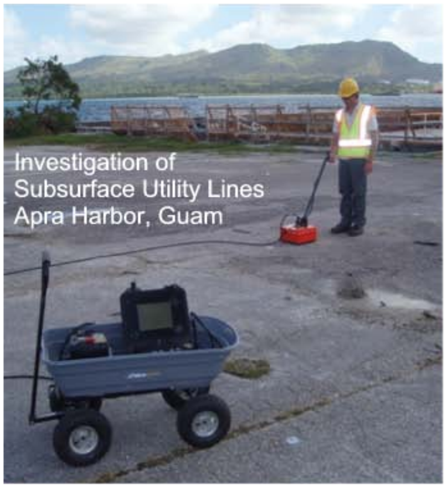
Ground Penetrating Radar Services

For Detection and Mapping of Underground Structures And Investigation of Earth Concrete Structures



Investigation of
Subsurface Utility Lines
Apra Harbor, Guam

Investigation of
Steel Reinforcement
in Concrete Wall
Long Beach, CA

Investigation of Cavities
Beneath Dam Spillway
Bull Lake, Wyoming

ADVANCED GEOSCIENCE, INC.
24701 Crenshaw Boulevard
Torrance, California 90505

For More Information Please Contact: Mark Olson, Principal Geophysicist and Geologist
Email: MGOlson@AdvancedGeoscience.com
Telephone (310) 378-7480

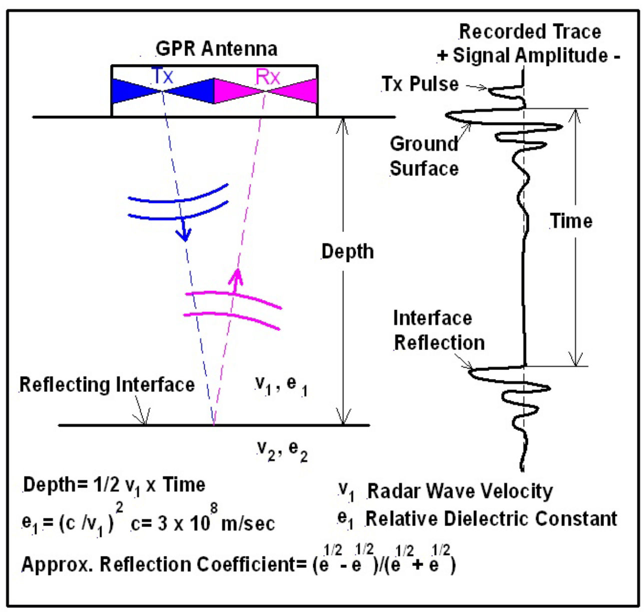
Introduction

Advanced Geoscience is a Torrance, California-based firm specializing in subsurface geophysical surveys and non-destructive evaluation of earth structures (website: www.AdvancedGeoscience.com). We perform smaller-scale geophysical and remote-sensing measurements for detecting underground structures, archaeological investigations, and investigations of concrete structures such as building foundations, retaining walls, harbor wharves, dams, tunnels, and bridges. We also perform subsurface geophysical surveys for deeper investigations related to geotechnical and environmental investigations, and geological exploration. This document provides more information on our capabilities of using ground penetrating radar (GPR) and related remote-sensing technology for imaging subsurface structures and the investigation of earth concrete structures.

Since our firm was established in 1997 we have completed numerous GPR surveys for investigations of subsurface utility lines, deeper pipelines, underground storage tanks, archaeological sites, and concrete structures. Several of these surveys were completed for agencies such as the US Bureau of Reclamation, City of Los Angeles Department of Public Works, City of Phoenix Department of Transportation, Alameda Transportation Corridor, US Navy, and the California Army National Guard. We have also completed GPR surveys for pre-construction and borehole clearance investigations at the Cedars-Sinai Medical Center, Kaiser Hospitals, Northrop Grumman, and Boeing facilities, as well as numerous petrochemical facilities in Southern California.

Technical Approach

Ground penetrating radar (GPR) works by pulsing microwave frequency electro-magnetic waves into the ground to record two-dimensional profile images of the subsurface. Reflection patterns are returned from interfaces separating materials with different electrical properties (dielectric constant). Materials having large differences in dielectric constant such as soil overlying metal and concrete structures exhibit stronger-amplitude reflections. The estimated depth to the reflecting interface can be calculated by using an empirical determination of the radar wave velocity through the overlying soil.



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24701 Crenshaw Blvd. Torrance, California 90505 Tel (310) 378-7480 Fax (310) 872-5323

Commercially available GPR systems were first introduced over 30 years ago primarily for deeper subsurface investigations. Since this time GPR recording systems and antennas have undergone engineering improvements to extend their capability to the imaging of smaller features within concrete structures.

Advanced Geoscience uses state-of-the-art GPR equipment developed by Geophysical Survey Systems, Inc. (www.Geophysical.com). This equipment is capable of digitally recording and processing radar profile data in the field.

To image reflection patterns from underground structures we typically use FCC-licensed GPR antennas in the frequency range 80 to 900 mega-Hertz. Deeper structures such as underground foundations and larger diameter pipelines in the depth range 5 to 40 feet are imaged using lower-frequency 80 to 200 MHz antennas. Shallower structures such as utility lines in the upper 10 feet are imaged using higher-frequency 400 to 900 MHz antennas. To investigate reflecting interfaces within concrete structures we typically use much higher-frequency antennas in the range 900 to 2,500 MHz.

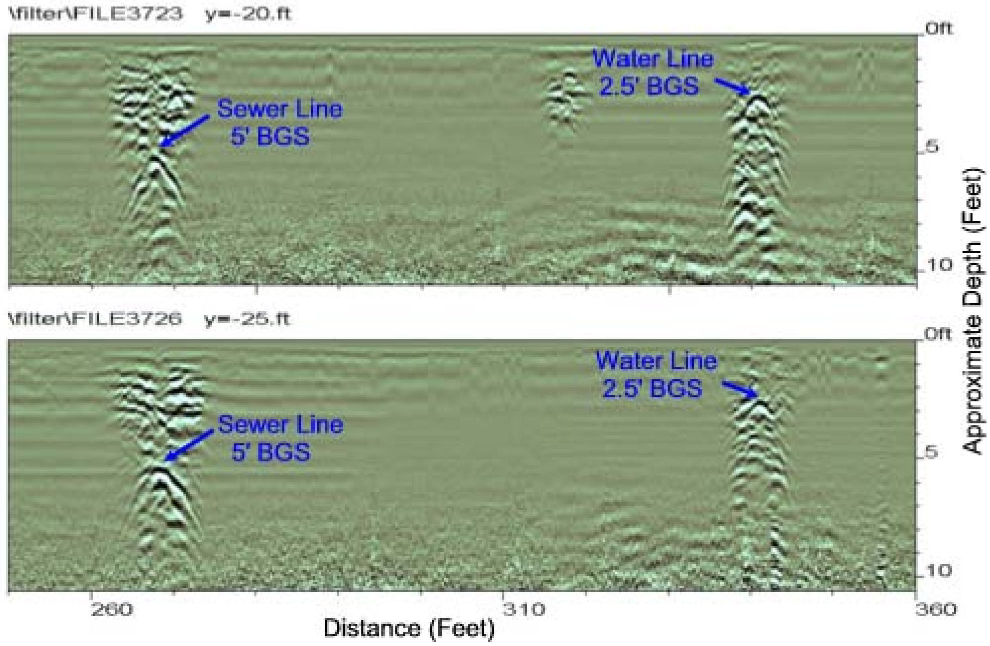
The GPR antennas are moved across the ground surface or the surface of concrete structures as they transmit and receive radar waves. Profile images such as the ones shown below are digitally recorded as the antenna moves over reflecting surfaces from pipelines, steel reinforcement, concrete-soil interfaces, air-filled cavities (voids), and other interfaces. These 2D profile images are displayed in the field during the surveys and evaluated. Further evaluation of the GPR profiles is performed using the 2D and 3D image enhancement software GPR-Slice™ (www.GPR-survey.com). Digital signal processing using GPR-Slice can enhance weaker reflection patterns on the 2D profiles. In addition, where GPR profiling is conducted along closely-spaced grid lines, 3D data bases of GPR reflection amplitude can be created and used to evaluate reflection patterns from structures in plan view. These plan view “time slices” of the GPR reflection amplitude across a survey grid can provide a detailed 3D imaging of reflections in areas where there are closely-buried pipelines, archaeological structures, or smaller features within concrete structures.

Ground Penetrating Radar and Remote-Sensing Services

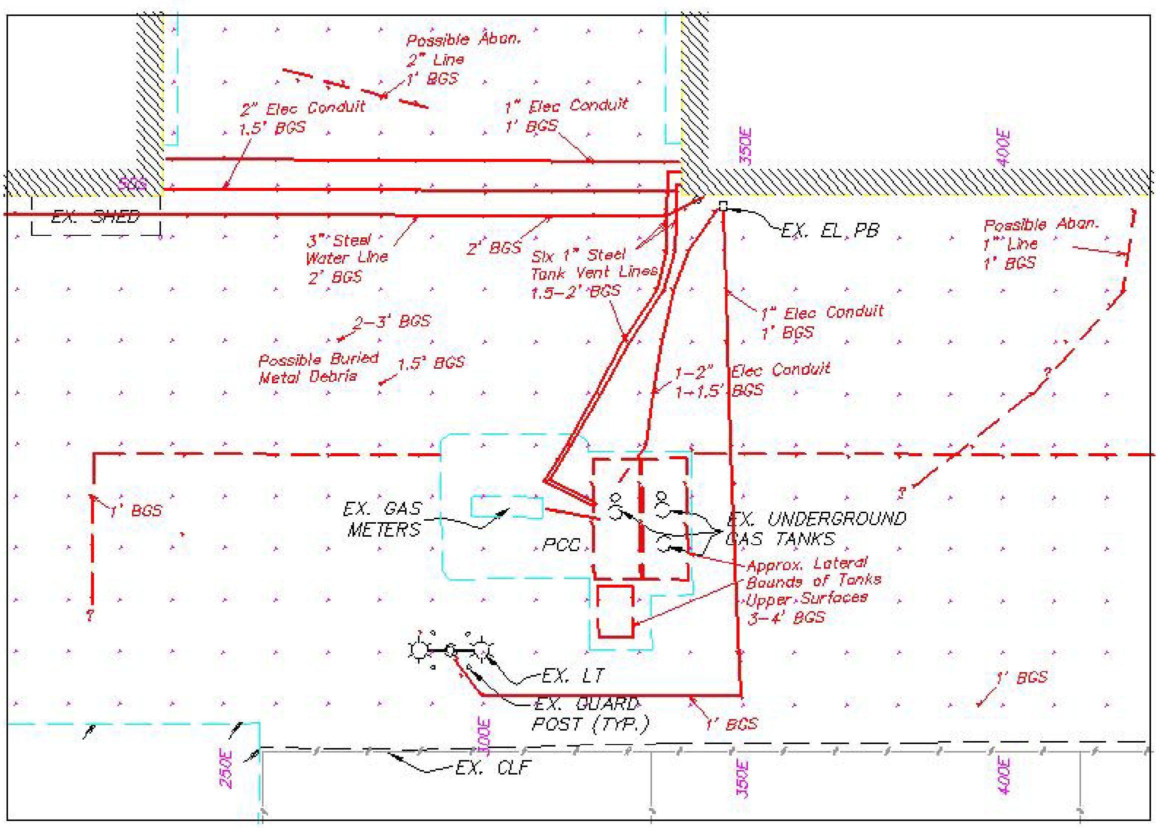
The following lists some of the GPR and related remote-sensing services we perform. Examples of the various project data displays are also provided.

Subsurface Ground Penetrating Radar 2D/3D Surveys

- Detection of Underground Structures, Utilities, and Pipelines
- AutoCAD mapping of Underground Structures, Utilities, and Pipelines
- Investigation of Subsurface Building Foundations
- Investigation of Former Excavations and Burial Pits
- Investigation of Subsurface Cavities (Voids)
- Investigation of Archaeological Sites



Shows paralleling 400-MHz GPR profiles with arch-shaped reflection patterns (enhanced by digital processing) from a water line 2.5 feet below the ground surface and deeper sewer line crossing beneath the survey area. Depth scale is based on the measured velocity of radar waves at this site.



Shows AutoCAD mapping of GPR reflection patterns (in red lines) from subsurface pipelines and fuel storage tanks. This map was extracted from the GPR reflection mapping of a 10-acre military facility.

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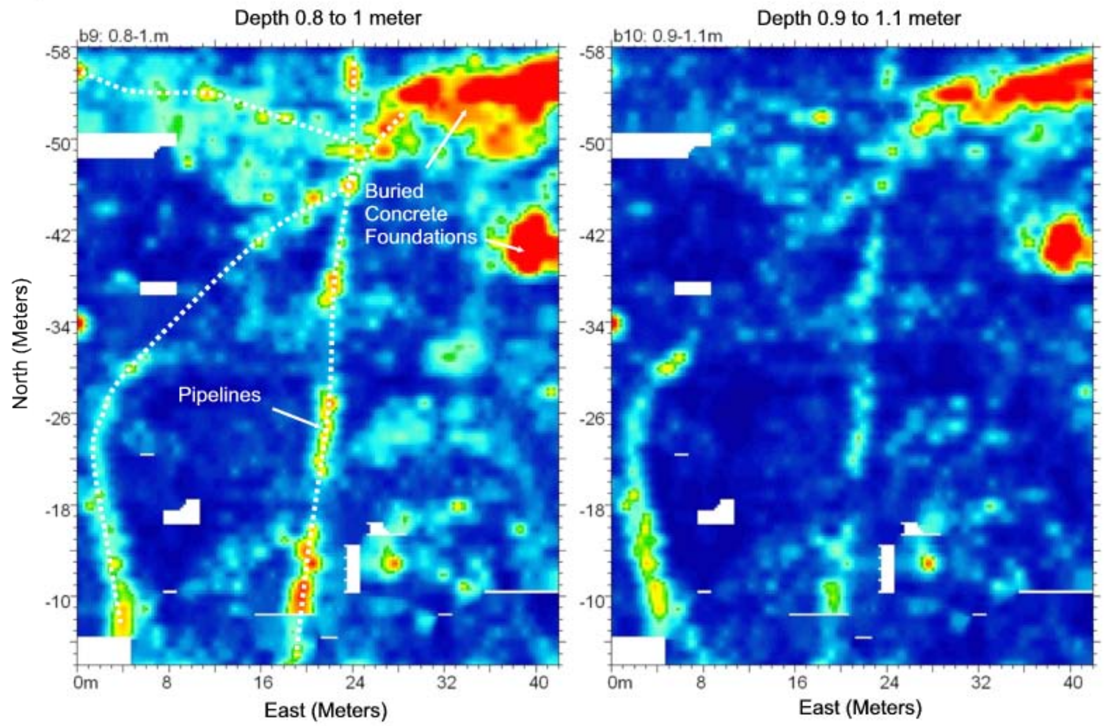
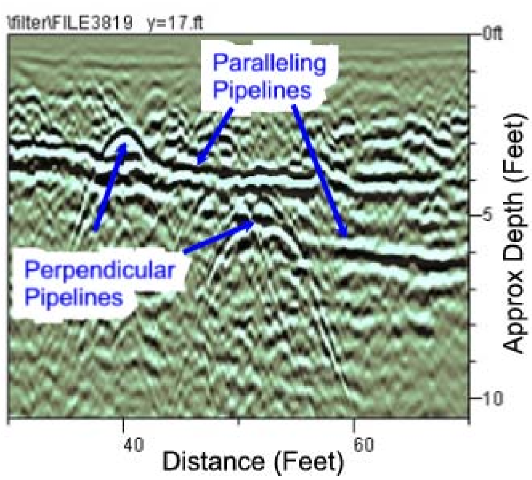


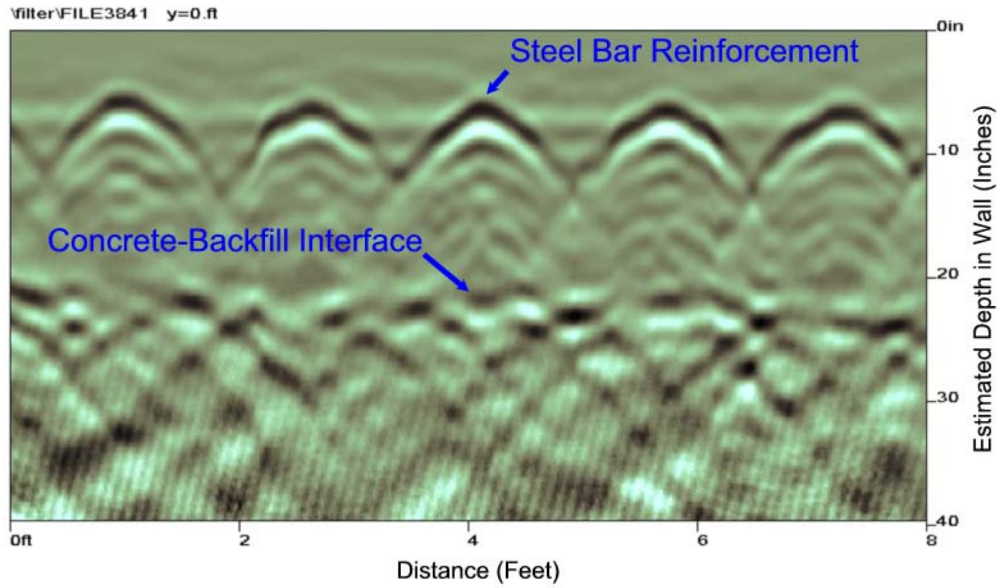
Shows selected "time slice" images from a 3D GPR survey of subsurface structures conducted by recording 200-MHz GPR profiles along east-west grid lines spaced 1 meter apart. These images show plan views of radar reflection amplitude variations returning from two different depth intervals. The red and yellow areas of higher-amplitude reflection energy show the lateral bounds of former concrete foundations beneath the existing ground surface. The narrower linear patterns indicate pipelines and other features.



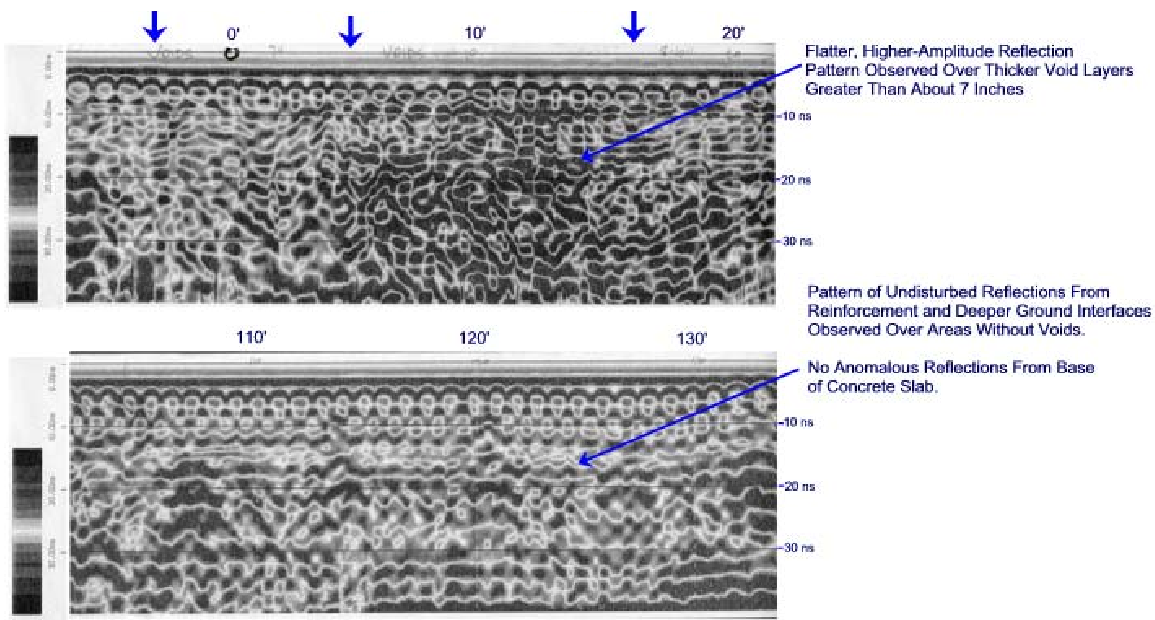
Shows a 400-MHz GPR profile recorded above paralleling and perpendicularly orientated pipelines at two different depth levels. The deeper paralleling pipeline appears to connect to the intersecting perpendicular line and indicates a 90-degree bend in the orientation of this subsurface utility line at this location.

Ground-Penetrating Radar 2D/3D Surveys of Concrete Structures

- Evaluation of Steel Reinforcement Pattern and Integrity
- Detection of Utility Lines in Concrete Foundations
- Locations of Post-Tension Cables and Other Structural Elements
- Investigation of Lateral Extent of Foundation Footings and Pile Caps
- Detection of Voids and Fractures within Concrete Structures
- Evaluation of Concrete Thickness and Integrity
- General Investigation of Drilling and Coring Obstructions



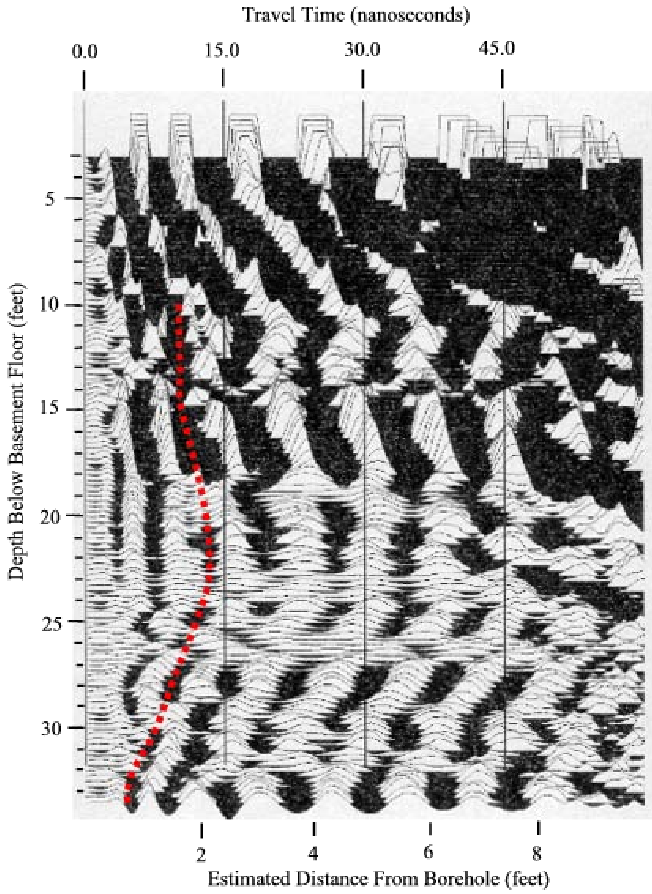
Shows 900-MHz GPR profile from highway overpass concrete wall. This 2D profile is 8 feet long and shows arch-shaped reflection patterns from vertical steel bar reinforcement 6 inches into the wall. A reflection pattern is also visible from the concrete-back fill interface about 22 inches in the wall.



Shows two 400-MHz GPR profiles across the concrete spillway of a dam. These 2D profiles show smaller arch-shaped reflections near the surface from layers of steel bars spaced 1-foot apart. The first profile shows anomalous reflections form voids discovered by core holes beneath the spillway slab.

Borehole Ground Penetrating Radar Surveys

- Detection of Underground Structures Beneath Buildings
- Evaluation of Pile Length
- Evaluation of Vertical Shape of Larger Diameter Piles

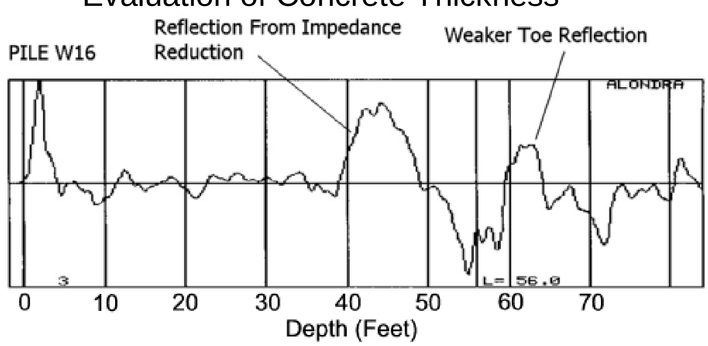


Shows 100-MHz GPR profile from borehole radar survey performed in the basement of a hospital to evaluate the shape of belled caissons beneath the foundation. A small diameter borehole was drilled along side the building column attached to one of the caissons and used to lower a specialized borehole radar antenna. The onset of the reflection pattern highlighted by the dashed red line reveals the positioning and approximate shape of the side of the concrete caisson.

Advanced Geoscience also performs seismic and sonic pulse echo measurements to investigate conditions in concrete structures, such as cast-in-drill-hole piles. For the Alameda Corridor Project we conducted sonic pulse echo testing on over five hundred piles installed in saturated alluvial sediments. The following lists these and other remote sensing services we perform.

Sonic Pulse Echo Measurements

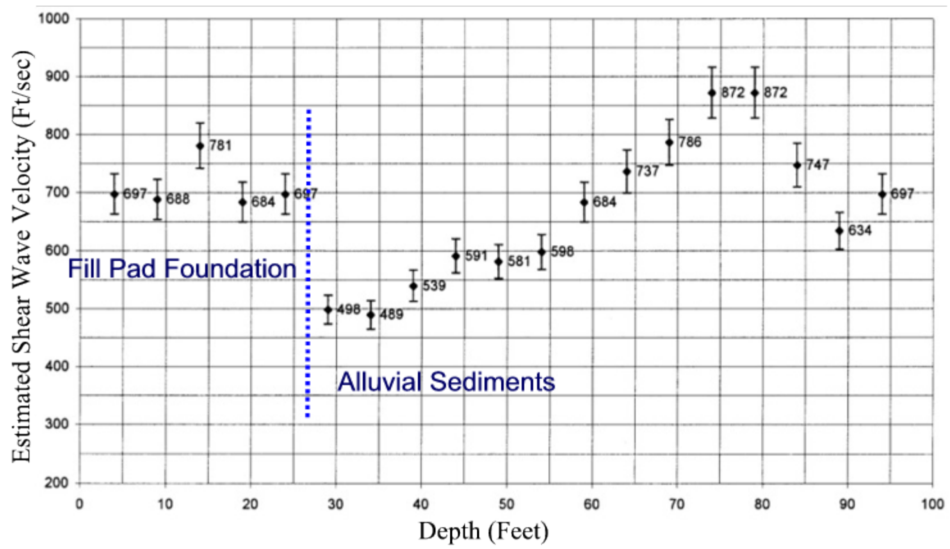
- Evaluation of Pile Shaft Length
- Evaluation of Structural Integrity of Piles
- Detection of Voids within Concrete Structures
- Evaluation of Concrete Thickness



Shows a sonic pulse echo test record for 36-inch diameter cast-in-drill-hole pile. Record shows vibration patterns recorded from a small hammer impact to the top of pile. Record reveals evidence of a shaft impedance reduction at a depth of 40 feet from the pile top. This impedance reduction was caused by a reduction in the pile shaft diameter at that depth.

High-Resolution Seismic Refraction and Crosshole Borehole Surveys

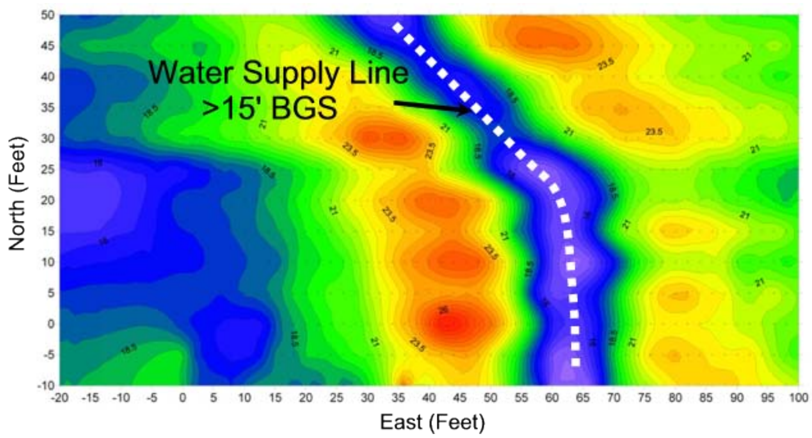
- Evaluation of Pile Shaft Length
- Evaluation of Structural Integrity of Piles
- Detection of Buried Concrete Structures
- Evaluation of Lateral Bounds of Buried Concrete Structures



Shows seismic shear-wave velocity profile from crosshole survey between two boreholes positioned on a harbor wharf fill pad foundation. The abrupt decrease in shear-wave velocity between 24 and 28 feet indicates the maximum depth of the fill pad. Below this depth the profile of gradually increasing velocity is typical of native alluvial sediments in this area. Crosshole shear-wave velocity surveys such as this can also be used to estimate the length of concrete pile shafts connected to building foundations.

Electromagnetic and Magnetic Multi-Sensor Surveys

- Detection of Underground Structures, Utilities, and Pipelines
- Investigation of Archaeological Sites
- Detection of Buried Concrete Structures
- Evaluation of Lateral Bounds of Underground Structures



Shows contour map of ground electrical conductivity variations in the upper 20 feet. Dashed line shows orientation of 36-inch water line buried deeper than 15 feet in saturated river bottom sediments.

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