Texas A&M Transportation Institute

Lives, Time and Resources

FDR Project Selection and Upfront Testing

Tom Scullion TTI

FULL DEPTH RECLAMATION WITH ASPHALT BINDERS

STATE OF THE ART

Spring 2020

Overview of Presentation

1. Challenges/Opportunities for FDR in Texas
   - TxDOT and Counties
2. Critical steps in FDR candidate evaluation and design process
3. Use of NDT in upfront testing
4. Case studies

TxDOT Challenges and Opportunities for FDR

- <u>Opportunities</u> No shortage of candidates
  - Roads with base problems
  - Energy Sector roadways
  - Inadequate width - make foundation layer

<u>Challenges</u>

- Variable pavement structure
- Construction on top of expansive clays
- Often poor existing base materials
- Early opening requirements in Energy Sector

Challenges for Counties

Sometimes High Growth
Heavy seasonal loads
Often very poor materials
Very thin layers

Working with Williamson County
Jeff Ivey Point of Contact

2 locations samples 8 inches deep

Dried, Sieve Analysis, PI - determines Job Mix options

Recommended Steps for Districts new to the FDR Design Process with Asphalt Binders

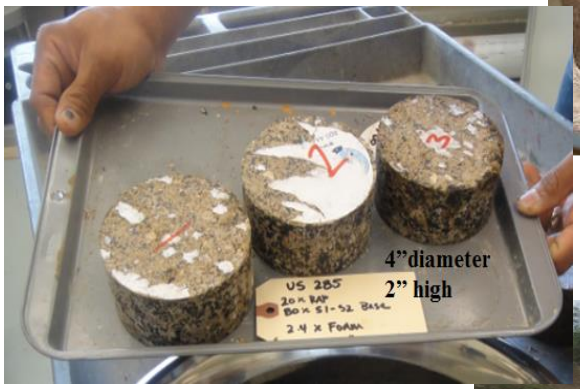
1. *Assemble Background information*
   - ✓ Coring logs
   - ✓ Maintenance
   - ✓ Typical section

2. *Non-destructive testing*
   - ✓ Ground Penetrating Radar (GPR)
   - ✓ Falling Weight Deflectometer (FWD)
   - ✓ Determine thickness & strength variability
   - ✓ Determine sampling locations

3. *Verify Pavement Structure & Sampling*
   - ✓ Auger or milling machine for sampling.
   - ✓ Drill logs for project

4. *Laboratory Mixture Design* ***(Dale)***
   - ✓ Plasticity Index
   - ✓ Moisture-Density Curve
   - ✓ Binder tests (foaming)
   - ✓ Asphalt %, additive %, add rock % and foaming water %

5. *Pavement Thickness Design* ***(Stephen)***



6. *Construction Quality Control* ***(Richard)***
   - ✓ *Depth of pulverization*
   - ✓ *Gradation*
   - ✓ *Moisture content*
   - ✓ *Emulsion content*
   - ✓ *Foaming asphalt properties*

7. *Construction Quality Assurance* ***(Shane)*** *– Density*

8. *Performance Evaluation* ***(Tom)*** *– FWD and Visual*

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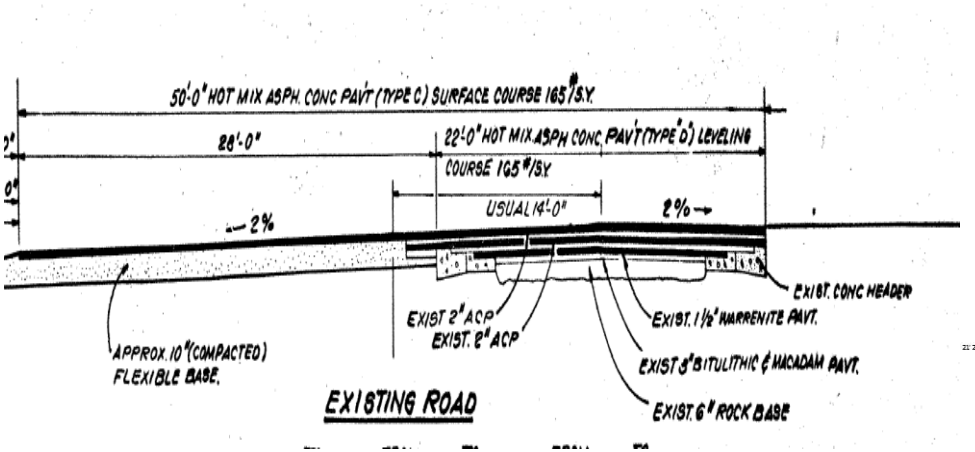
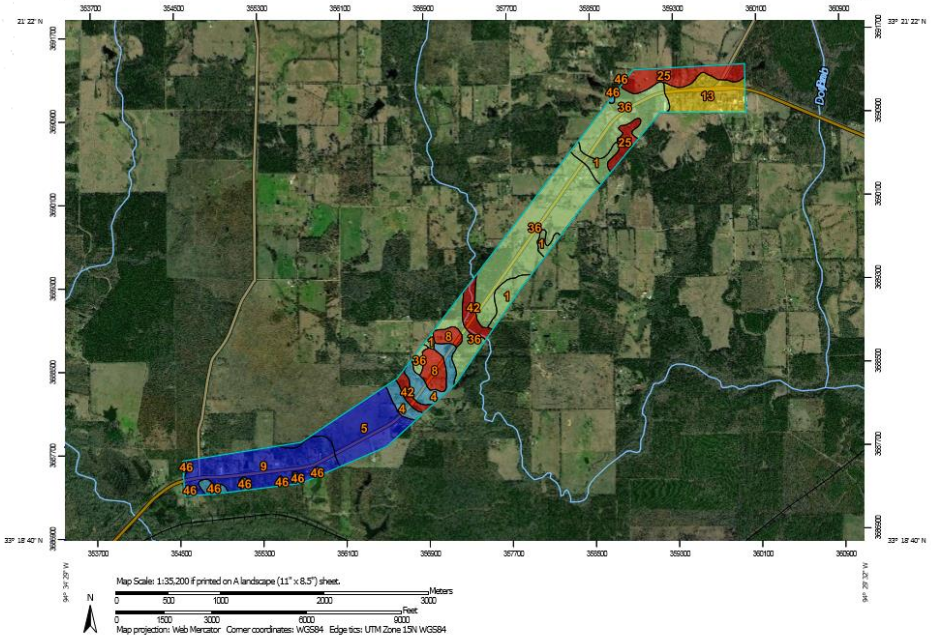
Step 1 Assemble Background Info





Typical section from candidate

1.5 inch Warrenite ?
3.0 inch Bitulithic ?

Step 2 Recommended NDT GPR
(use visual + GPR to select sampling locations)

- **Integrated Video and FWD**
- **Data collected at highway speed (60 mph)**
- **Effective depth of penetration 20 ins**
- **TxDOT has 5 available units**
- **Measures layer thickness and locate subsurface defects and changes in base type**

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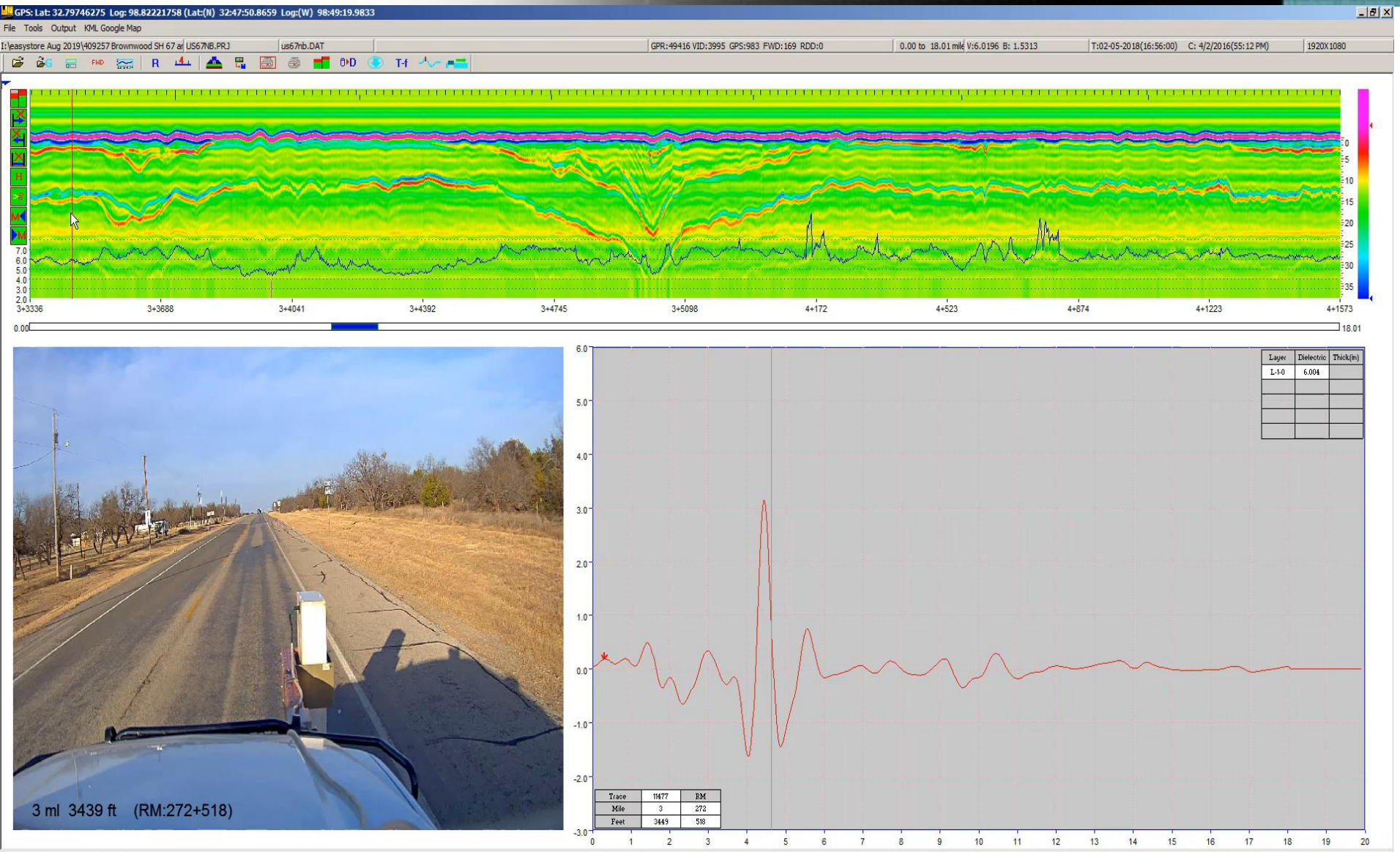
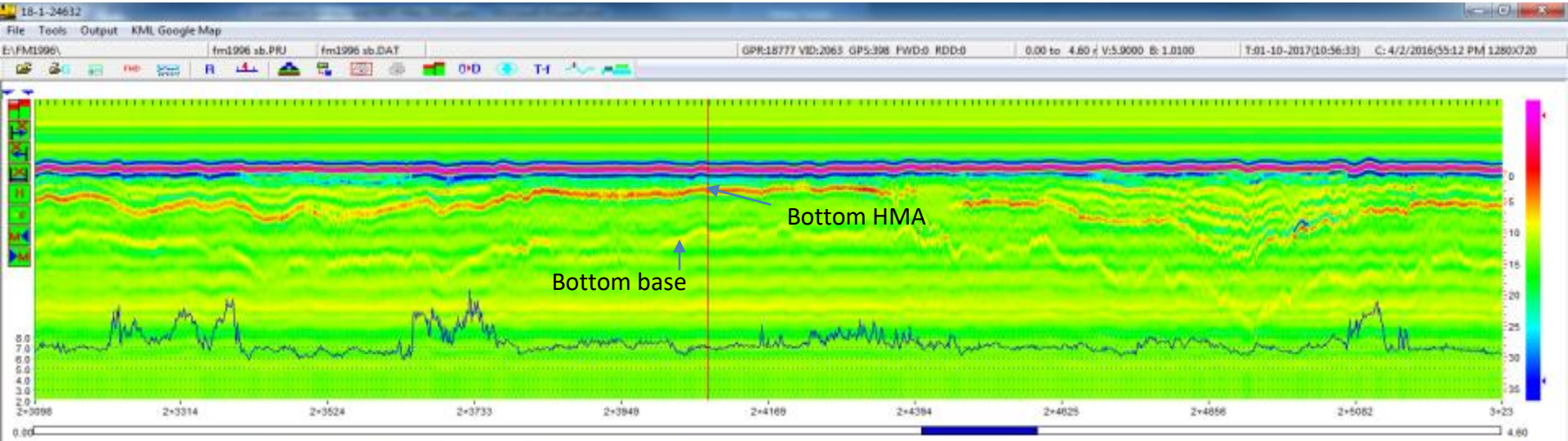
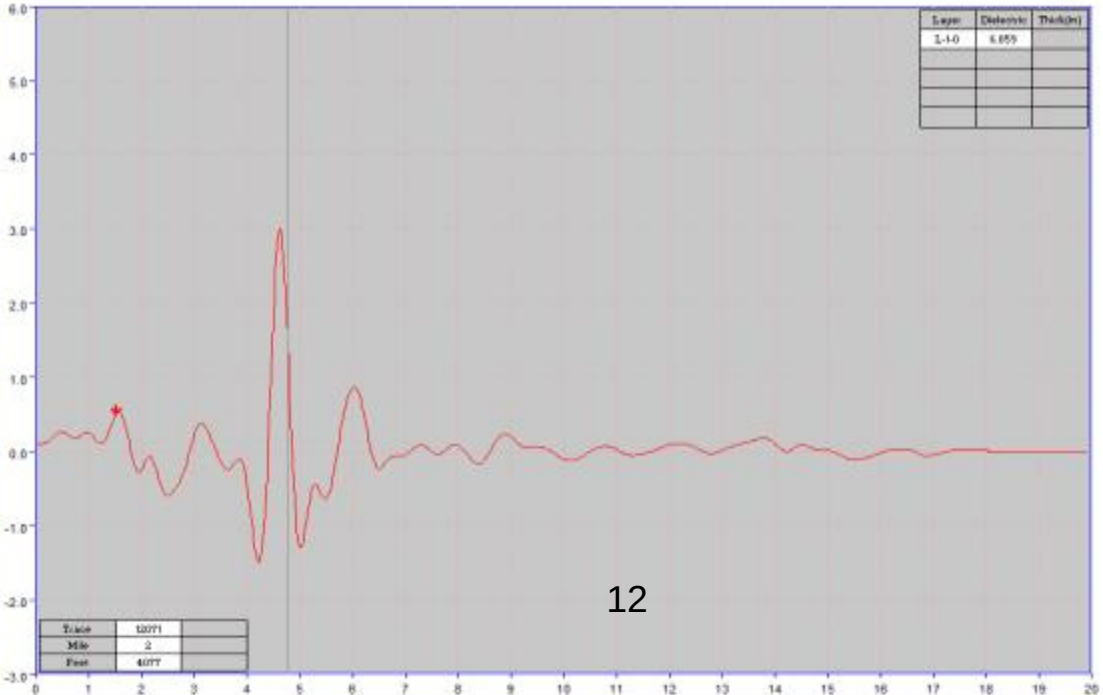



Bottom HMA
Bottom base


FM 1996
Waco
2 ml 4078 ft



Step 2 in the FDR Process

- ✓ Falling Weight Deflectometer (FWD)
- ✓ Subgrade Modulus determination

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 6.1)

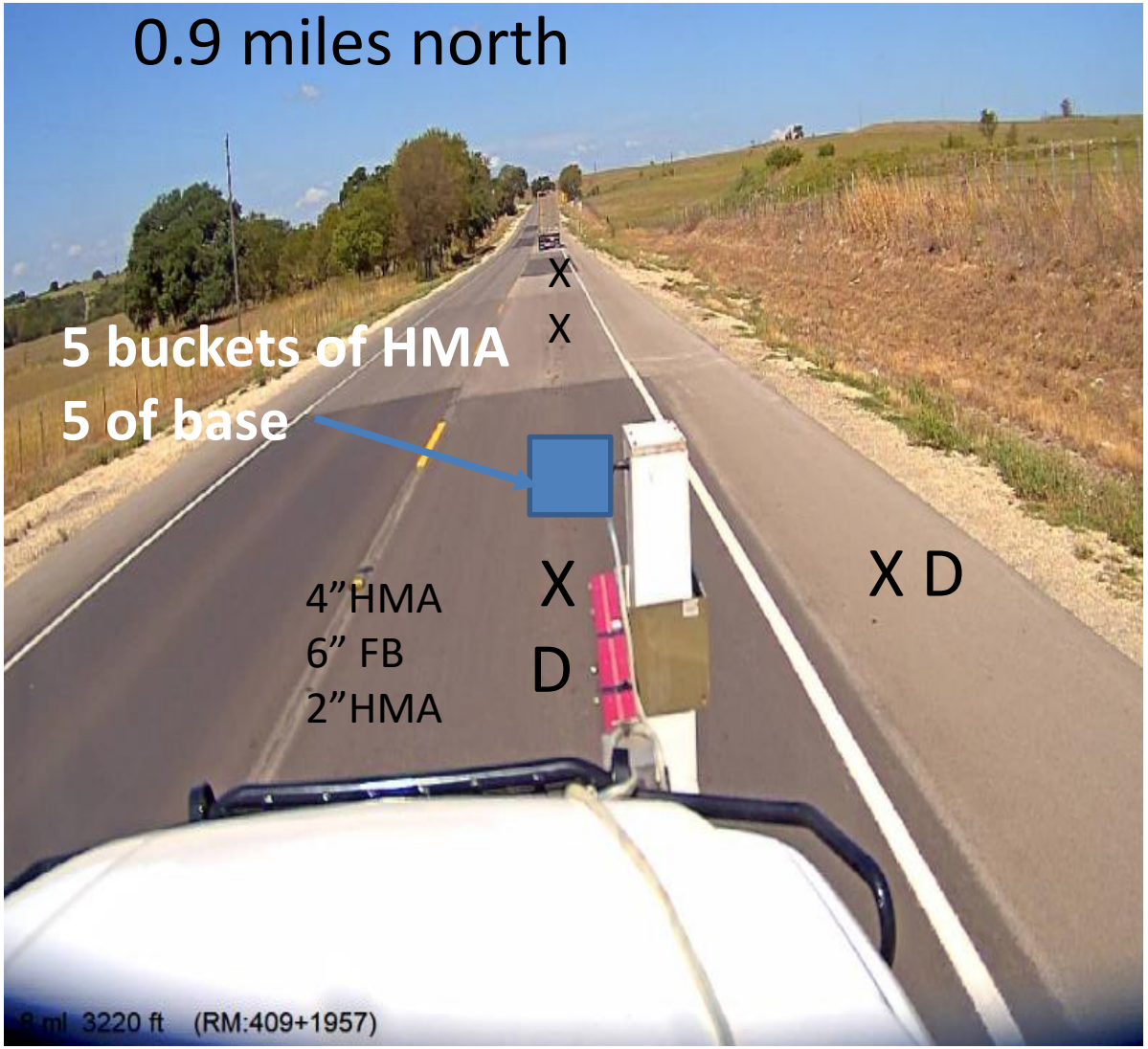
District:
County :
Highway/Road:

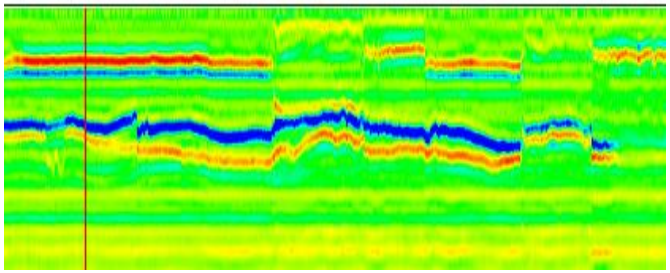
	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	1.70	663,400	663,400	H1: v = 0.35
Base:	8.00	10,000	150,000	H2: v = 0.35
Subbase:	10.00	10,000	100,000	H3: v = 0.35
Subgrade:	102.92(by DB)	10,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute RR/Sens	Dpth to Bedrock
0.000	9,266	10.89	4.84	1.66	0.97	0.56	0.48	0.41	663.4	98.5	32.0	47.7	11.51	54.6
0.104	9,201	6.73	2.94	1.59	1.13	0.75	0.58	0.49	663.4	150.0	50.1	64.1	28.01	178.9 *
0.201	9,321	26.21	15.94	7.49	3.69	2.00	1.25	0.90	663.4	48.2	10.0	12.7	10.76	80.3 *
0.301	9,310	12.98	8.20	3.50	2.18	1.60	1.35	0.95	663.4	133.3	20.3	20.3	13.36	111.0
0.400	9,628	5.91	2.88	1.63	1.12	0.73	0.72	0.66	663.4	150.0	50.1	59.6	29.92	159.9 *
0.502	9,727	7.81	3.96	2.30	1.71	1.31	0.93	0.82	663.4	150.0	79.4	27.4	12.85	200.7 *
0.600	9,332	10.96	5.60	2.45	1.57	1.09	0.76	0.70	663.4	117.5	37.2	29.0	8.47	131.4
0.707	9,102	15.11	9.02	4.18	2.36	1.44	1.02	0.82	663.4	112.4	12.8	20.4	5.91	123.7
0.800	9,354	13.08	6.87	2.75	1.67	1.15	0.92	0.81	663.4	97.9	26.5	26.5	11.08	78.2
0.901	9,431	11.27	5.13	1.94	1.20	0.90	0.65	0.54	663.4	94.4	42.3	36.8	12.59	64.4
1.000	9,113	18.09	9.67	3.70	2.13	1.48	1.13	0.91	663.4	65.5	16.5	20.3	11.19	67.7
1.101	9,266	6.89	2.71	1.61	1.26	0.98	0.77	0.64	663.4	150.0	79.4	43.3	21.68	300.0 *
1.201	9,157	6.64	3.23	1.79	1.25	0.85	0.57	0.45	663.4	150.0	79.4	38.5	10.20	151.9 *
1.300	8,795	16.21	7.26	3.78	2.74	2.03	1.56	1.09	663.4	47.4	85.0	14.5	6.90	300.0
1.400	8,763	17.61	8.50	3.96	2.66	2.13	1.67	1.33	663.4	49.3	45.6	14.5	11.09	259.9
Mean:		12.43	6.45	2.96	1.84	1.27	0.96	0.77	663.4	107.6	44.4	31.7	13.70	122.6
Std. Dev:		5.59	3.54	1.58	0.77	0.50	0.37	0.25	0.0	40.0	26.0	16.2	7.14	64.5
Var Coeff(%):		44.98	54.94	53.37	41.95	39.72	38.40	32.80	0.0	37.2	58.5	51.2	52.10	52.6

Step 3 Sampling

Use of GPR to select locations





Full Sample (mill)

X Augur location Drill log + samples 2 ft into subgrade

D DCP

Step 3 Sampling Equipment

Auger

Milling Attachment

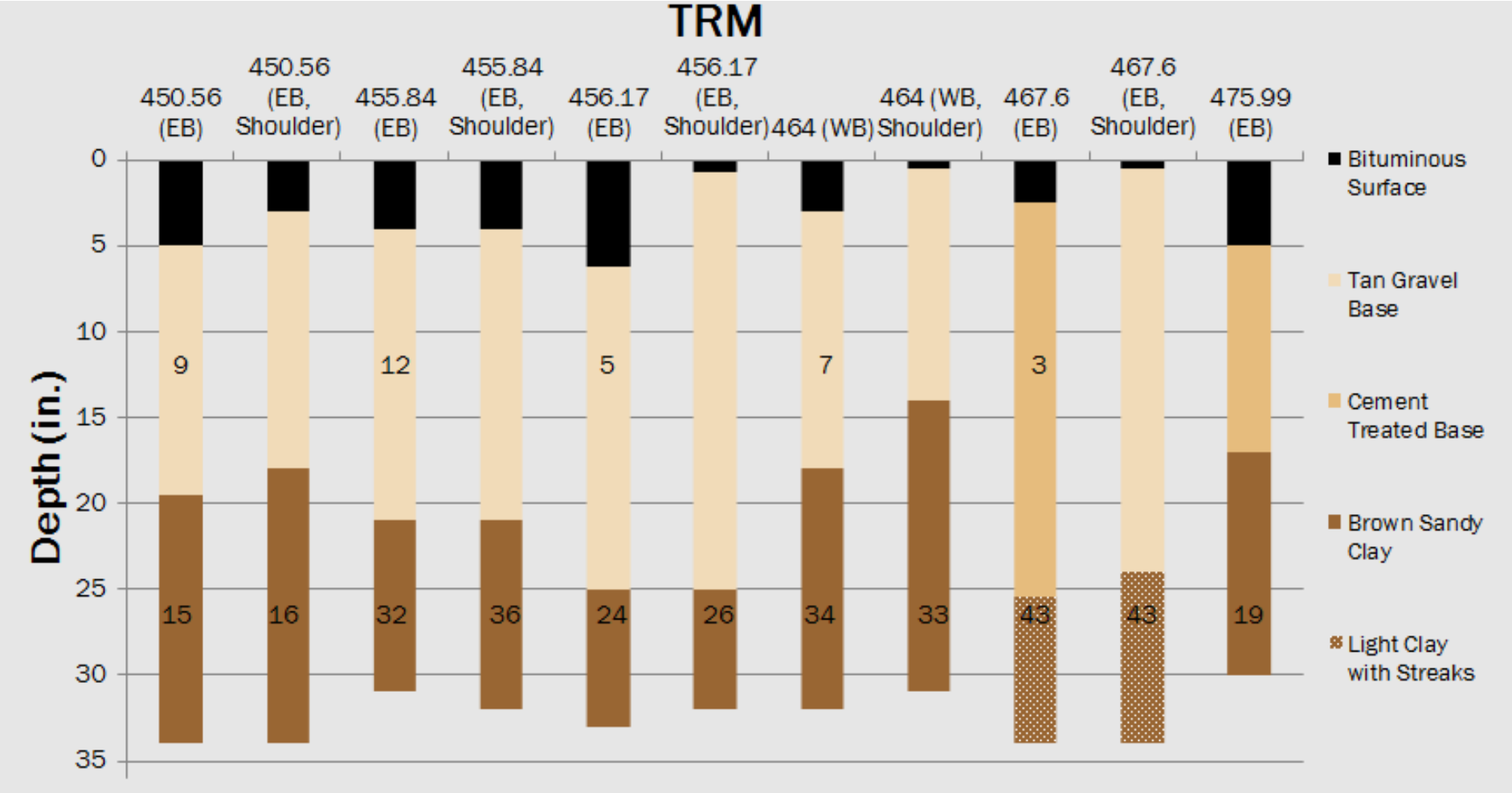
Gradall

Basic Evaluation of project and materials

a) Thicknesses, b) Base Quality c) PI, d) Drill Logs

Critical Steps in the FDR Process

Coring Log



Why so much Upfront Testing?

TxDOT's 1st foamed asphalt project (2000) < 1 year old

SEVERE RUTTING, ALLIGATOR & LONGITUDINAL CRACKING

CENTER/BETWEEN WHEELPATHS

OUTSIDE WHEELPATH

Recycled 10 inches deep - Problem: locally only 7 inches of pavement over black clay

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TxDOT's updated Stabilization

Texas Department of Transportation

Treatment Guidelines for Soils and Base in Pavement Structures

Geotechnical, Soils & Aggregates Branch
Materials & Pavements Section
Construction Division

August 2018

Proposed Roadway Sampling Recommendations

Table 5. Sampling Roadway Materials.

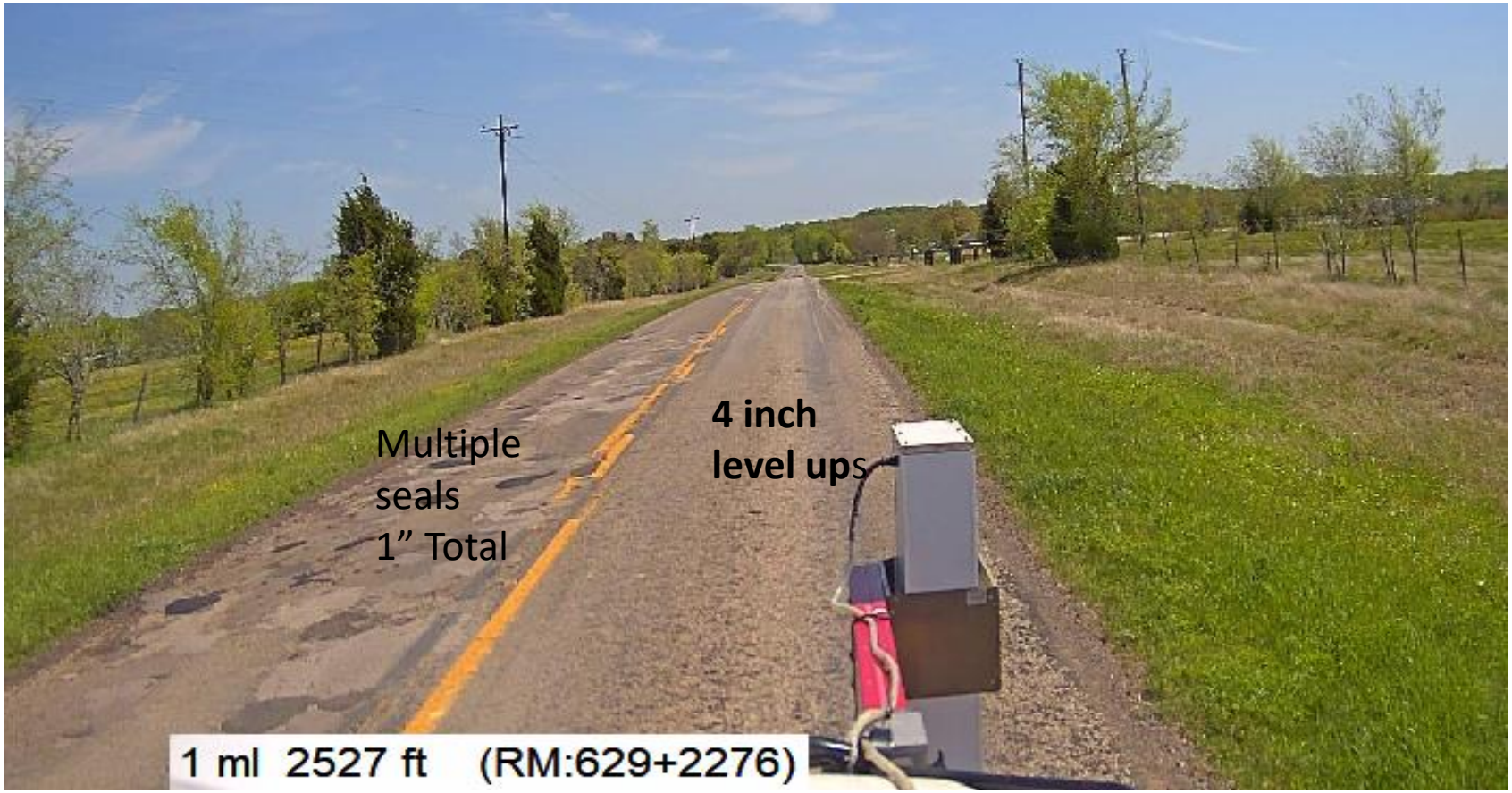
Step	Recommended Approach	Acceptable Approach
1	Obtain historic plans. Conduct GPR survey.	Obtain plans and maintenance history.
2	Using plans and GPR survey, determine critical locations for sampling. Cover expected range of RAP and total pavement thickness.	Unless otherwise determined from plans and maintenance history, perform drill logs at 1 mi. spacing of the pavement structure including at least the top 10 in. of subgrade. For short projects (< 1 mi.), sample and log a minimum of 3 locations.
3	Sample and log each location to include at least the top 10 in. of subgrade.	Review drill logs. Select locations representing significantly different materials for follow-up bulk sampling.
4	At each location of significantly different materials, use a small recycler or auger to obtain samples of materials expected in the road-mix. Typically, the top 8 to 10 in. of pavement contains these materials.	At each location of significantly different materials, use a small recycler or auger to obtain samples of materials expected in the road-mix. Typically, the top 8 to 10 in. of pavement contains these materials.
5	If RAP exceeds 2 in. in the existing pavement, maintain the RAP and salvage base separately.	If RAP exceeds 2 in. in the existing pavement, maintain the RAP and salvage base separately.
6	Collect approximately 400 lb. of sample for each set of different materials requiring a mixture design.	Collect approximately 400 lb. of sample for each set of different materials requiring a mixture design.

Case Studies

1. FM 3080 Tyler
2. SH 176 Odessa
3. SH 302 Odessa

- Is this an FDR Candidate
- Will one design work throughout
- Where to pull samples
- What recommendations for lab testing

FM 3080 Tyler District



Districts first Asphalt FDR project to be done with in house forces as a demo

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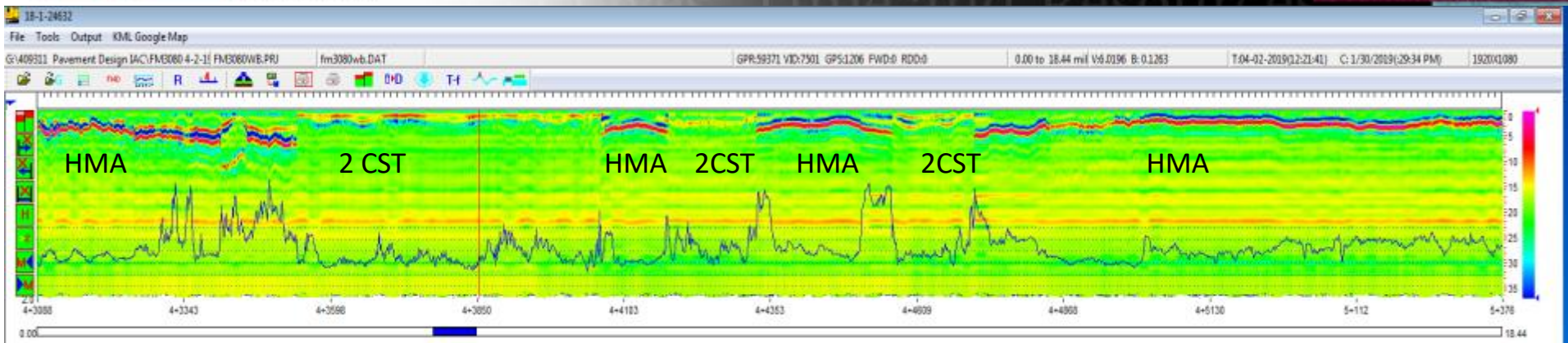
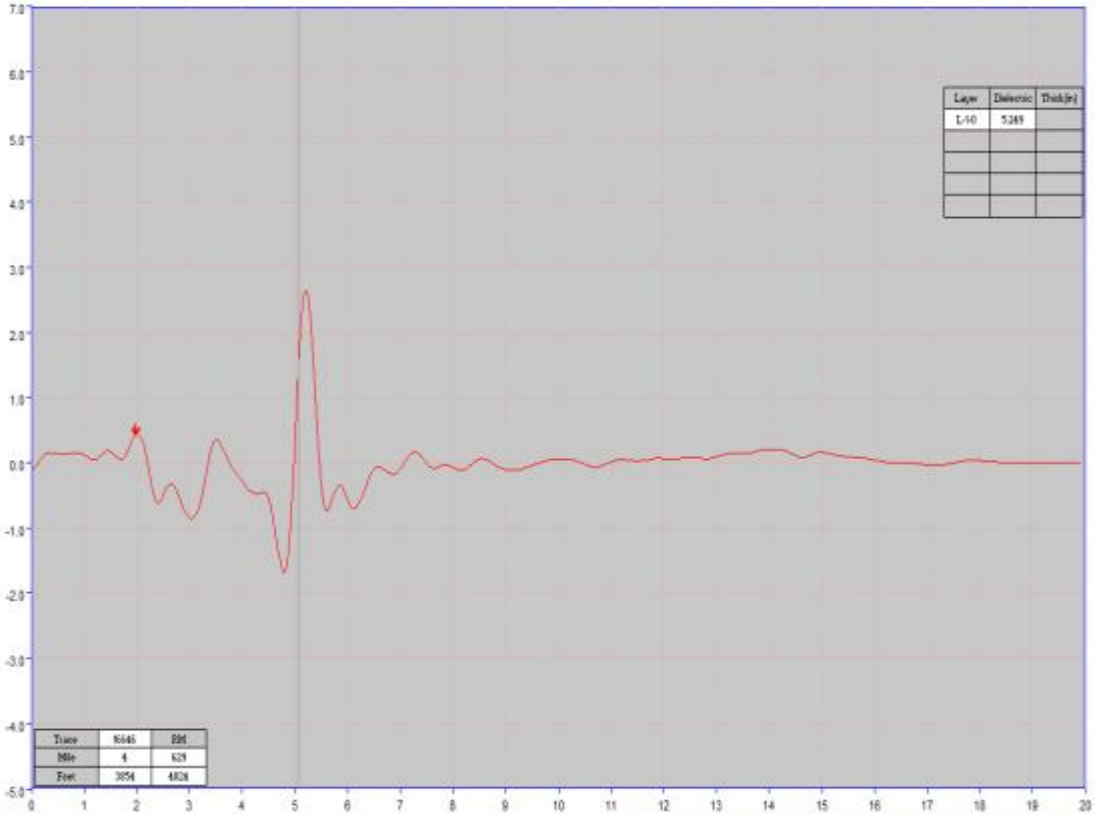
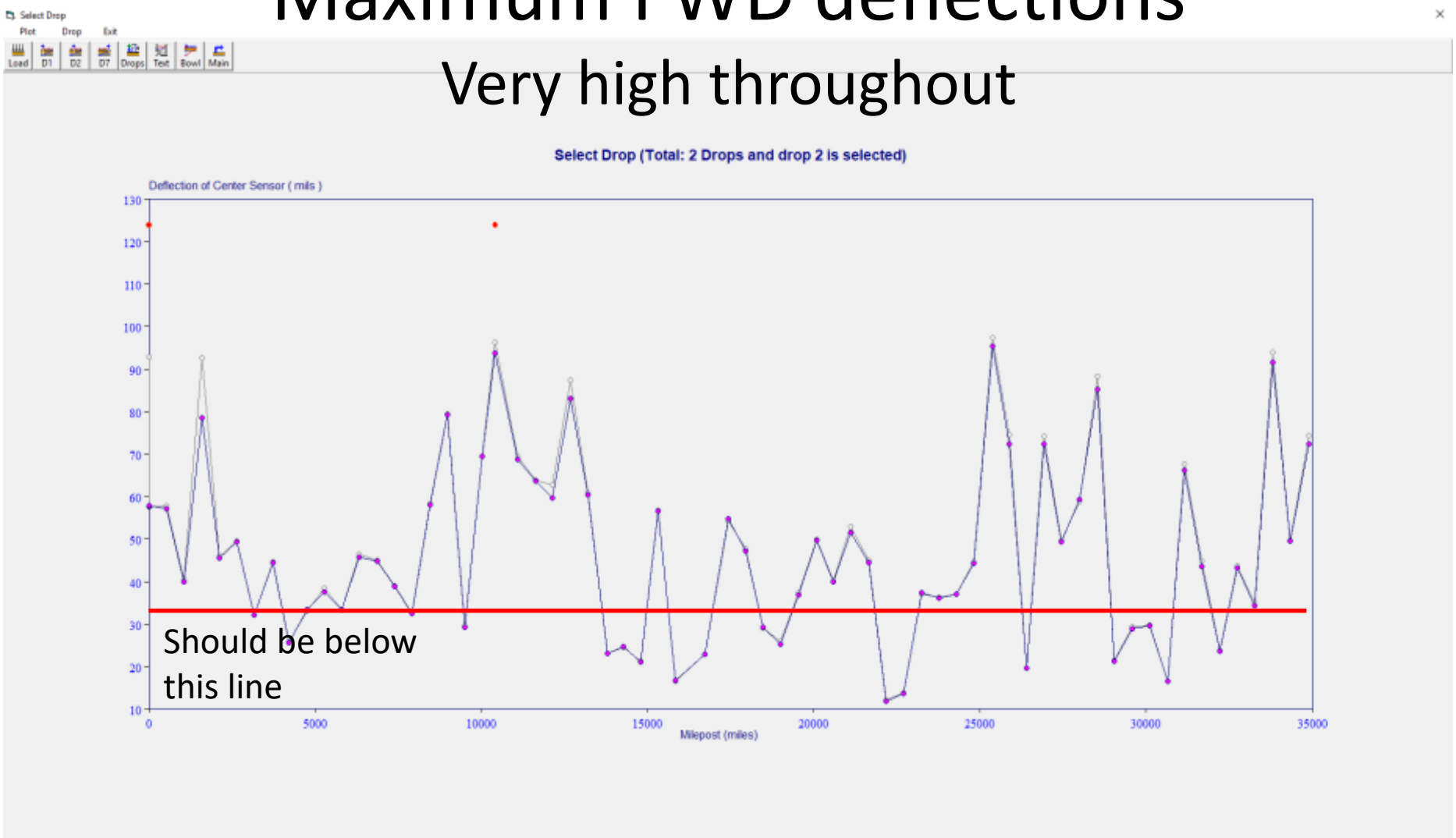




Maximum FWD deflections

Very high throughout



Sampling location 2 at TRM 630

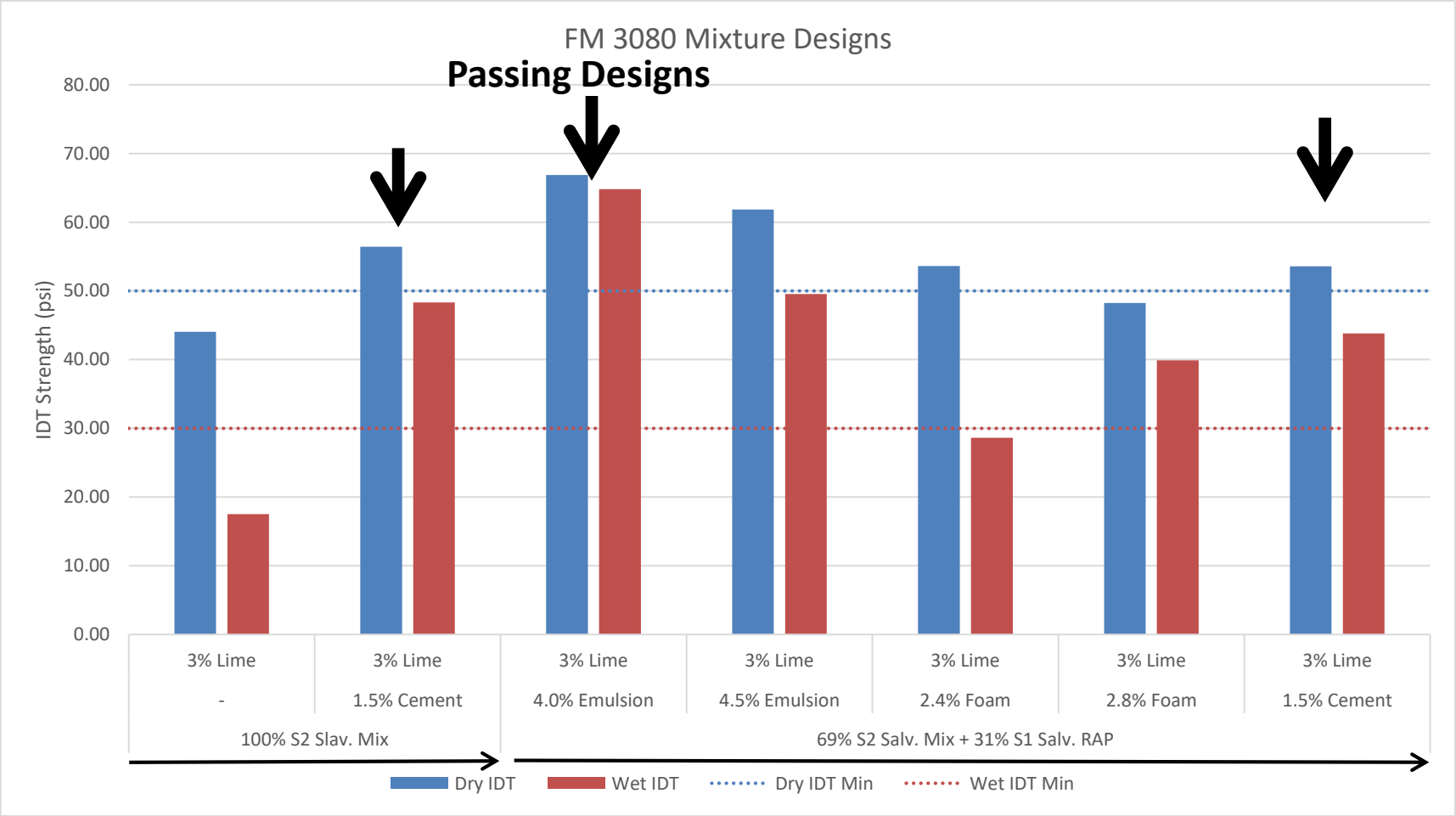
Typical bad location 1” seals + 10 inch clay contaminated gravel base

Milling machine to pull samples
For lab FDR

Materials from Location 2
Poor gravel base and Clay subgrade

Clay Contaminated Gravel base PI = 20 Field Moisture content around 10%

Lab results from FM 3080



In House Project **Add 3 inches of RAP treat 10 inches with 3% lime** **Next day Emulsion**

In House Construction (Fall of 2019)

- Add 3” RAP from stockpile
- Pretreat with 3% lime
- Treat with 4% emulsion

Two miles of 6 completed

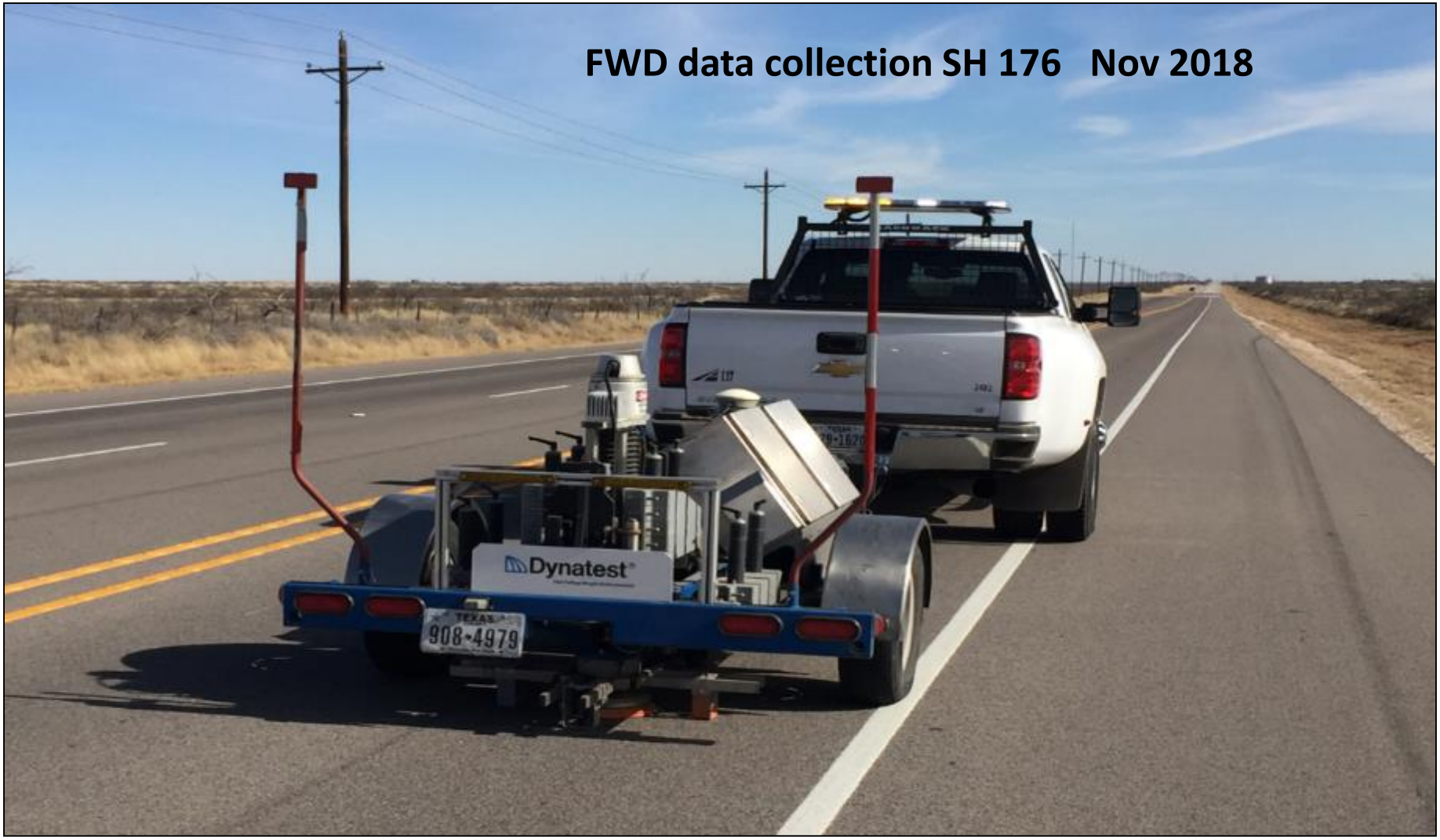
Project winterized till spring 2020

SH 176 Odessa Nov 2018
Damage shortly after construction

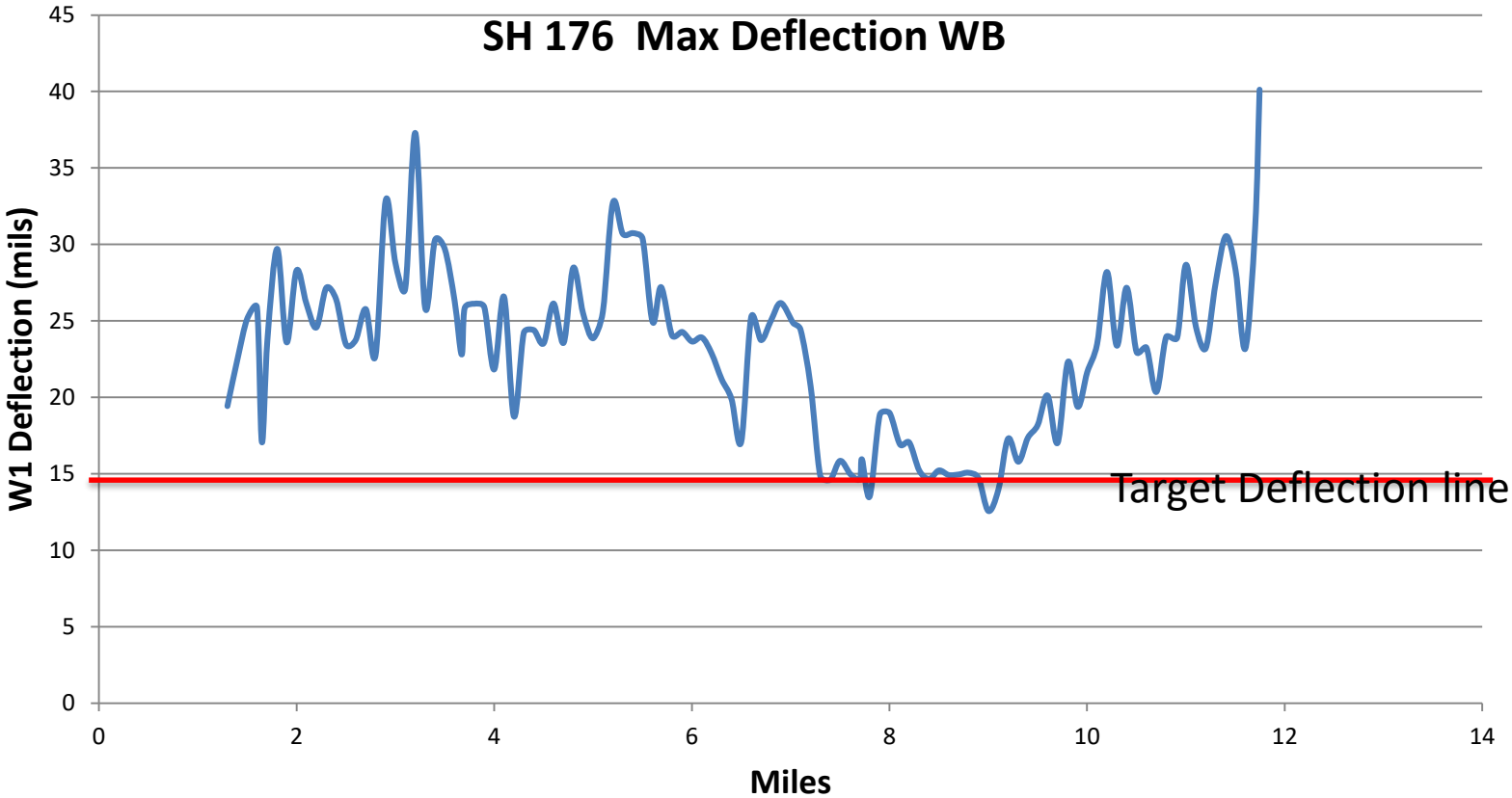
Location WB 1
NM state line

Location WB 3
HazMat Repair area
4 inches of HMA

Location EB 4



FWD data collection SH 176 Nov 2018



Based on Design assumptions deflections should be below red line
Pavement substantially weaker than designed

Layer Moduli from Modulus7

Adjusted Mean Moduli (ksi)	1399.10	30.89	0.00	27.48

Base **Subgrade**

Assumed Design Values **70 ksi** **30 ksi**

Subgrade good (similar to design assumption)
Weak base is the cause of high deflections
Either base is wet or base is low quality **Probably both**

Other Observations – Location 4 EB

In-situ moisture content 8.7% in flex base layer

Seal easily peeled up by hand throughout project extents

Preliminary Lab strengths on Flex Base

Item 247 Grade 1 and 2 Requires 35 psi minimum

SH 176 – 10.1% OMC & 124.0 pcf Max Dry Density

0 psi confining pressure Tx-117-E Part II (molded sample sit at room temperature inside triaxial cell for 24+/- 1 hr)

- Sample 1 Corrected stress, psi. – 11.9
- Sample 2 Corrected stress, psi. – 11.1

Conclusion SH 176 The base is the problem

Placement of Foamed Asphalt Test Section

- 1% Cement + 3.2% Foamed Asphalt (based on lab testing)
- Placed April 30 – May 1, 2019
- Opened to traffic each evening
- One-Course placed May 2, 2019

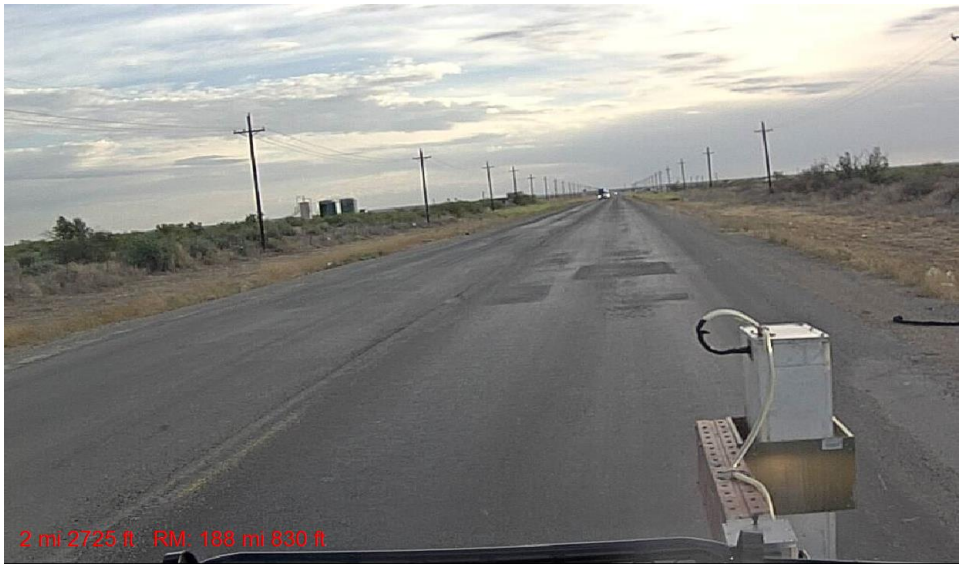
Mix in cement, foamed asphalt, and compaction water in 1 pass operation

SH 176 1500 ft In house test section

Failed section with very poor Base 1% Cement and 2.4% Foam (PG 64-22)

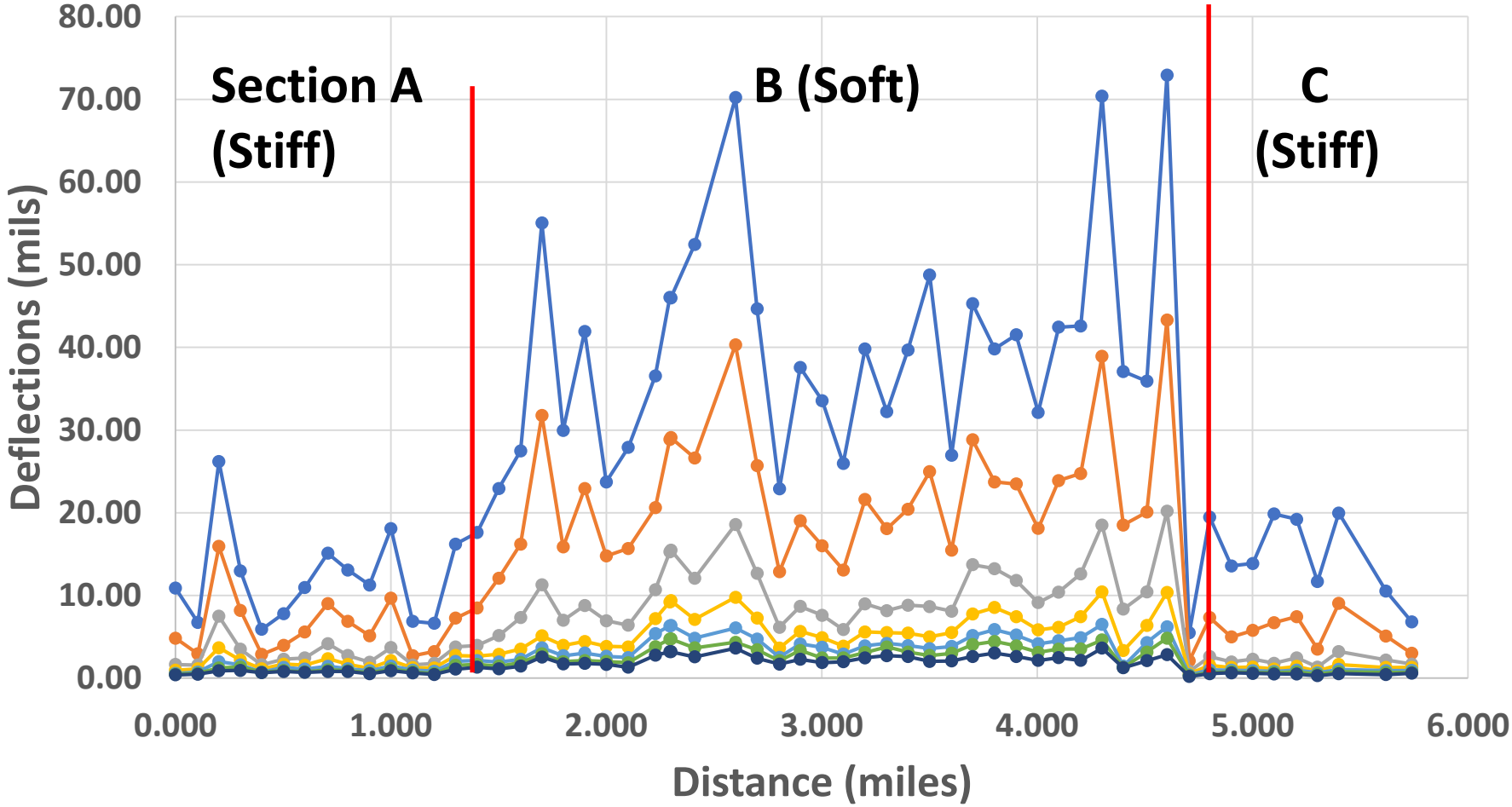
<u>High Modulus Waterproof bases with no cracking</u>

SH 302
In middle of energy sector
ADT 50% trucks - 20 million ESAL's
6 mile long



1.5 inch of multiple seals over two flex base layers

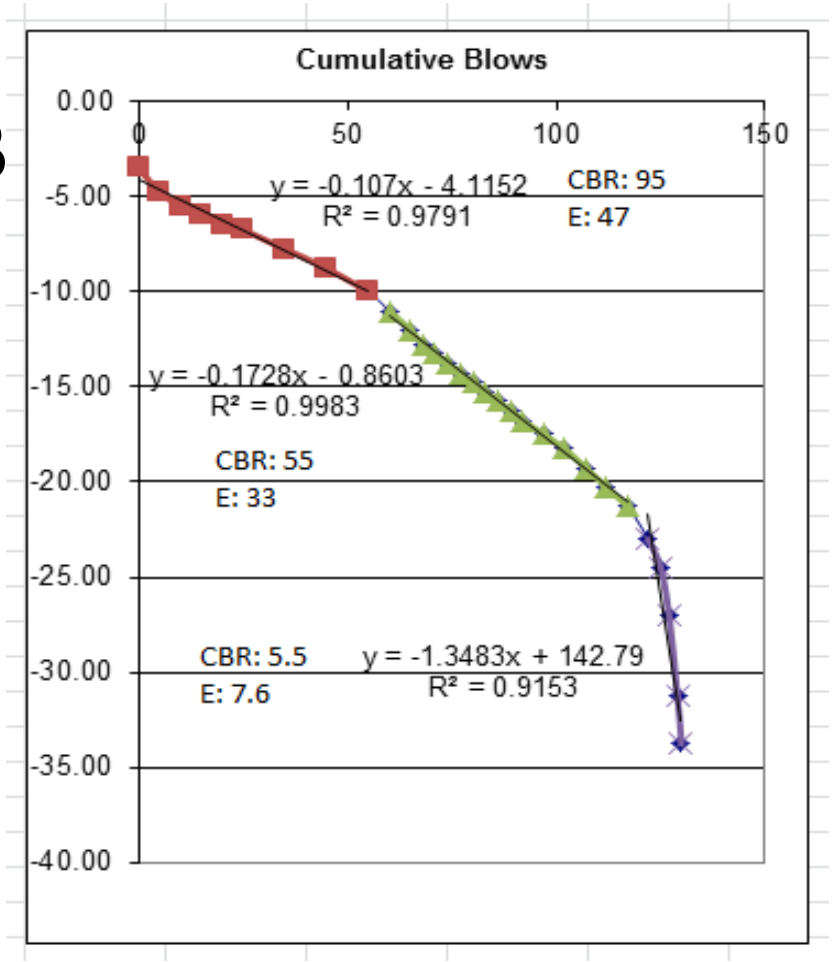
SH 302 Odessa Deflection data



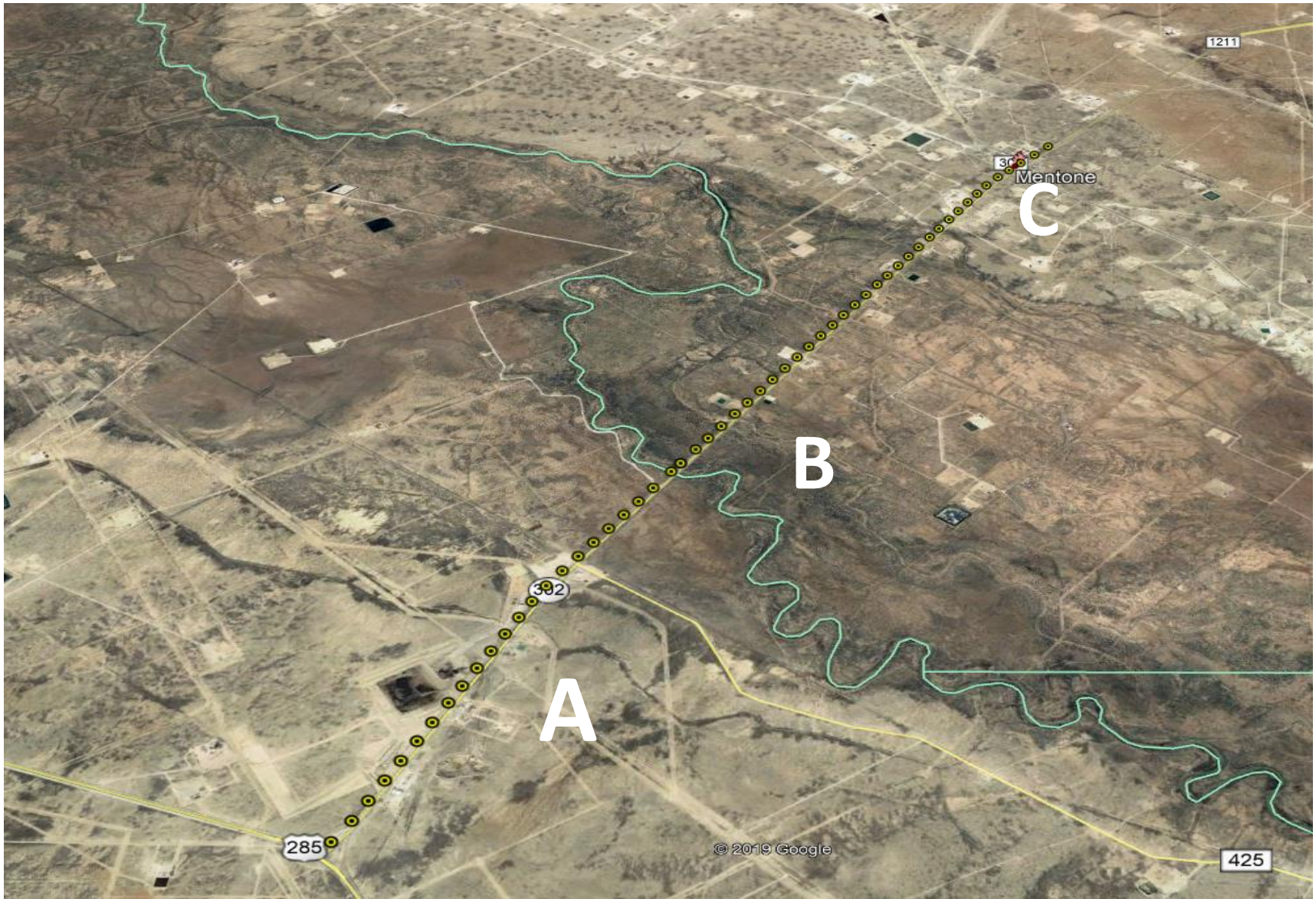
Project with Large variation in Strength (Different rehab for each)

Section B

Sampling and DCP Testing



Clay Contaminated base
Turns to Jello 2 ft down


1211
Mentone
C
B
A
302
285
© 2019 Google
425

Laboratory Results

Section	% Residual Emulsion	Cement %	Lab Dry* IDT (psi)	Lab Wet* IDT (psi)	Min Dry IDT (psi)	Min Wet IDT (psi)
A and C	2.4	1	94.0	71.4	50	30
B	2.4	1	51.2	15.3	50	30
B	2.4	1	52.6	18.9	50	30
B	2.4	2	67.0	29.7	50	30
B	0	2	38.8	26.1	50	30
B	0	4	46.1	27.8	50	30

* As per Special Spec Average of 3 samples

Section A and C **Great Results**

Section B **Marginal (use existing as foundation layer)**

Pavement Design Summary Sections A and C

Superpave	Base Type	Subbase	Approach
4 inches = 20 years time to first overlay	8" Emulsion treat existing HMA and base (and widened section)	Existing	Widen first with flex base say 12" (two six inch thick lifts) – ensure lower lift is well compacted). Stabilized full width with emulsion

Section B (Swamp section)

Superpave	Base Type	Subbase	Approach
4 inches = 17 years time to first overlay	Add New base 8" inches thick - emulsion treat	Stabilize 8 inches deep full width 2% Cement	Widen first, cut 12 inches deep, add Geogrid, 4 inches of Bull rock and 8 inches of flexible bas
4 inches = 22 years time to first overlay	Add New base 8" inches thick - emulsion treat	Stabilize 8 inches deep with 2% Cement and 2.4% residual emulsion	Same as above

More Discussion on this section later

Conclusions

- Upfront testing is important in order to
  - Select sampling locations
  - Avoid surprises in construction
  - Part of the structural evaluation to determine if this highway is suitable for either FDR or CIR
  - Basic tests indicate what combination of stabilizers to try in the lab
  - Do not go to construction without a passing mix design