# *Implementation of GPR Mapping for Density of New Pavement*

by

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Infrasense, Inc.

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***Blacksburg, VA***

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# Presentation Outline

- Background and Basic Principles
- Results of Previous Studies
  - (FDOT, MnDOT)
- Evaluation Rt. 125 in Lee NH
- Summary of Findings

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# Technical Background

- Highway GPR is commonly used for layer thickness, bridge deck evaluation
- Horn antenna can measure pavement dielectric
- Dielectric is directly related to density, assuming material composition is uniform
- This relationship has been confirmed in previous studies (since 1998 in Finland)

# GPR Horn Antenna Equipment





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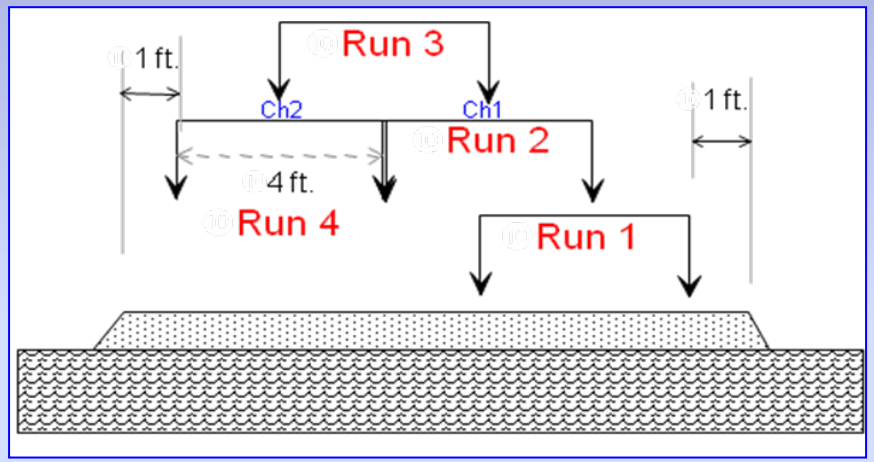
# Survey Procedure

Laser switch

Marker cone




Dual Antenna Survey Layout

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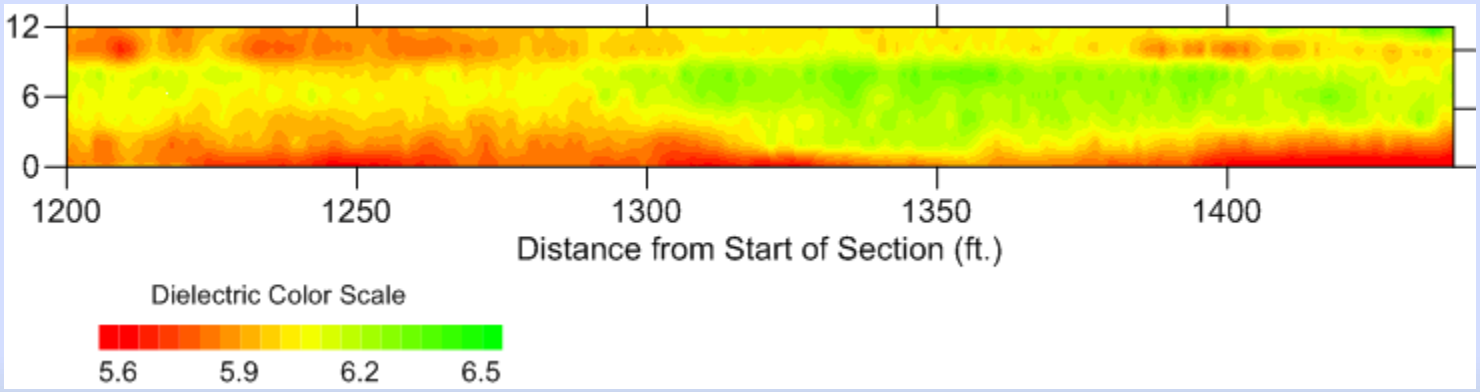
# Automated (GPRQA) Analysis

| | A | B | C |
|---|---|---|---|
| 1 | Station | Offset | Dielectric |
| 2 | 0.25026 | 0 | 5.73877 |
| 3 | 0.50052 | 0 | 5.565659 |
| 4 | 0.75078 | 0 | 5.418099 |
| 5 | 1.00104 | 0 | 5.602684 |
| 6 | 1.25131 | 0 | 5.569718 |
| 7 | 1.50157 | 0 | 5.620329 |
| 8 | 1.75183 | 0 | 5.499176 |
| 9 | 2.00209 | 0 | 5.551801 |
| 10 | 2.25235 | 0 | 5.576707 |
| 11 | 2.50261 | 0 | 5.528082 |

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# FDOT Field Validation Testing (2008)

- Field Validation Trials were completed on three different construction projects.
  - New Construction Projects:
    - State Road 20 (Town of Interlaken)
    - State Road 23 (Duval County)
  - Asphalt Resurfacing Project:
    - State Road 222 (City of Gainesville)

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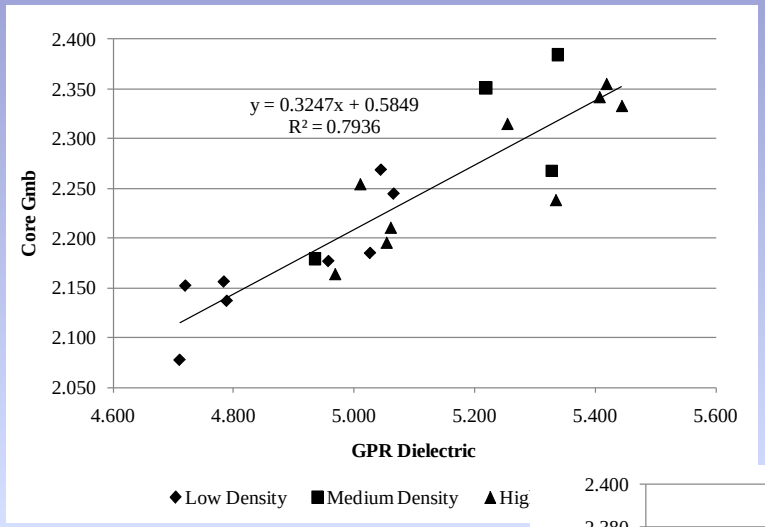
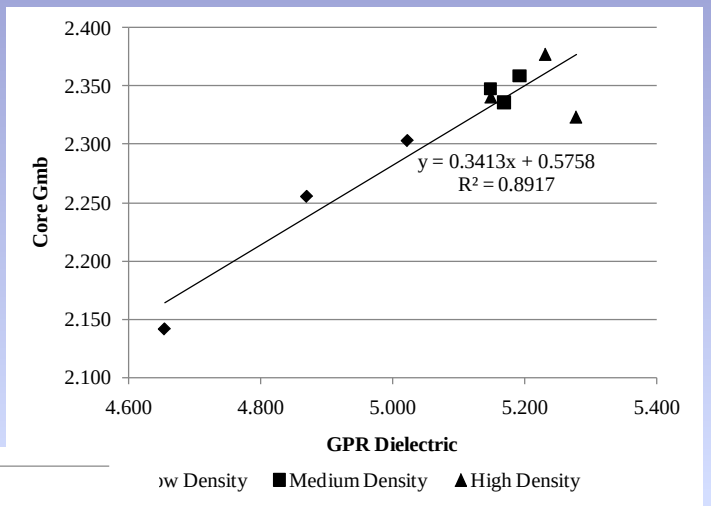
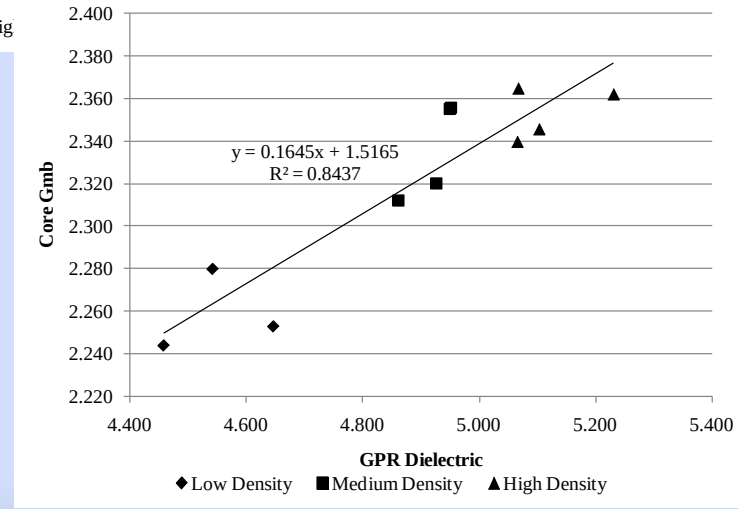
# Overall Correlation for 3 FDOT Projects




SR 20 Results
$R^2 = 0.79$




SR 23 Results
$R^2 = 0.89$




SR 222 Results
$R^2 = 0.84$

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# MnDOT Testing – Summer 2012


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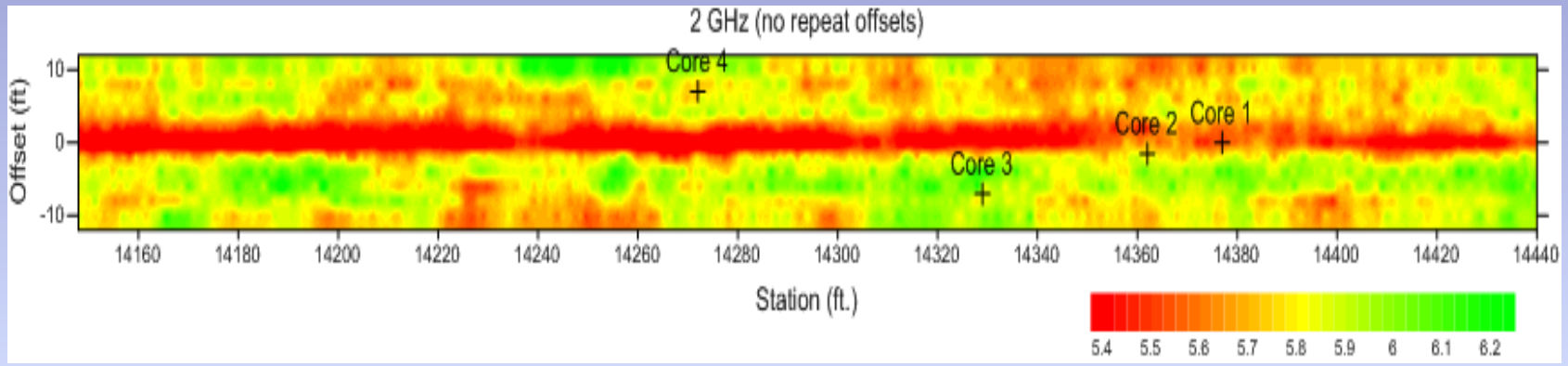
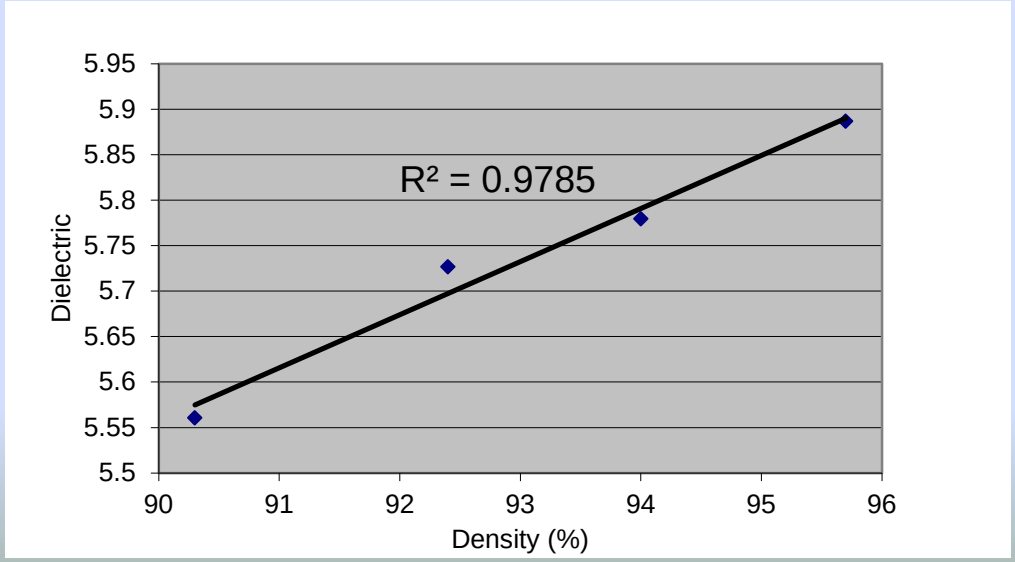
# Example MnDOT Results

## TH13 (June 27-28, 2012)

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# Rt. 125 in Lee, NH

- 4-mile paving project  (Aug-Sept, 2013)
  - Leveling course plus 1¼" wearing course
  - 2 travel lanes and 2 shoulders
- Partial use of Intelligent Compaction
  - Southern half conventional
  - Northern half IC
- GPR included in project to map density variations
  - Conventional vs. IC
  - Other spatial variations
  - Correlate GPR dielectrics to core densities

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# GPR Equipment for Lee Project

Marker cone at S end of project

2 GHz Antenna

Laser Sensor

DMI

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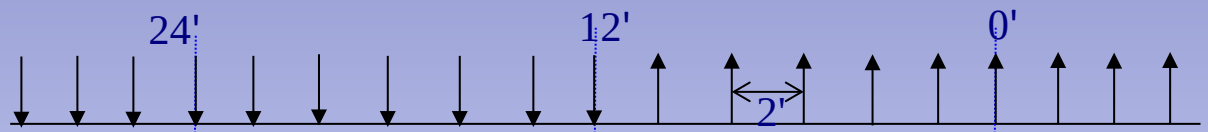
# Pass Layout




west shoulder seam

center seam

east shoulder seam

= offset and direction of GPR data line

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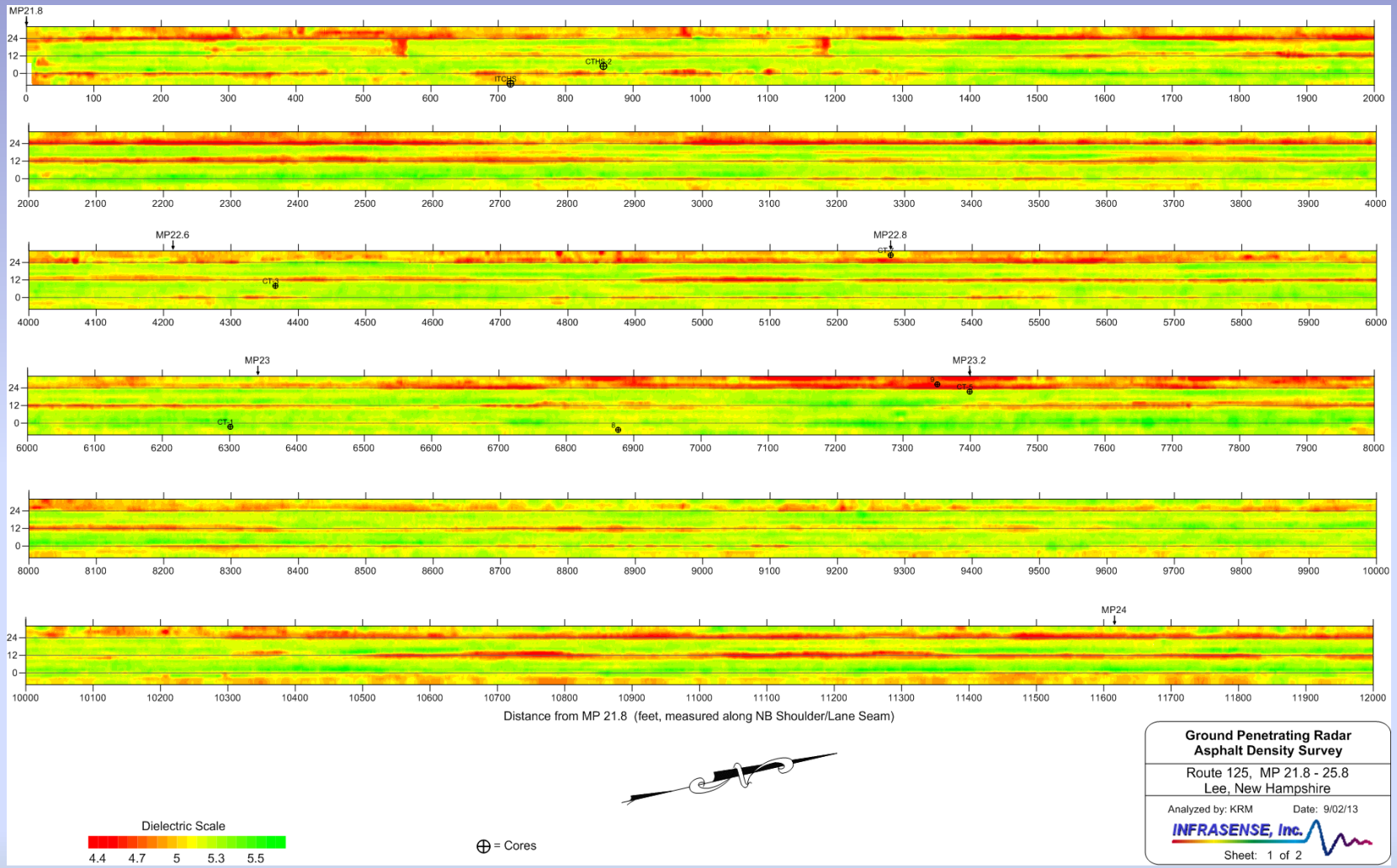
# Dielectric Map – MP 21.8-24.0

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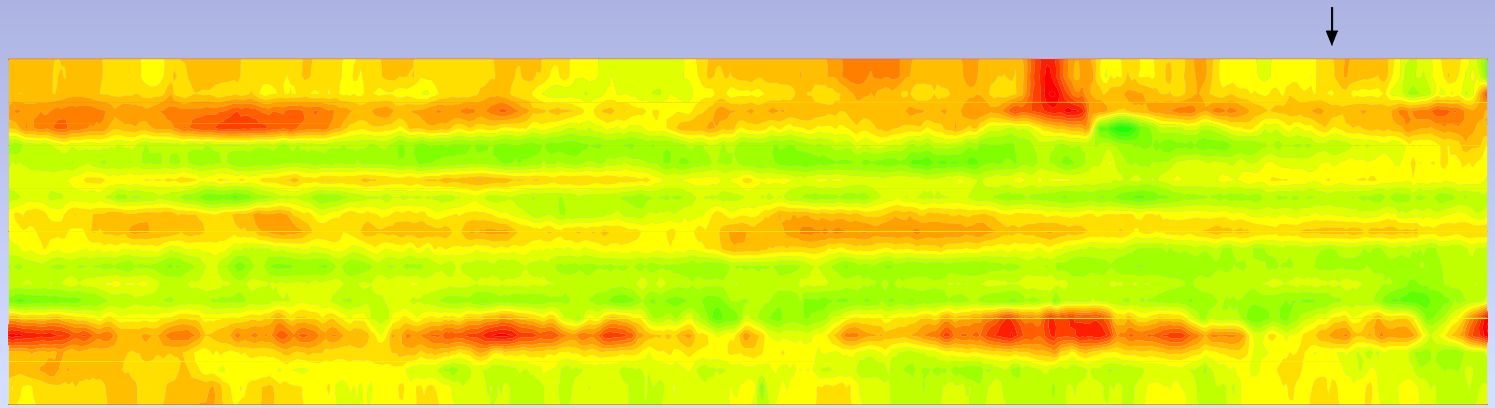
# Dielectric Map Detail



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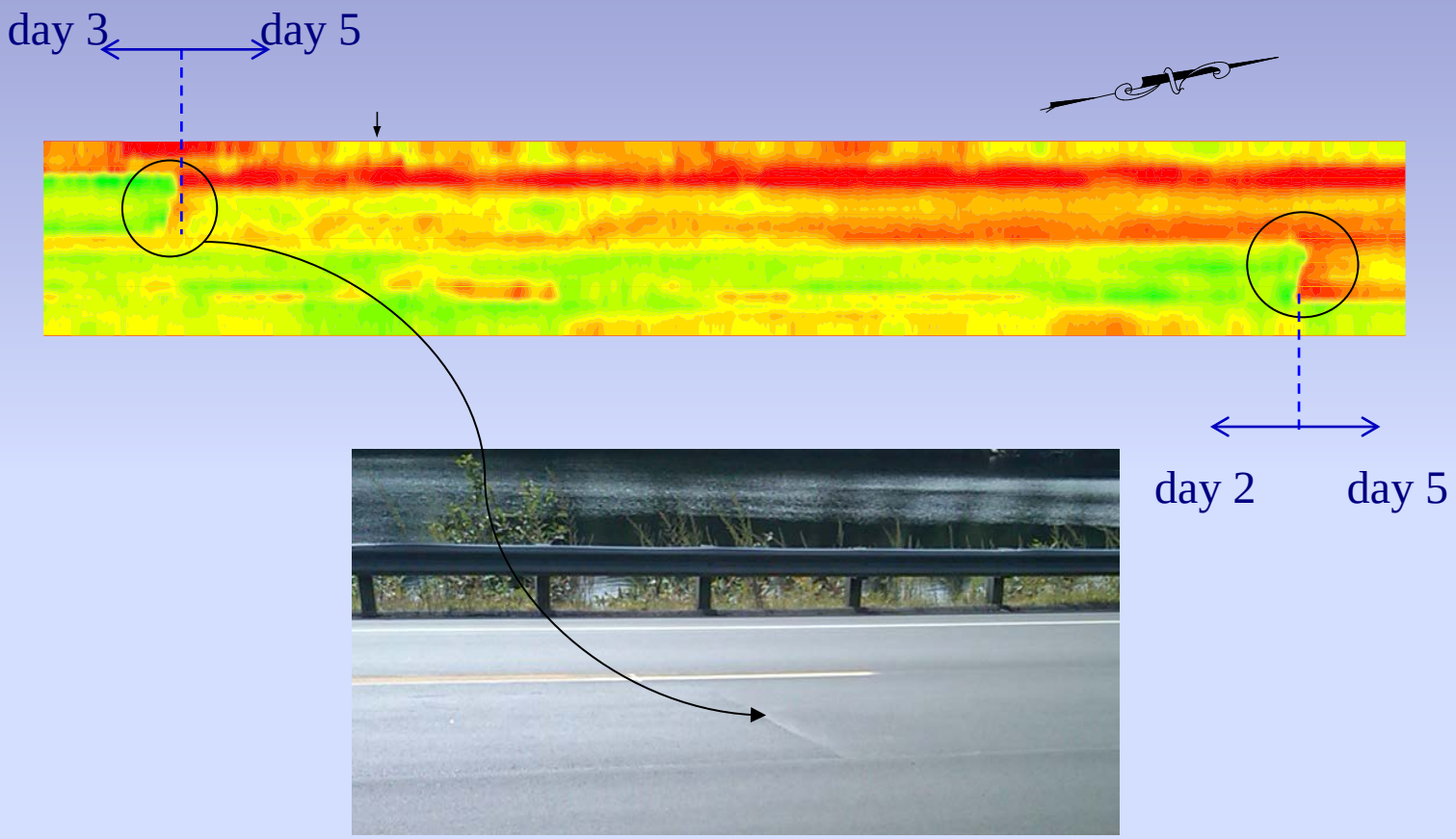
# Paving Features Revealed

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# Observations from Dielectric Map

- Low density observed along the seams
- Start/stop discontinuities show up clearly
- Area paved during 5$^{th}$ day has lower density
- No distinct difference between area paved with IC and area paved with conventional procedure
- SB shoulder has large area of low density.
  - MTV not used in this shoulder

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# Correlation with Core Density

- Cores taken as part of normal QC process
  - 1 core per 750 tons of mix
- Cores taken at selected locations
- Density/air void measured from cores
- Core density correlated with GPR dielectric

# Dielectrics vs. QA Cores

| Core ID | Station (ft. from MP 21.8) | Offset (ft. from NB Shldr Seam) | Density (Gmb/Gmm) % | Dielectric from GPR |
|---|---|---|---|---|
| CT-1 | 6301 | -2.5 | 94.6 | 5.30 |
| CT-2 | 12611.5 | -1 | 94.4 | 5.04 |
| CT-3 | 4366 | 8 | 96 | 5.20 |
| CT-4 | 13723.5 | 4 | 94.7 | 5.23 |
| CT-5 | 7399 | 21.5 | 93.3 | 5.05 |
| CT-6 | 14744.5 | 20.4 | 95.4 | 5.16 |
| CT-7 | 5279 | 29 | 94.3 | 5.06 |
| CT-8 | 19838.75 | 12 | 91.5 | 4.59 |
| CT-9 | 16889 | 24 | 92.9 | 4.56 |
| ITCHS | 718 | -7 | 94.3 | 5.02 |
| CTHS-2 | 856 | 5 | 95.5 | 5.28 |

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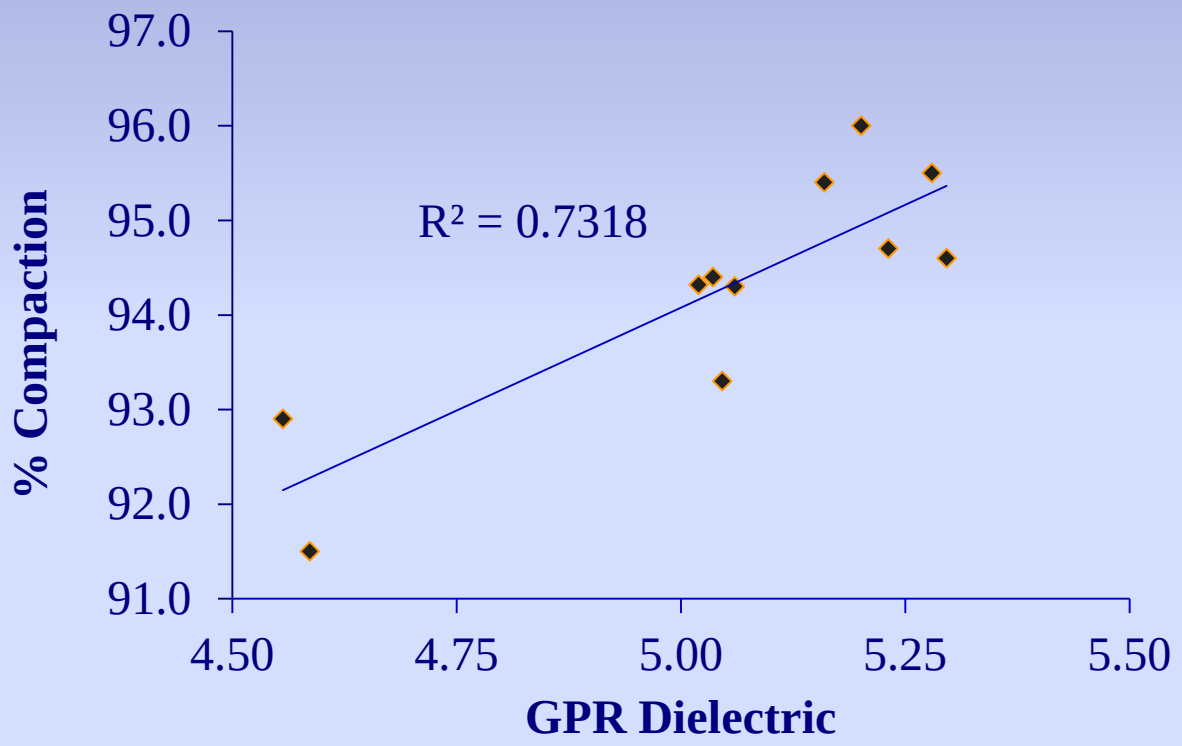
# Dielectric/Density Correlation: QA Cores

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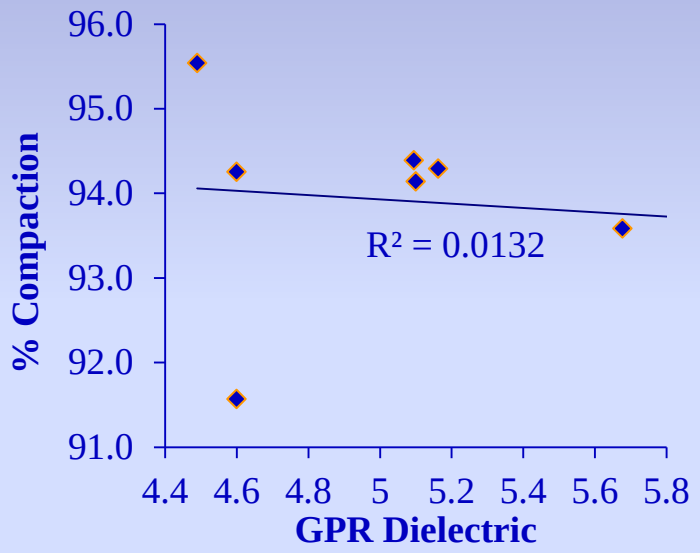
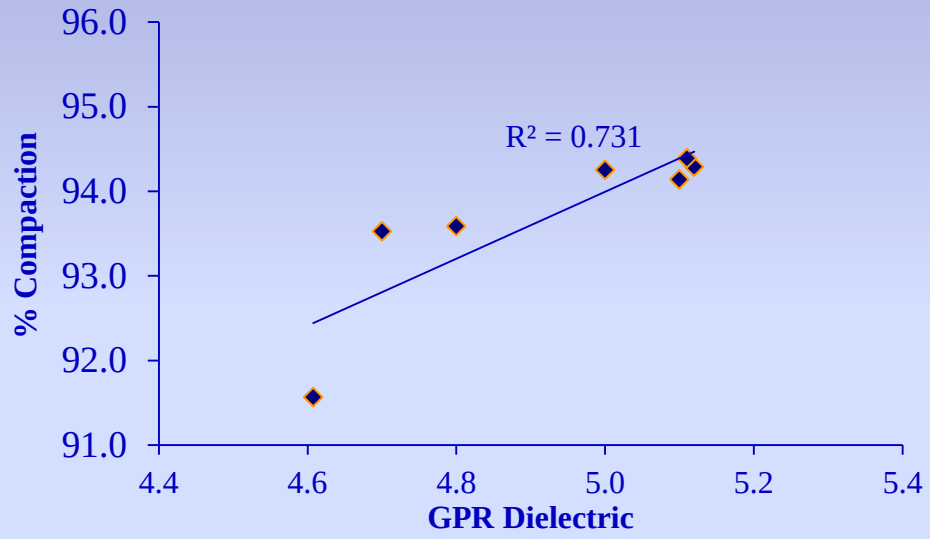
# Dielectric vs. Density: Selected Cores




Raw




With Offset Adjustment

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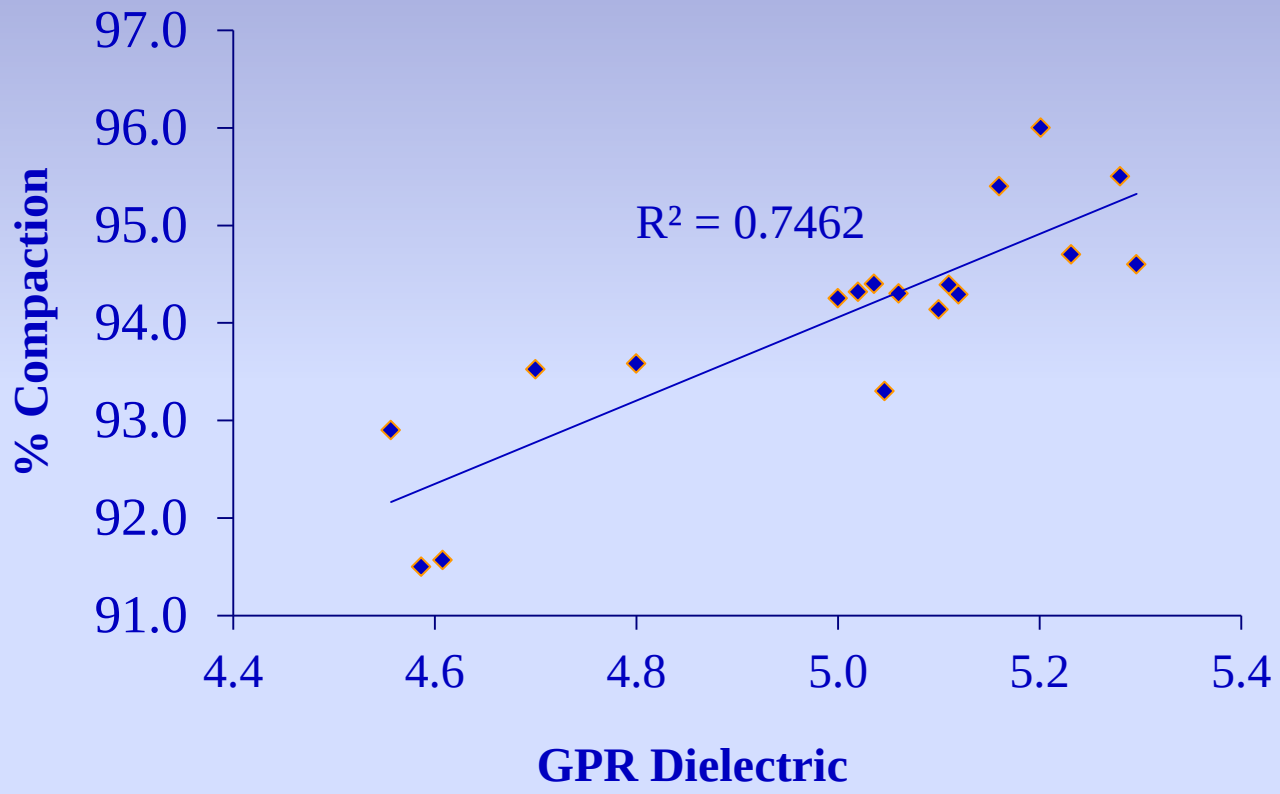
# Dielectric vs. Density: All Cores with Adjustment

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# Summary

- GPR dielectric data reveals density variations that are not apparent from random coring
- Data can be collected at normal driving speed
- Calibration of dielectric data to density requires:
  - A controlled calibration section (500 – 1000 feet)
  - Precise positioning of the GPR and core data (e.g. GPS with base station or RTK correction)
  - Careful selection of locations for coring to obtain a full range of dielectric and density values.

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