Austin Road Case Study

Water Well Placement Combining Resistivity Imaging and Seismoelectric (EKS) Tools

Authors David Boleneus and Philip Moyle combine effort in search for domestic water sources by evaluating and comparing results from two proven exploration methods, earth resistivity imaging (aka profiling) and seismoelectric (EKS) sounding. A commingling of EKS and resistivity imaging expands our dimensions in exploring for water.

SCENARIO - Due to increased pumping from nearby wells, domestic-use well lost water on rural property located in the Little Spokane River aquifer basin about 5 miles northeast of Nine Mile Falls, WA. The original 330-ft-deep well was drilled through 90 ft of lake sediments and an additional 240 ft into relatively poorly fractured to massive granite. Lakebeds consist of interbedded layers silt and fine sand with clay zones. The original well produced 8 gpm water initially. The water is thought to have drained down the well casing from a small sedimentary aquifer perched on top of the granite rather than from fractures from shallow depth. Well water derived from the well was stored in a 3,000-gallon cistern from which domestic demand was supplied.

Customer engaged Hydro-Imaging to locate a new productive well with a capacity of 5-10 gpm (gallons per minute) or higher. Based on a neighbor's well drilled 6 years prior near a small creek that transects both properties, customer focused investigation on an area similarly situated on his property approximately 400 ft south of the existing well. Depth to granite in this area near the creek was thought to be much less, possibly ≤ 30 ft, as granite crops out on a steep mountainside south of the creek. In addition, spring water was observed to surface on the north side of the creek annually during spring and early summer.

BACKGROUND INVESTIGATION - Hydroimaging Inc. conducted a **resistivity imaging profile line** 669 line feet in length in 1995 with the north-to-south (left is north) profile (Figure 1). Personnel used 28 take-outs spaced each 32.6 ft (10 m). Equipment used is Supersting R1/IP made by Advanced Geosciences Inc.

Suspected water zones are shown in low resistivity zones (blue) with more favorable zones <80 ohm-m with favorable zones (at 447 line-ft on profile) at approximate depths from **30 ft to 75 ft** which places the water zones atop and within the zone of weathered of granite bedrock. Hard, non-water bearing bedrock is seen at 107 ft depth on the profile. The highest resistivity zones up to 2675 ohm-m are interpreted as hard bedrock as entered by survey at 669 line-ft. The resistivity line spans from the county road on north, passes the old well at 85 line-ft, passes between EKS sites b5 and b9 at 475 line-ft and crosses the creek at 540 line-ft and ends on granite outcrop (Figure 2).

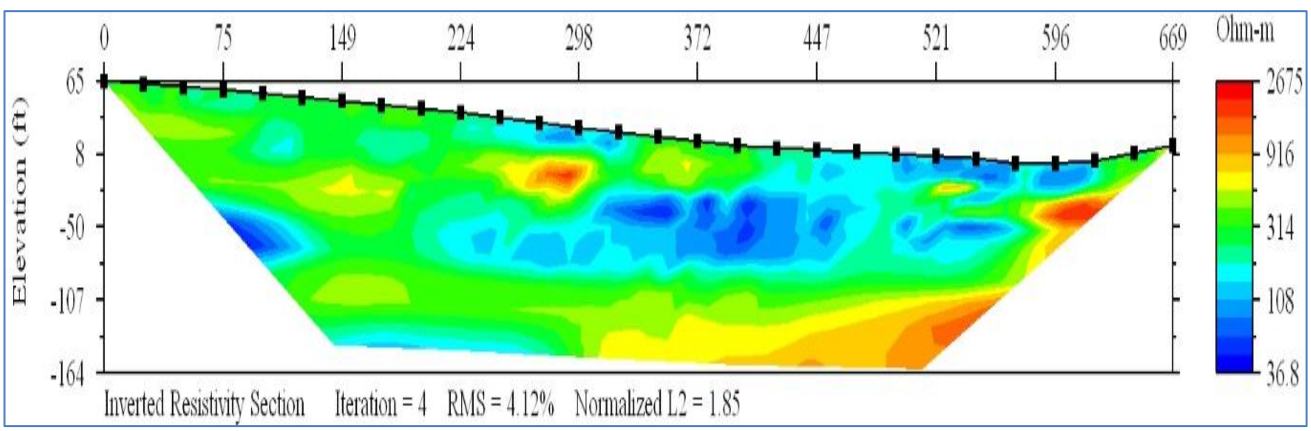

Figure 1. Resistivity Imaging Profile (north to south)

CURRENT INVESTIGATION – Hydroimaging recorded 10 seismoelectric (E-K) soundings in 2021, hereafter referred to as EKS, on the property. Equipment used includes Model 2500 Seismoelectric system and processing software made by GroundFlow. The first EKS site (a1) was conducted near the existing "dry" well to establish control parameters for the sediments and granite. An additional nine soundings were conducted in a staggered, west-to-east linear pattern in an open field near a creek. EKS a2 was conducted near the spring that often flows early each year, and EKS a3 and a4 were conducted approximately 50 ft and 100 ft north of a2 stepping away from the creek. Each EKS event produces two profiles: a hydraulic conductivity that approximates granite, and an electrical response that infers an aquifer boundary and flow rate.

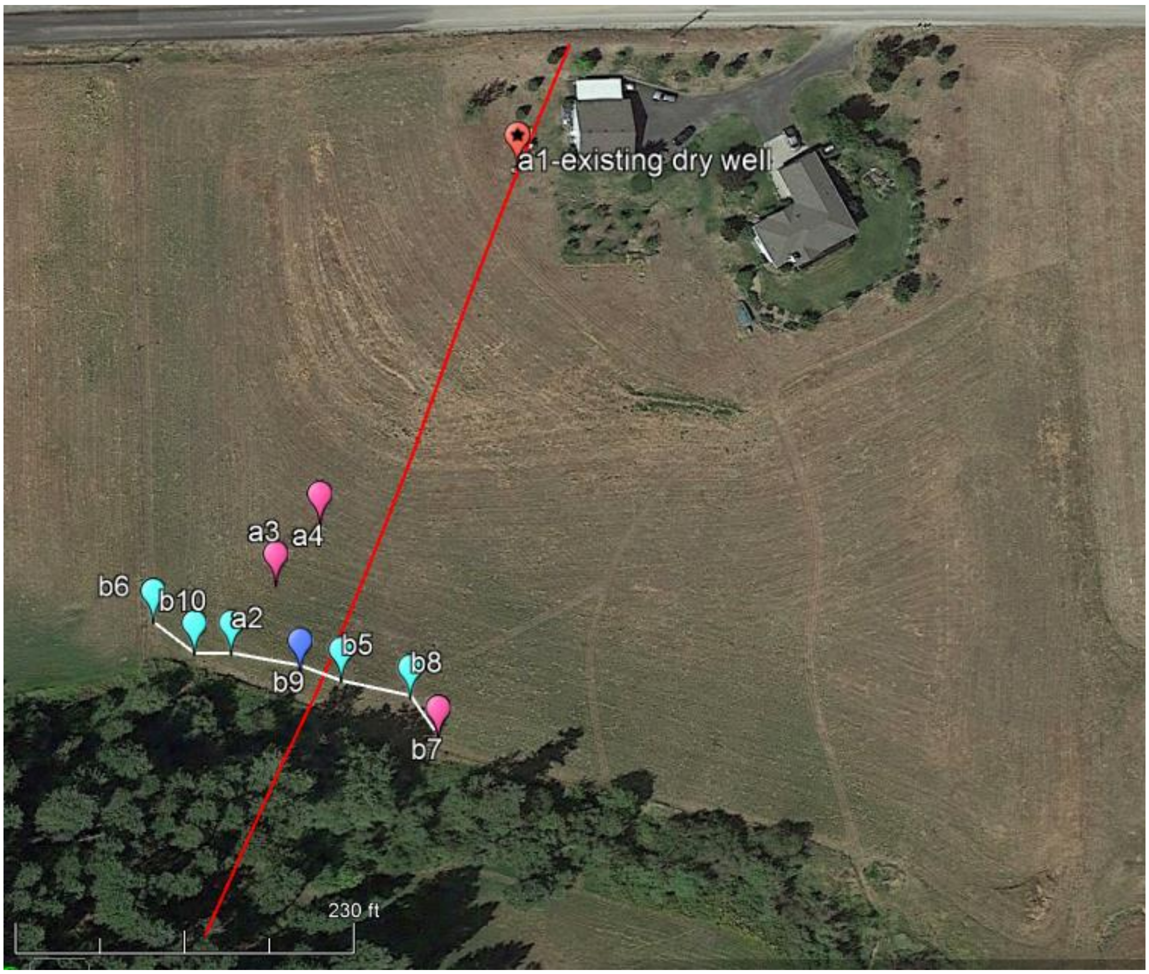

Figure 2. Aerial photo courtesy Google Earth
Resistivity imaging profile (red), EKS profile of sites (white)

EKS a2 showed a moderately positive millivolt response; however, EKS a3 and a4 demonstrated low millivolt responses that may establish a north boundary. It was then decided to conduct six additional E-K soundings (b5-b10) east and west along the profile from a2 holding to a similar distance, 75-100 ft from the creek. This profile spans part of depression on the west that borders on a subdued drainage that slopes southward toward the creek. Positive electrical responses with flow rates ranging from 5 to 8 gpm at less than 100 ft deep were acquired in EKS b5, b6, b8, b9, and b10, whereas no relevant response was acquired in EKS b7, with b7 as the eastern-most location and perhaps defining a boundary on the east. The electrical response, estimated at about 32 gpm, was identified at a depth of about 20-40 ft in EKS b9 which still lay close to the spring. Depth to granite in the EKS profiles nearest the creek indicated depth of about 30-35 ft, similar to the neighbor's well to the west. The same profiles showed minimal hydraulic-conductivity response below a depth of 175 ft which by experience indicates hardest bedrock (or granite).

Profile below shows 2-channel EKS electrical responses (seismoelectric) along a west to east profile (west on left side) located by white line on aerial photograph. Sicilia water well on left located 250 ft west of EKS b6 site shows glacial gravels to 34 ft and lake bed sediment that overlie granite encountered at 44 ft. EKS responses indicating water zones range 0.002 – 0.015 V. Heavy black horizontal lines denote upper and lower limits of water flow rate approximations given in gallons per minute. Dashed line identifies depths of hard bedrock as interpreted from hydraulic conductivity data (not shown) co-recorded with EKS data. At EKS site b9 a 32 gpm estimate is interpreted as water "puddling" within gravels atop granite above 35 ft depth with 8 gpm estimate "peak" EKS electrical responses at depth 96 ft - 102 ft that identifies a water zone in weathered granite penetrated by new well drilled in 2021. The EKS depth estimate of the water zone at 35-102 ft is in general agreement with resistivity imaging profiling that identified a water zone centered at depth that ranges in depth from 20 ft to 85 ft. Estimation errors may be minimized by improvement in velocity assumptions used to process the EKS data. Nevertheless, the EKS and resistivity imaging data together combine to expand dimensions in exploring for water. The time required to collect field data and computer processing of EKS and resistivity data is similar but EKS data offers a decided advantage that EKS data can be obtained to much greater depth ranging >1,000 ft. NSA – No significant aquifer. Depth estimates in feet (right) to 400 ft and meters (left) to 120 m.

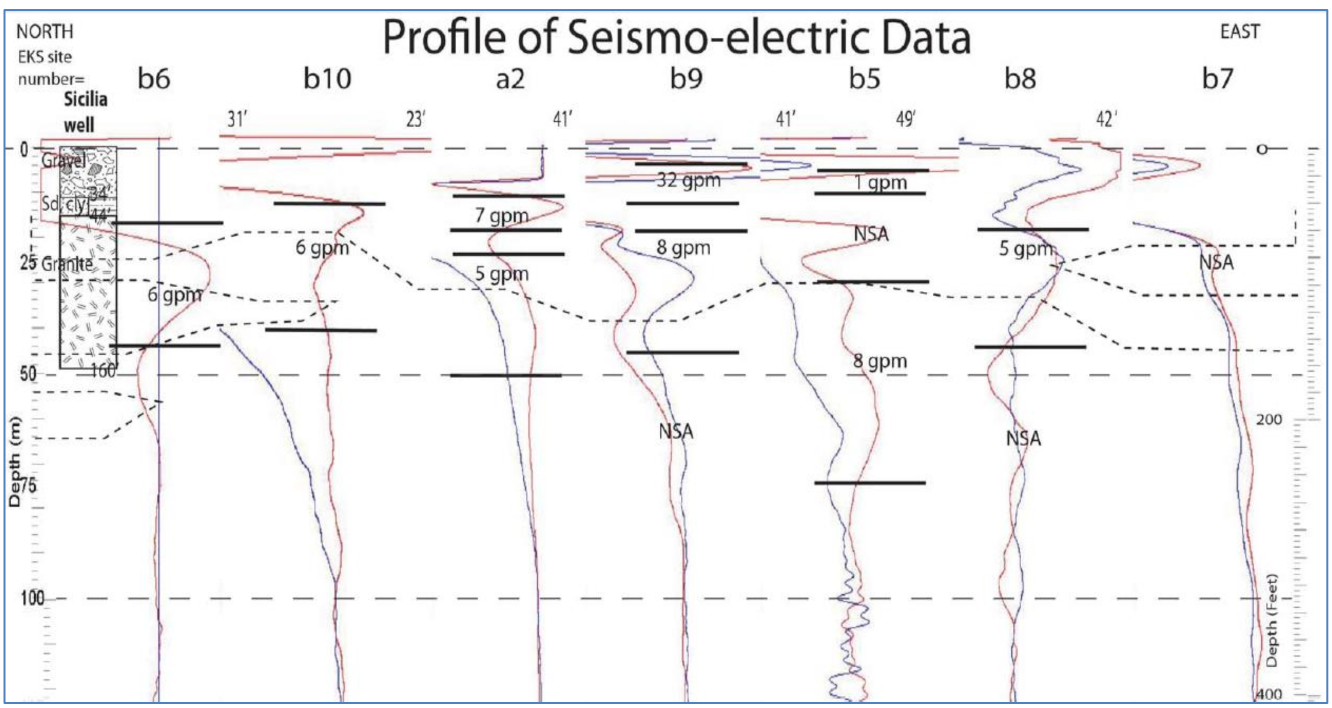

Figure 3. Seismoelectric (EKS) profile (west to east)

NEW WELL – Customer drilled a new well at EKS station b9 October 11-13, 2021. The well penetrates approximately 33 ft of sediments to the granite bedrock to a total depth of 301 ft. One zone of fractured soft granite from 53-63 ft yielded brownish water that cleared up by the next day. From 200-301 ft, a medium hard black-white granite was also fractured. Static water level was 35 ft deep when the well was completed. A one-hour pump test of the well with stem set at 296 ft yielded 4.2 gpm.