Purpose of the Project

With rapid urban development and infrastructure expansion in residential zones, pre-excavation identification of subsurface utilities and anomalies has become critical. This project aimed to detect potential subsurface cavities and map historical qanat routes in a neighborhood in eastern Tehran using **Ground Penetrating Radar (GPR)**. The study was designed to mitigate construction risks, enhance worksite safety, and ensure long-term structural stability.

Methodology

The geophysical survey employed the **PinPointR GPR system** (ImpulseRadar) (Figure 1), a state-of-the-art device featuring **dual 400/800 MHz antennas** for simultaneous high-resolution shallow imaging and deeper subsurface penetration. Key advantages of this system include:

- **Enhanced resolution and precision** compared to single-frequency GPR units.
- **Real-time GPS integration** (multi-frequency GNSS) for centimeter-accurate georeferencing.

Data acquisition involved systematic grid-based profiling across the site. Raw radargrams were post-processed in *Geolitix*™ to filter noise, enhance signal clarity, and generate depth-sliced 3D models. Cross-validation of electromagnetic wave reflections with geospatial coordinates ensured precise anomaly mapping.

Figure 1 - Overall view of the project site.

Figure 2 - The ImpulseRadar GPR device, PinPointR model, along with the multi-frequency GPS.

Design and Implementation

A total of **25 linear profiles** were executed across client-specified high-risk zones. To optimize spatial resolution, a **bidirectional grid** (dense parallel and perpendicular lines) was deployed, facilitating:

- High-density subsurface coverage.
- Cross-sectional analysis of anomaly geometry.
- Integration of 3D volumetric models for stakeholder review.

Key Findings

1. **Shallow Anomalies (<5 m depth):** Multiple high-amplitude reflections indicate probable **qanat tunnels** and localized soil voids.
2. **Soil Heterogeneity:** Variations in wave attenuation suggest mixed lithology (e.g., clay lenses, collapsible strata), correlating with surface instability risks.
3. **Technical Limitations:** Signal penetration was reduced in areas with conductive soils, underscoring the need for complementary methods (e.g., ERT or borehole logging).

Figure 3 – Field Deployment of GPR System: field specialist conducts a grid-based GPR survey using the **PinPointR dual-frequency antenna system** *(ImpulseRadar)*.

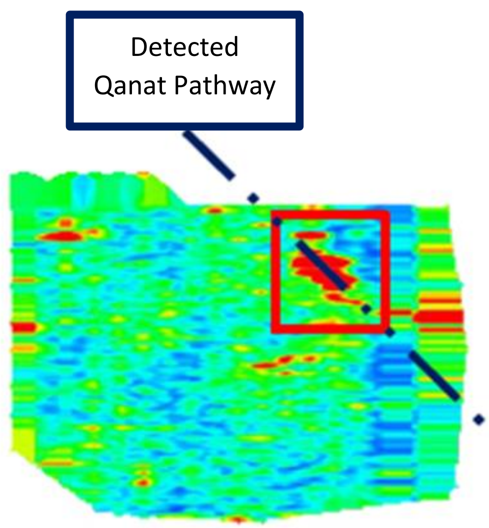

Figure 4 – GPR-Uncovered Qanat Pathway: Depth slice visualization (via Geolitix™ software) reveals a subsurface qanat system identified during GPR survey in eastern Tehran.

conclusion

This GPR survey successfully identified critical subsurface hazards in eastern Tehran, directly supporting construction risk management strategies. The concentration of anomalies in discrete zones highlights the legacy of qanat systems and localized geotechnical vulnerabilities. For comprehensive risk assessment, we recommend:

- **Multi-method verification** (e.g.,ERT, SRT, drilling at flagged coordinates).
- **Urban planning integration** of GPR data to prioritize reinforcement measure.