



Finally, Useful Underground Mapping

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CEO





Wandering & Locating Currently

Wandering

Limited to shallow structures with little information



SUE Level B

Paint on the ground –
guides excavation & construction



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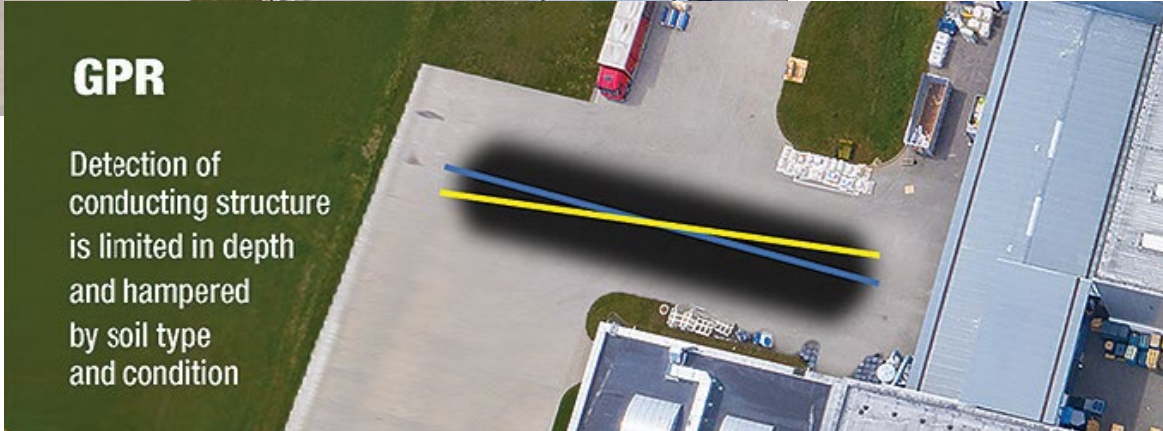


SUE Level B

Paint on the ground – guides excavation & construction

GPR

Detection of conducting structure is limited in depth and hampered by soil type and condition



SUE Level B

Provides intermittent & incomplete 3D information



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Hydrovac

Likelihood of finding all structures is very low



SUE Level A
Provides “eyes on” ...
when you find it



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SUE Level B

Paint on the ground – guides excavation & construction

Current Technology Cannot Provide Design-Quality Information

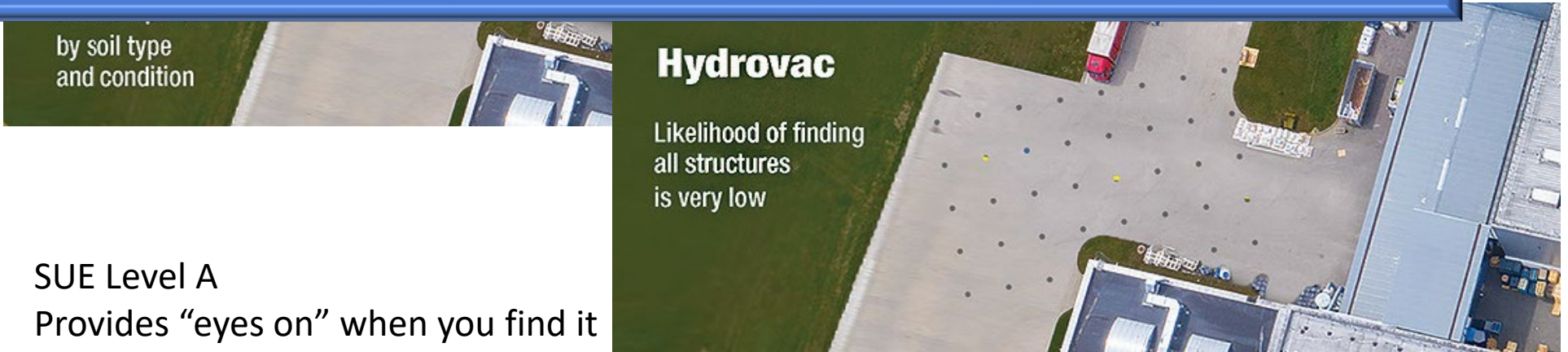
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What's Really Needed?

All Structures Detected and Laterally Positioned



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Depth & Position (3D) Information About Structures



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In All Soils, Soil Conditions & Surfaces



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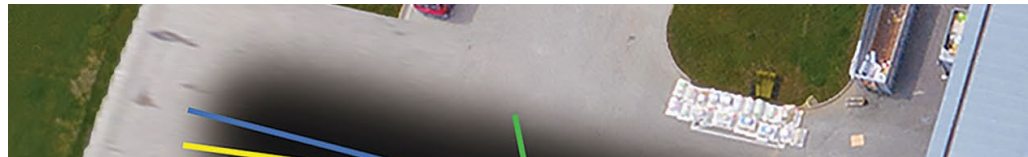


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All Structures Detected and Laterally Positioned

Depth & Position (3D) Information About Structures

In All Soils, Soil Conditions & Surfaces



But How?

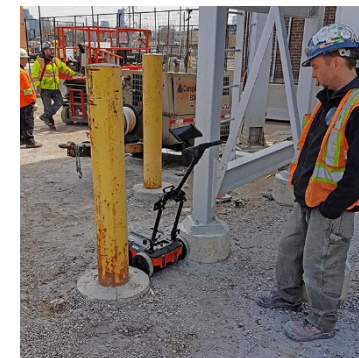
structures in 3D –
down to 35 feet





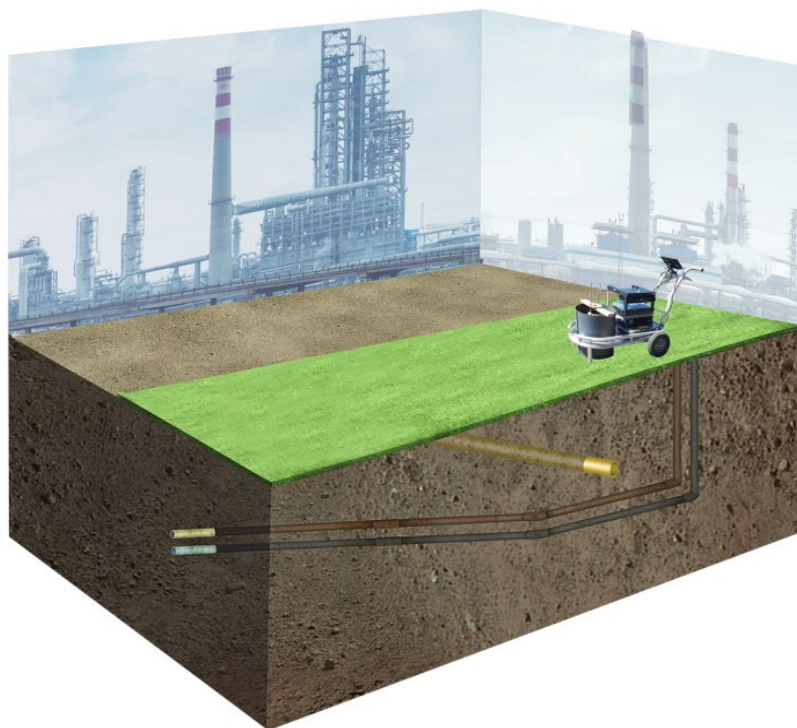
Non-Invasive Remote Sensing

- Radiation
 - Too Big
 - Too Dangerous
- Electromagnetic Sensing
 - Current Standard: GPR, Wands, Magnetometers
 - Limitations Well-Known
- Acoustics
 - Seismic & Ultra-sound





Sound Echo-location

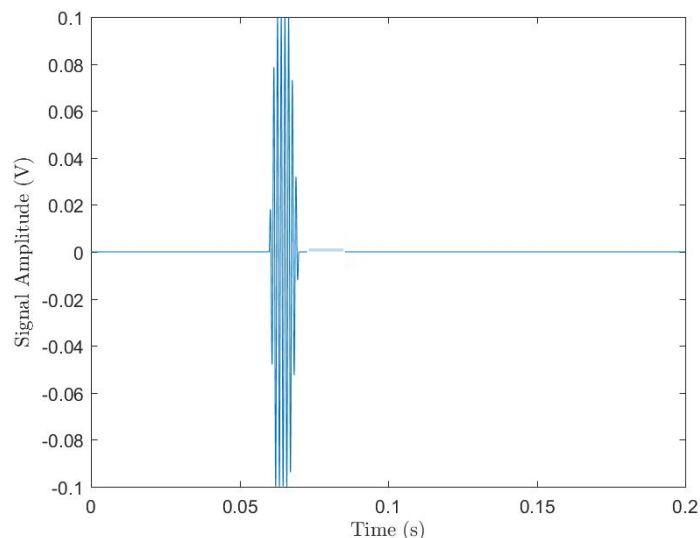


- Sound Pulses
- Crafted Waveforms
- Correlation for Timing
- Sound Speed Model for Depth
- Surface Survey for Location

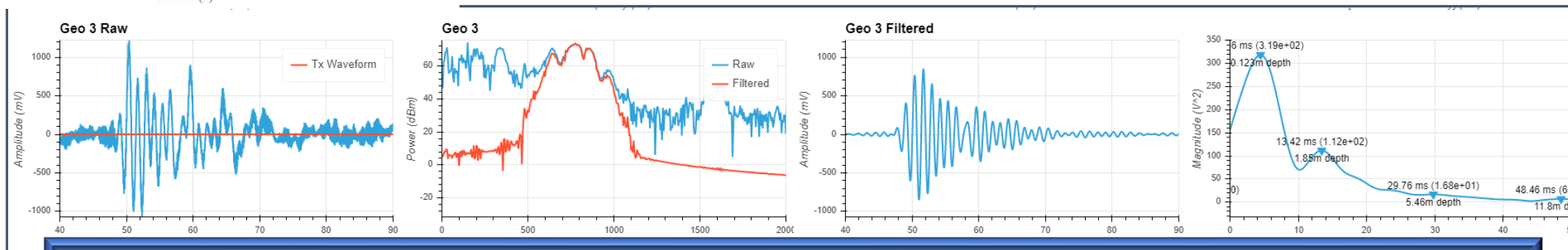
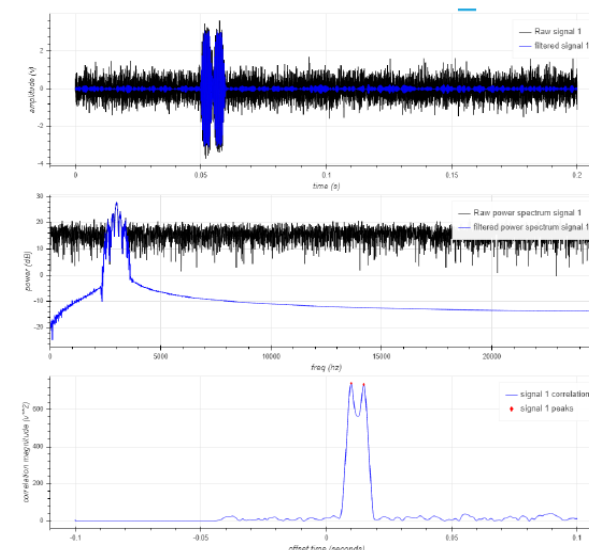
Crafted, Pulsed Sound Is How!



Sound Pulses & Acoustic Processing



- Pulse Length & Resolution
- Pulse Sequences
- Waveforms & Chirps
- Overlapping Returns

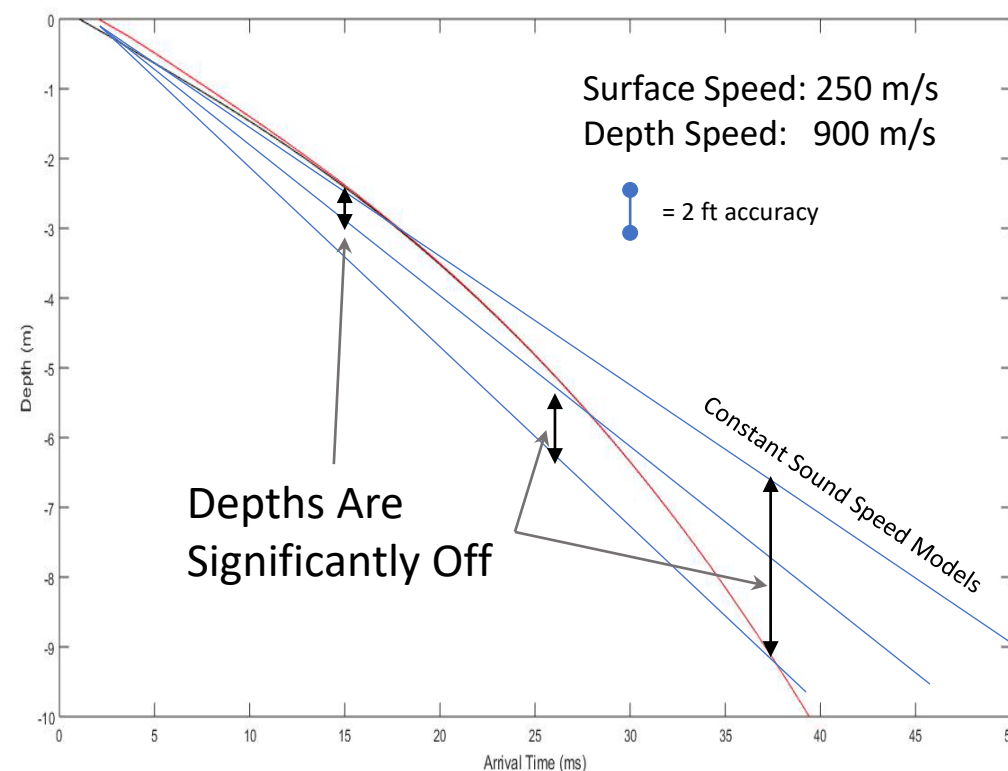


Significant Number Crunching Involved



From Time to Space

- “Depth = Rate * Arrival Time / 2”
- Rate is Not Constant – Calculus, YAY!!
- Sound Speed Increases With Depth
 - Soils Consolidate
 - Pore Spaces Fill With Water
 - Pore Sizes Shrink
 - Layers Shift (A → B → C)
- Must Be Calibrated by Site

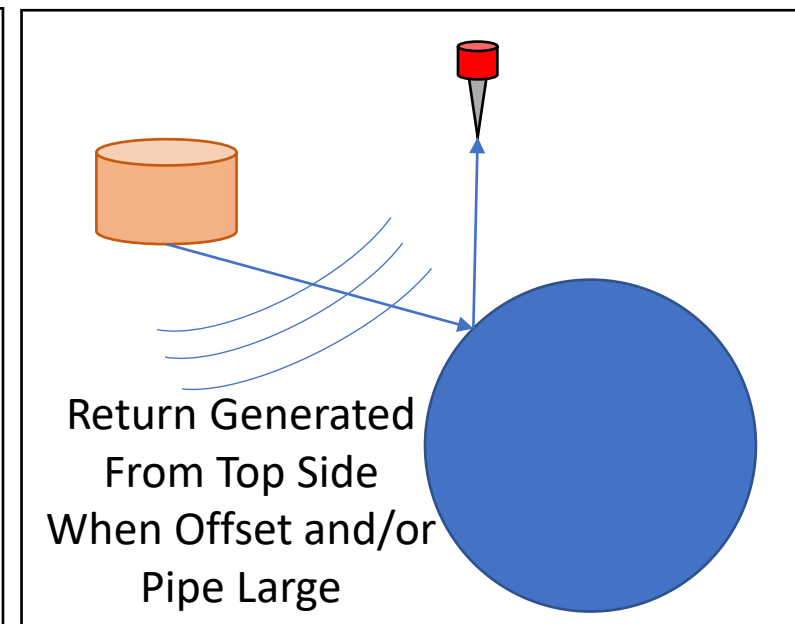
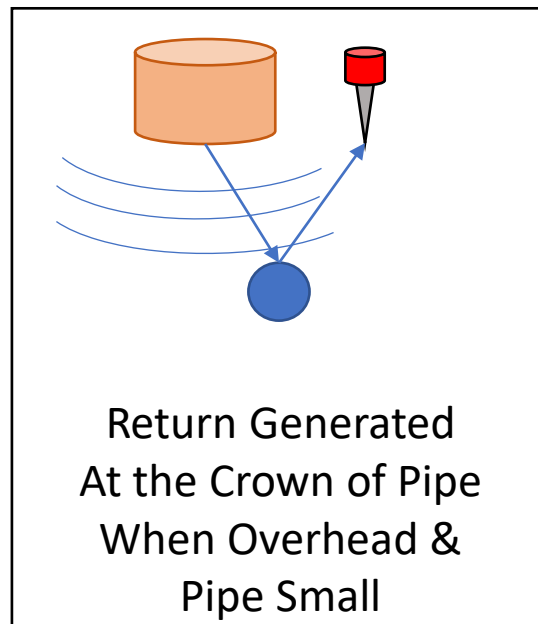
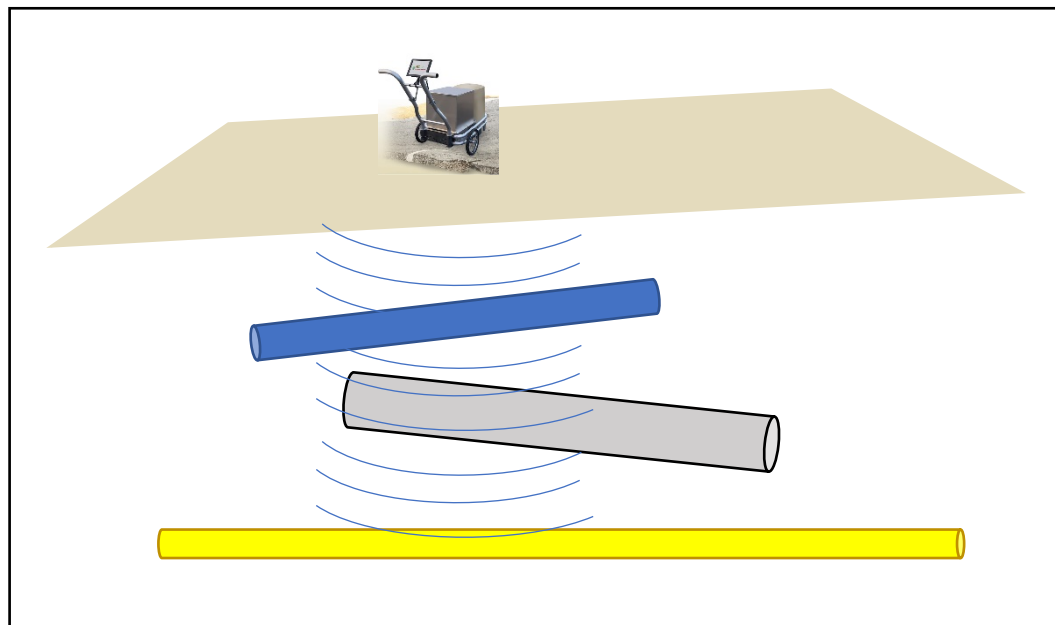


Sound Variation Critical for Accurate Depths



What Does an Acoustic Return *Mean*?

- Back-scatter occurs at a surface where the impedance changes
- Acoustic impedance combines sound speed with density



Sound Return Signal Generated at Top of Structure



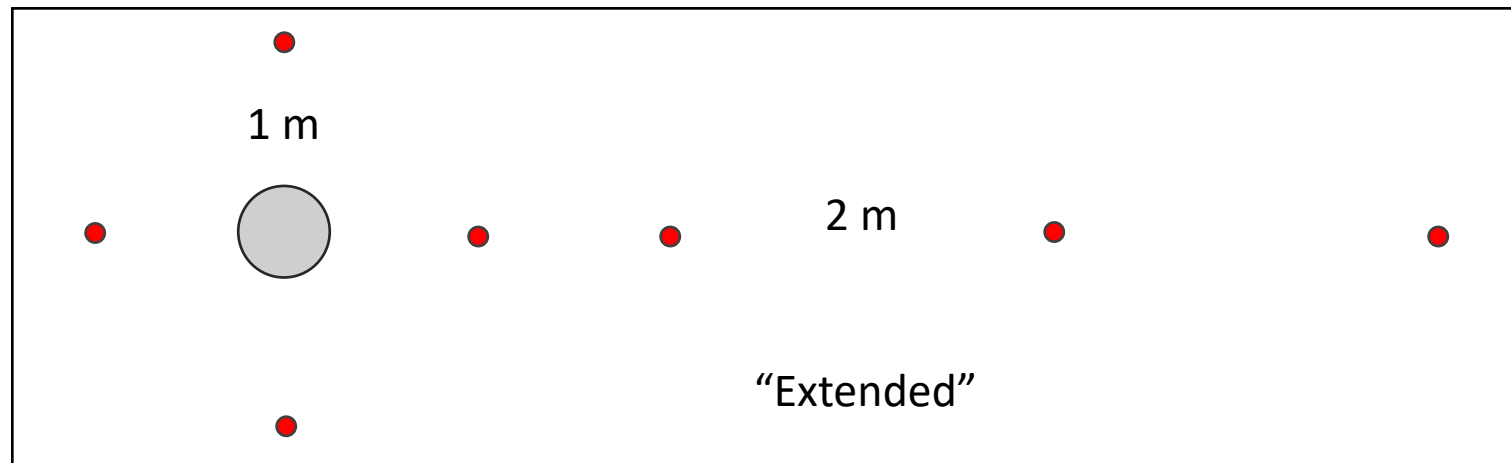
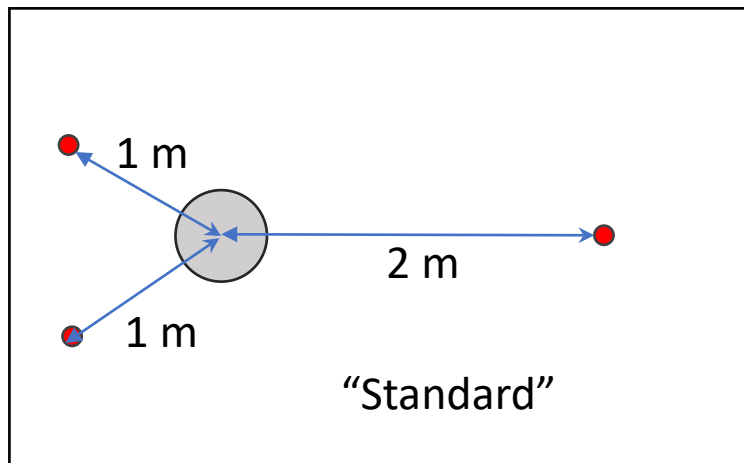
Why Does Sound Perform Better?

1. Propagates in All Soil Types
2. Propagates in All Soil Conditions
3. Propagates Through Most Surfaces (Concrete, Asphalt, Open)
4. Penetrates Deeper Than Other Approaches – Down to 30+ feet
5. Scatters From All Man-Made Structures
6. Complex Waveforms and Pulse Sequences Are Easy to Generate

Acoustics Provides Complete, Accurate Results



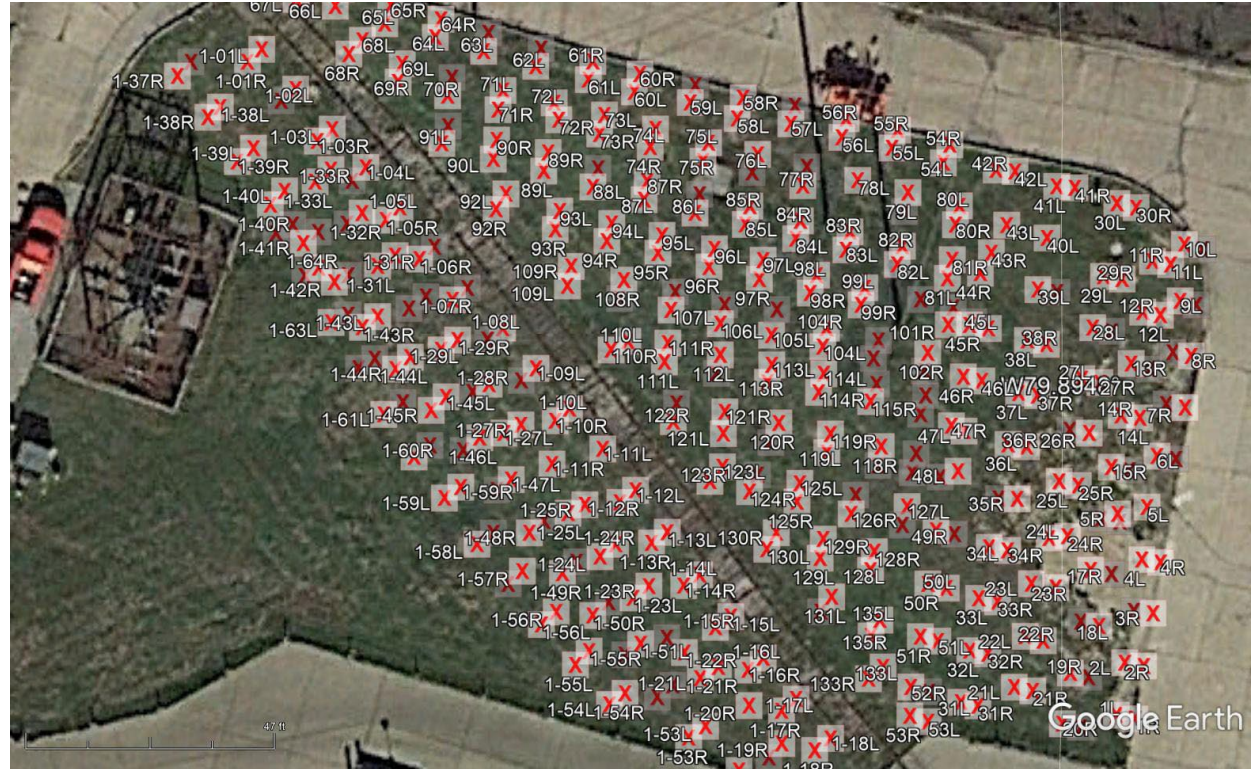
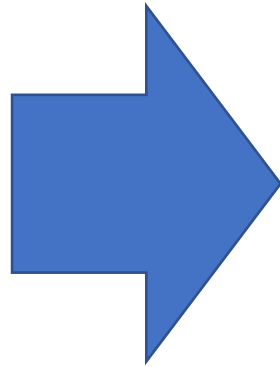
Multiple Receivers Improve Resolution



- Correlations Between Channels Improves Structure Identification
- Slight Differences Between Channels Indicates "Off-Center" Structure
- "Extended" & Others Increase Geometric Insight & Coverage



Single-Sonde to Underground Maps

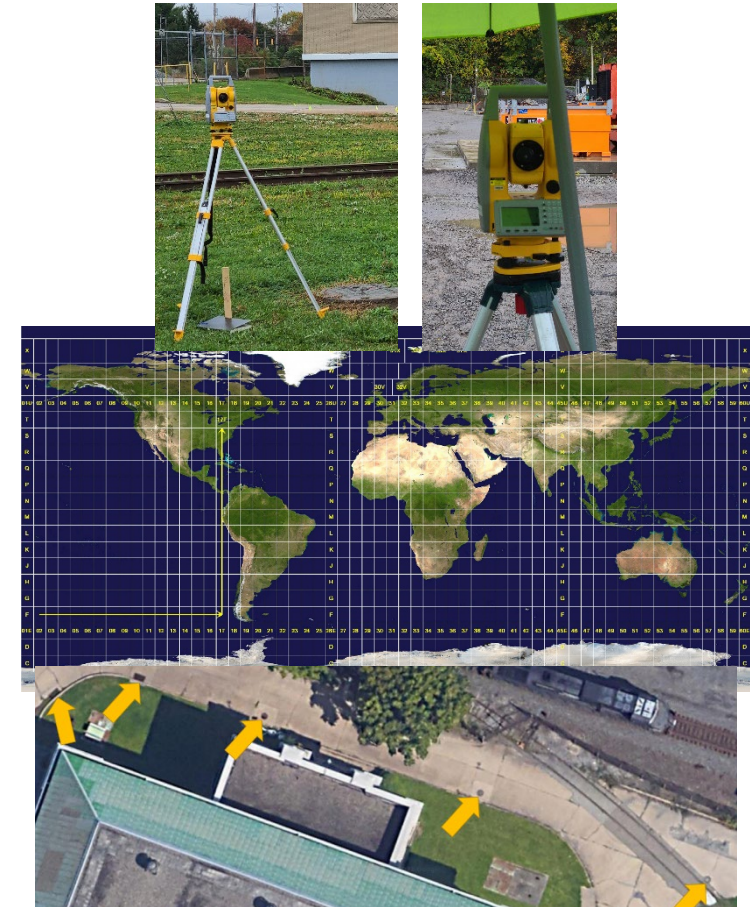


- Acoustic Probing Is Local
- Need Many Collections to Create a Map



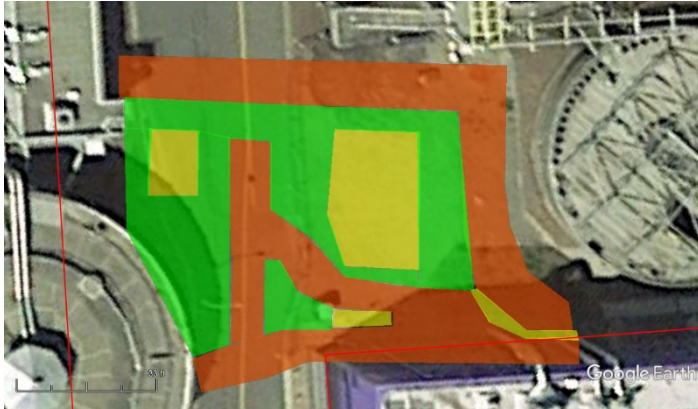
Coordinates and Registration

- Local Coordinates
 - Acoustic Survey Coordinates – “Frames”
 - Project Coordinates
- Global Coordinates
 - Latitude-Longitude-Altitude (GPS)
 - UTM-Altitude
 - ECEF
- Intermediates
 - State Plane
 - MPLSS (Township-Range)





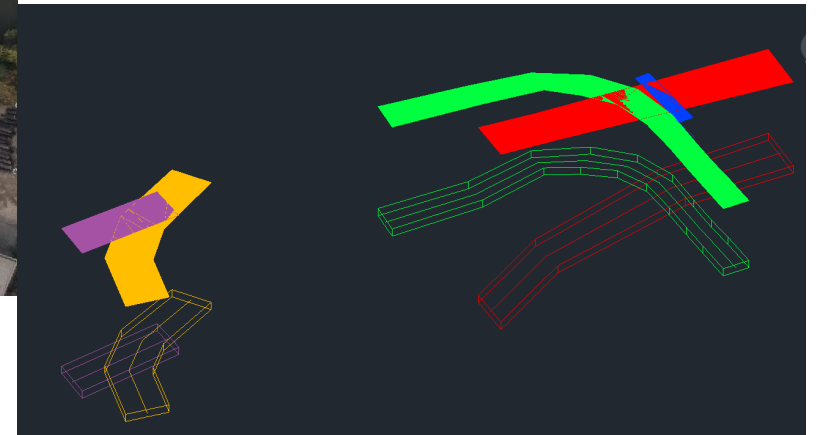
Different Representations for Different Uses



DigSafe™ Map – Shows where acoustic returns occurred.

2D Map: indicates where structures are and ties them into surface features.

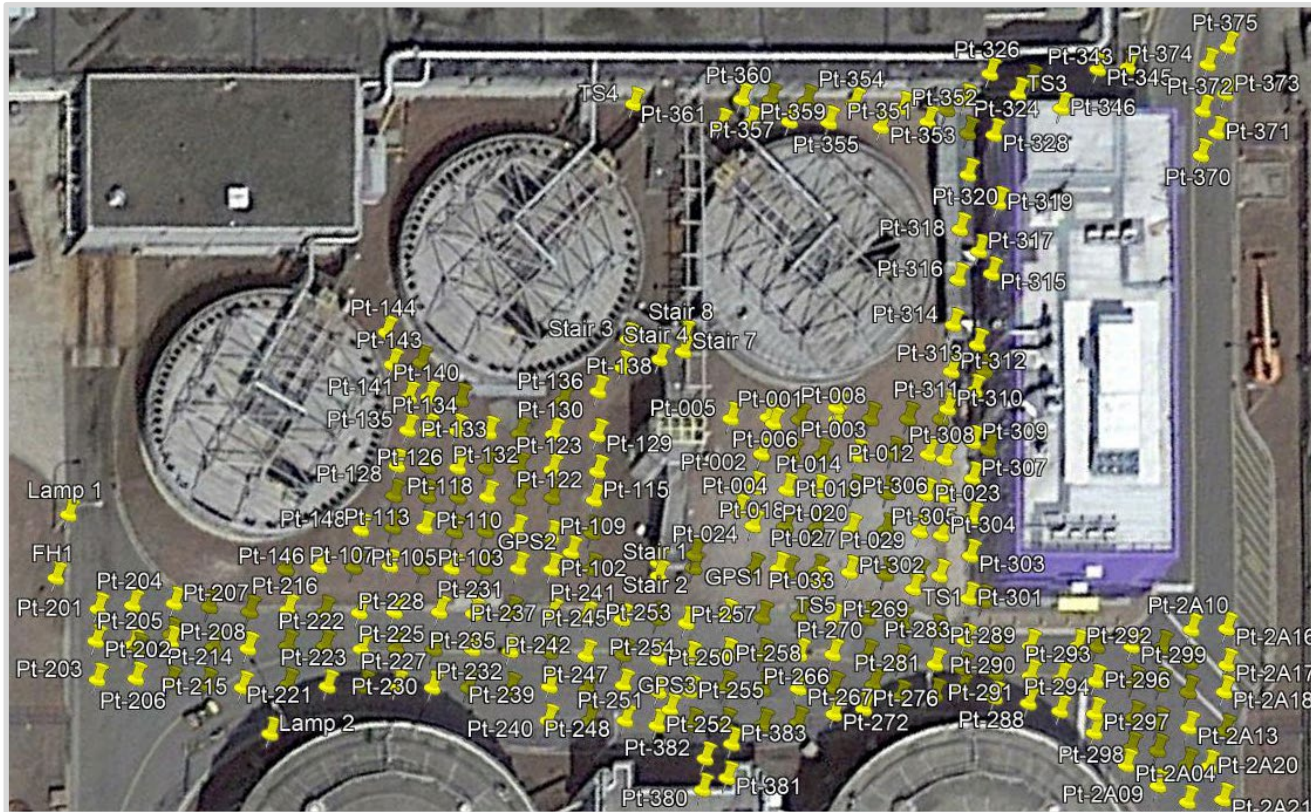
Feature depths profiles available



3D CAD Map: Provides Complete 3D information in standard CAD formats



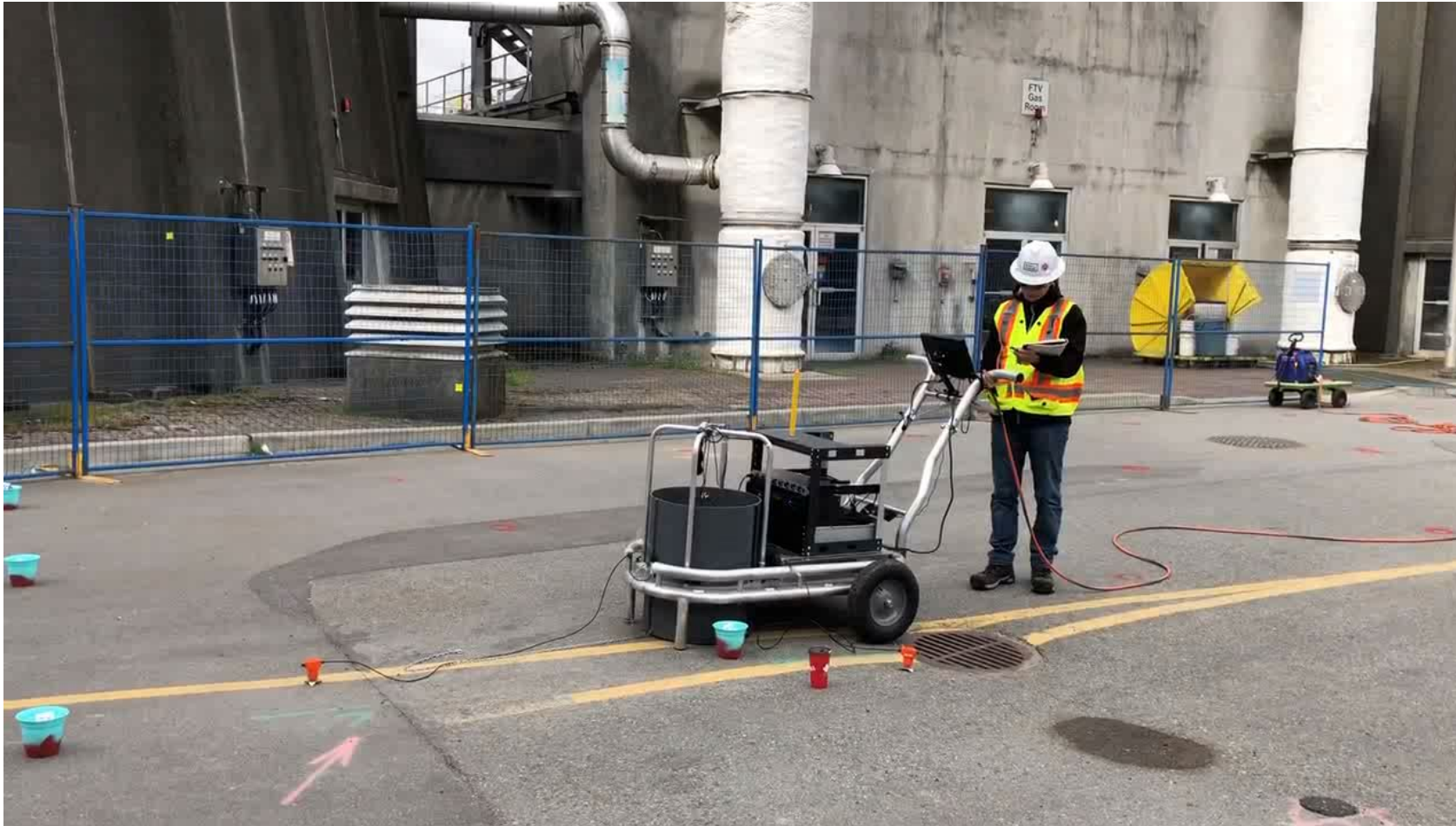
Waste-water Treatment Project



- 350 Acoustic Collections
- 400 Survey Points
- 0.4 Acres
- 4 Field Days
- Island in River Delta
- Saturated Soils
- Tried GPR, no results

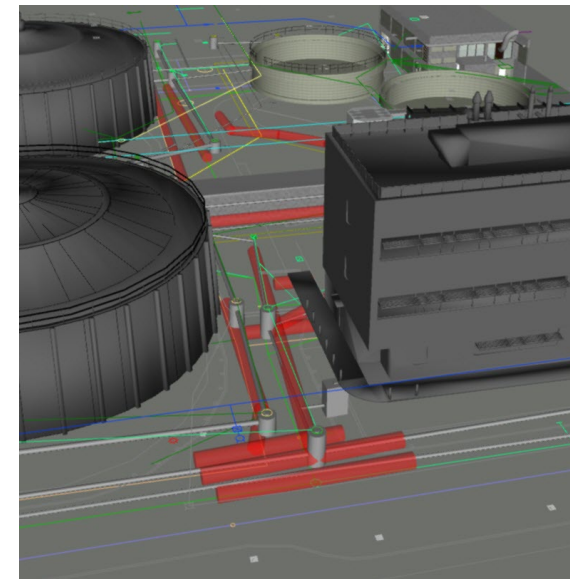
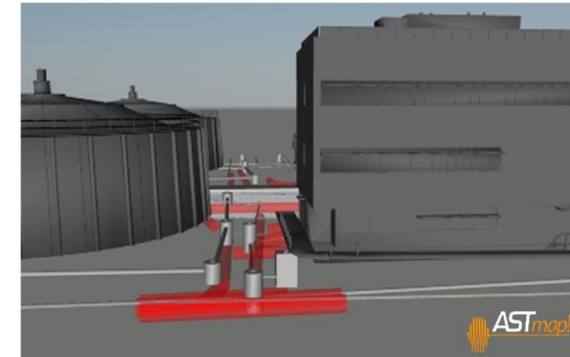
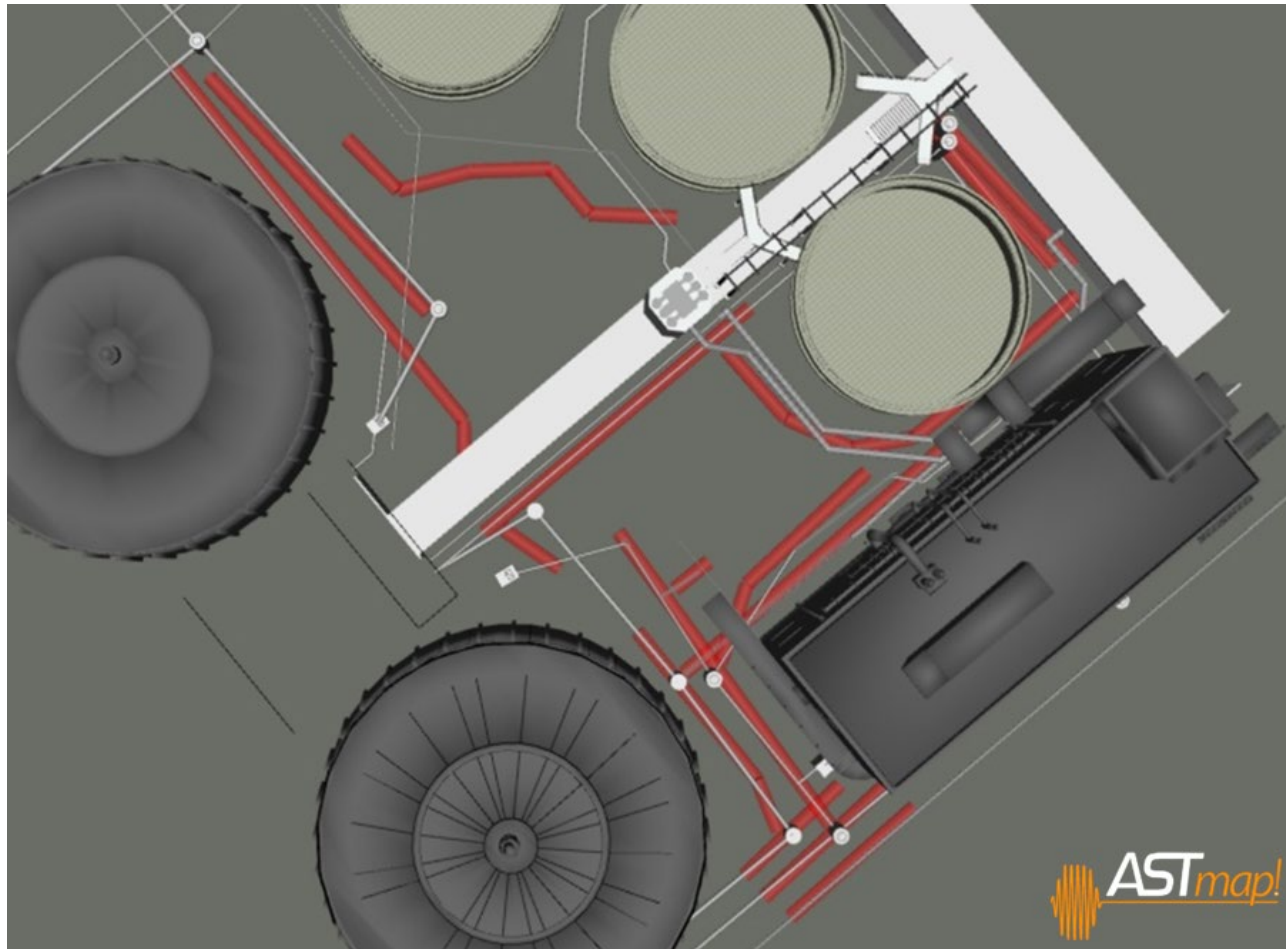


Waste-water Treatment Project



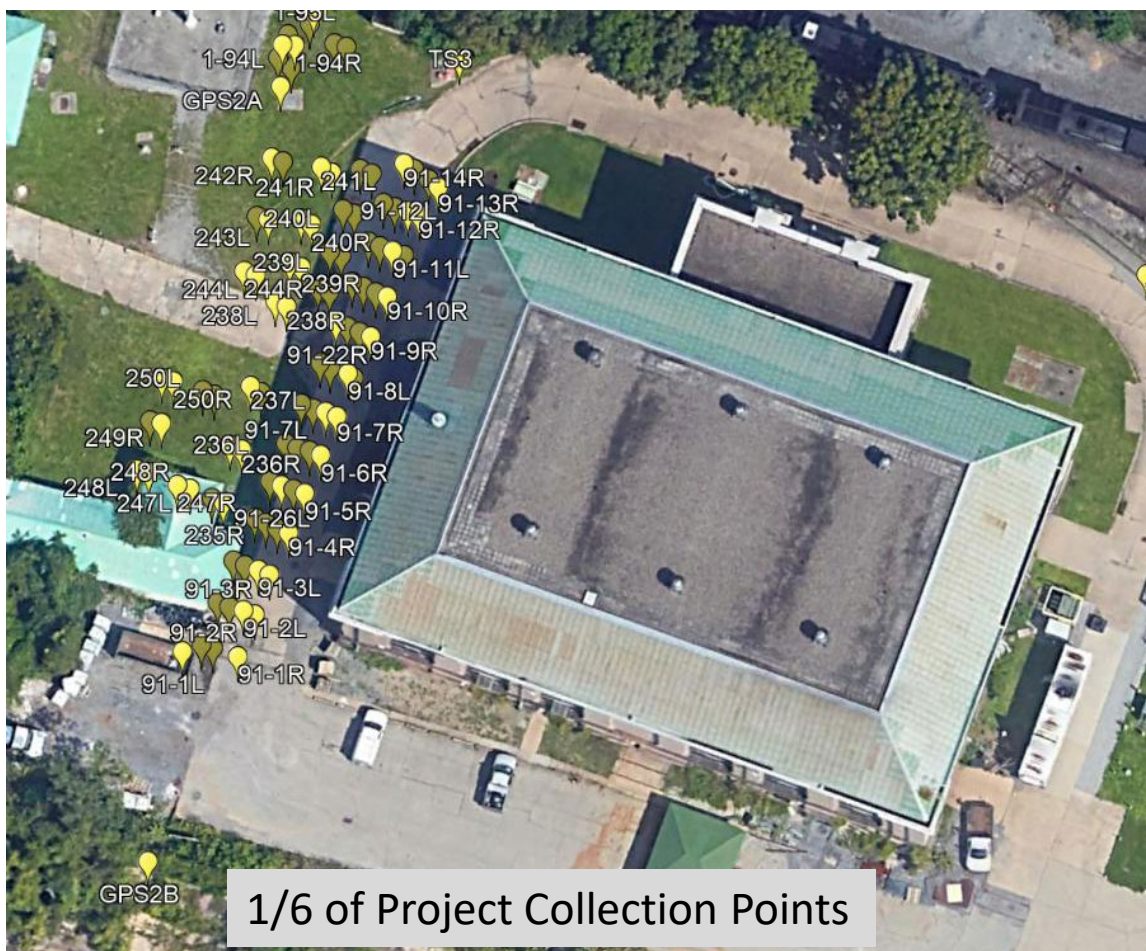


Waste-water Treatment Project





Water Treatment Project



- 600 Acoustic Collections
- 1000 Survey Points
- 3.5 Acres, 3 separate areas
- 9 Field Days

- Rain & Drizzle
- Adjacent to River



UNDERGROUND CONSTRUCTION TECHNOLOGY

The Underground Utilities Event | July 13-15, 2021 | Music City Center | Nashville, TN

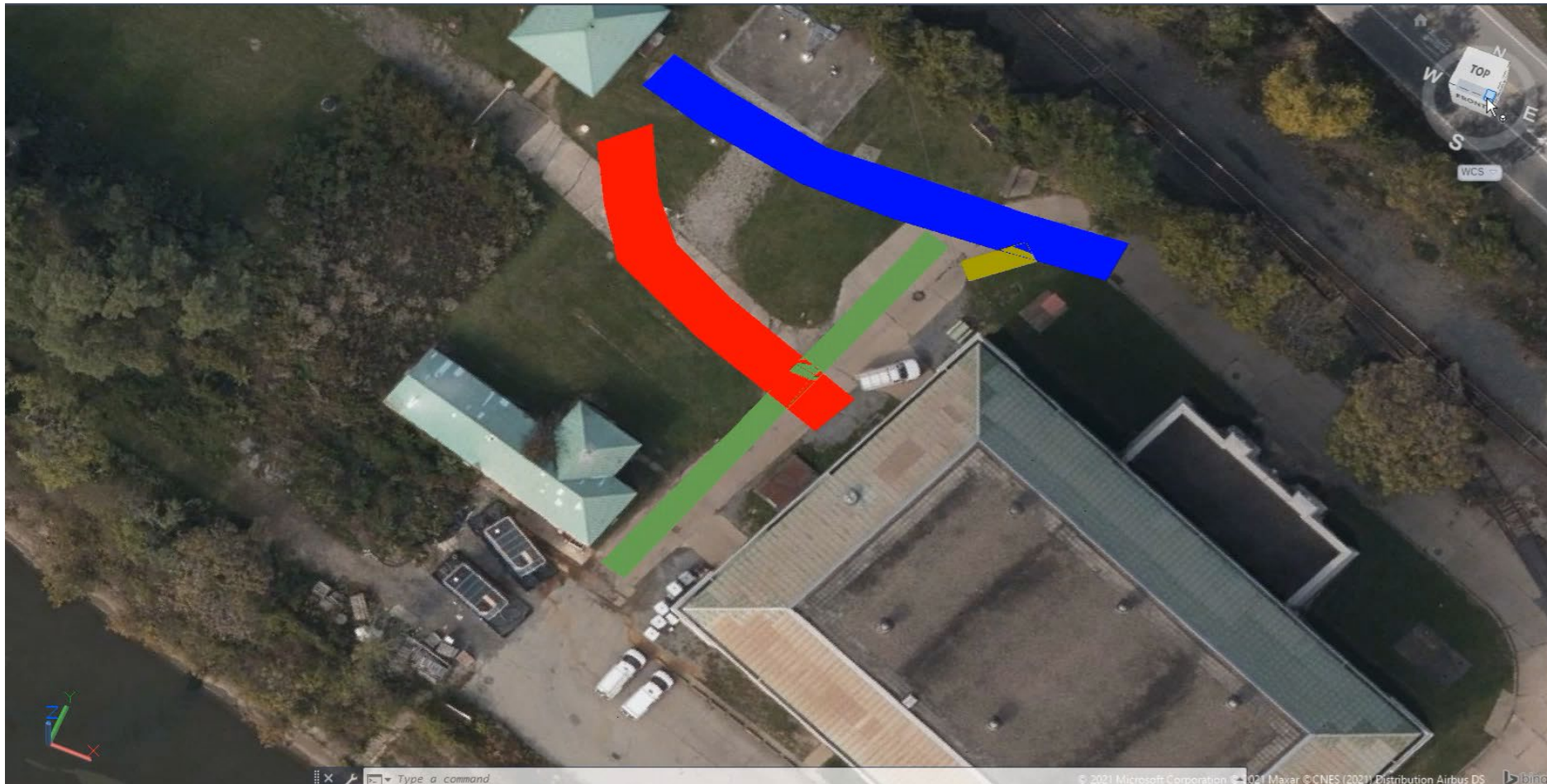


Water Treatment Project





Water Treatment Project





Summary

- Acoustic Echolocation Enables Useful Underground Mapping
 - Complete
 - Accurate
 - Convenient
- Going Beyond Paint on the Ground
 - Persistent, Re-usable Information
 - CAD Format



Visit Us At Booth 445
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