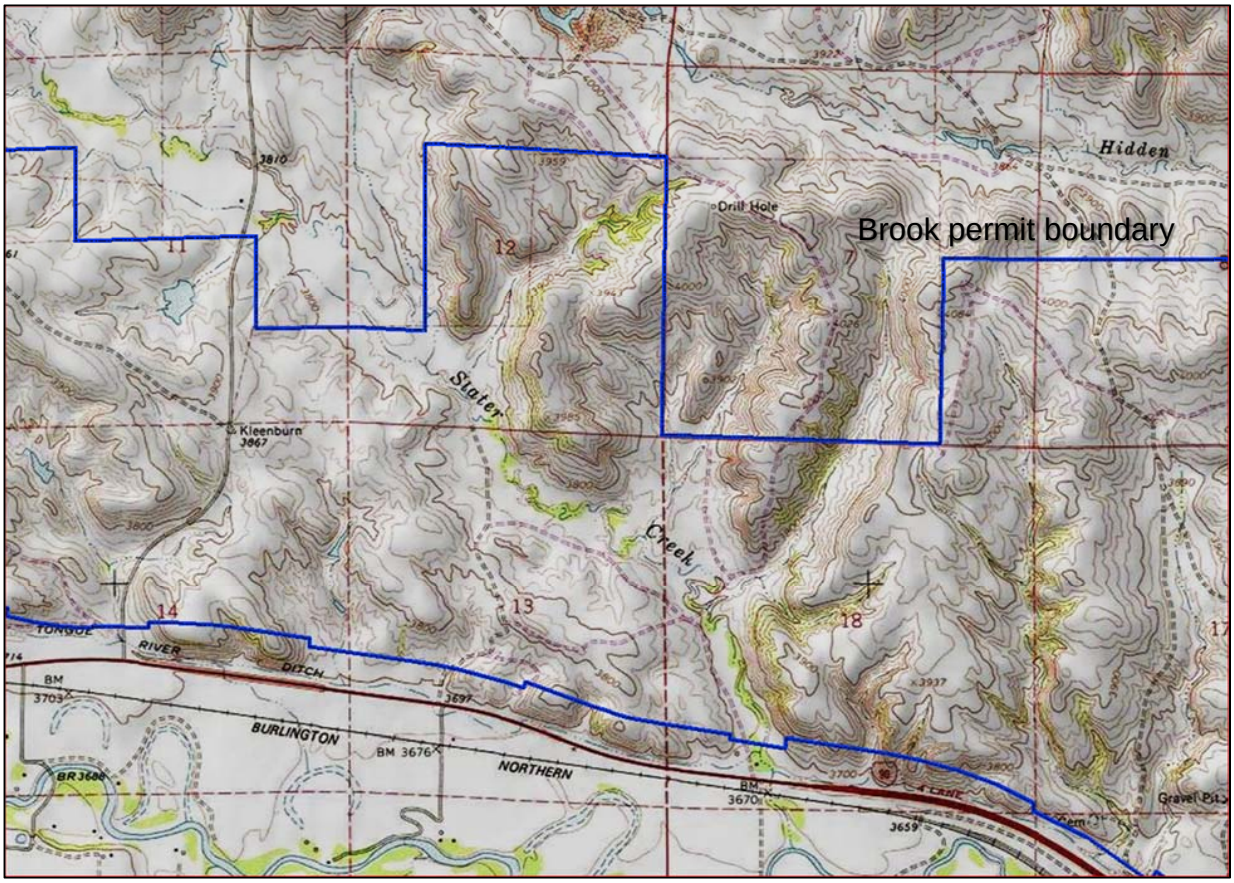
MEMORANDUM

TO: File, Ramaco Brook Mine TFN 6 2/025
FROM Bj Kristiansen, PG
RE: Brook Mine AVF Determination, Slater Creek
DATE: February 10, 2016

The following narrative is created for the determination of Alluvial Valley Floor (AVF) potential **within** the proposed permit boundary of the Brook Mine.

Ramaco Coal Company has submitted a permit application to LQD for a surface coal mine, to be operated in Sheridan County, Wyoming. The mine has been named the Brook Mine and is found on acreage located within T.57N., R.84W and R.85W. An AVF determination was initiated on September 24, 2015 when a group of LQD personnel visited the mine site for a field evaluation of one drainage, Slater Creek (Map, below). The entire length of the stream within the permit boundary was walked for evaluation purposes. The geomorphology, vegetation, and hydrology of the drainage was observed. Photos were taken to assist in AVF characterization.



Map 1 - Slater Creek topography within the proposed Brook Mine permit boundary.

DEQ Exhibit 15

Upon completing the field examination of Slater Creek and evaluation of aerial photography, Big Horn Coal Permit 213 AVF assessments, historic geologic maps, available literature, and personal communication within LQD, a determination of the AVF characteristics of the drainage within the Brook Mine proposed permit boundary has been made. The analysis of the Slater Creek AVF has determined that:

1. That portion of Slater Creek occurring in the SW ¼ sec.12, N ½ sec.13, T.57N., R.85W, and the W ½ sec.18, T.57N., R.84W. is classified at this time as an intermittent stream that has segments of perennial flow during wet years. (Figure 1).

2. Acreage directly upstream of the proposed Brook Mine permit boundary has been farmed in the recent past (1 to 2 years) along the margins of Slater Creek, northwest of the abovementioned land, for a distance of approximately 4 ½ miles. The primary crop has been hay used as feedstock for cattle. The farmed lands have historically been watered by flood irrigation methods from a ditch system fed by the North Branch of Slater Creek, originating in the SE1/4 SE1/4, sec.29,T.58N., R.85W. (Figure 2).

3. A segment of the Slater Creek drainage, from the SW ¼ sec.12, T.57N., R85W. to the SW ¼ sec. 18, T.57N., R.84W., has been examined and mapped by LQD staff with a goal of classification of AVF characteristics**. It was determined that 13.11 acres within the Brook Mine Permit Boundary are considered to be AVF** (Figure 3), based on the following criteria:
    a. This acreage is located in the SW ¼ SW¼ sec. 12, T.57N., R.85W., within the northern zone of **perennial flow**. (Figures 1 and 3). Water was present and flowing during the field examination on September 24, 2015.
    b. The streambed is underlain by 16 feet of unconsolidated stream laid deposits, as exemplified by a Ramaco alluvial monitor well, number 578512-AL. (Figure 4). Additionally, there is evidence of abandoned meanders and minor terracing (left). The channel bottom in this location does not occur within bedrock material, as it does further downstream where the channel is deeply incised. There is sufficient alluvial fill in the AVF area to present a relatively flat, unincised geomorphology. Geomorpholgy of the downstream reaches is consistant with deaply incised, intermittant drainange and is not AVF.

c. Subirrigation or natural flood irrigation occurring on the stream laid deposits is of sufficient extent to provide for flood irrigation agricultural activities. Artificial flood irrigation has been or is presently practiced on the valley bottom immediately adjacent

to the northwest corner of the area under study where alfalfa hay has been grown in the past. There are significant quantities of subirrigated indicator plant species in the form of grasses, sedges and rushes, and wetland shrubs (above). Subirrigated vegetation is also evident when viewing color-infrared aerial photography (2001) and seasonal, conventional imagery.

d. Identification of a water table exhibiting diurnal fluctuations as a result of transpirational losses is not yet possible due to the short baseline presently submitted by Ramaco for the Brook Mine permit application. The water levels in 578512-AL (below) have been

recorded and presented in a hydrograph running from September, 2013 through May, 2014, where the hydrostatic surface has increased by 0.4 feet. This would indicate a gaining system, as would be expected during the fall and winter when vegetation is dormant and transpiration is not occurring. The static water level in the monitor well is approximately 4 feet below ground level. This depth would indicate that potential subirrigation is available for some perennial grass species used as forage by ranchers.

e. Neither natural nor artificial flood irrigation occurs on Slater Creek within the Brook Mine permit boundary. The aforementioned adjacent hay meadows farmed by the neighboring rancher are artificially flood irrigated through a system of ditches and diversions. The hay meadows along Slater Creek upstream of the permit area have been irrigated for decades by the resident land owners. Since the stretch of Slater Creek under examination exhibited water flow in late September (below), it is assumed that the flow existed during the summer months. There have been no large rainfall

events during the summer of 2015 to contribute to flows so they are assumed to be perennial. Artificial flood irrigation within the studied acreage has potential to be performed at the same time that the upstream pastures are irrigated but water quantities are unknown at this time. Further research is needed to quantify available surface water. There was a historical attempt to irrigate Slater Creek within the proposed permit boundary in the early 1900s. This is documented by cancelled SEO water rights for the Connable Ditch and Lateral. Since the water rights were cancelled, it is assumed the attempt to irrigate failed. Miller Regression Analyses crafted for Slater Creek in the Brook Mine permit application indicates that the estimated 2-Year Annual Peak Flow for Slater Creek is 80 cubic feet per second (cfs).

f. Water analyses from the alluvial well indicates that the water is slightly saline in nature. The pH averages 8.0, Conductivity is 5,180 µmhos/cm, Total Dissolved Solids (TDS) is 5,210 mg/L, and Sodium Adsorption ratio (SAR) is 4.0. Use of this water in flood irrigation would be effective for forage crops as long as the salts were allowed to move downward through the alluvial materials and exit the system through sub-flow. Water quality samples were collected by Ramaco from a surface water monitoring station located on Slater Creek in the perennial flow section under study. The sample indicates a water type of magnesium-calcium sulfate. In this sample the pH was 8.58, Conductivity was 1,504 µmhos/cm, TDS equals 1,220 mg/L, and SAR was 1.9. Again,

the sample indicates some salinity but would suffice for the production of forage crops, such as alfalfa.

g. Soils in the study area are fairly homogenous, with a very fine, sandy loam (NRCS map symbol 154) occurring along the bottom lands along Slater Creek. The closest soil determined to be a Prime Farmland Soil by the NRCS (Figure 5) is located approximately 1 mile upstream from the AVF acreage.
h. The AVF acreage is located on lands that are characterized as undeveloped rangeland, no improvements to the land's productivity or management have occurred. The AVF acreage is not significant to farming.
i. None of the land within the Brook Mine permit boundary determined to be AVF will be affected by mining, according to the mine plan presented in the permit application.

4. Based on the analysis performed on the upper part of Slater Creek mentioned above, the tentative classification of the AVF is a "Case X" alluvial valley floor, as defined in Guideline 9, page 14. This is defined as:
    a. A stream for which the alluvial saturated zone storage capacity is great enough to contribute to stream flow. The stream is dry at some periods of the year.
    b. It is further identified by subirrigated vegetation that appears intermittently down the channel length (below).

    c. Hydrograph analyses for the comparison of alluvial water levels and stream stage are available in the Brook Mine permit application to identify baseflow and interflow components. At this time the baseline period of data collection is insufficient for definitive, long-term evaluation. Further investigation of the flow components is recommended.

5. A backhoe pit in the alluvial material proximate to the channel is necessary to identify the alluvial saturated zone. This activity can be enabled when the permit to mine is issued and affected area bond has been submitted.

The AVF determination of the acreage along the upper reach of Slater Creek within the proposed Brook Mine permit boundary has reached an impasse. LQD has performed as much of the analysis as is possible at this time. Potential AVF lands on Slater Creek upstream and adjacent to the northern permit boundary must remain as future evaluations due to inaccessibility at this time. A proposed plan for AVF determination for these lands will be crafted by the end of February, 2016.

Bj Kristiansen, PG
Natural Resources Program Principal
LQD – District 3

EXHIBITS

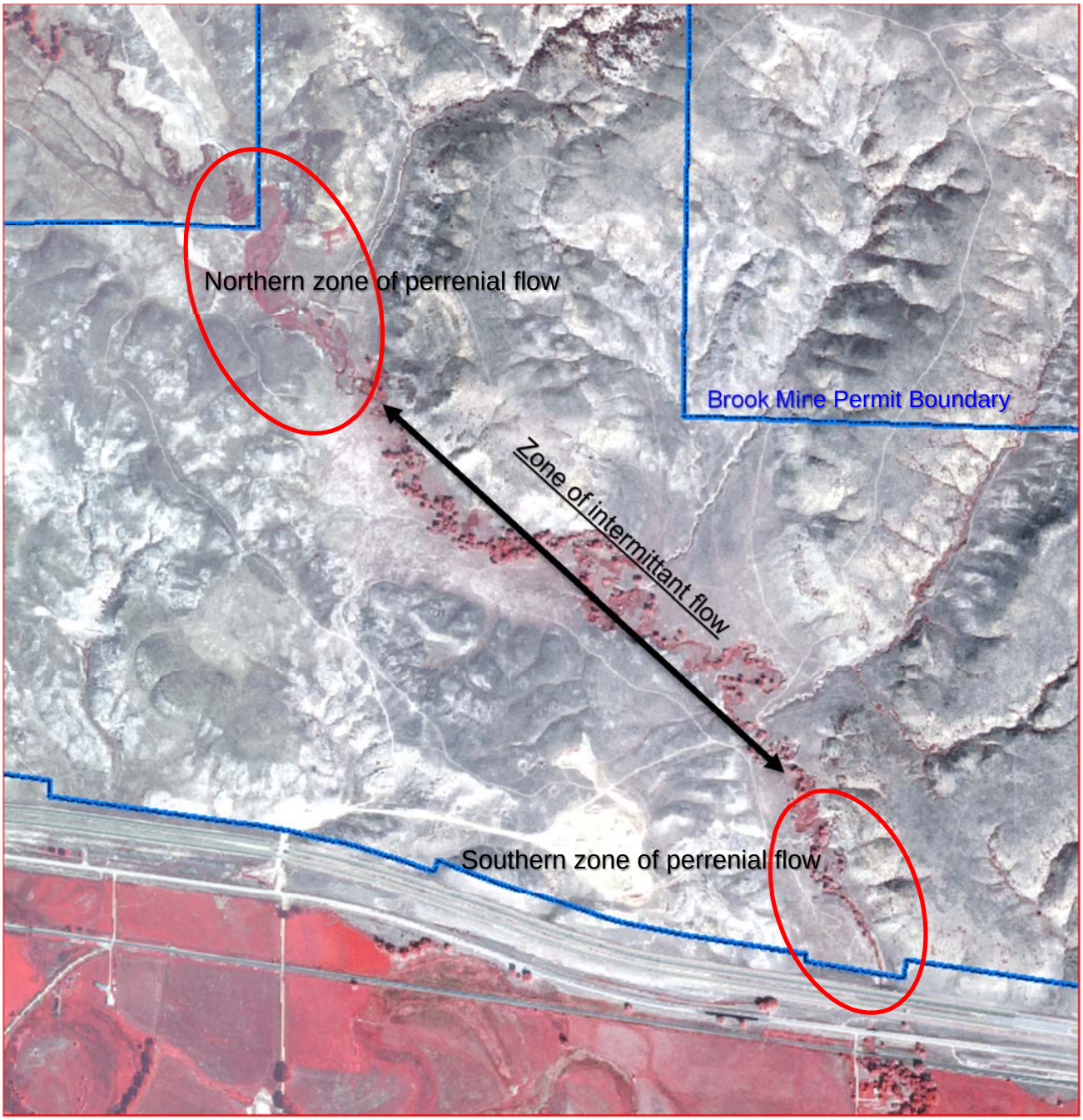


Figure 1 - Zones of perennial and intermittent flow, Slater Creek. Flows were observed on September 24, 2015 and are assumed to be constant throughout the summer months as well as the spring and fall. Color-Infrared imagery May 1, 2004.

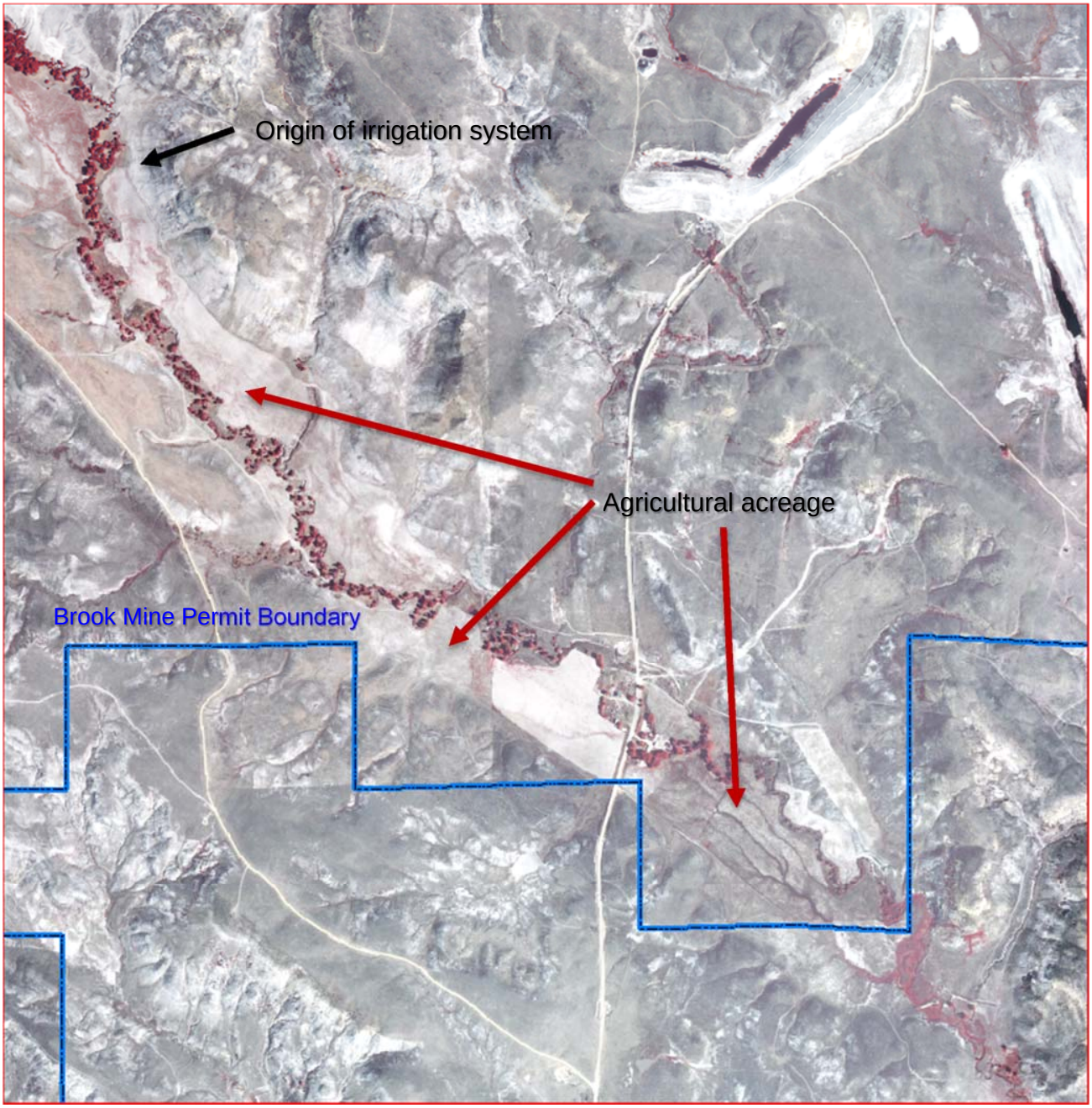


Figure 2 - Upstream section of Slater Creek showing agricultural acreage and irrigation system origination.

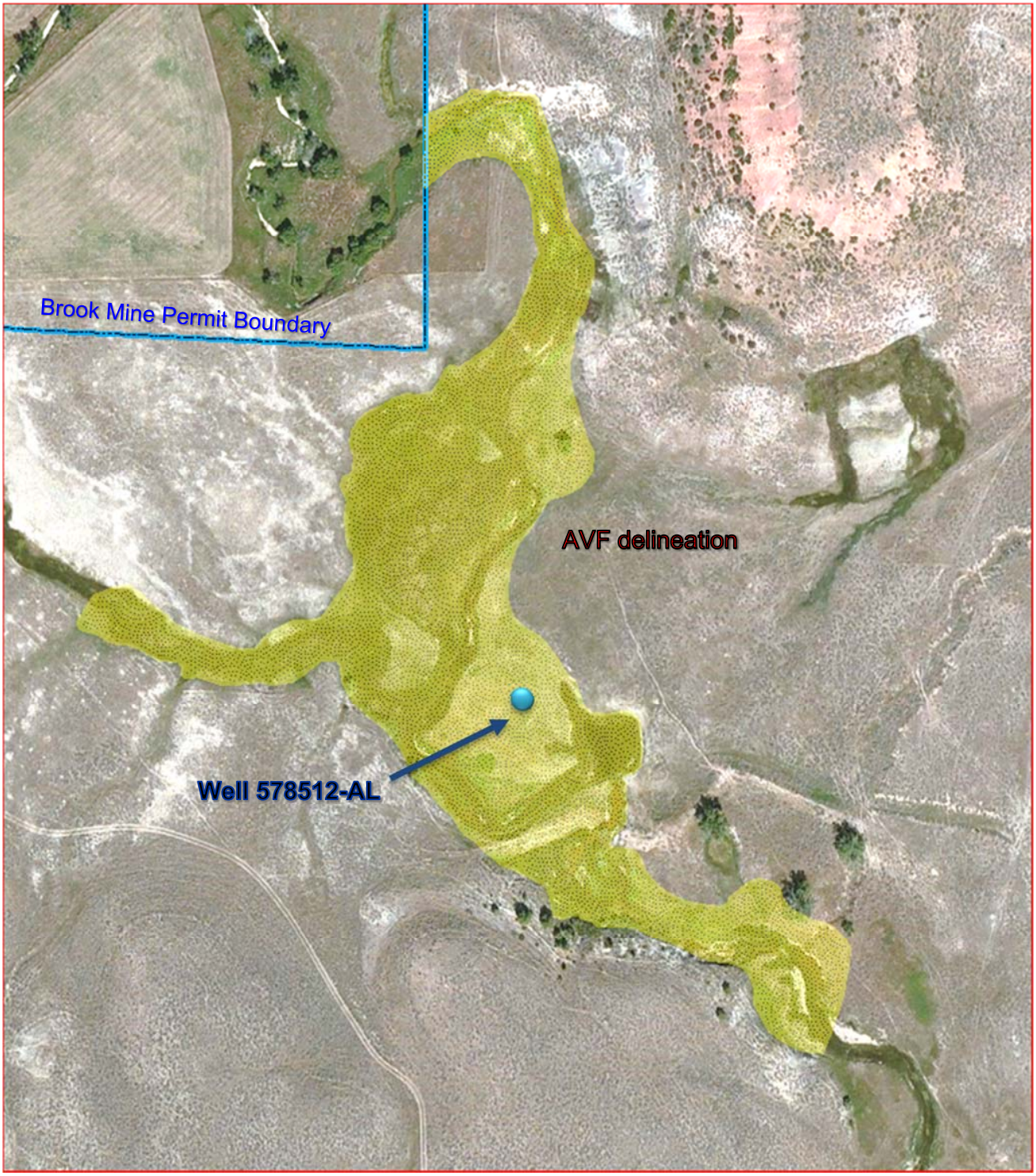


Figure 3 - Slater Creek AVF location, consisting of 13.11 acres. Mapped by examination of Color Infrared photography, current aerial imagery, and field examination.

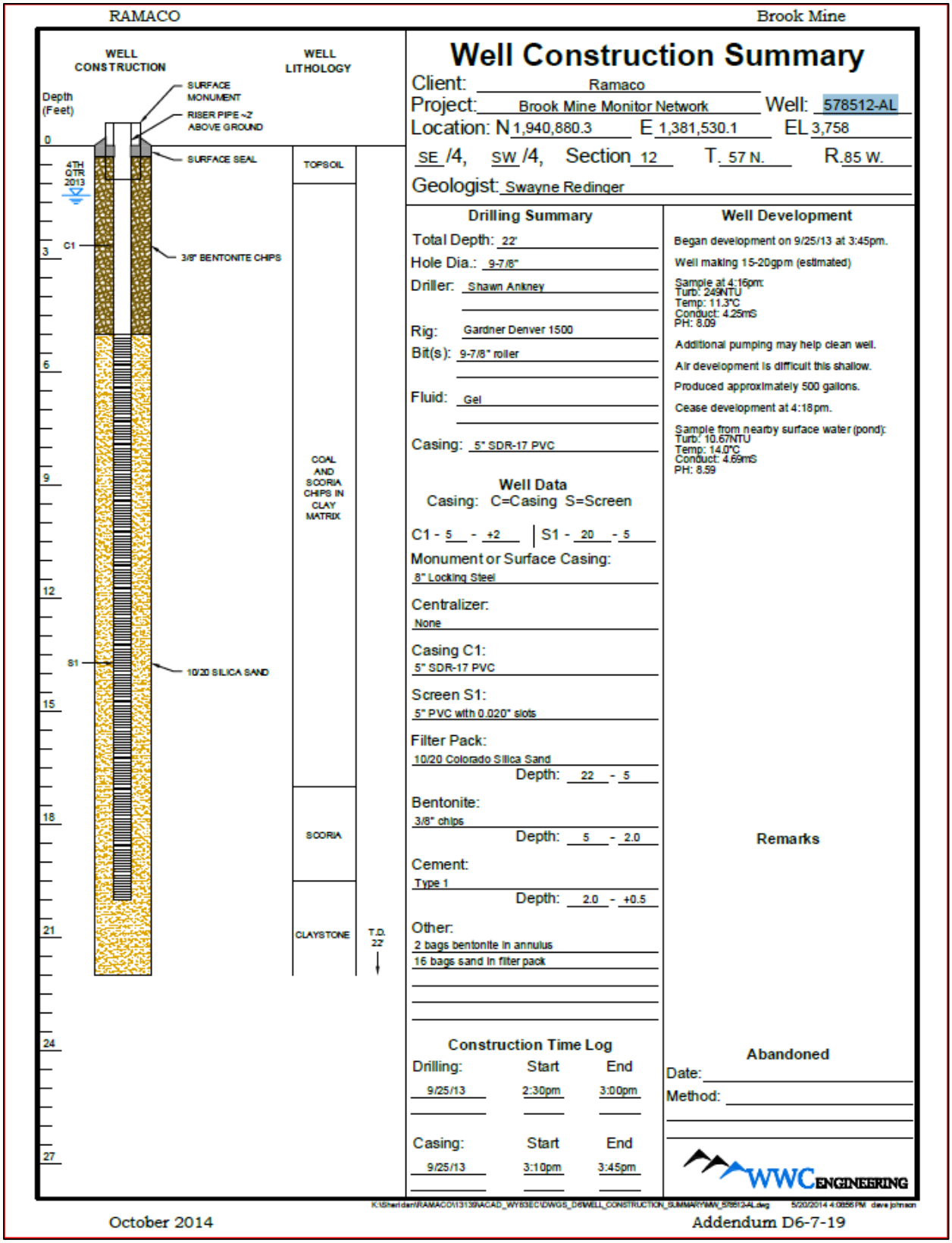


Figure 4 - Lithologic log for Alluvial Well 578512-AL

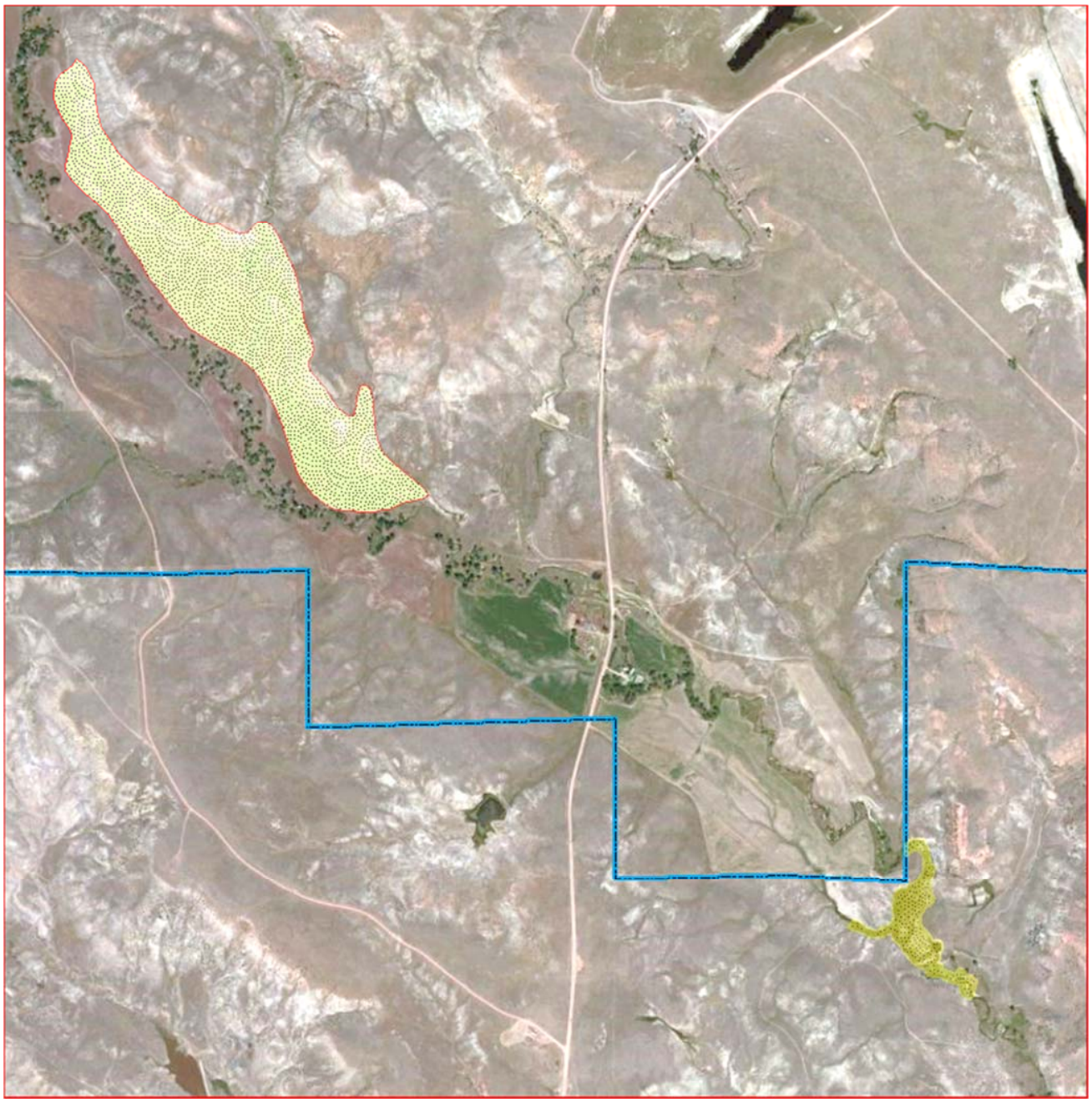


Figure 5 - Location of Prime Farmland, as defined by the NRCS, approximately 1 mile upstream from the study area.

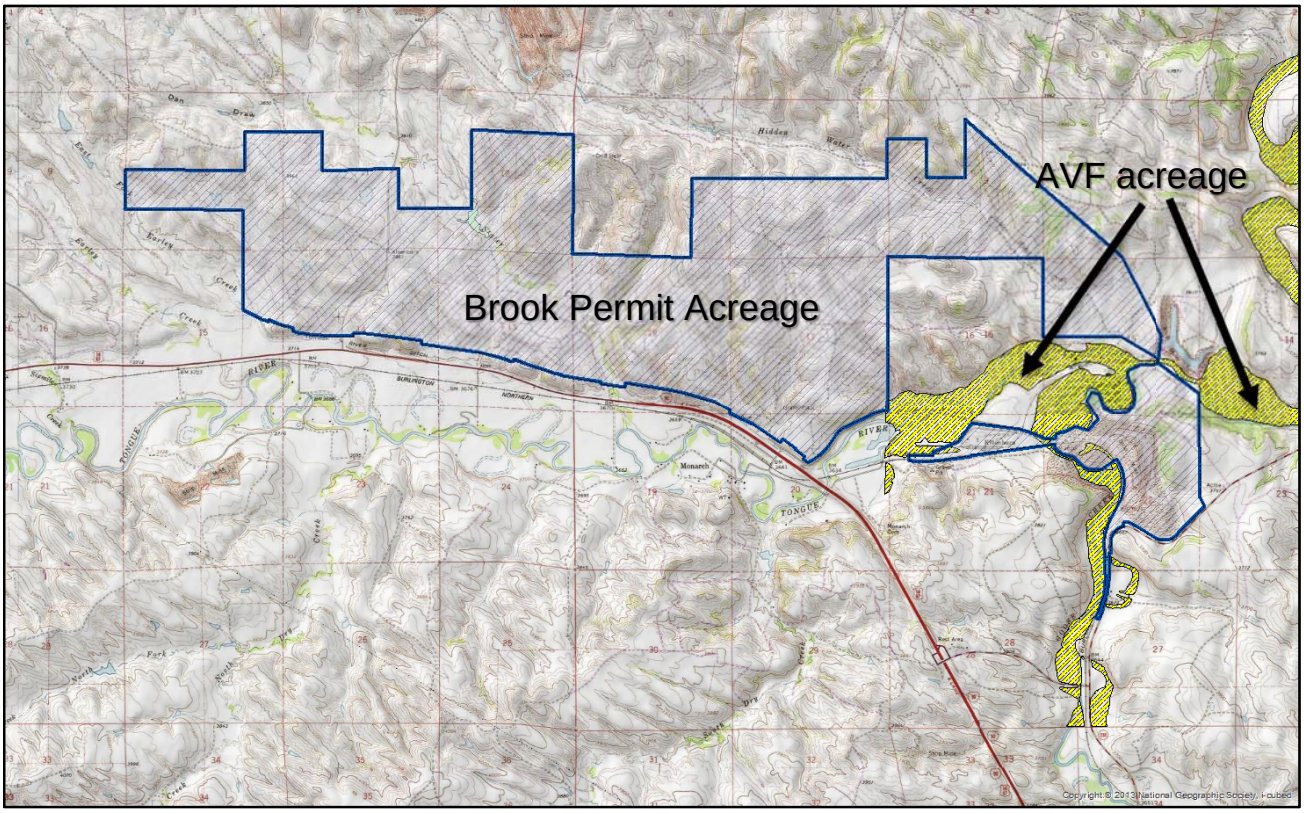


Figure 6 - AVF determinations along Tongue River (TR) and Goose Creek performed for the Big Horn Coal Company Mine Permit 213 T-1, 1981. Declared AVF in yellow stipple pattern.