SOUTH-EAST SCANNING

GPR Asphalt Thickness Assessment for the National Transport Research Organisation. Toowoomba Velodrome, QLD.

Ground penetrating radar, structural analysis, and utility detection specialists.

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Executive Summary

South-East Scanning was engaged by NTRO to undertake a longitudinal Ground Penetrating Radar investigation of asphalt thickness across four lanes of the Toowoomba Velodrome.

Four continuous longitudinal scan lines were acquired, with depth tags recorded at 10 m chainage intervals across 330 m of track length per lane. Thickness interpretation targeted the base of the asphalt layer using a consistent reflection-picking methodology across all datasets.

GPR-derived asphalt thickness across the surveyed lanes exhibits substantial longitudinal variability. Within the Inner-Centre Lane, destructive core samples recorded total asphalt thickness ranging from 60 mm to 129 mm. Similar variability trends were observed in the GPR dataset.

Comparison between core thickness and GPR-derived thickness at equivalent chainage positions indicates a mean absolute difference of approximately 21 mm. The largest localised discrepancy occurred in the Chainage 200 to 204 m region, where core measurements indicate significantly higher thickness than adjacent GPR-derived values.

Given that cores were not extracted directly along the scan line and that marked localised thickness variations are present over short longitudinal distances, these differences are considered representative of structural variability rather than systematic GPR calibration error.

Depth values exported from the Proceq system are reported to 0.01 m resolution, resulting in a quantisation tolerance of approximately ±5 mm once converted to millimetres. Observed variance between GPR and core data significantly exceeds this rounding tolerance and is therefore dominated by real construction variability and interpretation sensitivity.

This GPR survey provides a continuous longitudinal thickness profile across all lanes, enabling identification of relative thickness trends, localised thickening zones and general structural variability along the track.

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Methodology

Survey Methodology - Data Acquisition

South-East Scanning undertook longitudinal Ground Penetrating Radar surveys across four lanes of the Toowoomba Velodrome for NTRO.

Four continuous longitudinal scan lines were collected, with thickness interpretation recorded at nominal 10 m chainage intervals over approximately 330 m per lane.

The survey was undertaken using a high-frequency GPR system suitable for asphalt thickness determination, the Proceq GP8000, which uses stepped-frequency radar to provide highly detailed scanning data. A dielectric constant of 6.0 was applied consistently across all lanes for depth conversion.

A dielectric value of 6.0 is commonly adopted for dense asphalt materials and falls within the typical range reported in published literature for asphalt pavements. While the dielectric properties of asphalt can vary depending on aggregate type, binder content, air voids, moisture content, and compaction, accurate calibration of the dielectric constant at each location requires either a dense grid of destructive core samples or reliable known depth targets, such as embedded reinforcement or utilities. Such calibration points were not available at each chainage position.

Given the continuous nature of the survey and the limited number of core validation points, a uniform dielectric constant was assumed across all lanes to ensure consistent interpretation. This approach allows reliable assessment of relative longitudinal thickness variation, while acknowledging that minor absolute depth variation may occur where in situ dielectric properties differ from the assumed value.

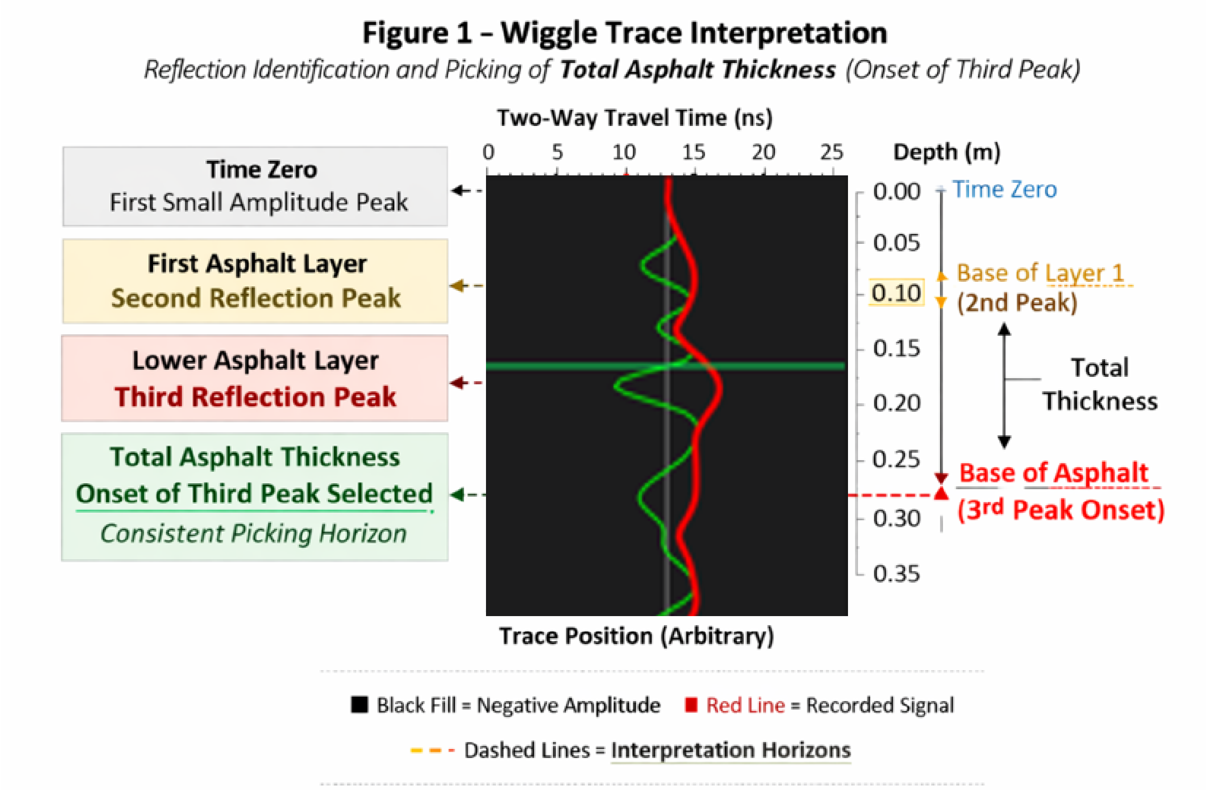
Scan lines followed the general longitudinal alignment of each lane. In areas where radar response was degraded by surface cracking or localised surface irregularities, interpretation positions were adjusted laterally or longitudinally by approximately ±100 to ±200 mm to obtain a clean, representative reflection response. This adjustment was minor relative to overall chainage spacing and was undertaken solely to ensure reflection clarity and consistency.

Thickness Interpretation Method

Depth interpretation targeted the total asphalt thickness.

Interpretation was performed consistently across all lanes using the following reflection identification protocol:

- The first small amplitude response was identified as time zero.
- The second reflection peak was interpreted as the base of the upper asphalt layer.
- The onset of the third reflection peak was consistently selected to represent the base of the asphalt structure and, therefore, total asphalt thickness.



In zones where the third reflection was weaker or partially attenuated, the earliest discernible onset of that reflection was selected conservatively to maintain consistency across the dataset.

This picking approach was applied uniformly across all 330 chainage positions per lane.

Data Export Resolution

Depth values exported from the Proceq system are reported to 0.01 m resolution. Following conversion to millimetres, this results in quantisation to 10 mm increments and an inherent rounding tolerance of approximately ±5 mm. This tolerance is minor relative to the observed structural variability and does not materially affect the interpretation of longitudinal trends.

Core Validation Observations

Destructive core samples provided by NTRO were extracted within the Inner-Centre Lane at nominated chainage positions. Cores were not taken directly along the GPR scan line; however, their longitudinal positions are considered representative of the surrounding track section.

Core thicknesses ranged from 60 mm to 129 mm, demonstrating substantial localised variability.

During extraction, several cores separated into two distinct segments. This behaviour is consistent with layered asphalt construction or zones of differential bonding between lifts and supports the interpretation of multiple reflection interfaces observed within the GPR data.

Comparison between core thickness and GPR-derived thickness indicates that the differences are dominated by localised structural variability and lateral position effects rather than by systematic calibration error.

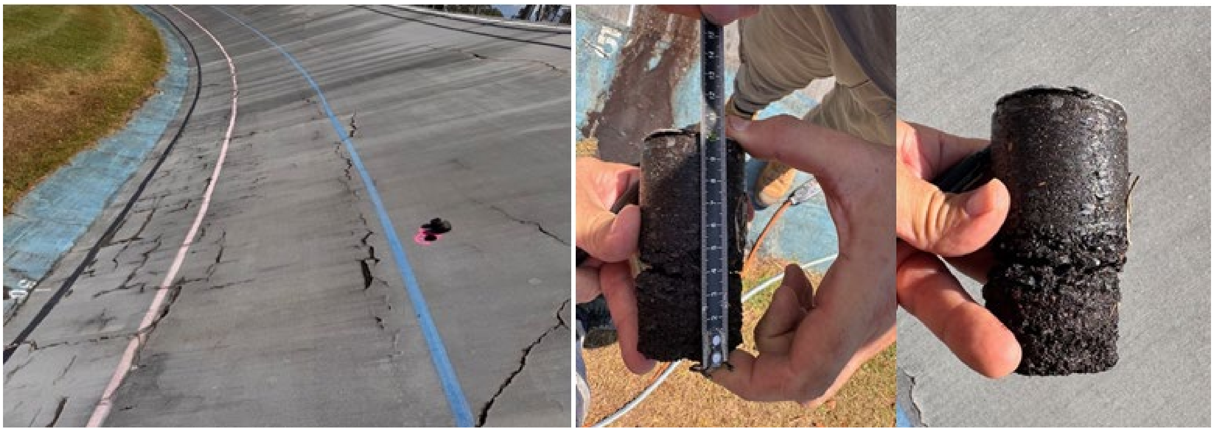


Figure 2: Figure 2 represents a physical core sample taken from the velodrome surface.

Interpretation of B-scan Data

Interpretation of total asphalt thickness relied on correlation between individual A-scan wiggle traces and the corresponding B-scan reflection horizons. In areas where the reflection contrast between asphalt lifts was strong, the third reflection peak was clearly identifiable in both the wiggle trace and the B-scan profile. In these locations, the onset of the third peak aligned well with a continuous reflector on the B-scan, allowing confident selection of total asphalt thickness.

However, the clarity of reflection was not uniform throughout the survey. In several zones, the deeper reflector appeared subdued or partially masked by signal attenuation, scattering and interference from overlying material interfaces. In some instances, the B-scan horizon at approximately 200 mm depth appeared visually continuous; however, the corresponding A-scan did not display a strong amplitude peak at that exact depth. Instead, a faint third reflection “bump” was present at a slightly shallower position, accompanied by a discernible change in signal energy and phase.

In such cases, interpretation prioritised the earliest consistent onset of the third reflection observable in the wiggle trace, rather than selecting a deeper, visually continuous but less well-defined B-scan horizon. This approach was applied deliberately and consistently across the dataset to avoid overestimating thickness in zones where deeper signal continuity may have represented constructive interference or layered scattering rather than the true asphalt–substrate interface.

The variability in reflection clarity reflects heterogeneous asphalt construction, variable lift bonding and material property differences across the track. As a result, thickness selection was not a simple automated horizon pick but required case-by-case professional interpretation to identify the most representative reflection event at each chainage location.

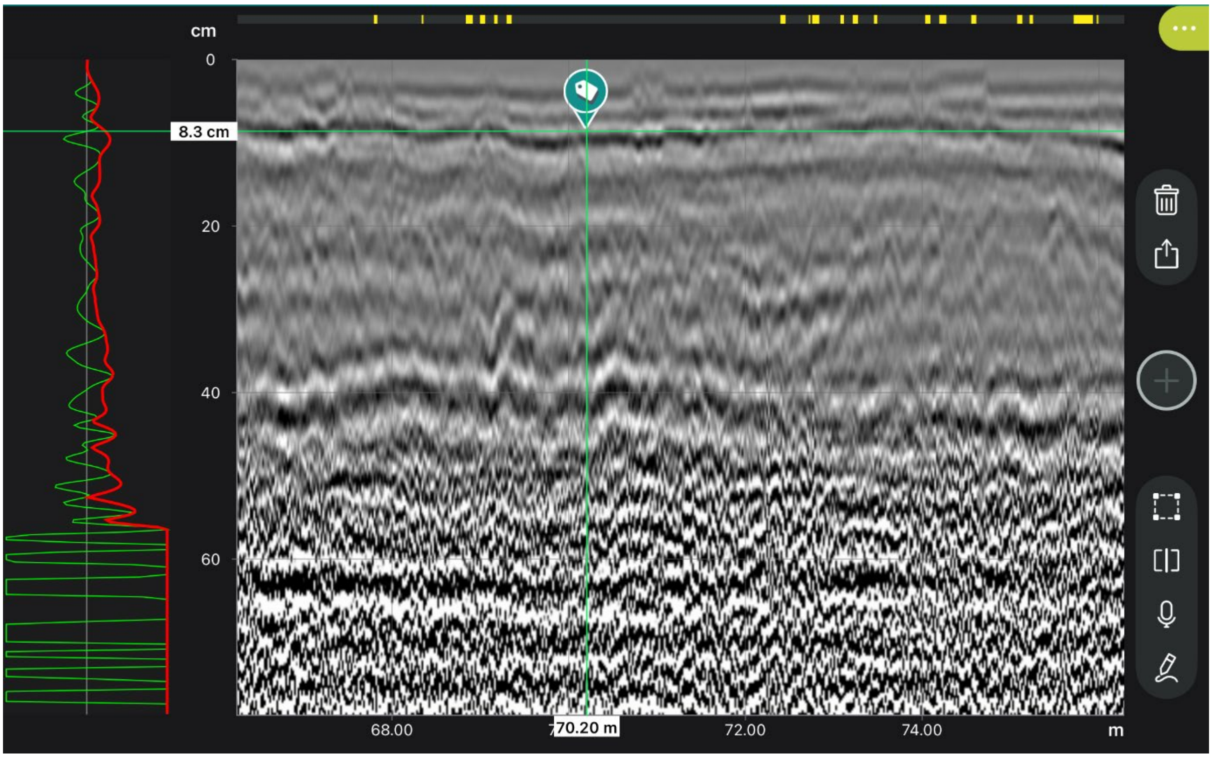


Figure 3: Example of Clear Third Reflection Identification

This dataset demonstrates a well-defined reflection sequence. The onset of the third peak is clearly identifiable on the A-scan wiggle trace and corresponds with a continuous, high-contrast reflector visible on the B-scan profile. The alignment between the wiggle trace onset and the B-scan horizon allows confident selection of total asphalt thickness at this chainage position. Reflection, continuity, and amplitude contrast are strong, resulting in minimal interpretive ambiguity.

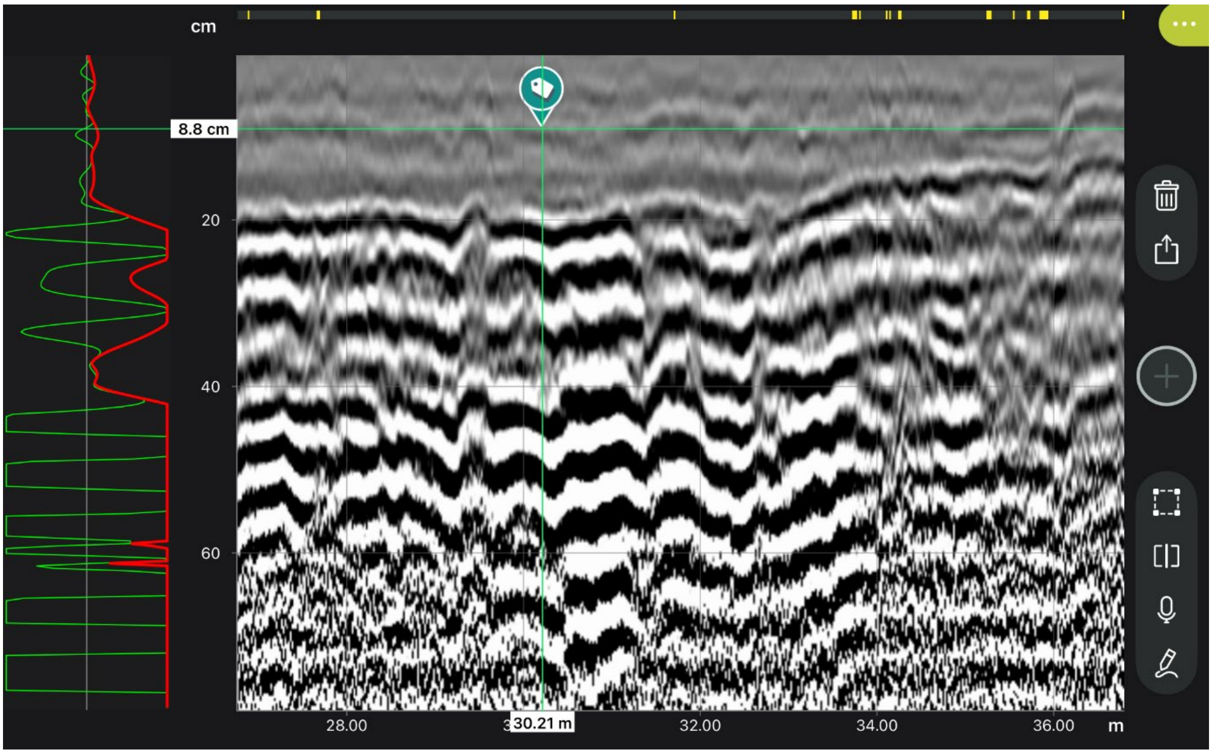


Figure 4: Example of Attenuated Third Reflection with Interpretation Required

This dataset illustrates a more complex reflection environment. While a visually continuous horizon is present on the B-scan at approximately 200 mm depth, the corresponding A-scan does not exhibit a strong amplitude peak at that position. Instead, a faint third “bump” is observable at a slightly shallower depth, accompanied by a discernible change in signal energy and phase.

In this instance, interpretation prioritised the earliest consistent onset of the third reflection visible in the wiggle trace over the deeper, visually continuous B-scan horizon. This approach was applied to avoid overestimation of asphalt thickness in zones where deeper signal continuity may represent interference or layered scattering rather than the true asphalt–substrate interface.

This example highlights the interpretive judgement required in heterogeneous asphalt sections and demonstrates why thickness selection was not based solely on automated horizon continuity.

Results

Longitudinal thickness interpretation was completed at nominal 10 m chainage intervals across approximately 330 m of track length for each of the four surveyed lanes. A total of 1,320 interpreted thickness points were generated across the velodrome.

The dataset demonstrates substantial longitudinal and localised variability in total asphalt thickness. Within individual lanes, thickness variation exceeding 60 mm was observed between the minimum and maximum interpreted values. Core validation within the Inner-Centre Lane confirmed this variability, with measured thickness ranging from 60 mm to 129 mm over relatively short chainage intervals.

Thickness variability was not confined to a single zone but occurred intermittently along the track length. In several locations, adjacent chainage positions exhibited notable variation, consistent with layered construction and differential asphalt placement. The observed variability is materially greater than the inherent export-resolution tolerance and reflects real structural variation in the pavement profile.

Where surface cracking and localised distress were present, radar response occasionally required minor positional adjustment to obtain a representative reflection. These adjustments did not materially alter the interpretation of the longitudinal trend.

Inner Lane

Interpretation of total asphalt thickness along the Inner Lane indicates measurable longitudinal variability across the full surveyed length.

Thickness values recorded at nominal 10 m chainage intervals demonstrate consistent fluctuation rather than uniform depth. Localised increases and decreases in interpreted thickness are present throughout the 330 m alignment, with no single zone exhibiting complete uniformity. The observed variation is consistent with layered asphalt construction and variable placement during installation.

In general, thickness transitions between adjacent chainage positions are gradual; however, several short segments display more pronounced change over relatively small longitudinal distances. These transitions are characteristic of construction variability rather than isolated interpretive artefacts, particularly given the consistent reflection picking methodology applied across the dataset.

No continuous zones of anomalously reduced reflection quality were observed that would suggest systematic misinterpretation of the base reflection within this lane. Reflection clarity was generally adequate to consistently identify the onset of the third peak representing the base of the asphalt structure.

The Inner Lane dataset therefore provides a reliable continuous longitudinal profile of asphalt thickness suitable for comparative assessment along the full track length.

Inner-Centre Lane

The Inner-Centre Lane exhibits the greatest degree of thickness variability within the surveyed track.

Destructive core samples extracted within this lane confirm total asphalt thickness ranging from 60 mm to 129 mm. The GPR-derived thickness profile exhibits similar variability, with intermittent zones of increased and reduced depth observed along the longitudinal alignment.

Notably, the Chainage 200–204 m region corresponds with core measurements indicating significant localised thickening. While the GPR-derived value at the nearest interpreted chainage position is lower than the corresponding core measurements, the cores were offset laterally from the scan line and separated into distinct segments during extraction, indicating layered construction and localised variation. Given the magnitude of the observed thickness change within short longitudinal intervals, this discrepancy is interpreted as spatial variability rather than a systematic calibration error.

Across the remainder of the lane, GPR-derived values demonstrate reasonable agreement with core thickness, with differences generally within the range expected for non-destructive interpretation, where dielectric properties and reflection clarity may vary slightly between locations.

The Inner-Centre Lane data therefore support the presence of significant longitudinal and localised structural variability within the asphalt profile.

Outer-Centre Lane

The Outer-Centre Lane presents a longitudinal thickness profile comparable in character to the Inner Lane, with consistent fluctuation across the surveyed length.

Thickness variation appears distributed rather than concentrated within a single region, suggesting construction variability occurred intermittently during placement rather than as a discrete structural defect.

Reflection quality in this lane was generally adequate to enable consistent identification of the third-peak onset. Minor attenuation was observed in isolated zones; however, reflection picking remained consistent with the methodology applied across all lanes.

No core validation was undertaken directly within this lane; therefore, interpretation is based solely on the continuous GPR dataset. Given the uniform-dielectric assumption applied across all lanes and the comparable reflection characteristics observed, the thickness values are considered internally consistent for longitudinal comparison.

Outer Lane

The Outer Lane exhibits longitudinal variability broadly consistent with the other surveyed lanes.

Thickness values fluctuate along the full 330 m alignment, with no extended sections of uniform depth. The pattern of variation suggests typical construction variability rather than progressive structural thinning or thickening in a single direction.

Reflection amplitude and clarity were generally sufficient to maintain consistent identification of the third reflection onset. Minor positional adjustment was occasionally required to avoid surface cracking and obtain a representative radar response, consistent with the methodology described previously.

As with the Outer-Centre Lane, no direct core validation was available for this lane; however, the similarity in reflection behaviour and variability patterns across all four lanes supports the reliability of the interpreted thickness profile.

Discussion

The longitudinal GPR survey demonstrates that the velodrome asphalt profile is not uniform in thickness and exhibits significant variability both along and across lanes.

Across the four surveyed alignments, thickness variation occurs intermittently rather than progressively. There is no evidence of a consistent linear increase or decrease in depth in any single direction. Instead, the data indicate localised thickening and thinning zones distributed throughout the track length. This pattern is consistent with variable asphalt placement during construction rather than post-construction differential wear alone.

Core validation within the Inner-Centre Lane confirms that total asphalt thickness can vary by more than 60 mm over relatively short longitudinal distances. The separation of cores into two distinct segments during extraction further supports the presence of multiple asphalt lifts and variable interlayer bonding conditions. These observations correlate with the multiple reflection interfaces observed in the GPR data and reinforce that the structure comprises layered asphalt construction rather than a monolithic section.

The most significant localised increase in thickness identified in the core data occurs within the Chainage 200–204 m region. While the GPR-derived thickness at the nearest interpreted chainage position is lower than the core measurement, the magnitude of thickness variation observed in adjacent zones suggests substantial lateral and localised construction variability. Given that the core locations were offset from the scan line, the discrepancy is interpreted as reflecting spatial variability rather than a systematic depth-conversion error.

It is also noted that surface cracking and localised surface distress were present in several areas. While GPR is not a direct structural integrity test, degraded surface conditions can influence radar coupling and reflection clarity. Minor positional adjustments were therefore made during interpretation to ensure consistent identification of reflections. These adjustments do not materially affect the interpretation of the longitudinal trend but highlight the heterogeneous surface condition of the track.

Overall, the dataset indicates that asphalt thickness across the velodrome is highly variable, with isolated thickening pockets and thinner sections present across multiple lanes. The observed variability substantially exceeds export rounding tolerance and is consistent with real construction variability.

The continuous longitudinal profile provided by GPR offers significantly greater spatial resolution than discrete coring alone and enables the identification of zones where thickness variations may be relevant to remediation planning and structural assessment.

Limitations

Ground Penetrating Radar is a non-destructive geophysical method that estimates material thickness based on electromagnetic wave velocity and reflection contrast between material interfaces. Thickness interpretation is therefore dependent on the assumed dielectric properties and on the identification of reflections.

A uniform dielectric constant of 6.0 was applied across all lanes for depth conversion. While this value is representative of dense asphalt materials, in situ dielectric properties can vary due to differences in aggregate type, binder content, air voids, compaction and moisture condition. Without continuous destructive calibration or embedded known-depth targets at each chainage position, local dielectric variation cannot be independently verified at every location.

Thickness interpretation relied on consistent identification of the onset of the third reflection peak to represent the base of the asphalt structure. In areas where reflection amplitude was reduced or partially attenuated, interpretation required professional judgement to identify the earliest discernible onset of that reflection. While methodology was applied consistently across the full dataset, minor interpretation tolerance is inherent in non-destructive testing of layered materials.

Core samples were not extracted directly on the GPR scan line and were offset laterally from interpreted positions. As asphalt thickness exhibits both longitudinal and lateral variability, exact point-to-point correspondence between core thickness and GPR-derived thickness is not expected. Core measurements are therefore considered representative validation points rather than direct calibration anchors for each interpreted chainage position.

Depth values exported from the Proceq system are reported to 0.01 m resolution, resulting in a quantisation tolerance of approximately ±5 mm following conversion to millimetres. Observed thickness variability across the track substantially exceeds this rounding resolution.

GPR does not directly assess material quality, bonding condition, density or structural integrity. The survey identifies only geometric variations in thickness. Any structural performance assessment or remediation design should consider complementary engineering evaluation as required.

Conclusion

South-East Scanning completed a longitudinal Ground Penetrating Radar investigation across four lanes of the Toowoomba Velodrome for NTRO, generating 1,320 interpreted thickness points at nominal 10 m chainage intervals.

The survey demonstrates that asphalt thickness across the velodrome is not uniform, exhibiting significant longitudinal and localised variability. Thickness variation is distributed intermittently along the track rather than occurring as a single progressive trend, indicating construction variability within the layered asphalt profile.

Destructive core samples extracted within the Inner-Centre Lane confirm total asphalt thickness ranging from 60 mm to 129 mm over relatively short chainage intervals. The magnitude of variation observed in the core data is consistent with that observed in the continuous GPR dataset.

Differences between core measurements and adjacent GPR-derived thickness values are interpreted as representative of spatial variability and layered construction effects rather than systematic calibration error. Observed variability substantially exceeds export resolution tolerance and reflects real structural thickness differences within the pavement.

The continuous longitudinal thickness profiling provided by GPR offers a comprehensive representation of asphalt depth across the full track length and enables identification of zones of relative thickening and thinning that may be relevant to remediation planning and material quantity assessment.

SUMMARY

Ground Penetrating Radar surveying was undertaken across four lanes of the velodrome track to assess asphalt thickness at 10 m chainage intervals over a full 333.33 m lap. Thickness values shown represent interpreted base of asphalt reflections derived from calibrated A–scan and B–scan data. Localised variability is present and values should be considered indicative of in situ conditions at the time of survey.

SOUTH EAST SCANNING

Geolitix link: N/A

Reflection Amplitude

Weak — Strong

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DATE(S):	30/01/2026
DRAWING:	1/1

Appendix 1: Chainage and Asphalt Depths

Dataset	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
Inner Lane	60	70	90	80	80	100	80	80	90	100	130	140	130	130	70	60	90	70	90	100	90	110	100	50	90	90	100	70	120	110	70	60	50	70		
Inner-Centre Lane	70	80	100	100	100	110	80	60	80	80	90	110	80	90	100	100	90	80	70	80	70	80	90	70	60	80	80	80	110	110	80	80	60	70	80	
Outer-Centre Lane	60	80	100	110	100	60	70	70	80	90	60	90	110	70	80	100	100	80	70	60	90	90	90	80	80	90	70	110	100	100	110	90	80	90	110	100
Outer Lane	60	50	70	90	70	100	70	70	80	90	90	80	100	80	70	80	70	80	100	90	80	100	70	90	80	70	60	80	80	70	70	70	70	70	60	50

Notes	Tolerance: Proceq DOCX export rounds Calculated Depth to 0.01 m (10 mm). After conversion to mm, each exported value represents the nearest 10 mm. Use an allowance of plus or minus 5 mm on individual points. See Lane1_Range_Table for auto-generated lower and upper bounds per chainage.

If you have any queries about this document or its contents, don't hesitate to contact South-East Scanning.

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