EVALUATING THE PERFORMANCE OF GEORGI
PAVEMENTS USING
GROUND PENETRATION RADAR (GPR)

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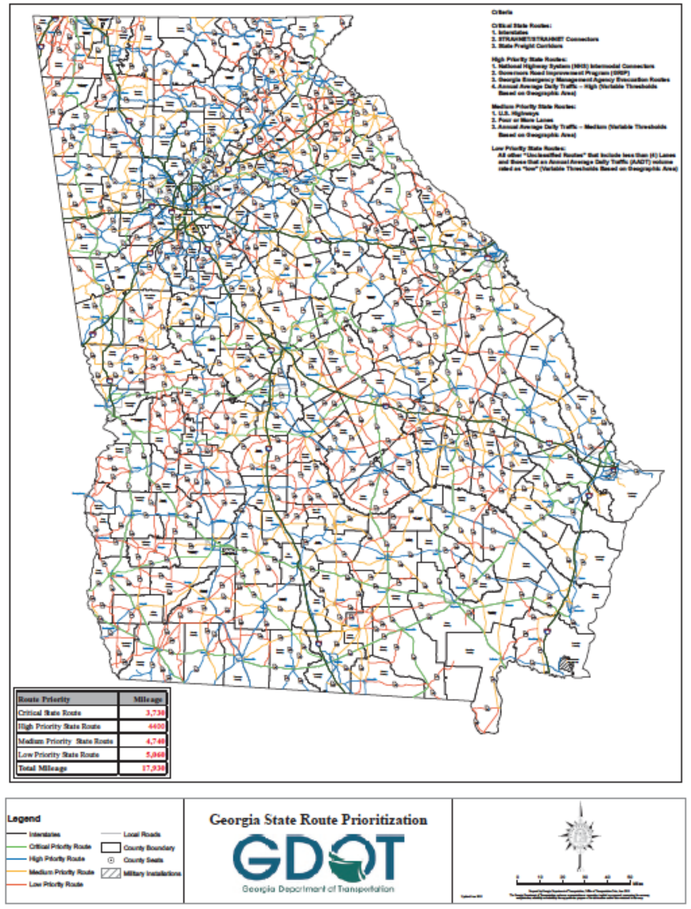
How Can Ground Penetrating Radar Serve Transportation Agencies?

Georgia Roadway Network

How can GPR be utilized for Asset Management?



128,620 total miles (7th largest in US)

Average investment in routine maintenance projects is $422M

What is Ground Penetration Radar (GPR)?

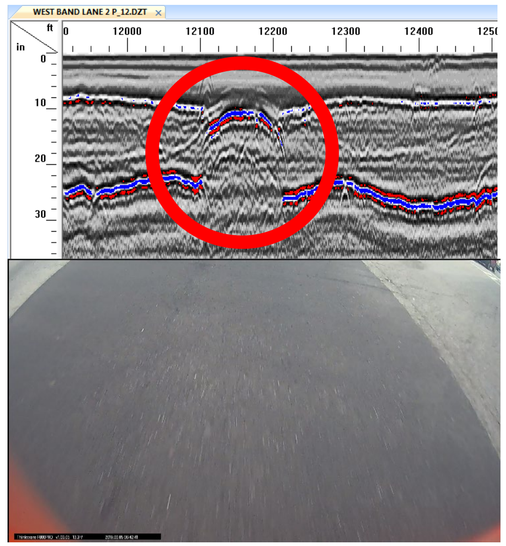
What is GPR?

GPR is one of the Non-Destructive Testing (NDT) methods used to investigate subsurface condition without drilling, digging, etc.

Ground Penetrating Radar

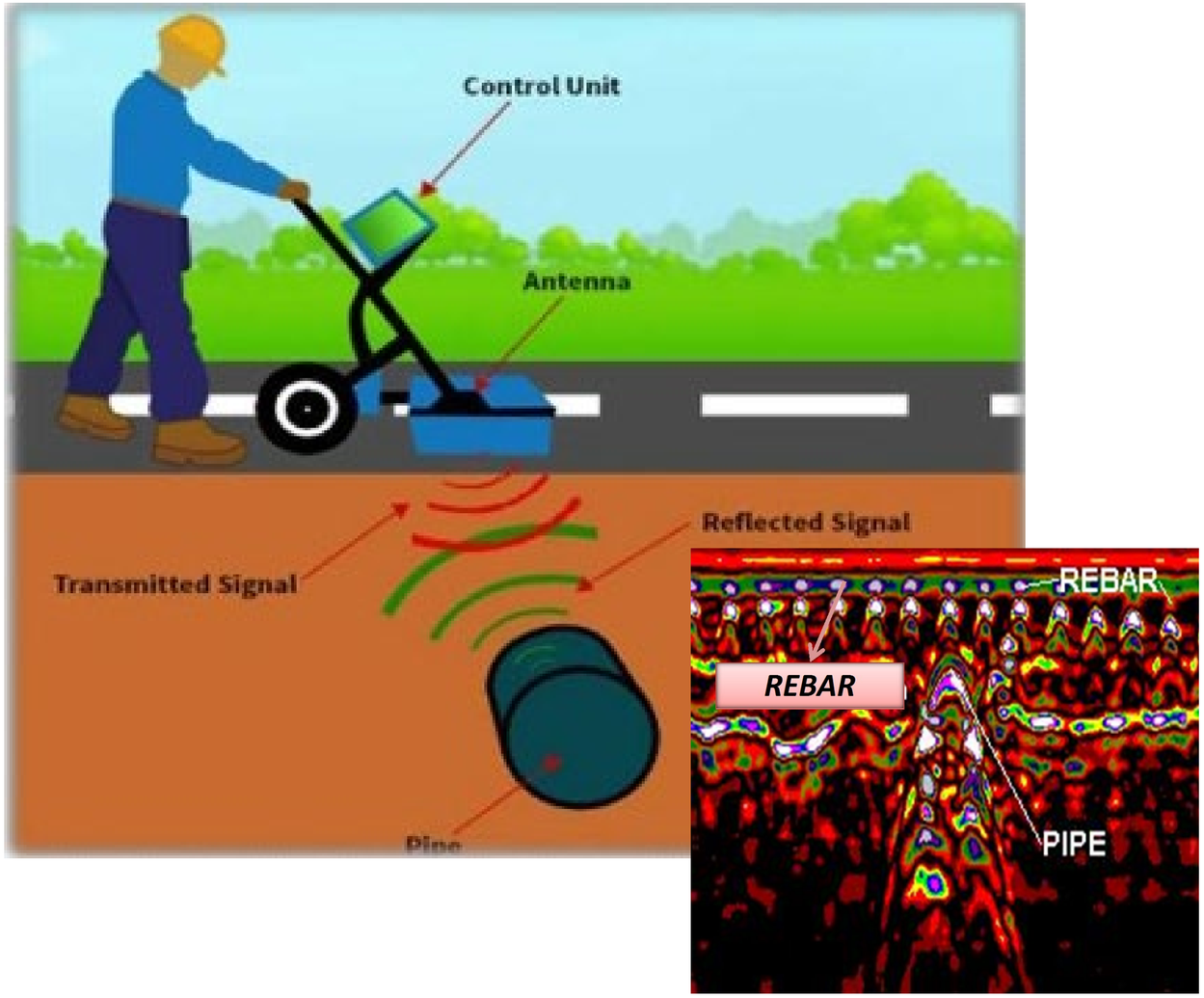
GPR can be a valuable resource for:

- Investigating Pavement Performance and Instituting Design Changes
- Performing Forensic Investigations to Determine Causes for Pavement Failures
- Identify Future Pavement Distresses Before They Occur



How does GPR Work?

Ground Penetration Radar (GPR)

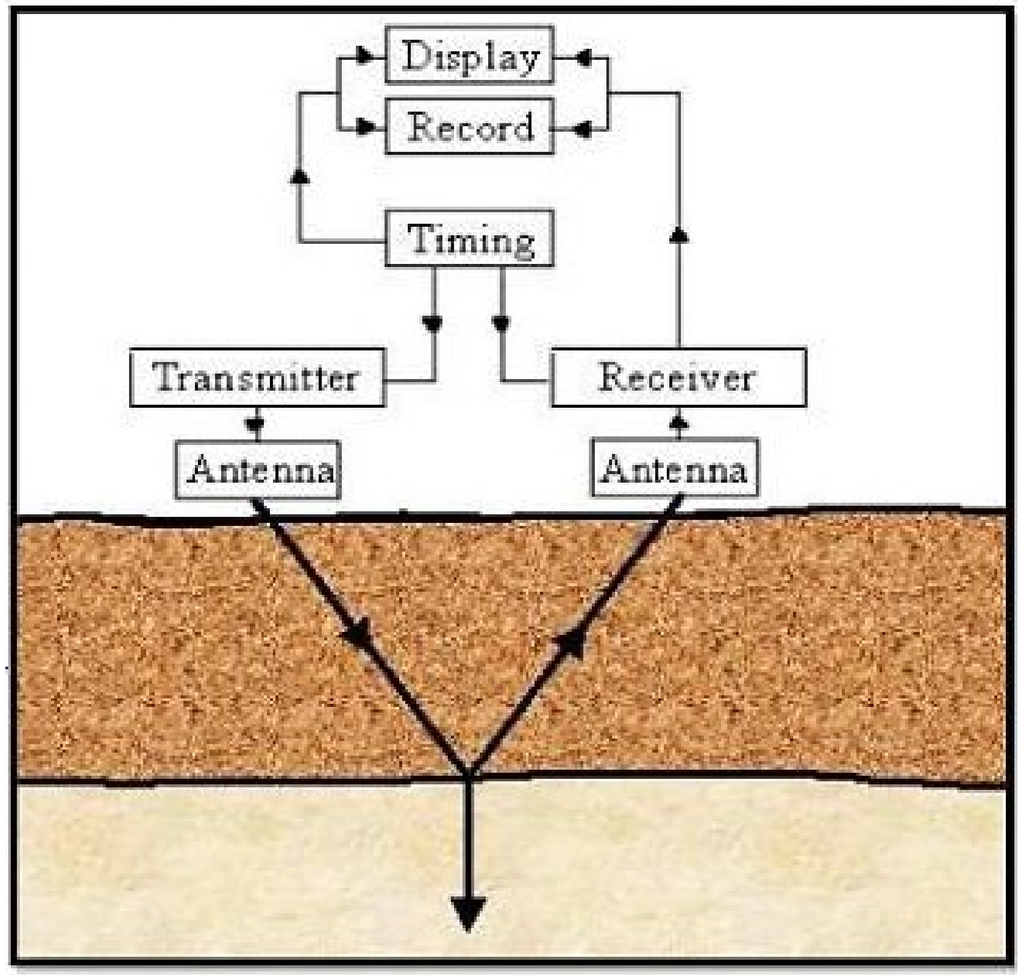


GPR is a geophysical method that uses radar pulses to image the subsurface.

GPR detects buried objects, pipes, voids, cracks, embedded reinforcing steel, groundwater levels, ice thicknesses.

GPR can be used in a variety of media, including rock, soil, ice, fresh water, pavements and structures.

GPR Working Principle



- An EM pulse is sent through an antenna, penetrating into the surveyed material.
- A portion of the energy is reflected back to the antenna when an interface between differing materials is encountered.
- Target depth is proportional to the time taken for the signal to travel down and back to a given layer.

GPR Working Principle

Each material in the ground is governed by two physical properties of material:

Electrical Conductivity

Measure depth of scan

Higher conductivity makes radar signal penetration difficult

The less water content of material; the less conductivity, and the deeper penetration into the ground!!!

Dielectric Constant

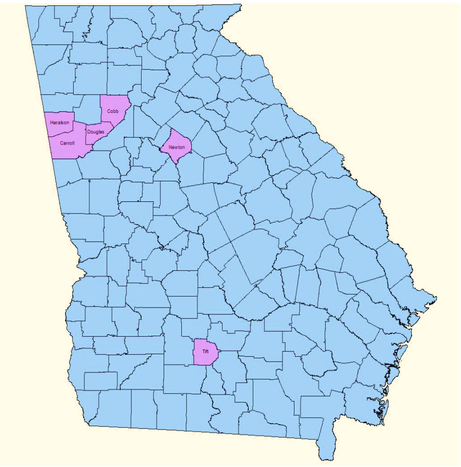
Show how fast GPR energy is moving over a material by *descriptive numbers*.

Ranged from 1 for air to 81 for water!

The higher the dielectric constant number (wet material), the slower the GPR energy travelling!!!

Investigating Pavement Performance

Case Study #1 - Evaluating Georgia Pavements



Project Locations

- Six Sites were investigated.
- Each site was divided four segments through 1 mile.

Site 1

Site 3

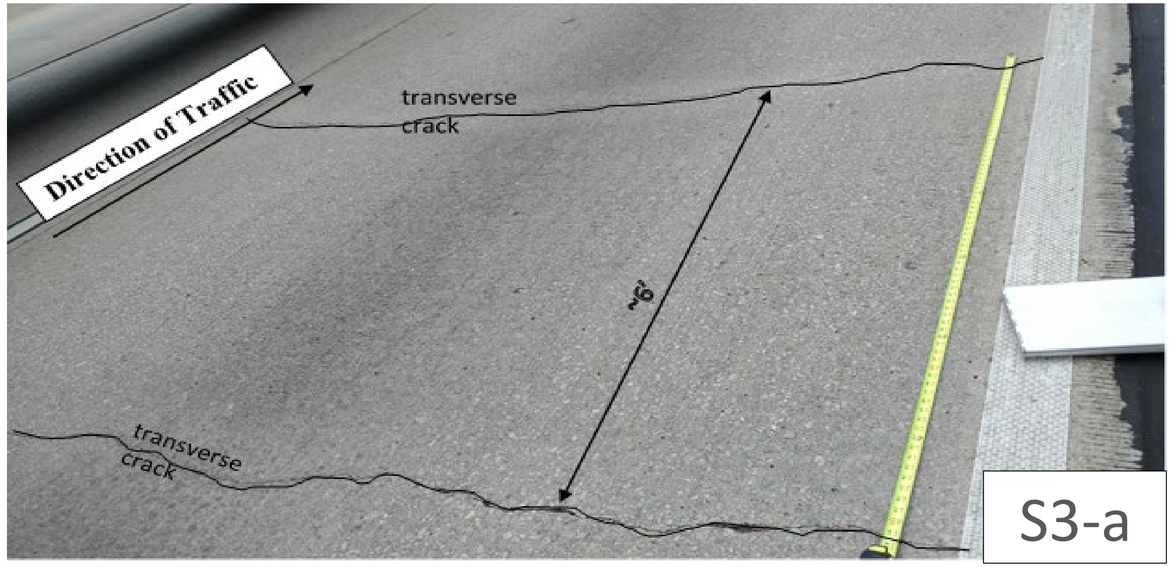
Site 5

Site 2

Site 4

Site 6

I-20 CARROLL COUNTY



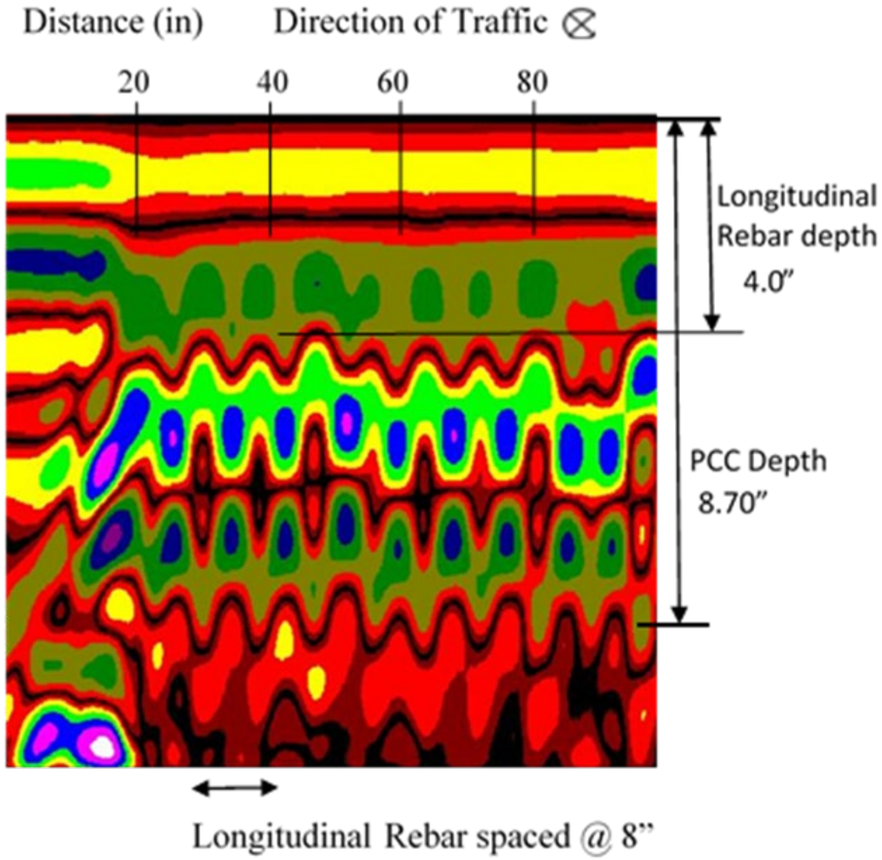
S3-a

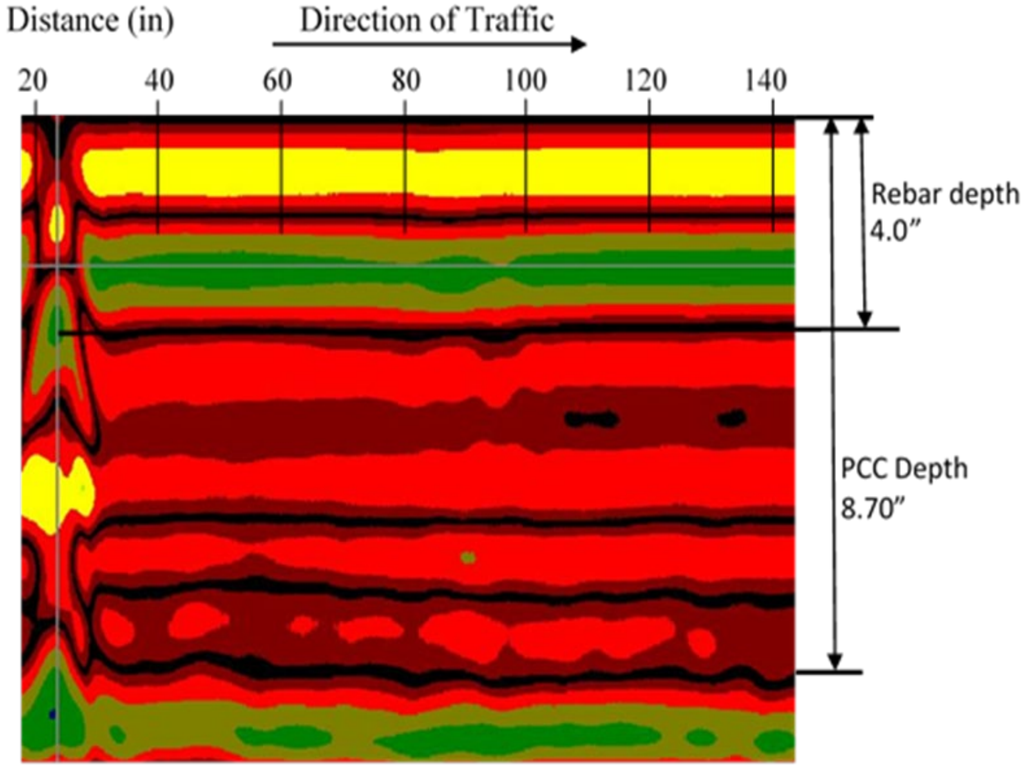
S3-a

S3-c

I-20 CARROLL COUNTY

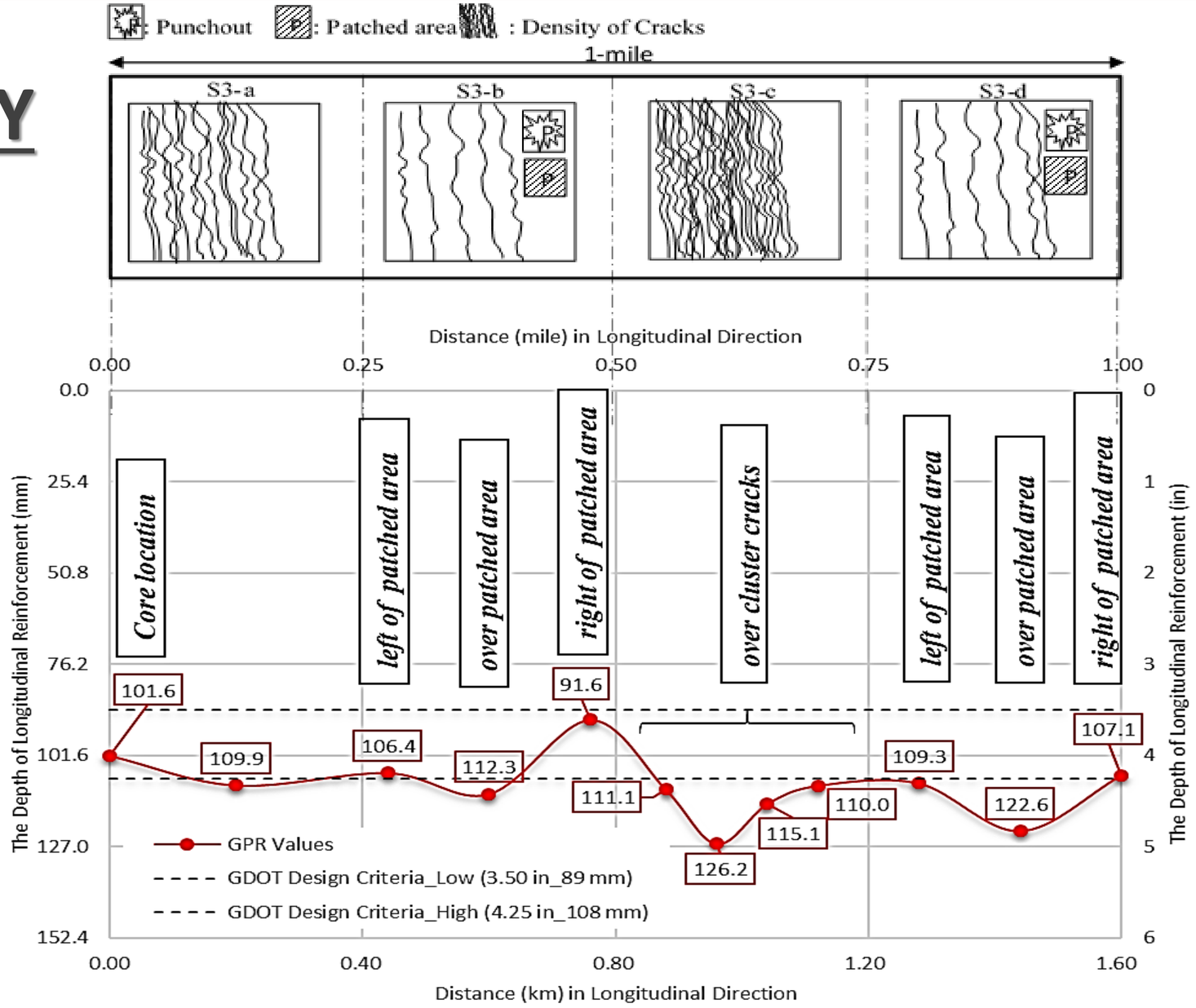
I-20 CARROLL COUNTY





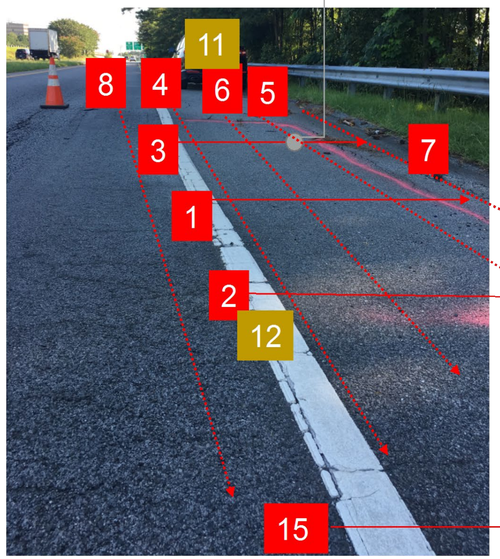
I-20 CARROLL COUNTY

Crack Pattern and Concrete Cover in Longitudinal Direction in Each Segment Along 1-mile



Forensic Investigation

I285/I85 Interchange



900 Hz scans

400 Hz scans

Core #1

Core #1

Core #3

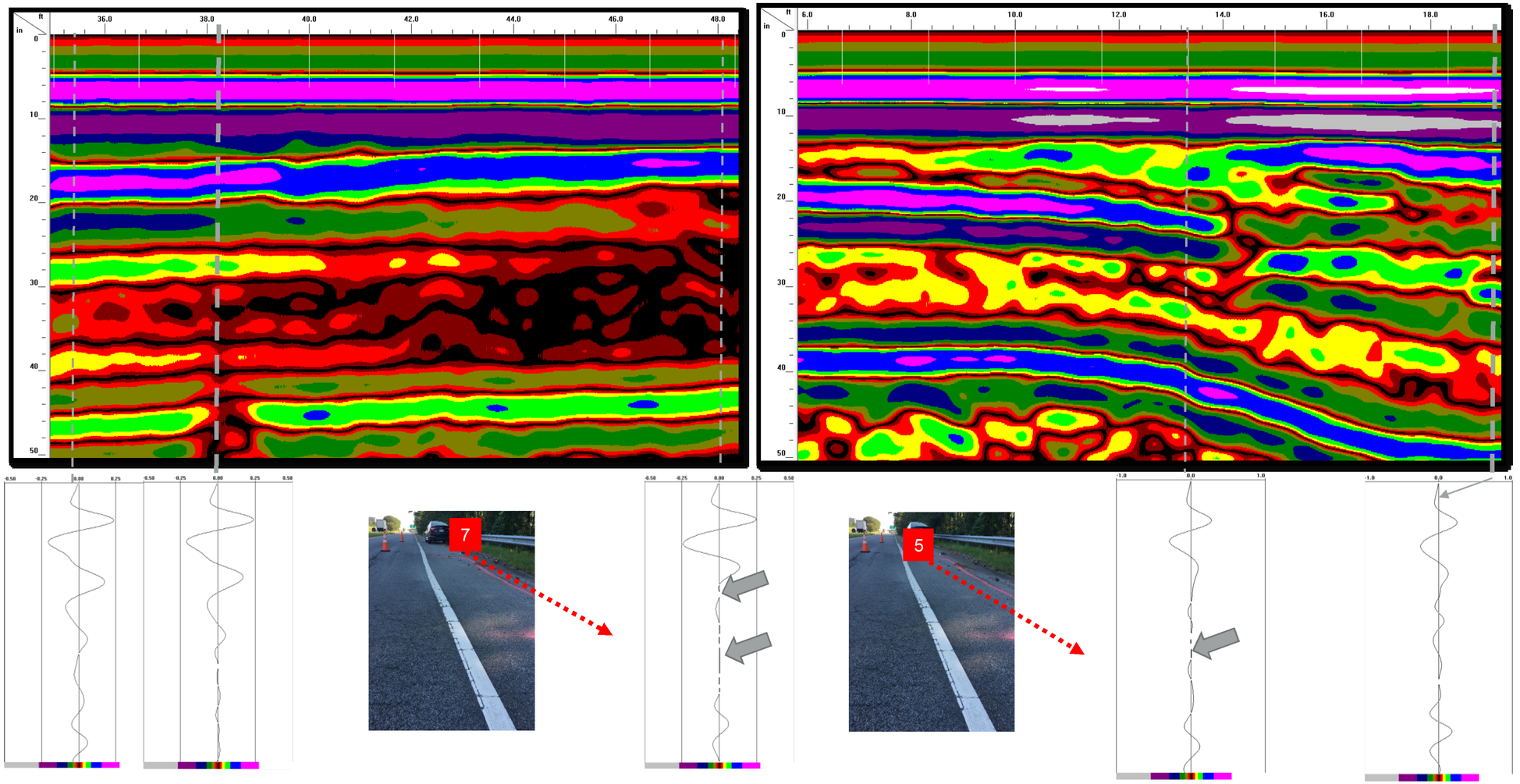
Core #3

Core #2

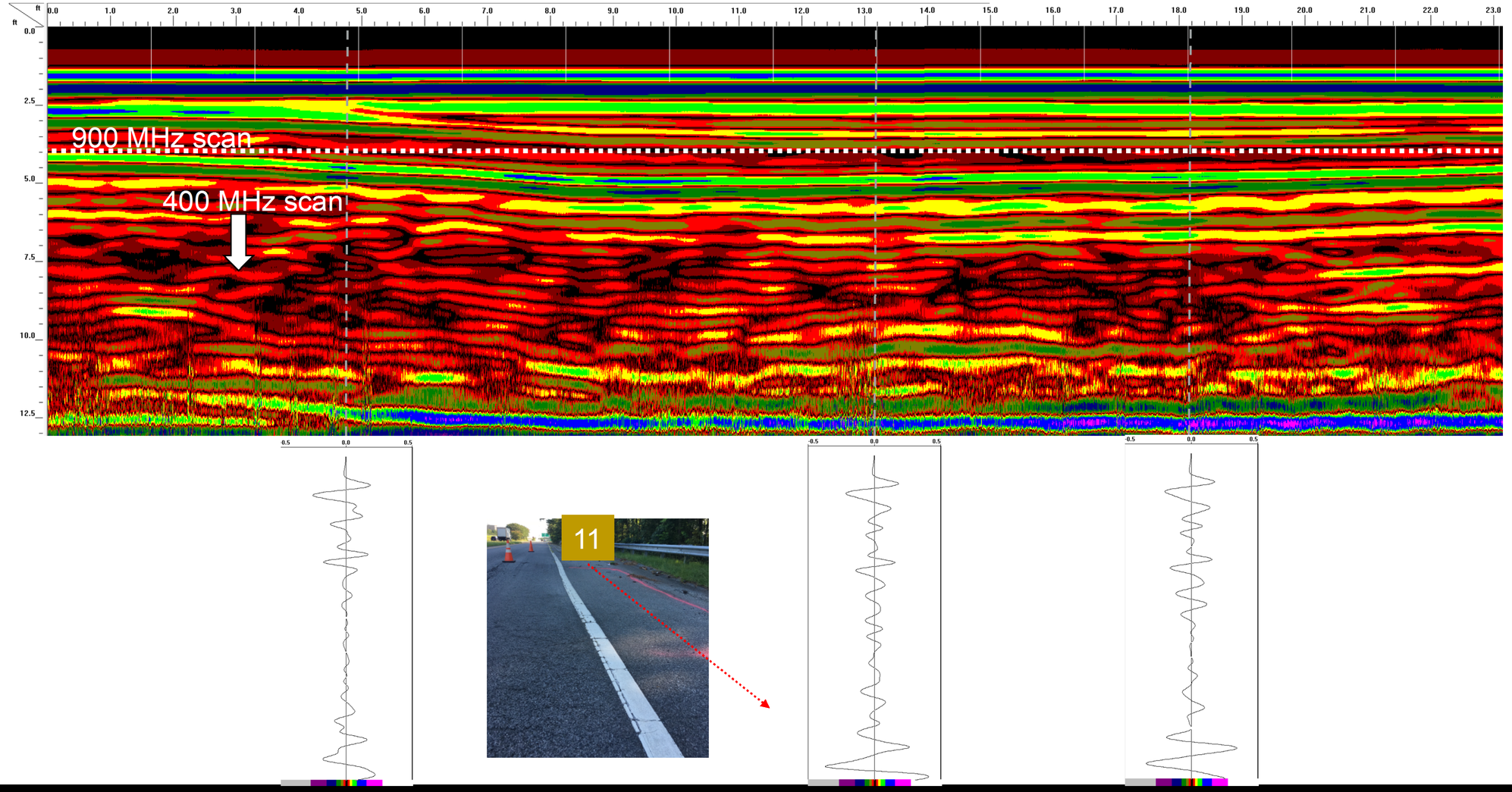
Core #2

Core #2

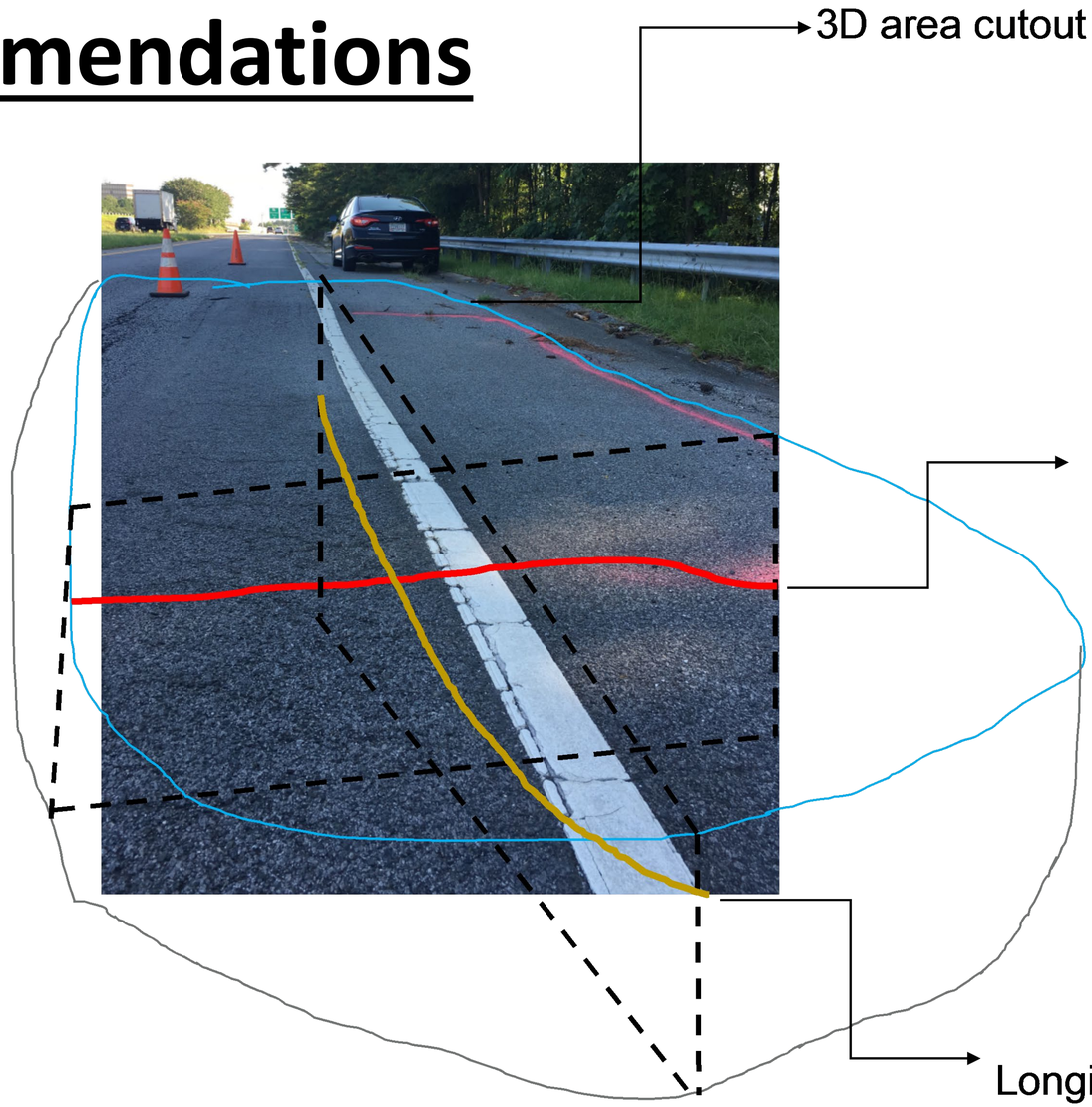
GPR Scan #7 and #5



Findings - Deep Scan

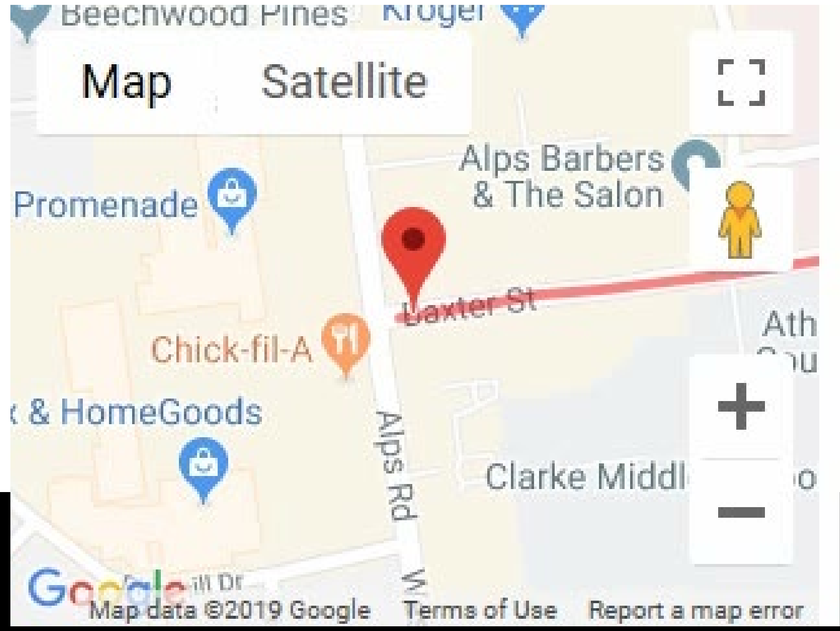


Recommendations

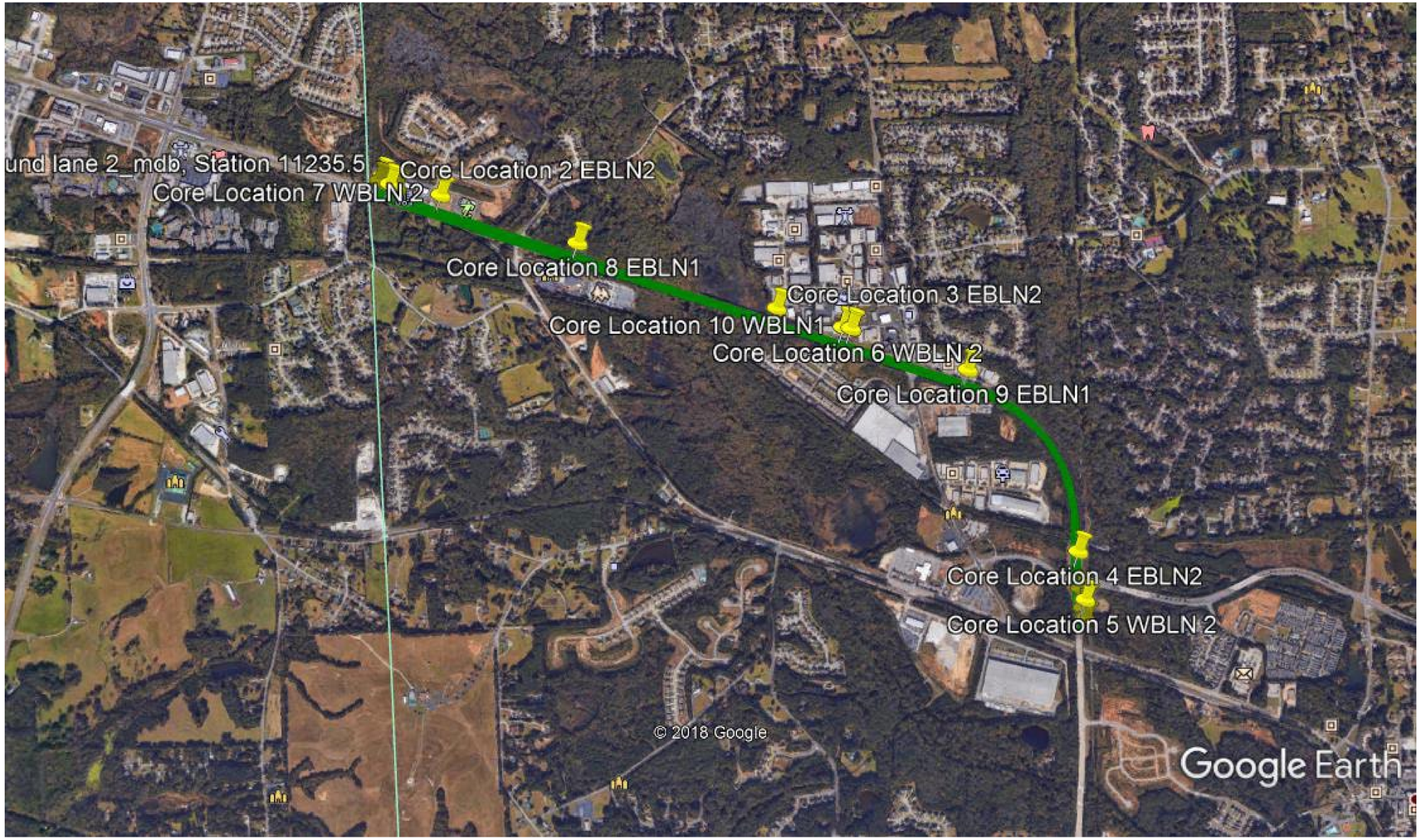


Using GPR to Identify Pavement Failure Due to Subsurface Issue

GPR Scan at Highway Speed



Case Study - SR 6, Cobb County, GA

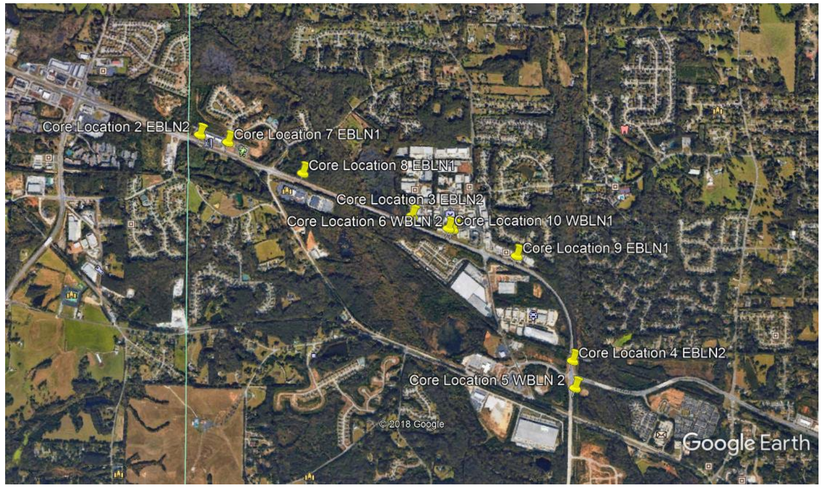


The team scanned 4 longitudinal sections in 30 min.

1. EBLN 1
2. EBLN 2
3. WBLN 1
4. WBLN 2

GDOT Coring Data

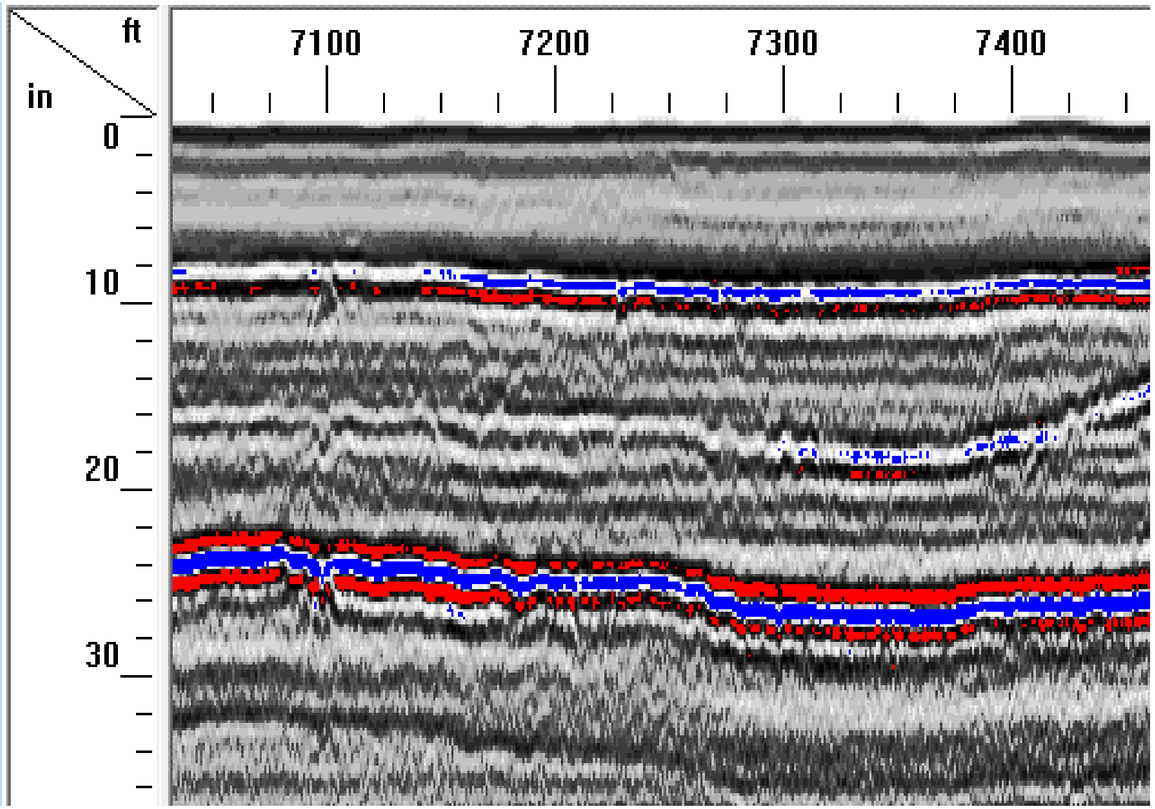
9 cores were extracted from tested sections, the material is found to be AC with an average thickness of 8.25in.



Locations and findings are as illustrated in the table

Core ID	Lane	Location		Material	Thickness (in)
		Lat(°)	Long(°)		
2	EBLN2	33°52'52.92"N	84°43'25.70"W	AC	8.00
3		33°52'35.51"N	84°42'30.83"W	AC	8.40
4		33°52'4.35"N	84°41'49.22"W	AC	9.25
5	WBLN2	33°51'58.52"N	84°41'48.64"W	AC	9.75
6		33°52'32.62"N	84°42'20.31"W	AC	7.25
7		33°52'51.30"N	84°43'18.43"W	AC	8.50
8	EBLN1	33°52'44.68"N	84°42'59.10"W	AC	7.50
9		33°52'26.89"N	84°42'3.77"W	AC	8.25
10	WBLN1	33°52'32.79"N	84°42'21.41"W	AC	7.00

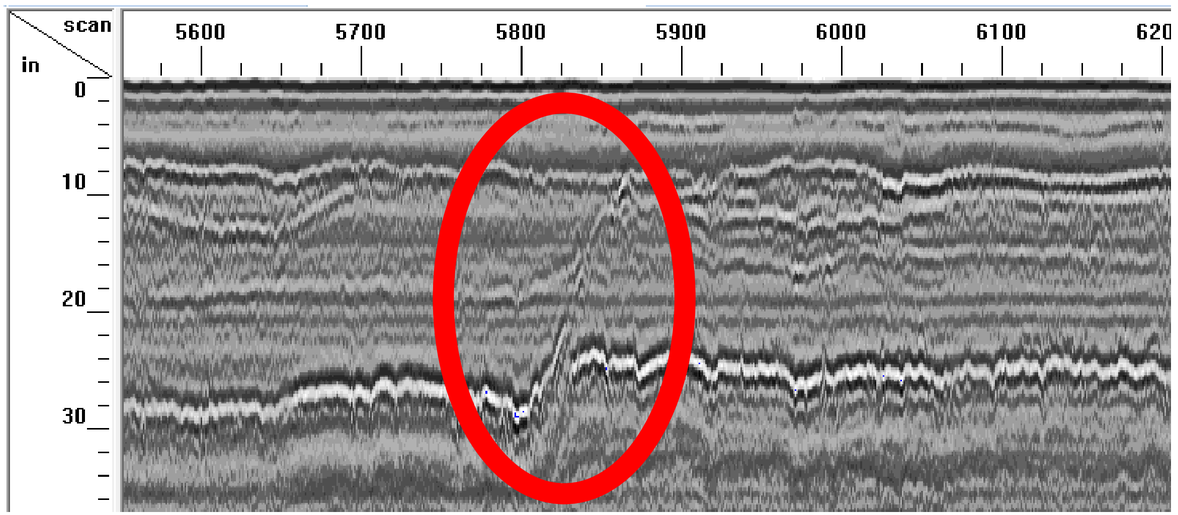
GPR Scan - Example WBLN 1

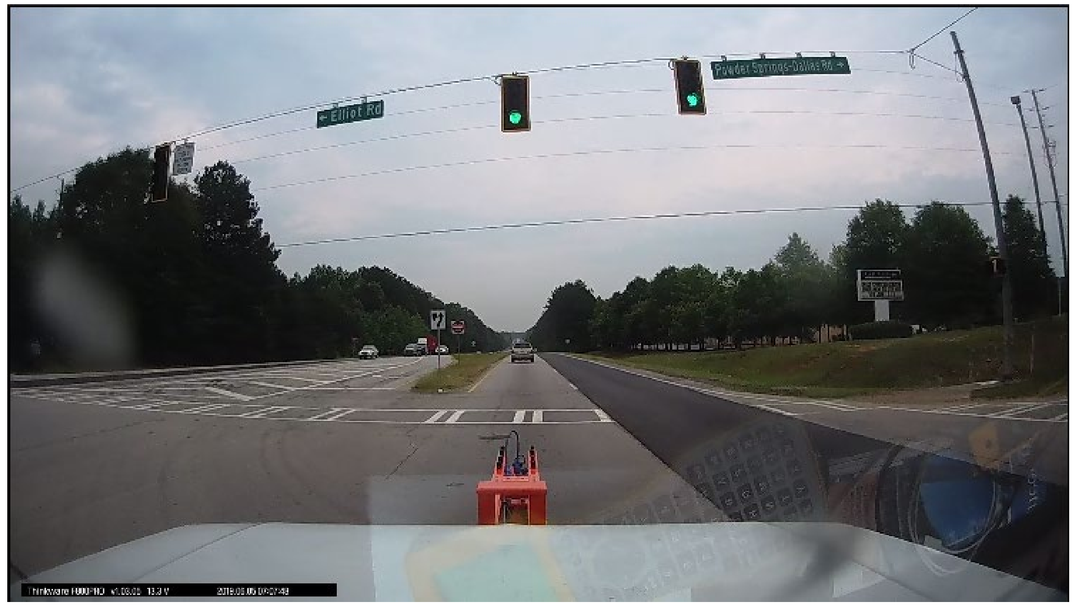


Layer	Thick (in)	Density (pcf)	Dielectric const.
AC	8	--	5.73
GAB	6 - 10	128	4.42
Subgrade	6 - 10	123	19.04

Unknown

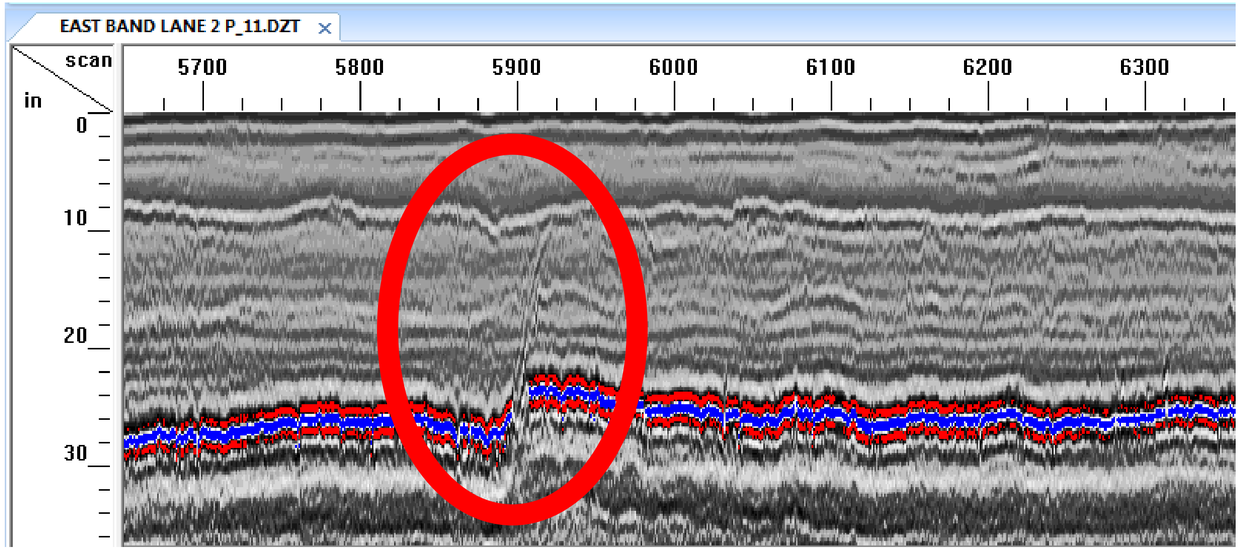
GPR Scan Findings – EBLN 1

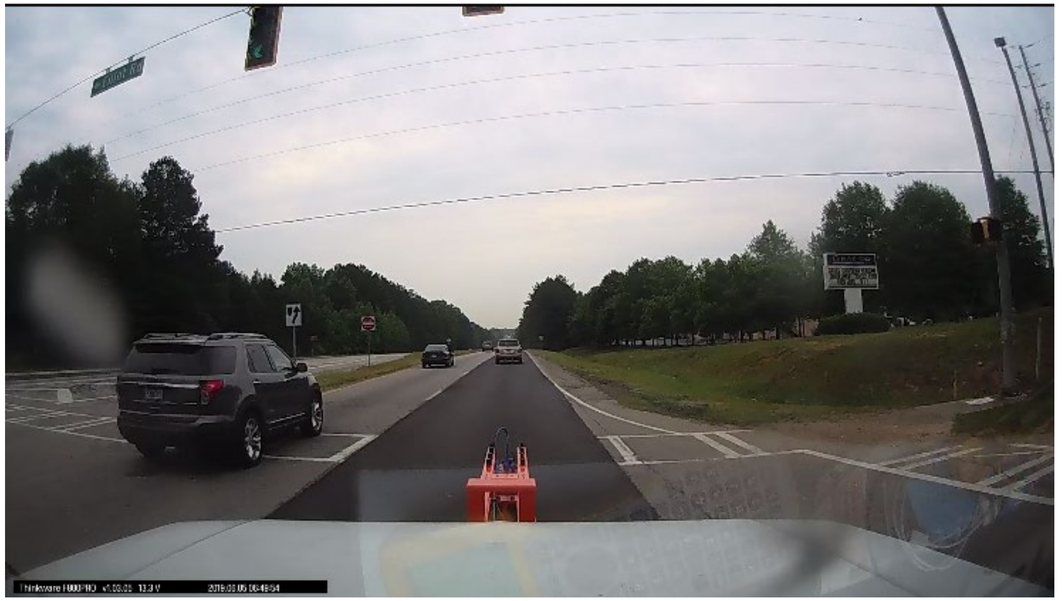




Description : fault in the layers
MP : 0.35 miles
Coordinates: 33°52'46.99"N, 84°43'6.61"W

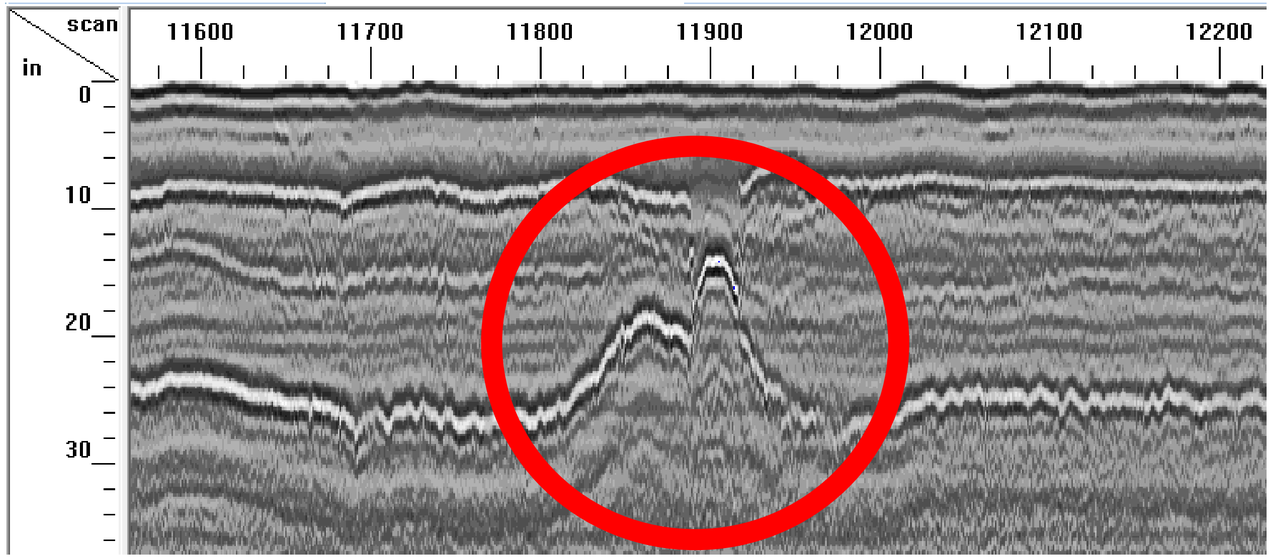
GPR Scan Findings – EBLN 2

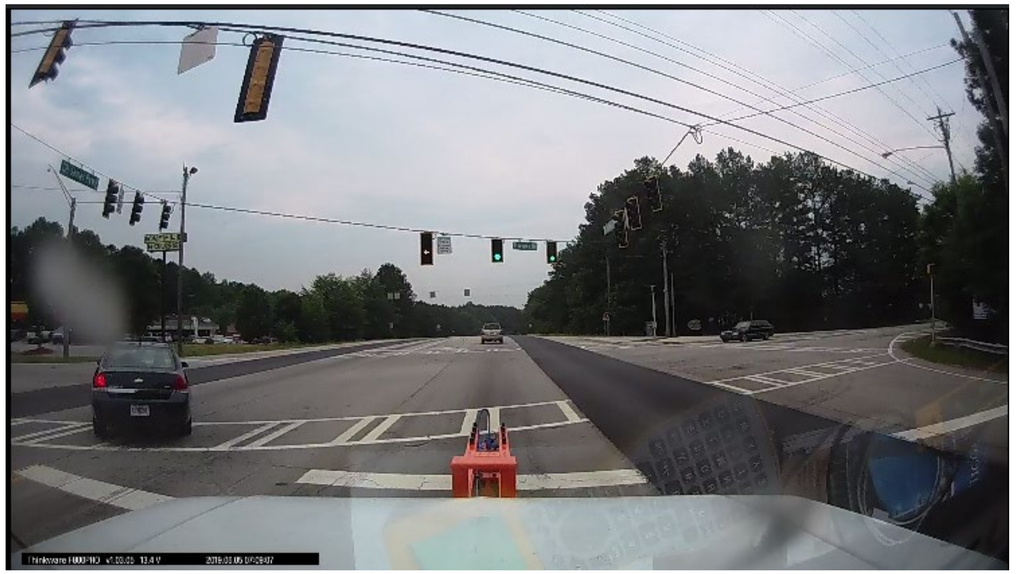




Description: Fault in rock layer
MP : 0.305 miles
Coordinates: 33°52'46.87"N, 84°43'6.70"W

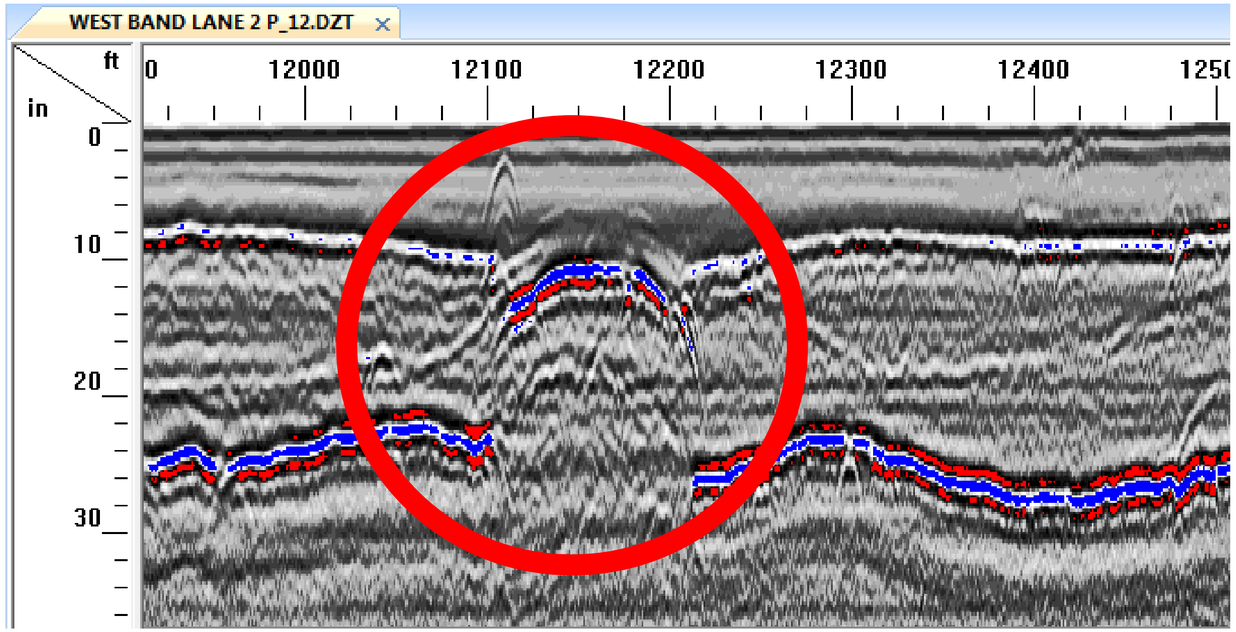
SR 6 – Cobb County

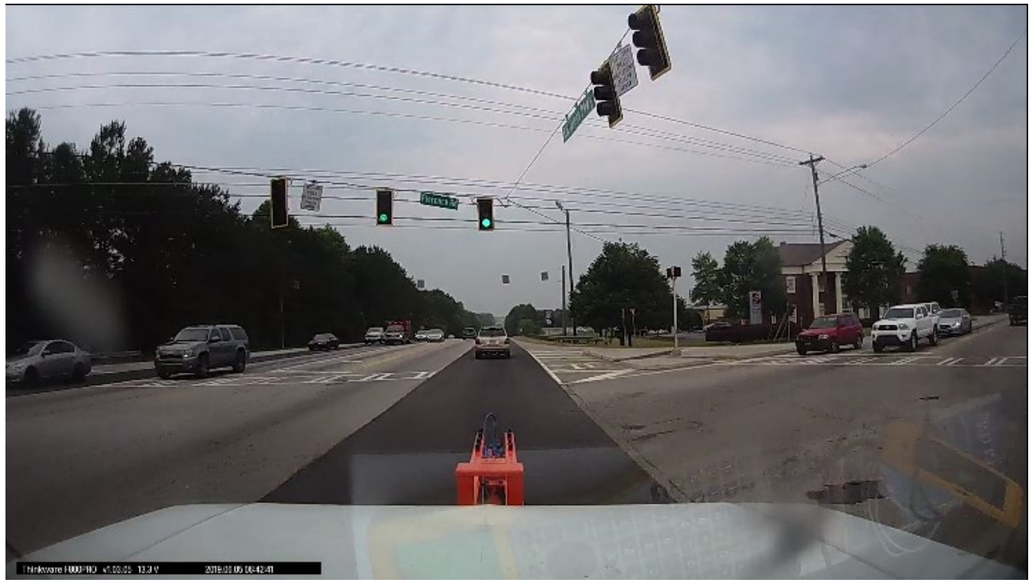




Description : rock layer hump
MP : 1.29 miles
Coordinates: 33°52'29.53"N, 84°42'11.80"W

State Road 6 – Cobb County





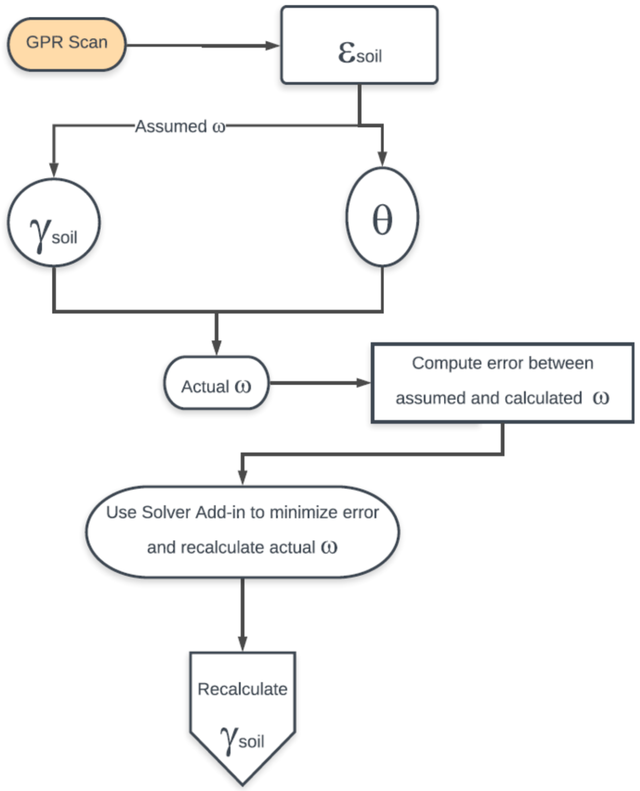
Description : rock layer hump
MP : 0.840 miles
Coordinates: 33°52'29.69"N, 84°42'11.26"W

Geological Findings

Estimation of Density for Aggregate Base and Subgrade Soils

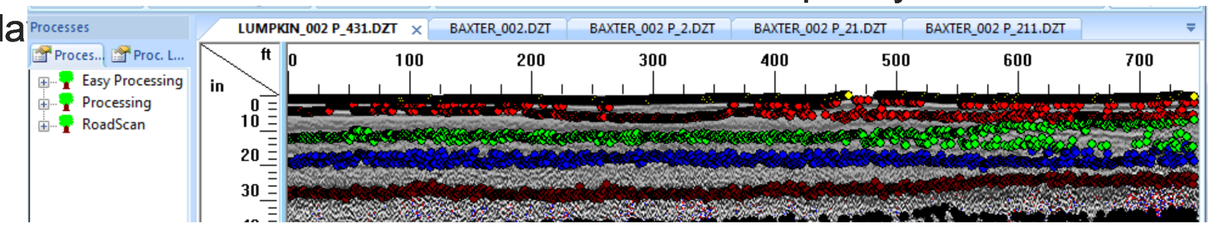
Procedure

Work flow chart



1

Use RADAN7 software to extract GPR scan frequency for different la



Use Topp et al. (1988) proposed equation to predict water content (θ) in the subsurface soil first based on the dielectric constant (ε_{soil}) of the soil.

2

$$\theta = -0.053 + 0.0292\,(\varepsilon_{soil}) - 5.5\times10^{-4}\,(\varepsilon_{soil})^2 + 4.3\times10^{-6}\,(\varepsilon_{soil})^3$$

$w = \theta / \gamma_{soil}$ (Topp et al., 1980)

3

Use the numerical model introduced to predict bulk density of the subsurface soil based on the dielectric constants of the soil

$$\gamma_{soil} = \frac{\sqrt{\varepsilon_{soil}}-1}{w\sqrt{\varepsilon_w}+\frac{1}{GS}(1-w)\sqrt{\varepsilon_s}-\left(\frac{1}{\gamma_{dry\,max}}\right)}$$

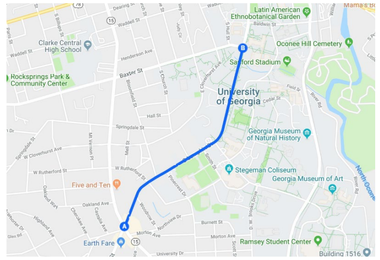
Plot a contour map for the density condition under the road pavement to detect defects under the road or the loss of soil material to proactively detect sinkhole locations

4

Case Study 1:

Lumpkin St., Athens, GA

- South Lumpkin street – Athens Clark County
- Scan Distance is 5598 ft (1.06 mile)
- Starting point (1205 S Milledge Ave)
- End point (705 S Lumpkin St)



A comparison was held between results of GPR scan and Pavement cores for 6 different spots at south Lumpkin street, and the results came as follows:

N.B. : the coring results were provided by Athens Clarke County Engineers

Core index	Latitude (°)	Longitude (°)	Core		GPR scan	
			HMA (in)	Aggregate Base (in)	HMA (in)	Aggregate Base (in)
C1	33.94273	-83.3835	2.00	6.00	2.15	6.14
C2	33.94342	-83.3822	3.50	6.00	3.60	6.22
C3	33.94613	-83.3785	5.00	4.50	4.89	4.93
C4	33.94905	-83.3776	3.75	5.50	3.94	5.53
C5	33.94443	-83.3801	3.50	6.00	3.60	5.87
C6	33.94376	-83.3817	4.75	4.00	4.98	4.18

Lumpkin road

GPR scan results

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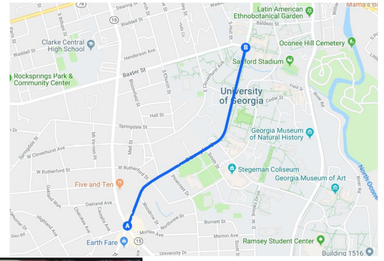

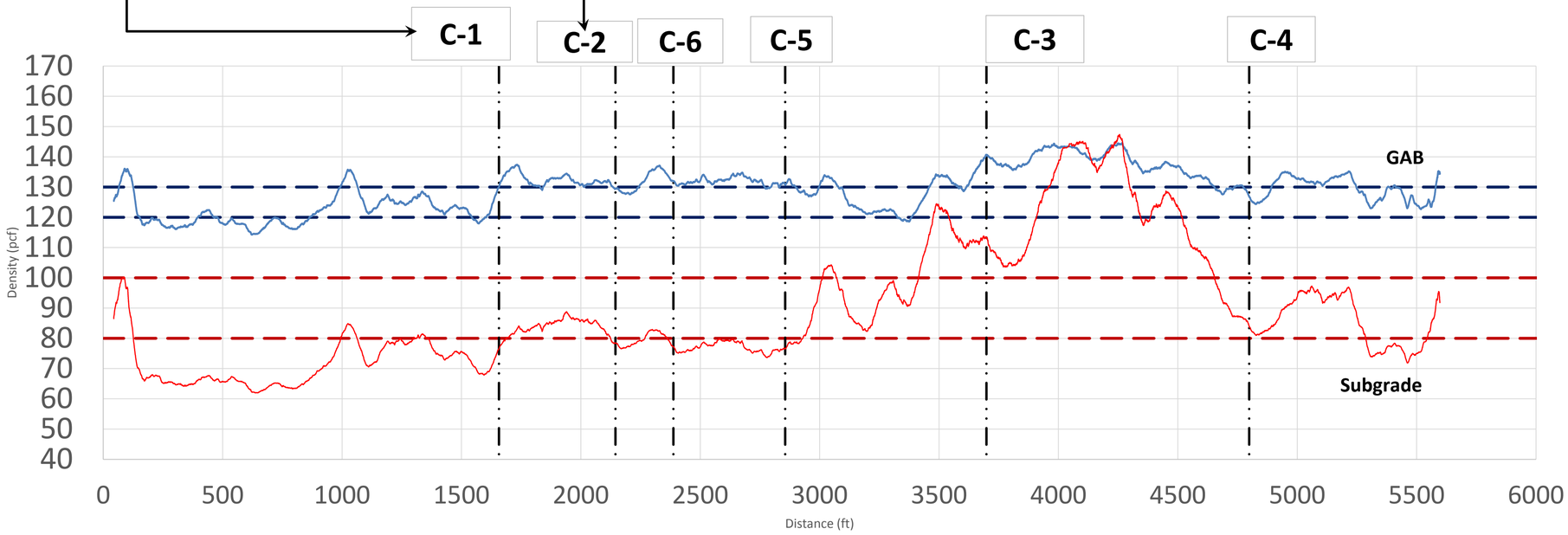

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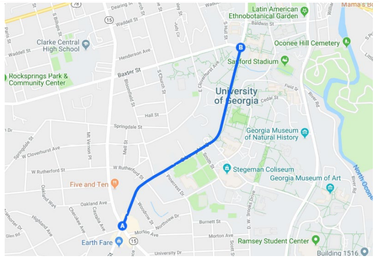
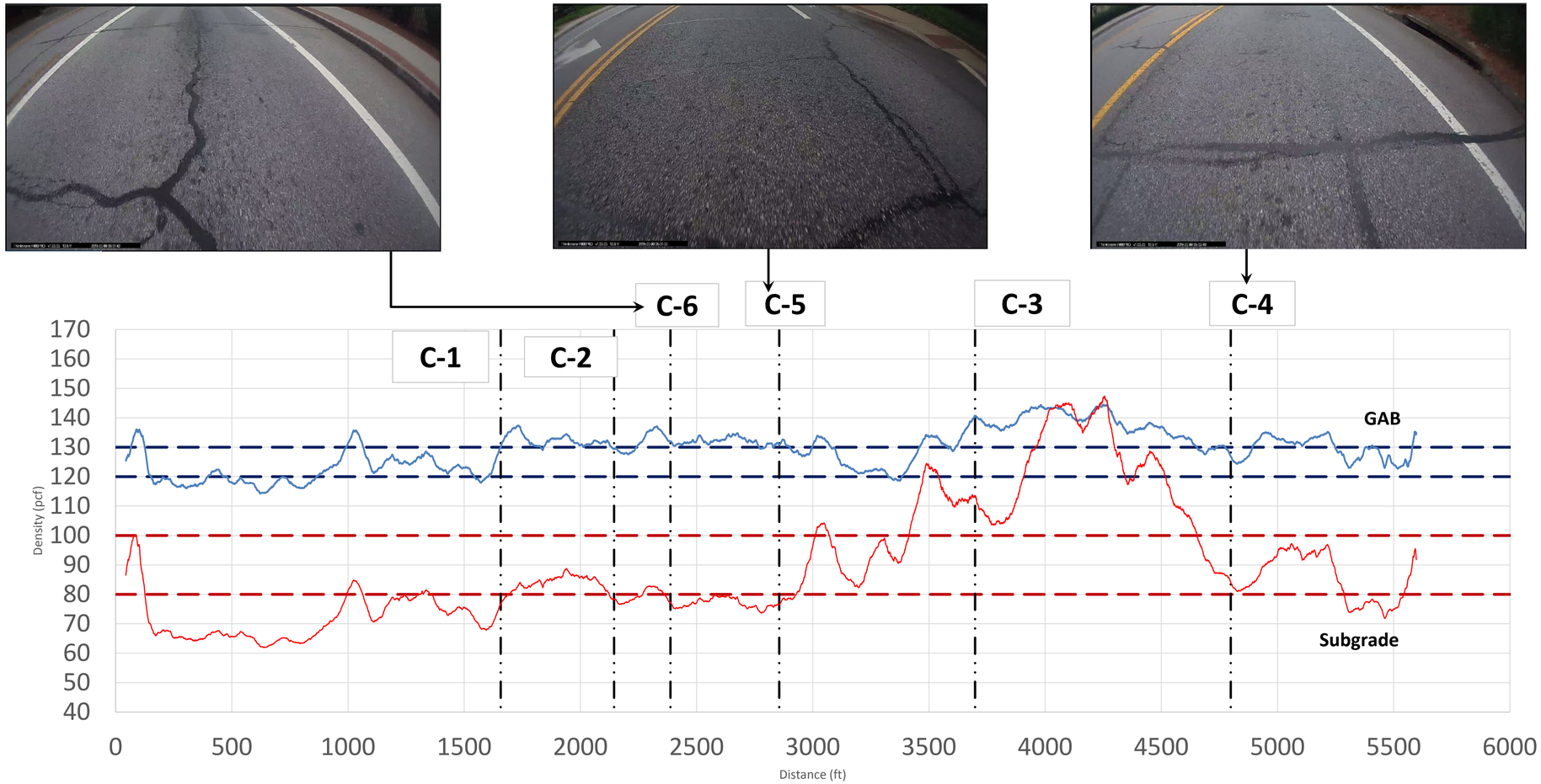
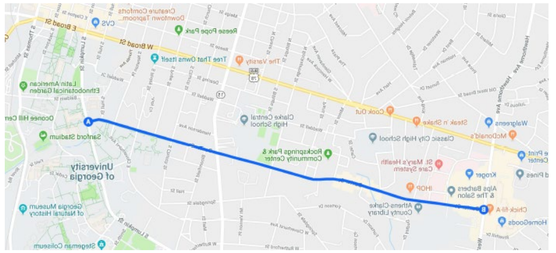




Case Study 2:

Baxter St., Athens, GA

- Baxter street – Athens Clark County
- Scan Distance is 9830 ft (1.86 mile)
- Starting point (705 S Lumpkin St)
- End point (Baxter and Alps OB)



A comparison was held between results of GPR scan and Pavement cores for 4 different spots at south Baxter street, and the results came as follows:

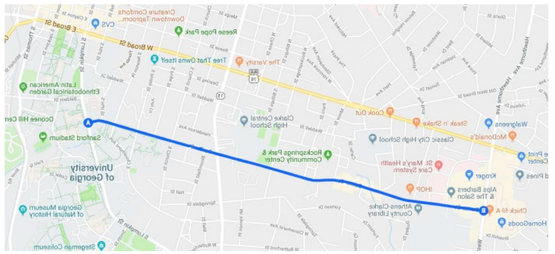
N.B. : the coring results were provided by Athens Clarke County Engineers

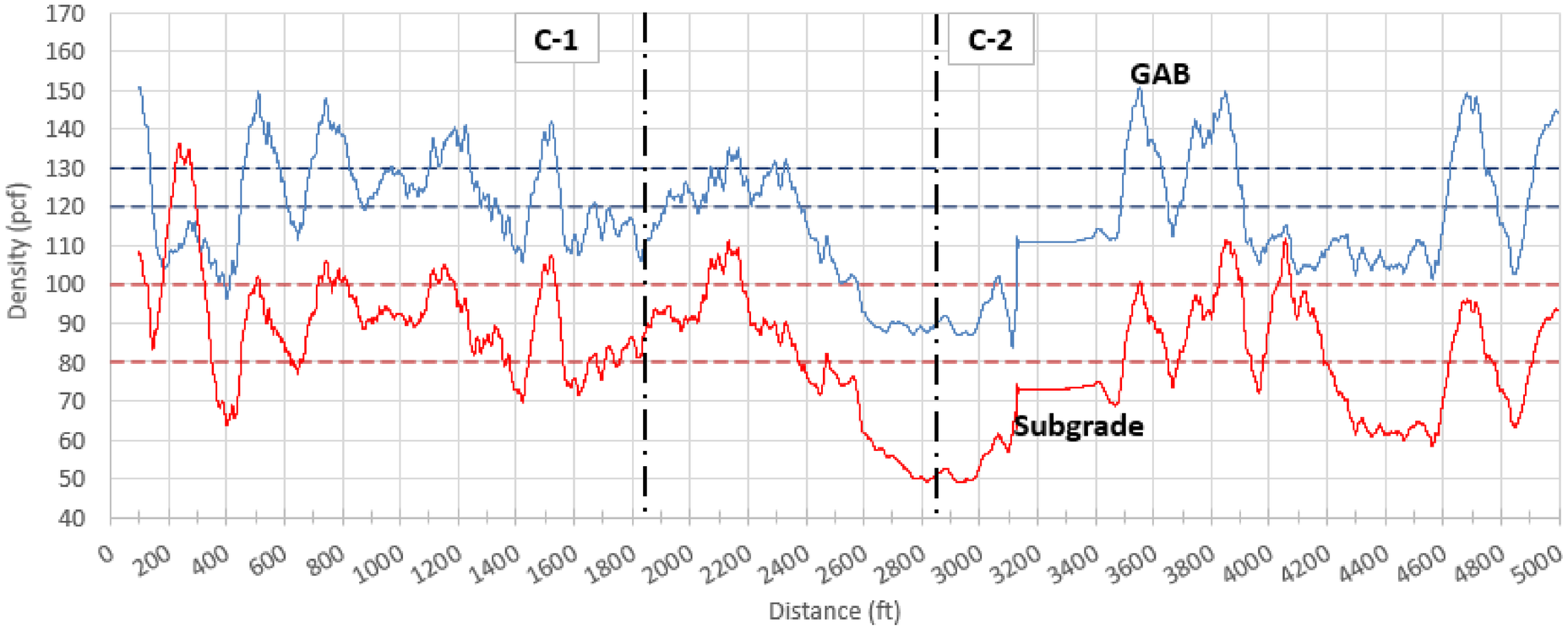
Core index	Latitude (°)	Longitude (°)	Core		GPR scan	
			HMA (in)	Aggregate Base (in)	HMA (in)	Aggregate Base (in)
C1	33.950287	-83.383242	7.00	2.00	6.30	4.65
C2	33.949517	-83.386423	5.25	2.00	5.01	3.75
C3	33.947594	-83.396363	5.75	3.25	5.88	4.32
C4	33.945774	-83.406352	5.75	4.50	6.17	5.05

Baxter Street

GPR scan results

- Baxter street – Athens Clark County
- Scan Distance is 9830 ft (1.86 mile)
- Starting point (705 S Lumpkin St)
- End point (Baxter and Alps OB)





Baxter Street

GPR scan results

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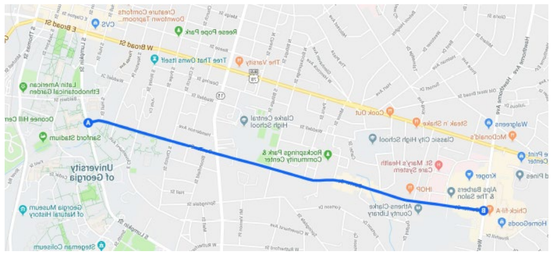

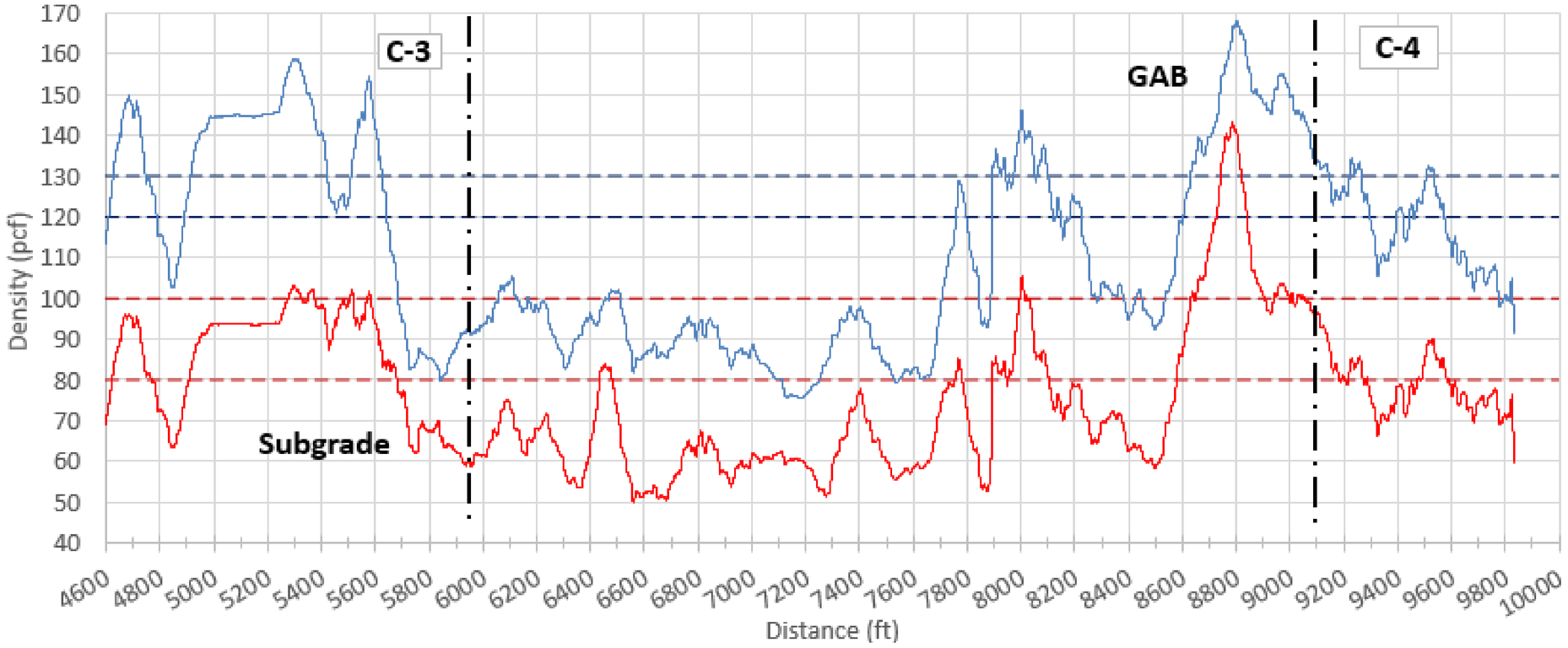

Conclusions

GPR is a good tool to aid State DOTs in locating and documenting objects or anomalies beneath a surface

A numerical approach has been tested to estimate the density of pavement foundation. Structural failure was linked to the lower density level of pavement foundation.

Future research is focusing on the estimation of materials' physical and mechanical properties (strength and elasticity) using GPR data.

Using the illustrated technique is the beginning of a new era in roads performance evaluation methodologies.

Thank You For Listening

Contact Us

Whether you have specific needs or just want to say hello, feel free to send us a message or give us a call.

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