

New Zealand Field Trials of Non-Nuclear Density Meters

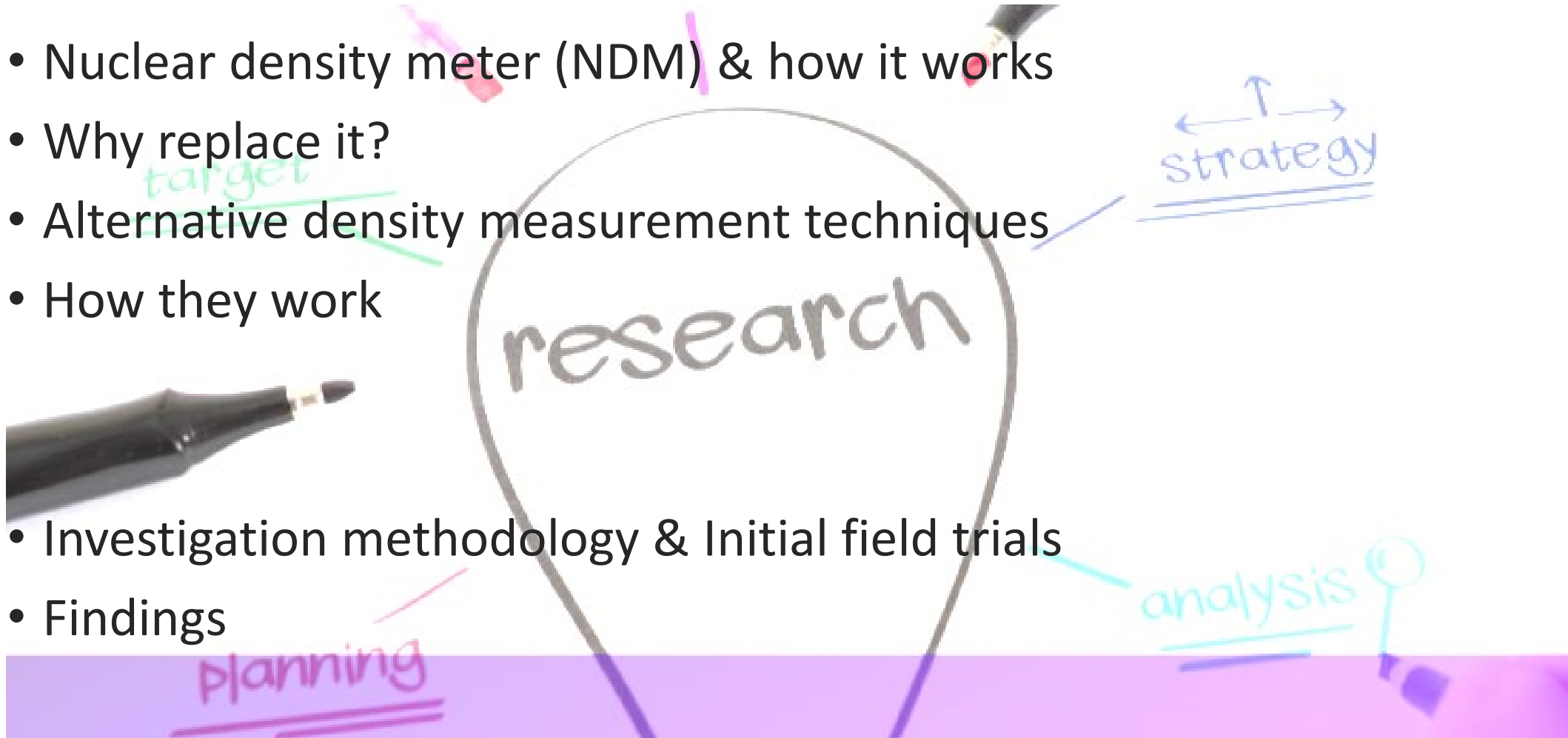
Dr Bryan Pidwerbesky

Technical Director – Pavements & Laboratories

Fulton Hogan Ltd

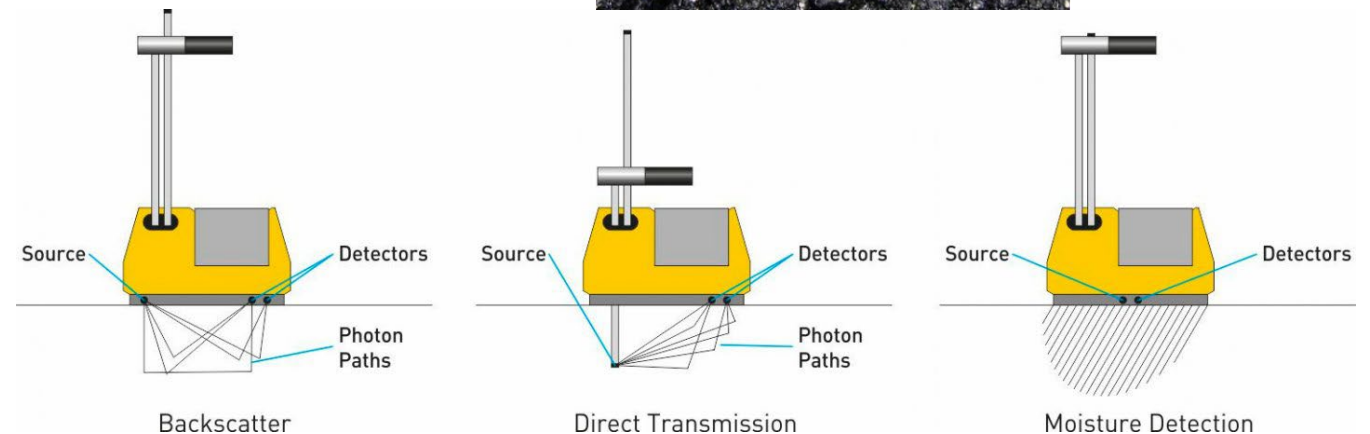
Outline

- Nuclear density meter (NDM) & how it works
- Why replace it?
- Alternative density measurement techniques
- How they work
- Investigation methodology & Initial field trials
- Findings



Nuclear Density Meter – how it works

- Radiation source emits gamma radiation
- Hydrogen molecules slow down or deflect radiation
- Detector counts received radiation
- Calculates density & moisture content
- Advantages
 - Since 1958, well proven
 - Non-destructive
 - Accurate & Precise
 - Asphalt & Granular materials



Nuclear Density Gauges limitations

- Limitations:
 - Health and Safety (during transit)
 - Operational Ownership
 - Storage Constraints
 - Long term radiation exposure personnel
 - Radiation leakage if damaged
 - Increased regulation



Alternative Density Measurement

Destructive Tests

- Sand/seed replacement
- Water balloon replacement



Non-Destructive Non-Nuclear

- Pavement Quality Indicator (PQI)
- Soil Density Gauge (SDG)
- Troxler PaveTracker™ 2701-B
- InstroTek NoNuke™



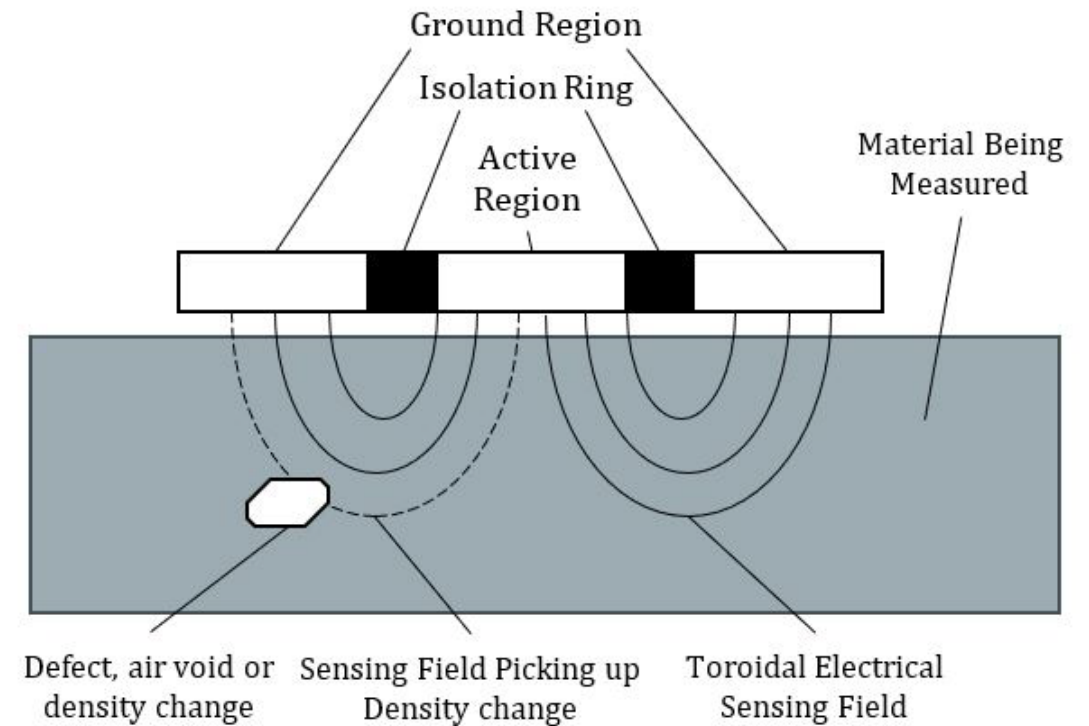
Selection Criteria

- Speed of operation
- PQI & SDG have
 - 30 years of development & field experience in USA
 - 7 years of usage in Australia
 - Local support



PQI Principle of Operation

- How it works
 - Emits electro-magnetic field through material
 - Receiver measures amperage & impedance (resistance) is calculated
 - **Impedance** → **Dielectric constant**
 - Density of material proportional to dielectric constant
- Dielectric Constants
 - Air ~ 1.0
 - Soil, Aggregates, Bitumen 4-5
 - Water ~80
- Dielectric constant function of relative volume of the particular material type i.e. aggregate, bitumen and air

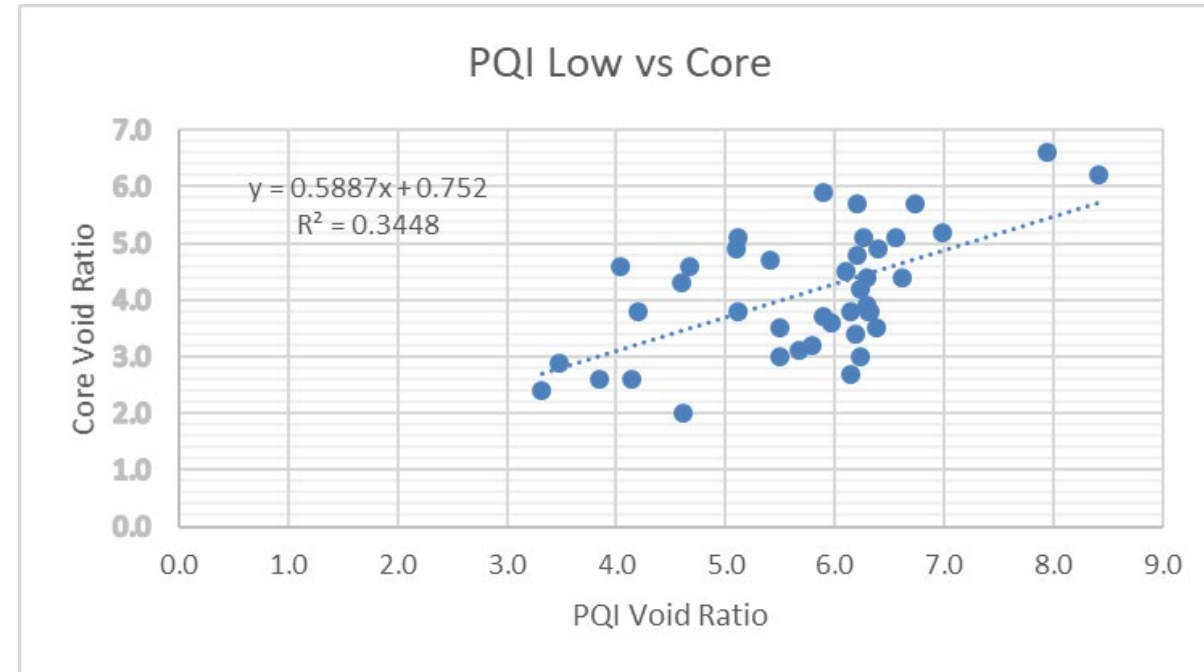
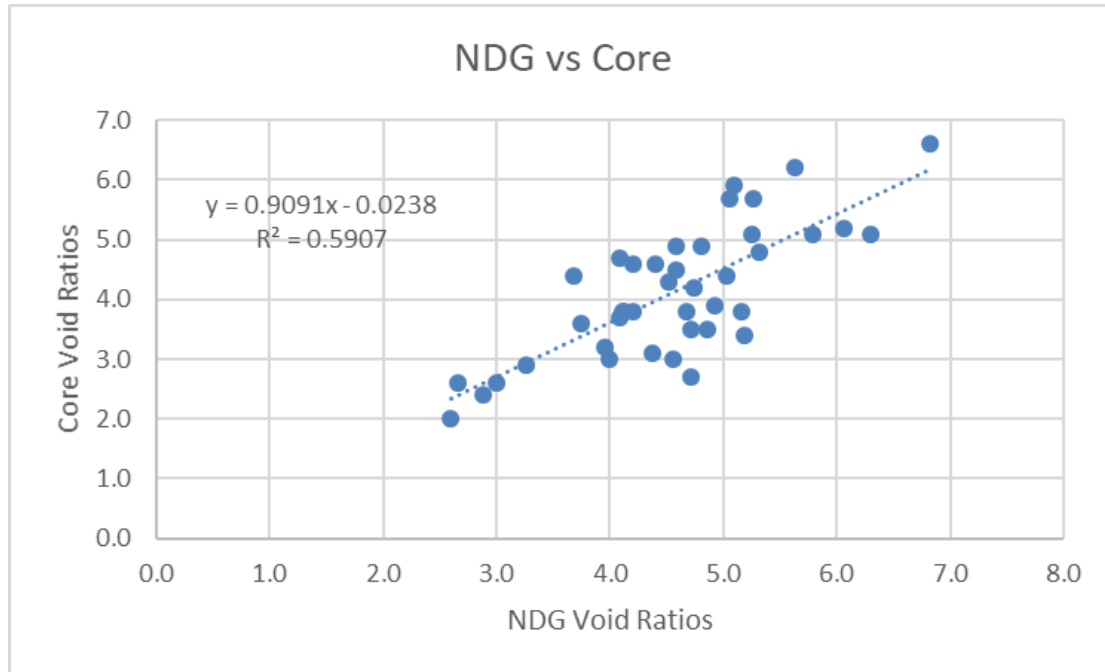


Research Methodology -Asphalt

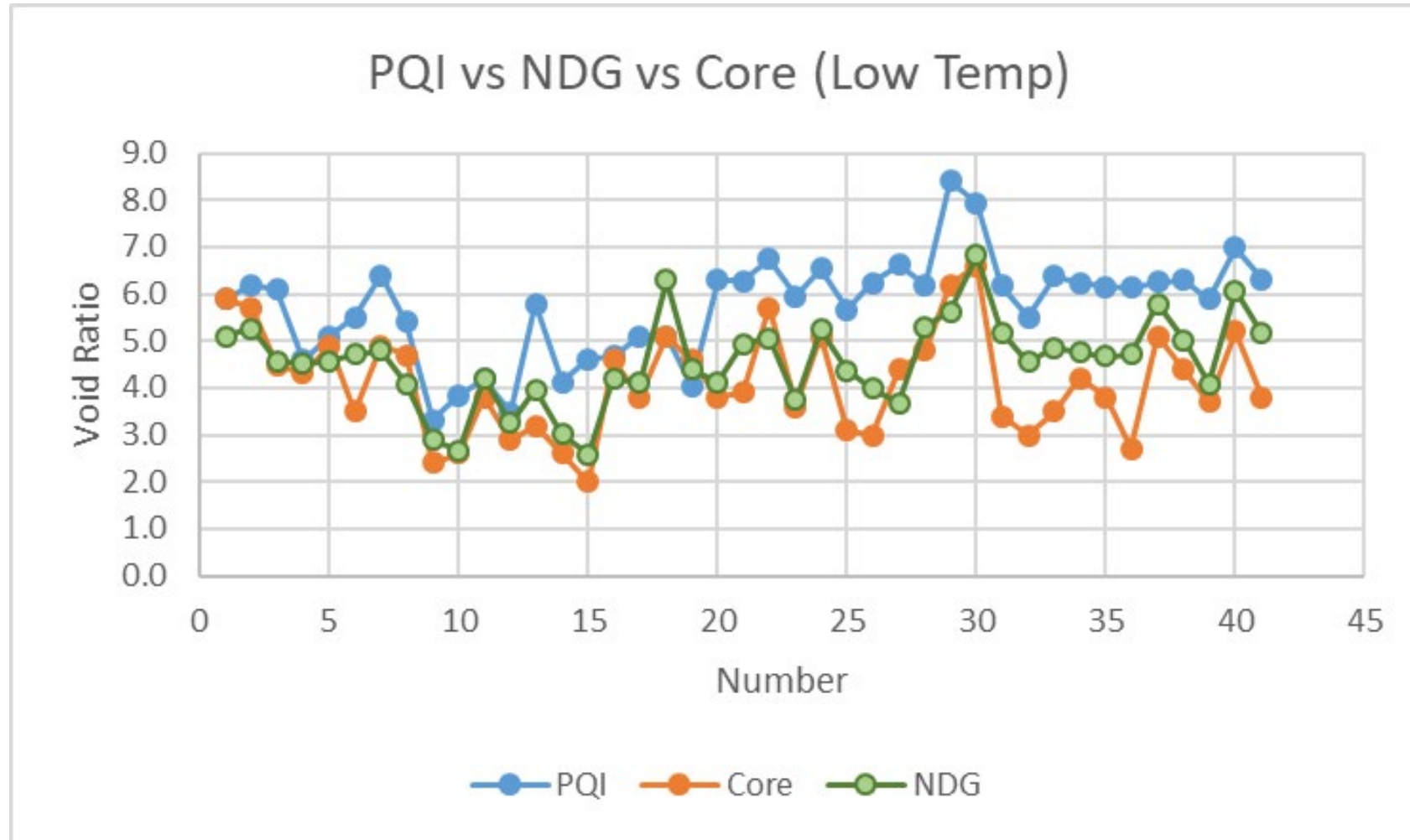
Conducted PQI, NDM readings & extracted cores at same location, using following procedure:

- Mark test position
- Record pavement & air temperatures, & time of each test
- Recorded calibration details for each device
- Ensured there was no water on or in the asphalt – asphalt surface must be absolutely dry before taking PQI readings
- Minimum of eight (8) test locations within each lot were identified & marked as per the random method in Clause 9.9.1 of NZTA M10: 2020
- For each location, NDM test consisted of calculated average of two readings taken at 180-degree angles to each other (handle parallel to paving train), rotated about centre point of NDM gauge
- For each location, PQI test consisted of calculated average of 3 readings taken with PQI rotated approximately 120 degrees after each reading
- All individual readings recorded
- Cores taken from centre of marked footprint
- Core densities determined in laboratory setting
- Plot PQI density versus core density, NDM density versus core density, & PQI density versus NDM density
- Linear regression including R-squared values & estimated regression functions.
- Assessed correlation between results of PQI density & core density, & between nuclear gauge density and core density

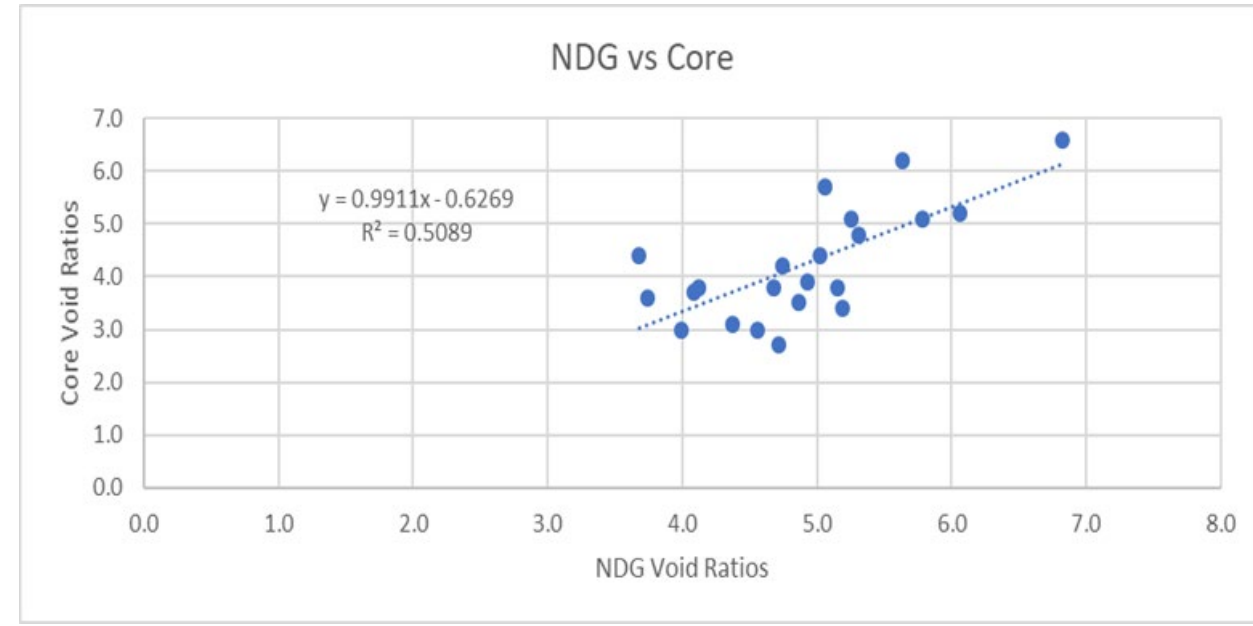
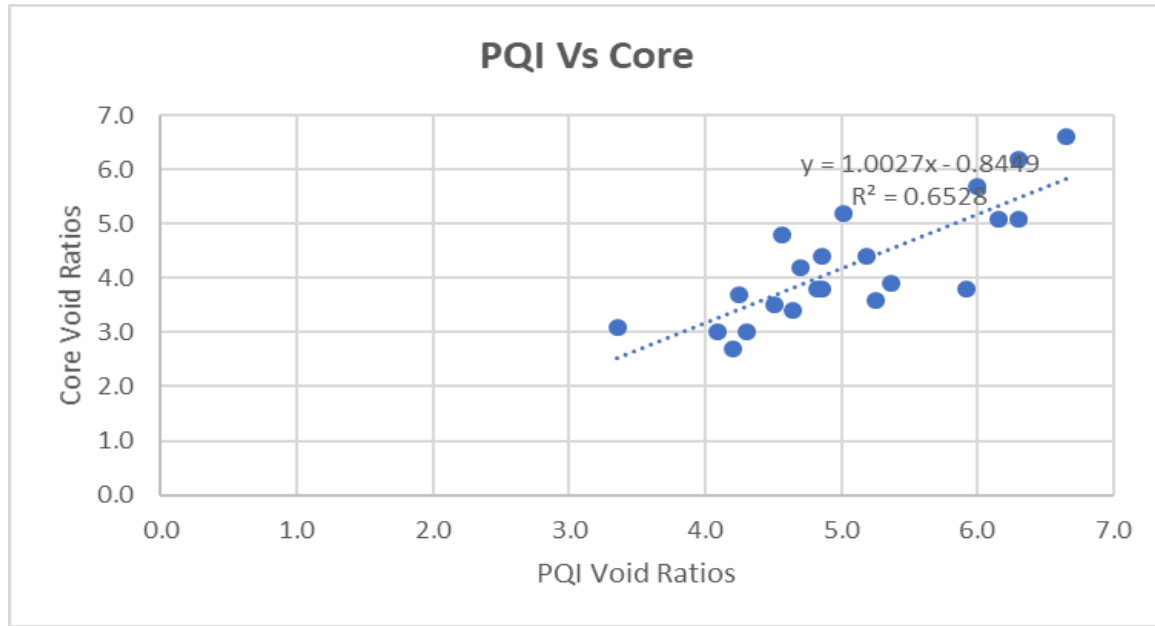
Results –Low Temperature (<math><40^{\circ}\text{C}</math>)



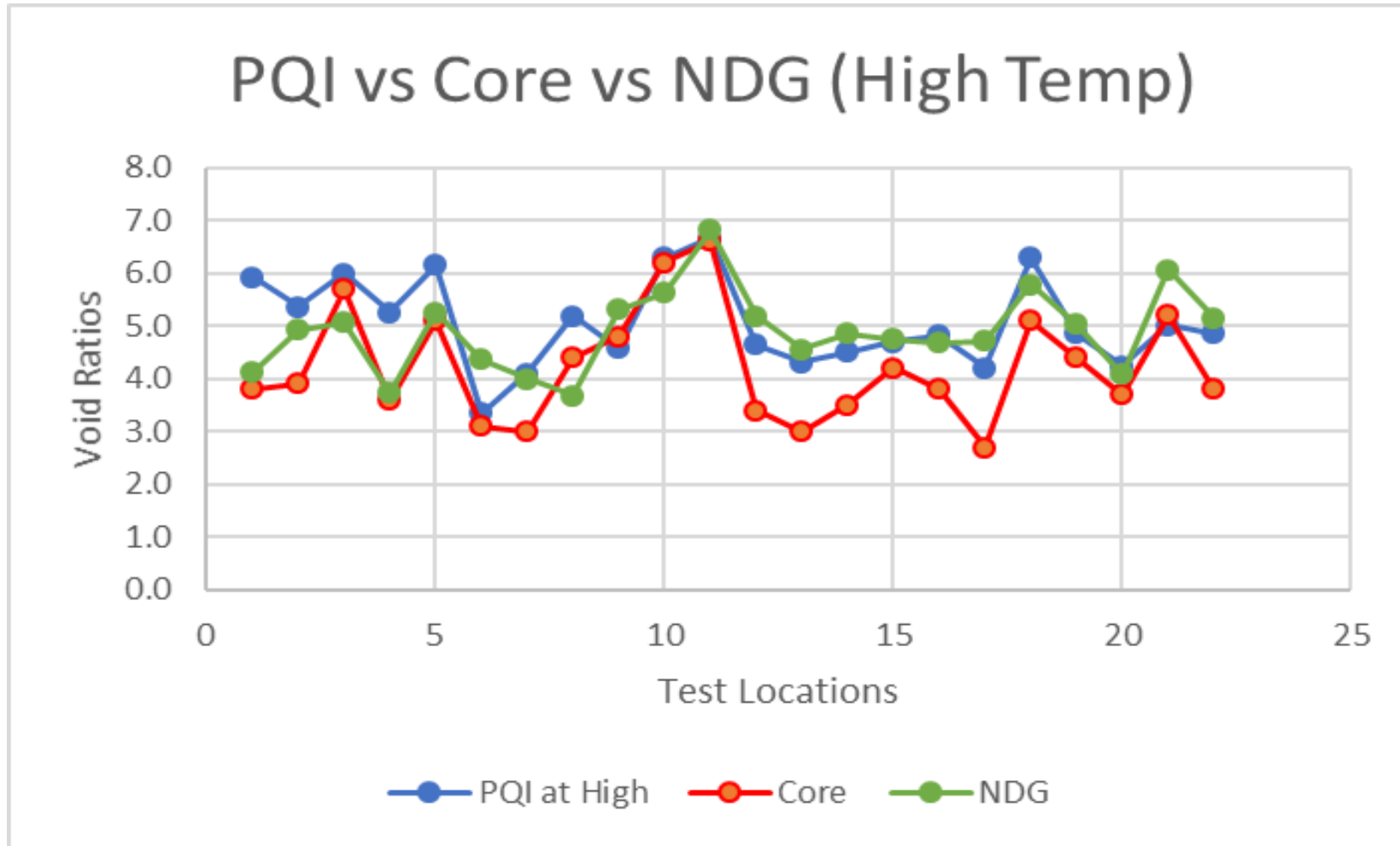
Results – Low Temperature (<math><40^{\circ}\text{C}</math>)



Results – High Temperature (40°C -90°C)



Results – Higher Temp. (40°C-90°C)



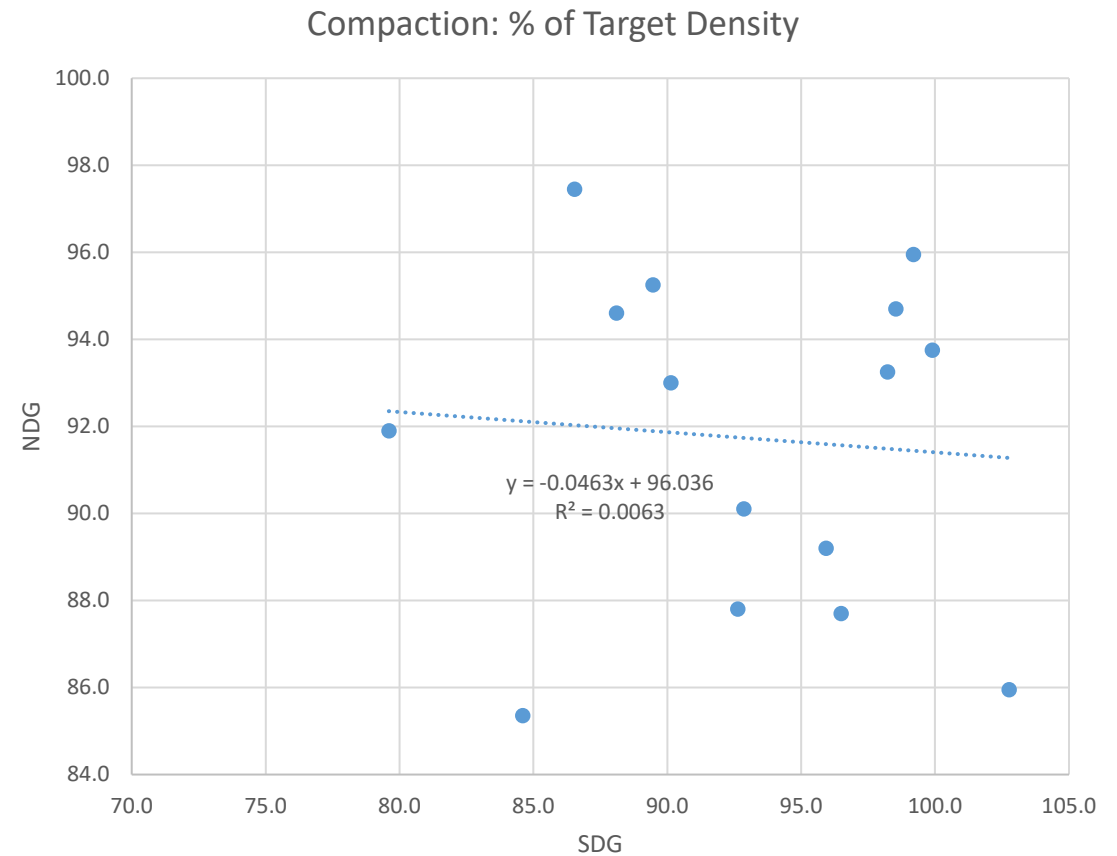
PQI & Asphalt Results

- Repeatable
- Dielectric constant affected by
 - Temperature
 - Moisture
- Accuracy & Precision best @
 - $> 40\text{ }^{\circ}\text{C}$ and $< 90\text{ }^{\circ}\text{C}$
 - Moisture = 0
- Monitoring compaction ✓
- Does not REPLACE cores



Soil Density Gauge (SDG)

- Similar research methodology as per asphalt but on aggregates
- Accuracy requires particle size, Atterberg limits (PL & LL), uniformity coefficient (Cu) & curvature coefficient (Cc) of material
- Requires regular calibration by sampling material & measuring moisture content by oven drying



Going Forward

- Study findings:
 - Precision
 - Accuracy
 - Correlation observations
 - Shortcomings
 - Process Control Tool
 - sensitivity to temperature & moisture
 - Replace NDM for asphalt compaction monitoring
 - Still do cores as final control
- SDG requires too much input & frequent calibration with oven drying so not replacing NDM on soils & aggregates
 - Assess other non-nuclear devices

