

## Procedure for Identifying High Quality Lithology Logs

We define high quality as a lithology log that is relatively deep, given the depth of wells in the area, with relatively (compared to other wells in the area) fine depth discretization in the lithology descriptions, and can be confidently located to within 20 m.

The following procedure identifies and extracts a sufficient number of high-quality lithology logs, contained in well completion reports (WCRs), to be used in the interpretation of the AEM data. This procedure is designed for use in California, using data provided by the California Department of Water Resources (DWR).

1. Based on the problem context, select a minimum density of WCRs that is required over the project area; e.g two wells per section.
2. Use the Well Completion Report Map Application (WCRMA) website hosted by the DWR (<https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37>) to view every WCR available online for the given survey area. The WCRMA could be used to download the WCRs, but for efficient downloading of WCRs organized by county, and then at the next level by township and range, the following file server is recommended: <https://cadwr.app.box.com/v/WellCompletionReports/folder/76239384629>.
3. The WCRs downloaded from the file server given in step 2 have their section imbedded in the filename, allowing for easy selection of the WCRs by section. For every section where lithology logs are needed, the first level of screening involves opening the WCR PDFs and selecting, from the large data dump of WCRs, four to ten WCRs with the following qualities. Once four to ten wells have been found in one section, move onto the next.
  - 1) good scan quality such that the text is legible.
  - 2) reasonably deep total depth and small thickness of described intervals. This can only be considered as a relative metric at this stage; i.e., if most of the wells in the area have been drilled to 300 feet with ~10-15 intervals described, a well that ends at 80 feet and only has four intervals described should be skipped.
  - 3) address or intersection and directions from that address to the actual well location. A location map helps the locating process but is not always necessary. This information makes it possible to attempt to locate the corresponding well for the selected WCR using Google Earth Pro (a free software program made and distributed by Google) and as such are early indicators of a high-quality lithology log.

Figure 1 shows examples of, on the left, a WCR that has all of the described qualities and, on the right, a WCR lacking them. The location map and address fields of the high-quality WCR are highlighted in red.

4. The selected WCRs must now be located. This is done by using the desktop application Google Earth Pro and navigating to the address or intersection listed in the address field. The next step is to either follow the written directions in the address field or use the location map to determine the well location. As an example, using the WCR in Figure 1:

The directions listed in figure 1 are, “50 feet south of Hume avenue, 1/2 miles west from 11<sup>th</sup> avenue.” In this case, the address to enter would be Hume avenue and 11<sup>th</sup> avenue. From this address, using the ruler tool, a half mile is measured along the road to the west, and then 50 feet is measured to the south. At the final location there should be a well head visible in the satellite imagery in Google Earth Pro. The location of this well head can be recorded by placing the mouse cursor over the well head and reading the coordinates. Figure 2 shows an example of these steps being followed with the well head circled. If a well takes more than ~10 minutes to locate, it is best to skip it and move on to the next well to avoid unnecessary time spent locating a single well.

This procedure was developed in a portion of the Central Valley with very dense well coverage. In areas where there are fewer wells to choose from, it may not be possible to only select wells with addresses and location maps. In this type of area, wells must be located by contacting the local health and environmental safety permitting office and requesting the permit application submitted for a given well. This permitting application will normally have more detailed information that can be used to locate a given well, but this location process is much more time consuming and complicated, and so will not be covered here.

The figure shows two side-by-side Water Well Driller Reports (WCRs) from the State of California, Department of Water Resources. The left report is a modern, high-quality WCR (No. 26378, dated 19/21-2) with clear, legible text and a location map. The right report is an old, handwritten WCR (No. 46527, dated 19/21-2) that is difficult to read and lacks a location map.

**Left Report (High-Quality WCR):**

- Header:** ORIGINAL File with DWR. STATE OF CALIFORNIA THE RESOURCES AGENCY DEPARTMENT OF WATER RESOURCES WATER WELL DRILLERS REPORT. No. 26378. Date: 19/21-2.
- Location of Well:** 50' South of Hume Ave., 1/2 mile West of 11th Ave. (highlighted in red).
- Well Log:** (12) WELL LOG. Total depth: 285 ft. Depth of completed well: 280 ft. Lithology: 0-10 Top Soil, 10-22 Sand, 22-64 Brn Clay, 64-68 Sand, 68-70 Blue Clay, 70-88 Brn Clay, Stringers Sand, 88-94 Hard Brn Clay, 94-103 Sand, 103-111 Brn Clay, 111-114 Sand, 114-141 Brn Clay, Stringers Sand, 141-143 Sand, 143-147 Brn Clay, 147-149 Sand, 149-154 Blue Clay, 154-175 Sand, Small Stringers Blue Clay, 175-189 Blue Clay, 189-192 Sand, 192-197 Brn Clay, 197-212 Sand, Small Stringers Blue Clay, 212-220 Blue Clay, Stringers Sand, 220-227 Sand, 227-237 Blue Clay, 237-240 Hard Fine Sand, 245- Blue Clay.
- Well Seal:** Cement.
- Water Levels:** Depth of first water: 20 ft.
- Well Tests:** None.
- Driller Information:** NAME: Myers Brothers, Inc. Address: 8500 E. Lucky Blvd., Hanford, Calif. License No. 280310. Date of report: July 28, 1977.

**Right Report (Old, Handwritten WCR):**

- Header:** DUPLICATE. WATER WELL DRILLERS REPORT. No. 46527. Date: 19/21-2.
- Location of Well:** 344 1/2 mi. W. 11th Ave., 150' S. of Houston (handwritten, difficult to read).
- Well Log:** (11) WELL LOG. Total depth: 72 ft. Depth of completed well: 66 ft. Lithology: 0-7 Heavy black sand, 7-20 Heavy sand, 20-51 mid yellow clay, 51-64 Gray clay, 64-72 Blue clay.
- Well Seal:** None.
- Water Levels:** None.
- Well Tests:** None.
- Driller Information:** None.

Figure 4.1. Side by side comparison of two WCRs. On the left is a high-quality well that is easy to locate, with the address and location map fields highlighted in red. On the right is an old, hard to read WCR with no location map and a very hard to decipher address. The lithologic descriptions are also very sparse and hard to read.

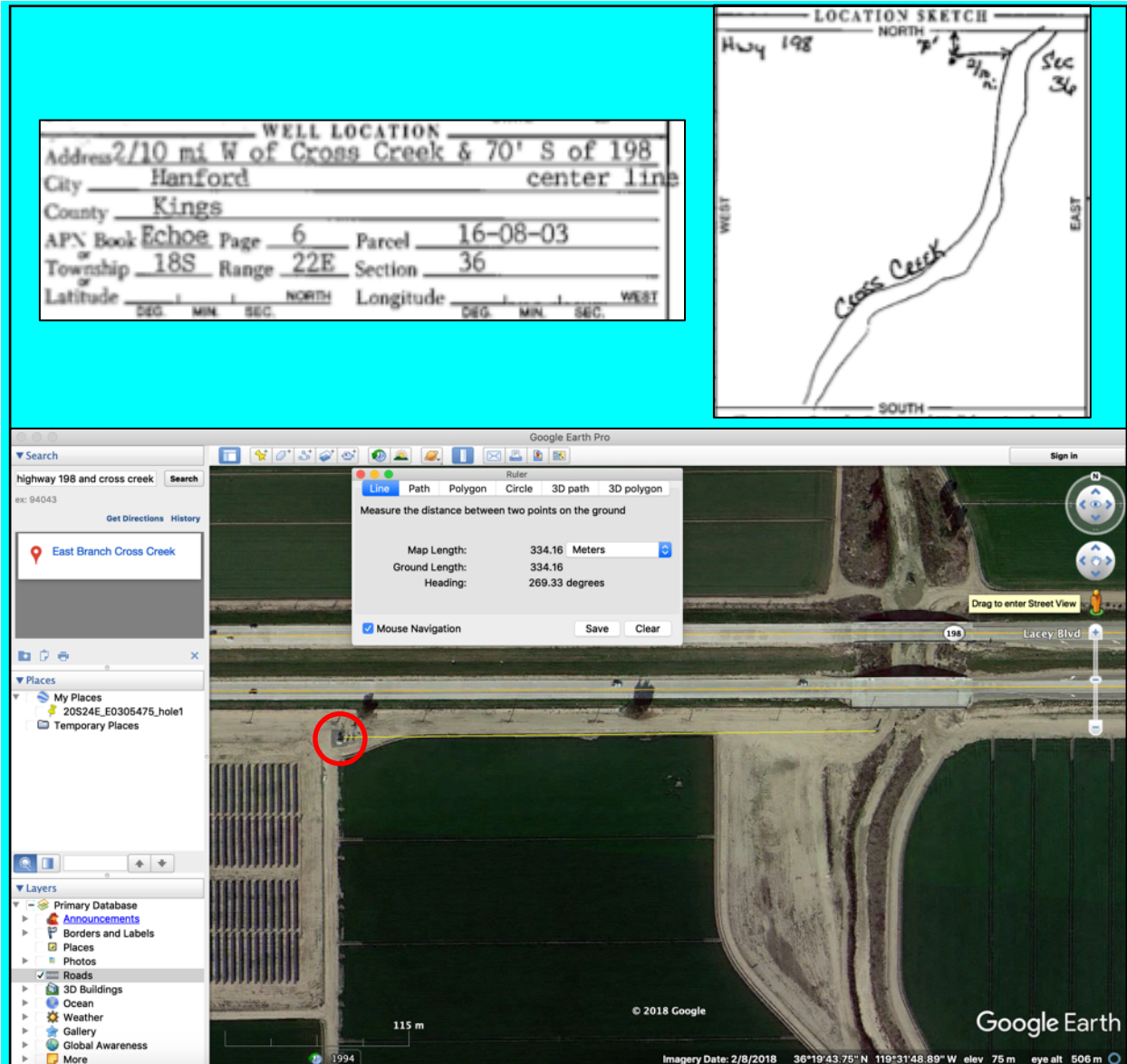


Figure 4.2. Screenshot illustrating how to follow directions and locate a well head in Google Earth. Top portion shows the address and directions on the left and the location map on the right; the bottom portion shows Google Earth with the directions measured out using the measuring tool. The resultant well head found is circled in red.