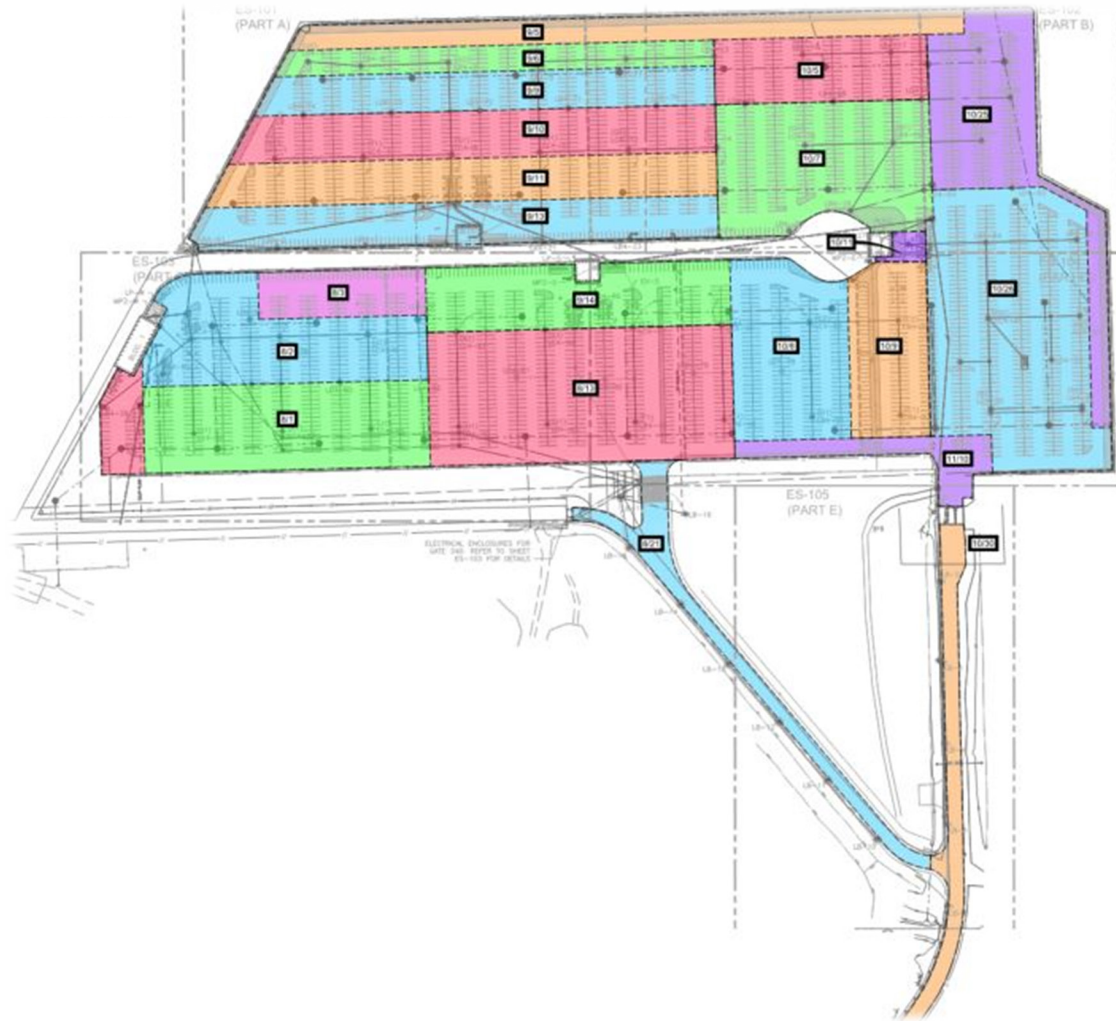
Original Pavement
Service Life

12-13 years



Full Depth Reclamation with Cement Stabilization

Strength Data From Field QC



7/21 = 1,679 SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	8/25 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	10/27 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221
8/1 = 11,306 SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	8/26 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	10/28 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221
8/2 = 8,500 SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	8/10 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	10/29 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221
8/3 = 3,254 SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	8/11 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	10/30 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221
8/13 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	8/15 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	10/31 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221
8/14 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	10/32 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221	11/12 = SYDS 20% SUBGRADE CY AGE PSI A 2 203 B 5 199 C 7 243 D 7 243 E 28 221

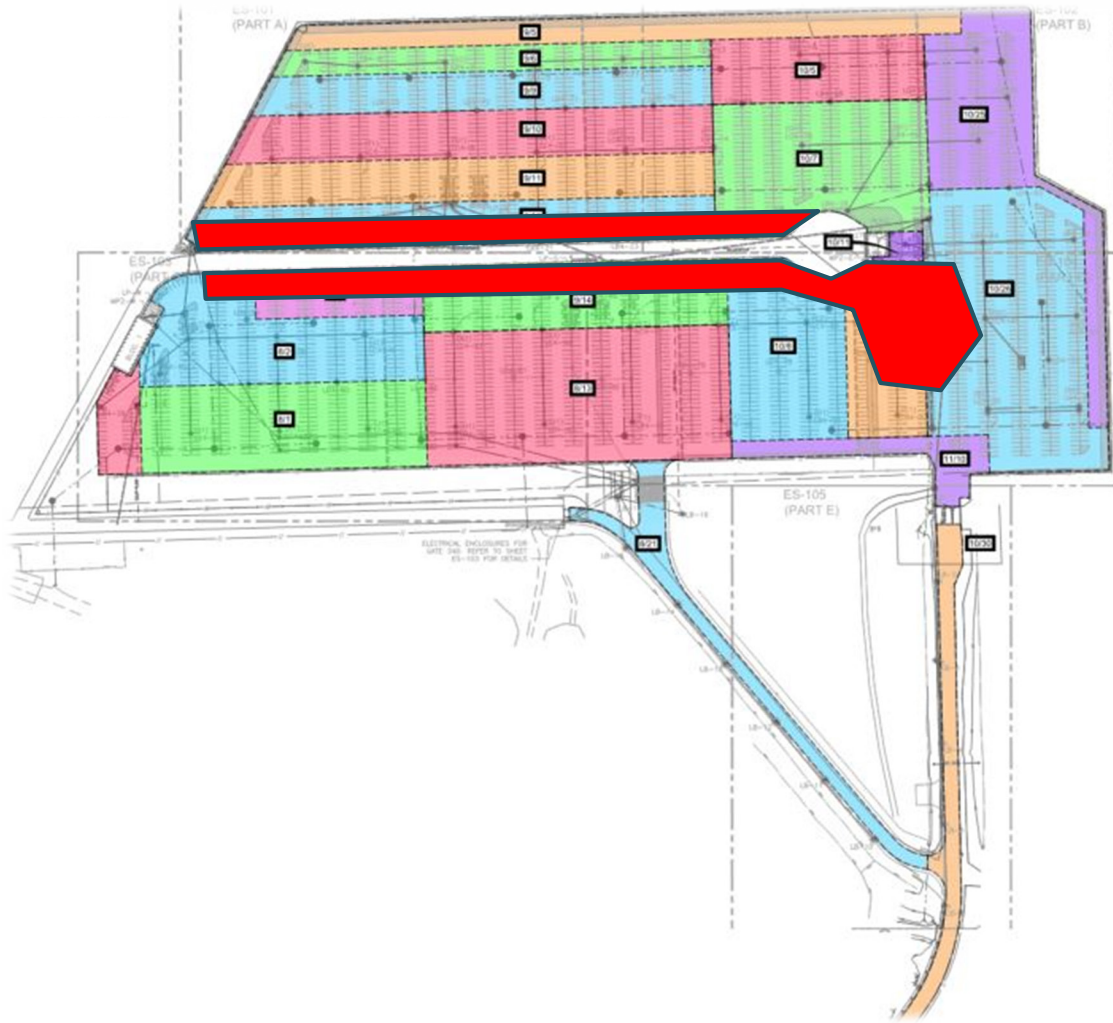
8/2 = 8,500 SYDS
20%-30% SUBGRADE

CY	AGE	PSI
A	4	203
B	5	192
C	7	243
D	7	203
E	28	316
F	4	138
G	5	152
H	7	154
I	7	158
J	28	221

Clay Pockets

Liquid Limits
20 to 30

Stabilized Base Clay
Contents
30 to 50% By Mass



301 = 1,679 SYDS 20% LPA SUBGRADE			605 = SYDS 20% LPA SUBGRADE			1007 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	2	100	A	2	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

811 = 11,306 SYDS 20% LPA SUBGRADE			806 = SYDS 20% LPA SUBGRADE			1008 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	2	100	A	5	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

812 = 8,300 SYDS 20% LPA SUBGRADE			810 = SYDS 20% LPA SUBGRADE			1009 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	4	100	A	2	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

813 = 3,254 SYDS 20% LPA SUBGRADE			811 = SYDS 20% LPA SUBGRADE			1010 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	2	100	A	2	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

814 = SYDS 20% LPA SUBGRADE			815 = SYDS 20% LPA SUBGRADE			1011 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	2	100	A	2	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

816 = SYDS 20% LPA SUBGRADE			817 = SYDS 20% LPA SUBGRADE			1012 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	2	100	A	2	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

818 = SYDS 20% LPA SUBGRADE			819 = SYDS 20% LPA SUBGRADE			1013 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	2	100	A	2	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

820 = SYDS 20% LPA SUBGRADE			821 = SYDS 20% LPA SUBGRADE			1014 = SYDS 20% LPA SUBGRADE		
CY	ASL	PS	CY	ASL	PS	CY	ASL	PS
A	2	100	A	2	100	A	2	100
B	5	100	B	5	100	B	5	100
C	2	100	C	2	100	C	2	100
D	2	100	D	2	100	D	2	100
E	2	100	E	2	100	E	2	100
F	2	100	F	2	100	F	2	100

10 Years in



Bus Loop at Clay Pocket



Green Lot

Image Date
04/24/2000





Green Lot

**Image Date
07/14/2022**

**Reconstructed
Summer 2015**

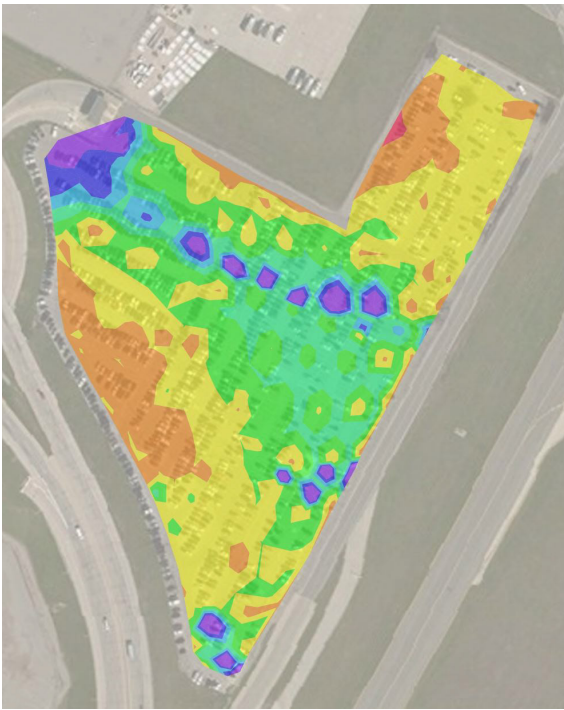
**Original Pavement
Service Life
Unknown**



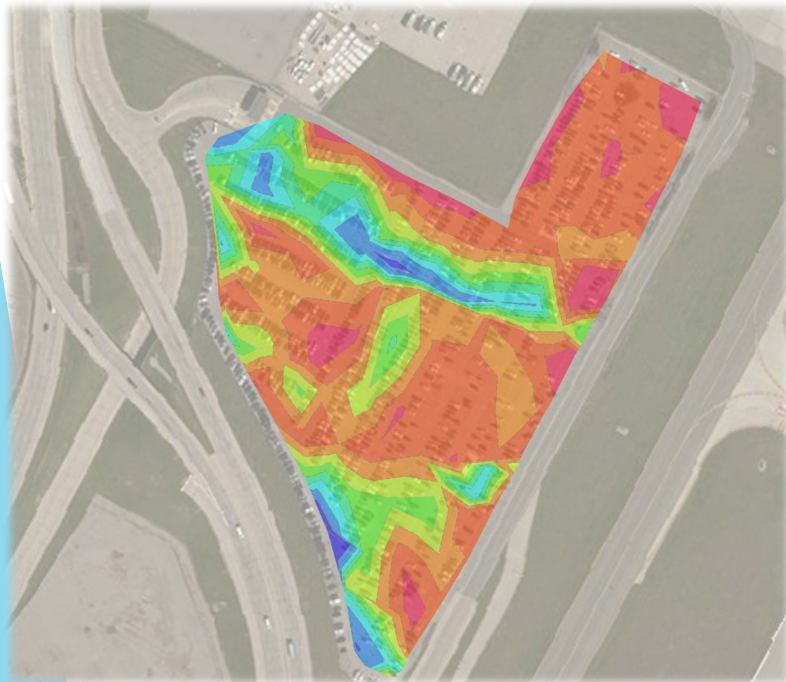
Green Lot

Falling Weight Deflectometer (FWD) Analysis

Structural Number (SN) and Apparent Subgrade Reaction (MR) Existing Condition



Interval	Minimum ESN	Maximum ESN	Area (SF)	Color
1	0.00	1.00	1017.06	Red
2	1.00	2.00	67706.65	Orange
3	2.00	3.00	170618.50	Yellow
4	3.00	4.00	100510.65	Light Green
5	4.00	5.00	60236.68	Green
6	5.00	6.00	17781.80	Cyan
7	6.00	7.00	14835.71	Blue
8	7.00	30.00	14053.69	Purple



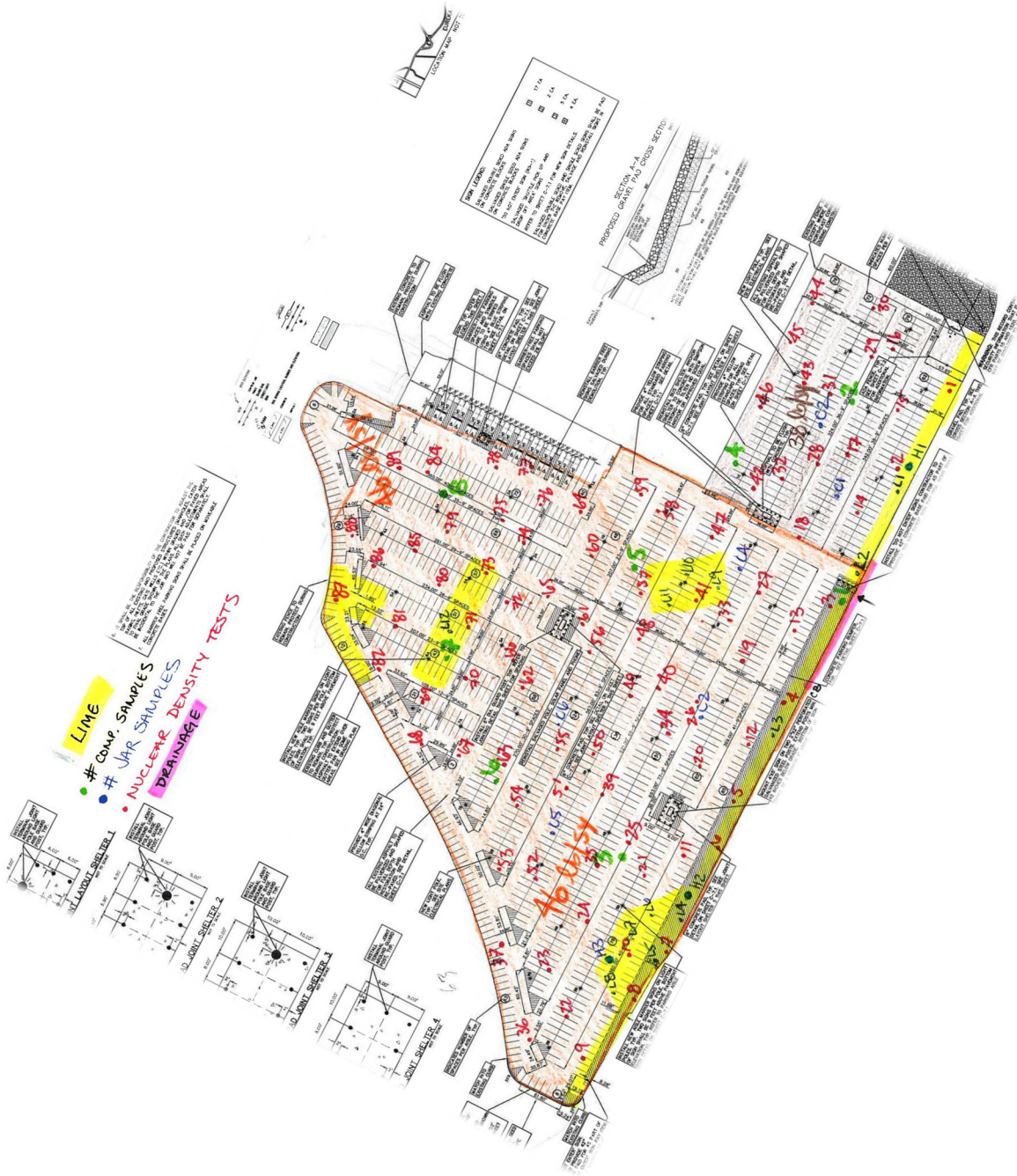
Interval	Minimum ESM	Maximum ESM	Area (SF)	Color
1	0.00	2000.00	31547.32	Red
2	2000.00	3000.00	159035.70	Orange
3	3000.00	4000.00	98392.45	Yellow
4	4000.00	5000.00	51960.07	Light Green
5	5000.00	6000.00	39992.09	Green
6	6000.00	7000.00	28467.87	Cyan
7	7000.00	8000.00	21709.49	Blue
8	8000.00	10000.00	14567.45	Dark Blue
9	10000.00	20000.00	2200.33	Purple
10	20000.00	35000.00	0.00	Black

Green Lot

Pre Treatment Areas Multiple Application Rates

46 LB/SY in Main Lot
38 LB/SY in Limestone
Section

~15% Pretreated at 35
LB/SY LKD



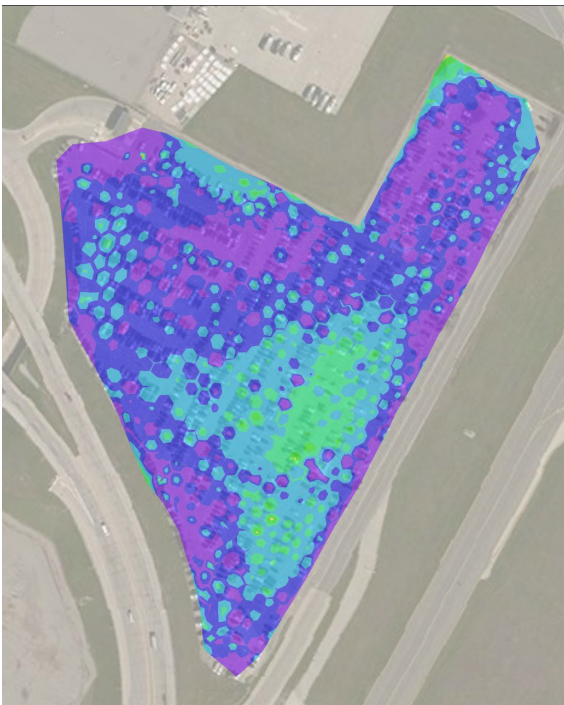
Green Lot

Falling Weight Deflectometer (FWD) Analysis

Structural Number (SN) and Apparent Subgrade Reaction (MR) Resurfaced Condition

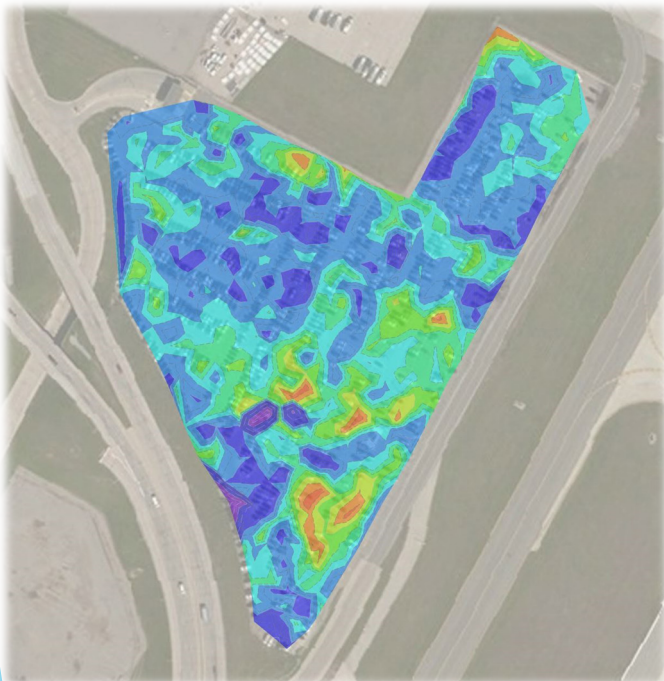
13.3 to 65.7 Inch Overlay Equivalence In ~ 26% of Area

Not Realistic For Flexible Systems



Interval	Minimum ESN	Maximum ESN	Area (SF)	Color
1	0.00	1.00	0.00	Red
2	1.00	2.00	4.50	Orange
3	2.00	3.00	118.82	Yellow
4	3.00	4.00	2698.43	Light Green
5	4.00	5.00	40096.93	Green
6	5.00	6.00	125335.82	Cyan
7	6.00	7.00	188960.73	Blue
8	7.00	30.00	126120.91	Purple

Interval	Minimum ESM	Maximum ESM	Area (SF)	Color
1	0.00	2000.00	0.00	Red
2	2000.00	3000.00	1306.95	Orange
3	3000.00	4000.00	7169.31	Yellow
4	4000.00	5000.00	15801.32	Light Green
5	5000.00	6000.00	34168.56	Green
6	6000.00	7000.00	74963.94	Cyan
7	7000.00	8000.00	107432.53	Blue
8	8000.00	10000.00	182297.89	Dark Blue
9	10000.00	20000.00	59583.62	Dark Blue
10	20000.00	35000.00	1880.32	Purple

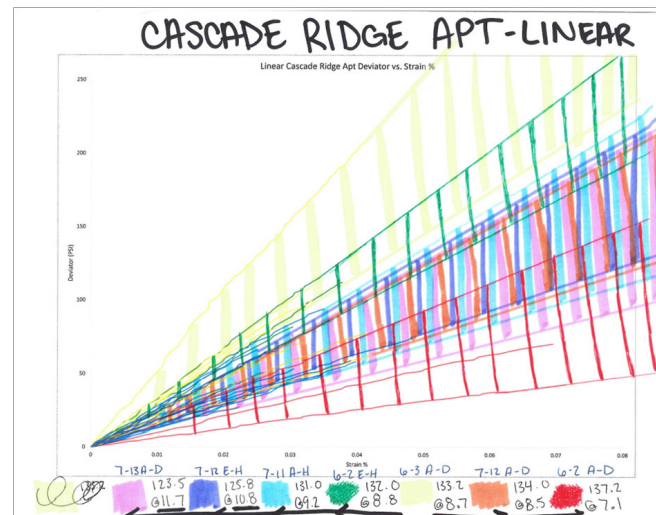
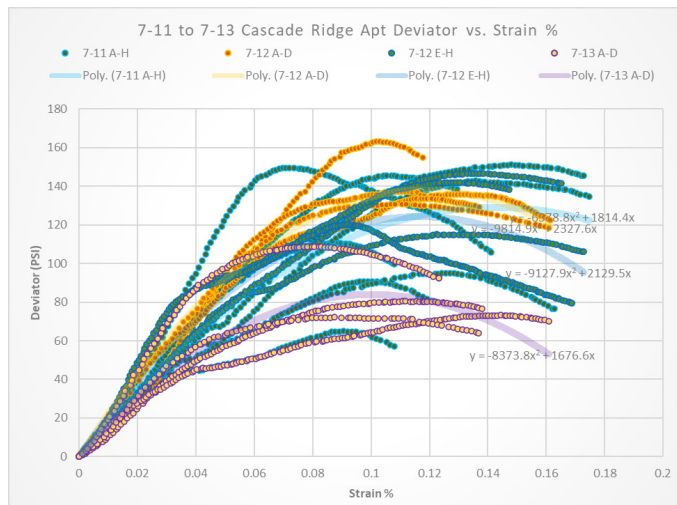
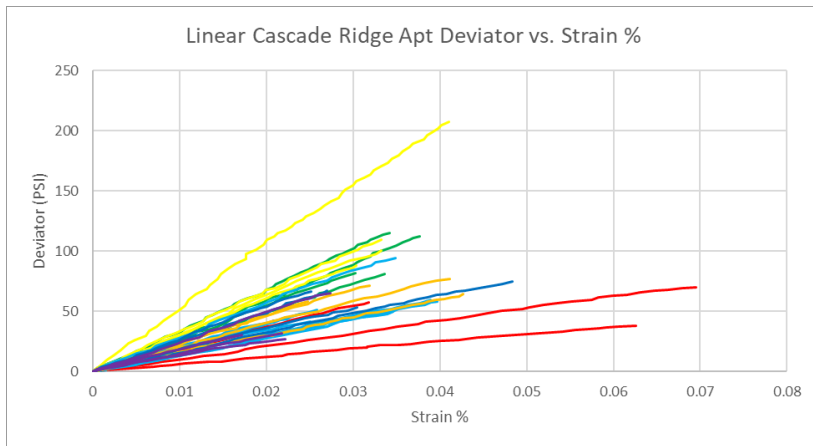
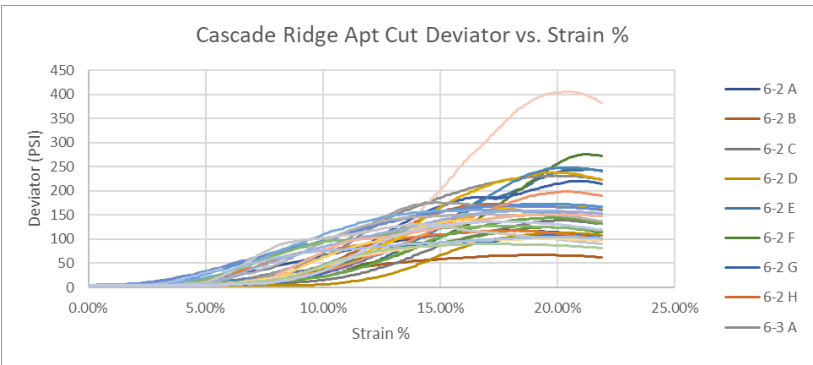


Semi Rigid Pavements

Coorelating Internal Stress Strain Relationships to Structural Data From FWD

Building Functions to Understand Material Properties and Hinge Point Where the Transition to Rigid Occurs

Including DCP Data from Initial Investigation





Green Lot
Image Date
01/31/2023
No Evidence of Major
Structural Failures



Rochester Church of Christ

Reconstructed 2017

60% - 80% Lean Clay

30 LB/SY LKD

38 LB/SY Cement



Rochester Church of Christ

60% - 80% Lean Clay



Rochester Church of Christ

60% - 80% Lean Clay



County Road Commissions

2014 - 2023 Full Depth Reclamation and Cold In place Recycling
Case Studies

Bay County

PROJECT	TO	FROM	LENGTH (MI)	METHOD	OVERLAY (IN)	ADDITIVE
MACKINAW ROAD	PINCONNING ROAD	TOWNLINE ROAD	2	CIPR	2	EMULSION
GARFIELD ROAD	PINCONNING ROAD	ERICKSON ROAD	4	CIPR	3	EMULSION/ JBAND
GARFIELD ROAD	ERICKSON ROAD	ANDERSON ROAD	3	CIPR	2	EMULSION
GARFIELD ROAD	HOTCHKISS ROAD	US-10	2	CIPR	3	EMULSION/ NOJBAND
GERMAN ROAD	PINE ROAD	TRUMBULL ROAD	1.5	CIPR	2	EMULSION
BEAVER ROAD	4 MILE ROAD	FRASER ROAD	3	CIPR	3	EMULSION

Deep Ditches

Built Up Sections

Buried Concrete

Lean Clays

Big, Flat and Straight

Occasional Cement but Generally Good CIPR Candidates





Bay County

P&H

**Material
Source and
Contractor
Located in
The County**

Ingham County

YEAR	PROJECT	TO	FROM	LENGTH (MI)	METHOD	ADDITIVE
2009	Williamston Road	City Limit	Haslett Rd	3.3	FDR	EMULSION
2012	Haslett Road	Park Lake Rd	CN Railroad	2.5	CIPR	EMULSION
2016	Jackson Rd	Baseline Rd	Fitchburg Rd	1.75	CIPR	EMULSION
2016	Williamston Road	Baseline Rd	Catholic Church Rd	5	CIPR	EMULSION
2016	Dietz Rd	Swan Rd	Carter Rd	1.2	CIPR	EMULSION
2016	Swan Rd	Osborne Rd	M-52	3.6	CIPR	EMULSION
2016	Carter Road	Procter Rd	M-52	2.8	CIPR	EMULSION
2016	Oak Street	City Limits	Kinneville Rd	0.5	CIPR	EMULSION
2018	Hagadorn Rd	Jolly Rd	Mt. Hope Rd (1/ 2 mi S)	1.5	FDR	EMULSION
2018	Efert Rd	Holt Rd	Willoughby Rd	1	FDR	EMULSION
2018	Jolly Road	Dobie Rd	Meridian Rd	2.4	FDR	EMULSION
2018	Haslett Road	M-52	Morrice Rd	2.5	FDR	EMULSION
2018	Williamston Road	West Rd	Howell Rd	3	FDR	EMULSION
2018	Fitchburg Road	Williams Rd	Friermuth Rd (1500 ft E)	3.35	FDR	EMULSION
2020	Beaumont Rd	Bennett Rd	Mt. Hope Rd	1	FDR	EMULSION
2020	Forest Rd	Farm Lane	Beaumont Rd	0.33	FDR	EMULSION
2020	Meridian Road	Howell Rd	Jolly Rd	6	FDR	EMULSION
2021	Bellevue Road	Onondaga Rd	US-127	6	FDR	EMULSION

Higher Traffic Volumes

Larger Elevation Changes

Frequent Wetland Crossings

Lean Designs

Fairly Straight with Need to Correct Grades





Ingham County

**Centrally
Located with
Good Access
to Contractors**





Emmet County

**Wilderness Park
Drive**

**Furthest North
So Far**

Wexford County Mackinaw Trail





Muskegon County

Giles Road



Eaton County

Creyts Road



Midland County

South Porter Road

Odd Road

11 Mile Road

Lenawee County Pocklington Road Cement Stabilization

City of Adrian Multiple Short Segments



Oakland County

**Waubeek Road
2014**

**Goodison Hills
2015**



Oakland County

Waubeek Road

Coorelates to
Layer Coefficient
0.2





US - 131
I-75
I-69
I-275
Telegraph Road

MDOT
SUBGRADE
STABILIZATION
2014 to 2023



Market Factors

2023 - Reclamation and Stabilization Industry

Major Investment



Additive Supply - Storage - Intermittent Supply



Additive Supply - Storage and Transportation



Despite Having Fewer Assets Freight, Manufacturing, Retail and Energy are an Overwhelming Market Share for Reclaimed Pavements

Return on Investment



Excepting Emulsions

Cement Based Stabilization Contributes to
Pavement Structure far More and as a VE Option
Wins Every Time



The background features abstract, overlapping geometric shapes in various shades of blue, ranging from light sky blue to deep navy blue. These shapes are primarily located on the right side of the frame, creating a modern, layered effect. The central area is a plain, light grayish-white.

Summary

Summary

- ▶ Use of Lime Kiln Dust is Effective at Offsetting Deterioration from Freeze/Thaw Cycling in Clay Soils Stabilized with Cement
- ▶ Engineered Emulsions Ideal for Reclaiming Rural/Suburban County Roads
- ▶ Cement is Still Ideal for Structural Deficient Roads
- ▶ Private Sector is Supporting the Industry More than Public
- ▶ Growth and Innovation is Stunted by Inconsistent Workload

Moving Forward

- ▶ Continuing to develop specifications to accommodate better geotechnical design
- ▶ Working with existing data to develop Michigan specific materials database
- ▶ 10 year mark for current case studies. Working to review conditions and update lifecycle database
- ▶ Added 275 and Telegraph Road to the MDOT High Volume Case Studies in 2023
- ▶ Beginning to Build Similar Database Surrounding Engineered Emulsion Projects
- ▶ Need to Update AASHTO 93 Style Design Methods to Account for Semi-Rigid Systems
- ▶ Need to Start Collecting Pre and Post Construction FWD Data to Emulsion Projects



**SOILS &
STRUCTURES**

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Thank You

Any Questions?