Canary Islands Underground Water Leak Detection Using Aerial Thermography

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~ Summary ~

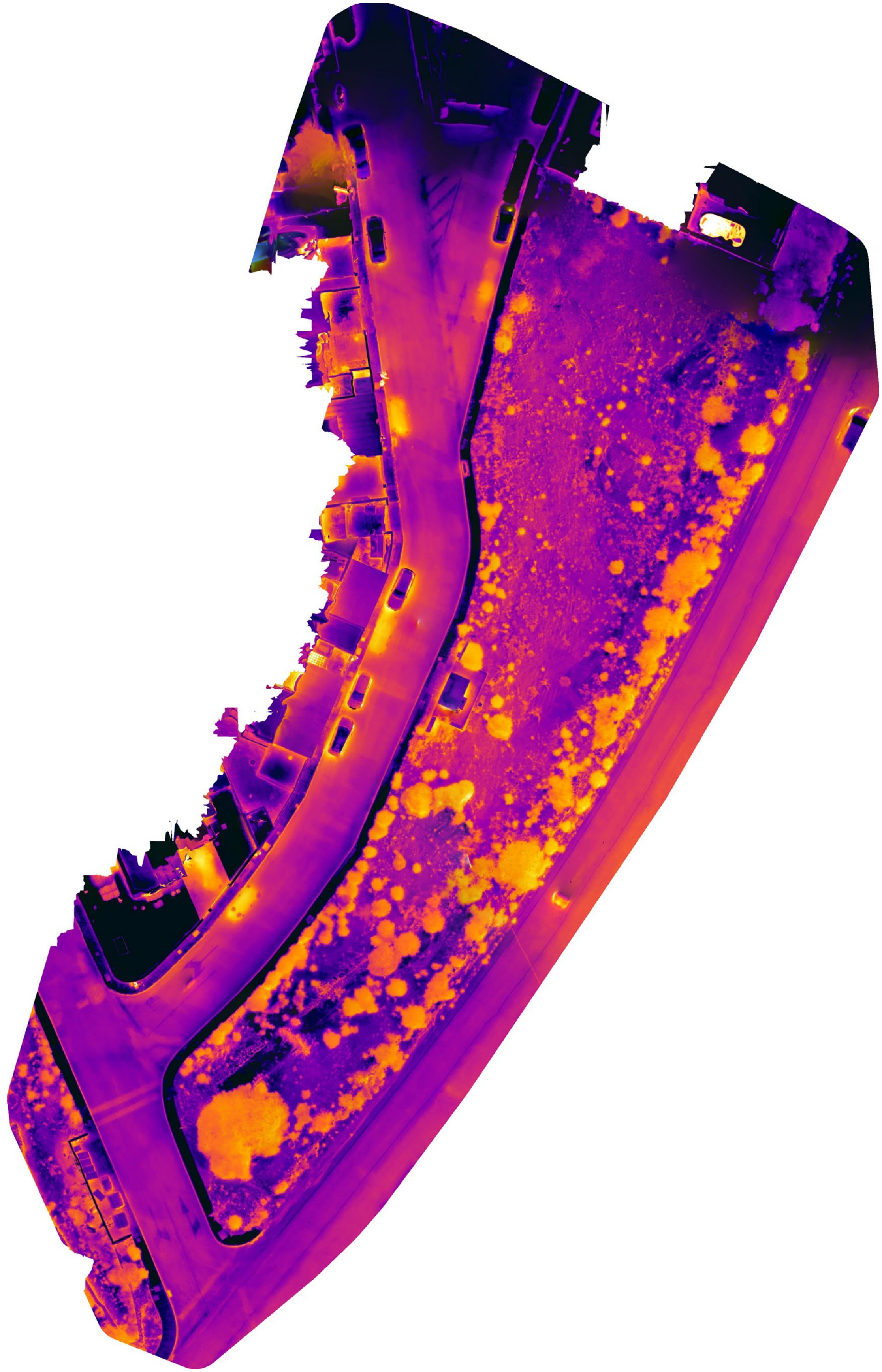
This Phase 1 proof-of-concept project explored the use of aerial thermography to support underground potable water leak detection in a volcanic urban environment. Conducted at a known leak site, the work focused on protocol development, survey timing, spatial resolution, and disciplined interpretation rather than blind detection. The study demonstrated where thermography adds value as a qualitative screening tool, highlighted its limitations, and established best-practice methods for future phased deployment.

Phase 1 Proof of Concept – Lanzarote Volcanic Urban Environment

This project documents a Phase 1 proof-of-concept study exploring the use of aerial thermography to support underground potable water leak detection in an urban environment. Conducted in a volcanic landscape with complex ground materials and buried infrastructure, the work was deliberately framed as a controlled technical investigation rather than a blind detection exercise.

The objective was not to “find leaks” in the traditional sense, but to determine whether thermography, when applied with appropriate professional discipline, could identify surface thermal behaviour consistent with known leakage and, importantly, to define where the technique adds value and where it does not.

Thermography Services (UK) Ltd was commissioned to act in a consultancy capacity, operating under Level 3 supervision, to develop a defensible methodology, oversee data interpretation, and produce a professional technical report suitable for informing future decision-making and potential Phase 2 deployment.



TL;DR – Key Takeaways

This Phase 1 project evaluated whether aerial thermography can support underground potable water leak investigations when applied with professional discipline.

- Thermography was tested at a known leak site to validate methodology, not as a blind detection exercise.
- Dawn surveys provided the most reliable and interpretable thermal data under near-equilibrium conditions.
- High spatial resolution (~3 cm GSD) was essential to resolve subtle leak-related surface behaviour.
- RGB imagery was critical for excluding false positives caused by surface repairs and infrastructure.
- Paved road surfaces proved diagnostic, while open land and vegetation were non-diagnostic.
- Thermography is an indirect, qualitative tool that supports prioritisation rather than confirming leaks.

Phase 1 confirms that aerial thermography can add value to underground water leak investigations when used as part of a controlled, protocol-driven workflow.

Project Context and Challenges

Underground water leak detection presents a fundamentally different challenge to traditional building or electrical thermography. Unlike exposed systems, buried potable water infrastructure cannot be directly observed and does not inherently generate strong thermal contrast at the surface. In this case, the site was located within a paved urban environment underlain by volcanic substrates typical of the Canary Islands. These conditions introduce several complicating factors:

- Highly variable ground materials with uneven thermal behaviour
- Asphalt surfaces subject to rapid solar loading and cooling
- Unknown pipe depths, bedding materials, and historical repairs
- Limited availability of survey-grade infrastructure drawings

Without careful control, these variables can easily produce misleading thermal artefacts. As a result, the project was approached with a strong emphasis on governance, protocol development, and cautious interpretation.

Thermography Objective and Theoretical Basis

Thermography does not detect water directly. Instead, it measures surface temperature distribution, which may be influenced by subsurface conditions such as moisture content, altered thermal inertia, or disturbed ground associated with leakage. When water escapes from a buried pipe, it can modify how surrounding materials absorb, store, and release heat. Moisture-laden materials typically warm and cool more slowly than dry equivalents.

In paved environments, this can manifest as subtle, spatially coherent thermal patterns rather than dramatic hot or cold spots.

Crucially, these effects are indirect and comparative. Thermography cannot confirm pipe integrity, leak rate, flow direction, or volume. Its value lies in supporting prioritisation and guiding further investigation when applied within known constraints.

For this project, the objective was therefore defined as follows:

- To assess whether surface thermal behaviour consistent with a known underground water leak could be identified
- To determine optimal survey timing and spatial resolution
- To establish a repeatable, defensible data collection and analysis protocol
- To document limitations and non-diagnostic conditions

Proof of Concept Approach

Phase 1 was deliberately conducted at a known leak location rather than as a blind search. This decision was fundamental to the success of the project.

By working at a site with confirmed surface water emergence and repair activity, observed thermal behaviour could be compared directly against reality. This allowed the methodology itself to be tested, refined, and validated without the pressure to “find something” where nothing may exist. This approach also enabled disciplined learning.

Features that appeared anomalous at first could be re-evaluated, downgraded, or excluded as evidence accumulated, reinforcing correct professional behaviour rather than confirmation bias.

Data Collection Protocol

A structured data collection protocol was developed before any analysis commenced. Given the qualitative nature of thermography and the subtle signals expected, ad-hoc or opportunistic capture was considered inappropriate.

Key elements of the protocol included:

- Radiometric thermal capture only
- Concurrent RGB imagery for contextual verification
- Dual survey timings: dawn and dusk
- Multiple flight altitudes to test spatial resolution
- Environmental data logging for each mission

The protocol was applied consistently across all flights, enabling meaningful comparison between datasets and reducing interpretive uncertainty.

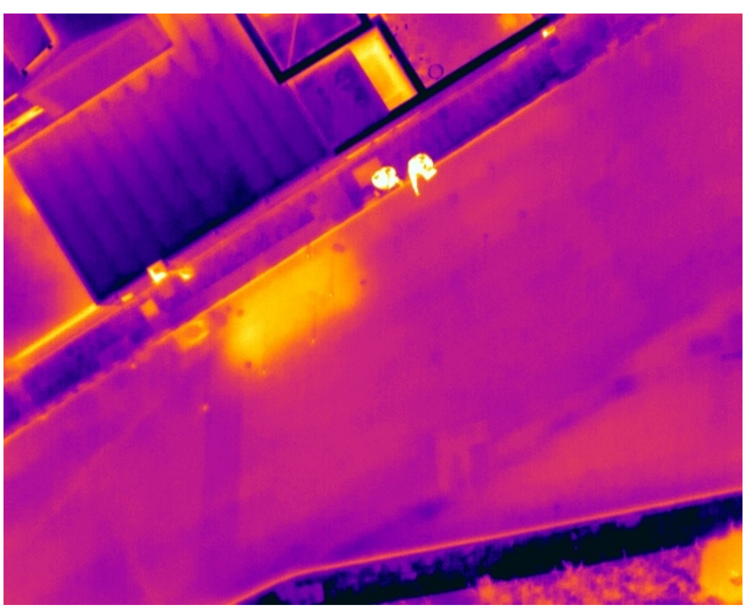
Survey Timing and Environmental Considerations

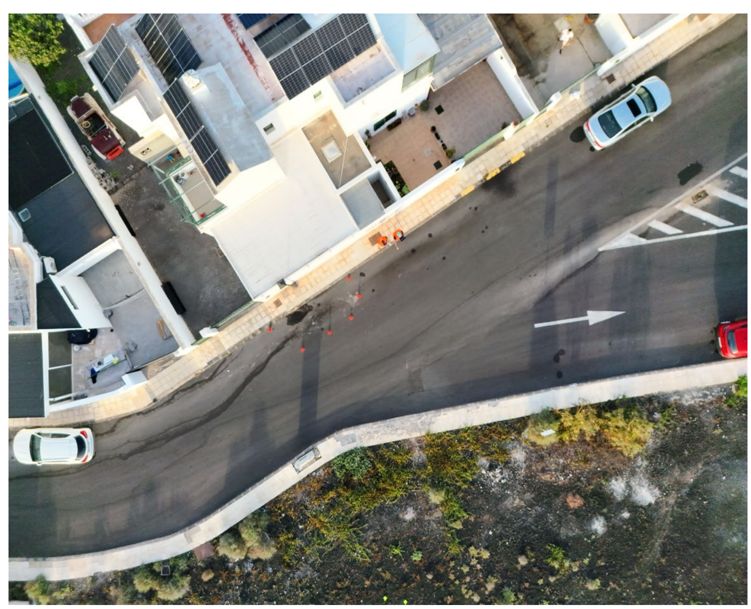
Two survey windows were selected to capture different stages of the surface thermal cycle.

Dusk surveys were conducted after daytime solar loading to observe cooling behaviour and potential evaporative effects. While visually striking, these datasets proved sensitive to recent surface activity, shading, and transient conditions.

Dawn surveys, conducted before significant solar loading, produced the most interpretable results. Under near-equilibrium conditions, subtle thermal differences associated with retained heat in moisture-affected sub-base materials became clearer and more stable.

This finding was one of the most significant outcomes of Phase 1 and directly informs best practice moving forward.





Spatial Resolution and Altitude Testing

Surveys were conducted at three altitudes to assess the impact of ground sample distance on interpretability. High-altitude data provided useful context but lacked the spatial resolution required to resolve small-scale surface behaviour associated with leakage. Mid-altitude data offered improved clarity but remained limited for diagnostic purposes. Low-altitude surveys, achieving a ground sample distance of approximately 3 cm, were essential.

At this resolution, localised anomalies, plume behaviour, and subtle gradients could be evaluated with confidence.

This confirmed that spatial resolution is a critical limiting factor in aerial thermographic leak assessment.

Data Processing and Analysis Workflow

All thermal data were processed using a controlled radiometric workflow. Environmental parameters recorded during capture were applied during post-processing to ensure consistency. Thermal spans were selected separately for dawn and dusk datasets to reflect different surface conditions. A single colour palette was used consistently within each dataset to avoid visual bias. RGB imagery was reviewed alongside thermal data at every stage.

This proved essential for identifying and excluding confounding factors such as surface reinstatement patches, kerb geometry, staining, shading, and street furniture. Selected datasets were processed into thermal and RGB orthomosaic using WebODM. This allowed spatial comparison across the site and provided an accessible visual tool for stakeholder review.

Findings at the Known Leak Location

At the confirmed surface water breach, thermography revealed a repeatable localised warm anomaly during dawn surveys. This anomaly was spatially coherent, distinct from surrounding asphalt, and aligned precisely with visible surface water emergence and staining. Adjacent to the breach, a diffuse plume-like thermal feature was observed.

Line profile analysis demonstrated a stepped temperature drop followed by shallow thermal decay, consistent with retained heat in moisture-affected near-surface materials rather than transient surface heating. These findings were consistent across multiple datasets and supported by RGB evidence, providing a high degree of interpretive confidence at this location.

Differentiation of Non-Leak Features

Elsewhere on site, several linear thermal features were identified crossing the road surface. Initial inspection suggested potential subsurface anomalies.

However, correlation with RGB imagery revealed surface indentations and manhole covers aligned with these features. The thermal signatures were stable, narrow, and lacked plume behaviour or surface water expression. These characteristics were consistent with service ducts or trench backfill zones rather than active leakage. Reclassifying these features as baseline infrastructure signatures was a critical step in avoiding false positives and reinforced the importance of contextual interpretation.

Non-Diagnostic Areas

Adjacent open land and vegetated areas were reviewed as part of the Phase 1 assessment. Thermal behaviour in these zones was dominated by vegetation structure, shading, and heterogeneous ground materials.

No repeatable patterns consistent with underground water leakage were identified. As a result, these areas were classified as non-diagnostic for this application. This finding reinforces that paved service corridors offer the most reliable medium for thermographic leak assessment in environments of this type.

What Phase 1 Demonstrated

Phase 1 confirmed that aerial thermography can contribute meaningful decision-support information at known or suspected underground water leak locations when applied correctly. It also clearly demonstrated the limitations of the technique. Thermography does not confirm leaks in isolation and cannot replace established detection methods. Its value lies in screening, prioritisation, and guiding targeted investigation when integrated with infrastructure knowledge and engineering judgement.

Lessons Learned and Best Practice

Several key lessons emerged from this project:

- Dawn surveys consistently outperform dusk surveys for interpretability
- High spatial resolution is essential
- RGB imagery is not optional, it is critical
- Infrastructure context determines confidence
- Open land areas are generally non-diagnostic
- Professional restraint is as important as technical capability

These insights now form the basis of a refined methodology suitable for future deployment.

Outcome and Next Steps

The Phase 1 proof-of-concept achieved its objective. It validated a disciplined approach to thermographic leak assessment, defined where value exists, and established clear boundaries around interpretation. The findings support progression to a targeted Phase 2 deployment, focused on known or suspected leak corridors, supported by improved infrastructure information and integrated with complementary detection methods.

Summary

This project demonstrates how thermography, when applied with appropriate governance, scientific understanding, and professional discipline, can support complex infrastructure investigations.

It also illustrates why careful methodology, honest interpretation, and clear communication are essential when working at the limits of a technique's capability. Phase 1 has laid a strong foundation for future work and provides a robust reference model for applying aerial thermography to underground water leak detection in challenging environments.

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Steve Fisher is a UK-based Level 3 Master Thermographer and director of Thermography Services (UK) Ltd. He specialises in advanced qualitative thermographic analysis across the built environment, renewable energy systems, and complex infrastructure applications, including aerial thermography and protocol development.

With extensive experience in building diagnostics, solar PV inspection, and infrastructure investigations, Steve operates at consultancy level, supporting clients, engineers, and inspection teams with defensible methodologies, disciplined interpretation, and professional reporting. His work places strong emphasis on governance, limitations of technique, and evidence-led decision support rather than speculative fault finding.

Steve regularly collaborates with international partners on proof-of-concept and pilot projects, providing Level 3 oversight, data interpretation, and reporting frameworks for challenging thermographic applications. He is particularly interested in the responsible use of thermography at the edge of its capability, where scientific understanding, restraint, and context are critical.