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DEPARTMENT OF WATER RESOURCES

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BEFORE THE DEPARTMENT

OF

WATER RESOURCES OF THE STATE OF IDAHO

IN THE MATTER OF BASIN 37 ADMINISTRATIVE PROCEEDING	Docket No. AA-WRA-2021-001 **PICABO LIVESTOCK, INC. EXHIBIT LIST**

COMES NOW **PICABO LIVESTOCK, INC.**, by and through its attorney of record, Gary D. Slette, hereby discloses the exhibit referenced below that will or may be introduced in the hearing of this matter.

1. Analysis of the Nature and Extent of Hydraulic Separation between the Lower Basalt Aquifer and the Upper Alluvial Aquifer in the vicinity of Picabo, Idaho. Prepared for Picabo Livestock, Inc., September 6, 2017, by Charles G. Brockway, Ph. D, P.E. .

DATED this 2nd day of June, 2021.

GARY. D. SLETTE

CERTIFICATE OF SERVICE

The undersigned certifies that on the 2nd day of June, 2021, he causes a true and correct copy of his PICABO LIVESTOCK, INC. EXPERT WITNESS DISCLOSURE to be served up the following persons in the following manner:

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Prepared for:

Picabo Livestock Company, Inc.
Picabo, Idaho

September 6, 2017

For information concerning this report, contact
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Analysis of the Nature and Extent of Hydraulic Separation between the Lower Basalt Aquifer and the Upper Alluvial Aquifer in the vicinity of Picabo, Idaho

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September 6, 2017

A. Overview

The U.S. Geological Survey, in cooperation with the Idaho Department of Water Resources, recently completed and published a numerical groundwater model of the Big Wood aquifer system, the first comprehensive model of the system to be developed. The model domain included essentially all of the aquifer from North Fork to Picabo.

Horizontal discretization of the model is uniform, with 100-meter cells throughout the domain. Vertical discretization of the model is accomplished in three layers. The 3-layer structure allows for the simulation of vertical gradients due to strata location which may have widely different composition and hydraulic characteristics. It also allows for the simulation of confined and semi-confined conditions which occur at various locations throughout the domain.

The most extensive presence of vertical inhomogeneity exists in the southern portion of the domain within the area known as the Bellevue triangle. West of a north-south line running approximately through Gannett, the upper water-bearing alluvium is separated from the lower water-bearing alluvium by a confining layer primarily consisting of clay or sandy clay. This arrangement induces artesian conditions in the lower aquifer and many high-producing artesian wells have been developed in this area. East of a north-south line approximately at Gannett, a vertical heterogeneity of a different sort exists. The upper water-bearing alluvium typically consists of the usual sand and gravel, but the lower water-bearing formation is basalt from the Snake River group which has intruded into the valley from the southeast. The basalt intrusion extends to a point approximately six miles west of Picabo. Between the basalt and the upper alluvium, a confining or semi-confining layer of clay or sandy clay typically exists. In addition, the upper portion of the basalt is often dense and unfractured, with water-producing zones located some tens of feet below the upper basalt horizon. These two features create a separation between the alluvium and the basalt production zone, and lead to artesian pressures within the basalt (though almost no wells have sufficient pressure to flow freely as in the western portion of the Bellevue Triangle).

The upper alluvium thins in an easterly direction, ceasing to contain water in the vicinity of Sportsman's Access. East of Sportsman's Access, the water-bearing alluvium is essentially non-existent and all wells are completed in the basalt zone. Near Picabo, the water table in the basalt dives steeply in an eastward direction toward the main body of the Eastern Snake Plain Aquifer.

B. Evaluation of Consistency of Model Calibration with Lithologic Data

A number of large irrigation wells draw from production zones in the basalt beneath the upper alluvium. Since the upper alluvium is known to contribute to reach gain in Silver Creek above Sportsman's Access and is simulated as such in the model, the degree of hydraulic interconnection or separation between the basalt production zones and the upper alluvium is of significant importance in assessing the liability of basalt wells for depletions of Silver Creek and the Little Wood River. The degree of separation depends on the thickness of the separating layer, its hydraulic conductivity, and its spatial extent.

In development of the Big Wood model, the modelers used the 3-layer structure to simulate the complex hydrogeology in the Picabo area. The upper alluvium was represented as layer 1, the intermediate zone as layer 2, and the lower basalt as layer 3. The model calibration algorithm known as PEST (for Parameter ESTimation), was allowed to vary hydraulic conductivities in each cell and within each layer, constrained to some specified range. The hydraulic conductivities arrived at by PEST and published in the final model for Layer 2 are depicted on Figure 1. This figure shows zones of hydraulic conductivity ranging from 0-1 m/day to 50-200 m/day. To put these values in perspective, Table 1 shows typical average hydraulic conductivities for various materials encountered in the Big Wood basin.

Table 1. Representative values of hydraulic conductivity.[1]

Material	Hydraulic conductivity	
	(m/day)	(ft/day)
Gravel, coarse	150	492
Gravel, medium	270	886
Gravel, fine	450	1476
Sand, coarse	45	148
Sand, medium	12	39
Sand, fine	2.5	8.2
Silt	0.08	0.3
Clay	0.0002	0.0007
Basalt [unfractured]	0.01	0.03
Granite, weathered	1.4	4.6
Glacial till, predominantly sand	0.49	1.6
Glacial till, predominantly gravel	30	98

[1] Reported in Todd (1980) Groundwater Hydrology, but originally from Morris and Johnson (1960). Summary of Hydrologic and Physical Properties of Rock and Soil Materials, as Analyzed by the Hydrologic Laboratory of the U.S. Geological Survey 1948-60.

Figure 1 illustrates the study area for the present analysis, generally east of Gannett. Within this area the predominant hydraulic conductivity in the model calibration for Layer 2 is 1 to 10 m/day (the green zone in Figure 1). Further west and east the calibrated values are 10 to 50 m/day (the blue zones). The average value is 9.54 m/day within the study area. The Layer 2 thickness in the model is a uniform value of 5 meters and the area of the green and blue zones is 7,277 acres. The orange zone further west, outside the study area, represents the low-permeability confining strata which creates the artesian well zone and is not of immediate interest in the present study.

In view of Table 1, the model-calibrated values are much higher than expected for a separating layer such as silt, clay, or dense basalt, but instead are consistent with fine to coarse sand. The lowest calibrated values (1 m/day) are still 12.5 times larger than those expected for silt, 100 times larger than those for basalt, and 5,000 times larger than those for clay. But, the important question is whether that calibration is consistent with what is actually observed in the well drilling records in the area. Even though the groundwater modelers utilized well logs to guide the model stratification, they did not manually select hydraulic conductivities based on actual lithology indicated in the logs. Instead, they allowed PEST to tell them what they should be. Using PEST in this manner is not necessarily inappropriate, but it is always important to bring scientific interpretation to bear on actual field data, where available, to ensure that the calibrated values are reasonably consistent with reality. It also must be understood that the output from PEST is not a unique solution; the system is so highly over-specified that hundreds – perhaps thousands – of different combinations of hydraulic conductivities would yield essentially the same calibration fit.

In order to test the hypothesis that the model-calibrated hydraulic conductivities are consistent with actual lithology, well drilling records within the area of interest were obtained from IDWR files and analyzed. The analysis was restricted to those wells with sufficient depth to reach the underlying bedrock (there are a number of shallow domestic wells which are completed only in the alluvium). This restriction was necessary to accurately ascertain the extent and nature of the separating layer, which is typically either fine-grained material directly above the basalt, or dense basalt. A small number of logs were either uninterpretable or were deemed to be clearly in the wrong location based on local knowledge. Wells drilled outside the model domain and into the granitic formations were not included. As noted above, in the vicinity of Picabo alluvium is minimal with no water and the water table dives off steeply in the basalt. There were no logs found in Sections 28 and 29, T1S R20E. A total of 56 logs met the criteria and were analyzed (Figure 2; Appendix A).

An idealized schematic of the typical lithology indicated by the well logs is shown in Figure 3. The logs are relatively consistent, indicating upper alluvial strata consisting of material ranging from clay to gravel in texture. Sand or gravel layers in the alluvium typically contain water (the "upper water"). The upper water is shallow (typically 0 to 15 feet below ground), and is generally connected hydraulically with the spring-fed streams such as Grove Creek, Loving Creek, and Silver Creek proper. The upper water contributes directly to reach gain in the Silver Creek system via these mechanisms.

Below the upper alluvium, basalt is present. The basalt typically consists of alternating layers of dense, unfractured rock and fractured, water-bearing zones. The uppermost strata of the basalt, i.e. just below the the alluvium-rock interface, may either water-bearing or dense and unfractured.

Between the upper water-bearing alluvium and the basalt, a low-permeability confining layer typically exists, characterized by well drillers as "clay," "sandy clay," "clay with gravel," or "clay with sand." Water is not typically indicated in this zone. Almost all wells are cased through the alluvium, and in every case the log indicates a static water level considerably higher than the depth to first water in the basalt. The average difference between the static water level and the depth to first water in the basalt is 68 feet, not including 13 wells which were flowing under artesian pressure. This is unambiguous evidence that water-bearing zones in the basalt are present under confined or at least semi-confined conditions.5

A tabulation of well information is shown in Appendix A. The total thickness of the separating layers is assumed to be equal to dimensions C + D on Figure 3. In some wells this underestimates the separation thickness because of the presence of fine-grained strata between layer C and the upper alluvial water. In some wells, either C or D is equal to zero because one of the strata is not present. In one well (#25), there appears to be no separating layers. The average total thickness is 46 feet, the median is 38 feet, and the 25-th / 75-th percentile range is 18.6 to 58 feet. The spatial variation of the thickness of layers C and D is illustrated graphically on Figure 2.

In some wells near the center of the study area, the alluvium is very thin and there is no water present in the alluvium (Figure 2). This appears to be an area of a basalt mound reaching close to the surface.

The data indicates that the actual degree of separation between the lower basalt and the alluvial water is significantly greater than exists in the calibrated Big Wood model. A layer of clay and/or dense basalt with an average 46-foot thickness will reduce the vertical transmissivity between these layers to minimal levels. As an estimate, it was assumed that when a driller indicates "clay" the material probably is not pure clay and does not have a hydraulic conductivity approaching 0.0002 m/day (Table 1), but likely is closer to the value for silt of 0.08 m/day. The average "clay" thickness is 33 feet and the average "rock" thickness is 48 feet (refer to data in Appendix A). Calculating a weighted average using 0.08 m/day for clay and 0.01 m/day for rock yields a composite hydraulic conductivity of 0.039 m/day (0.13 ft/day). Multiplying this value by the average separating layer thickness of 46 feet (14.0 m) yields a transmissivity of 0.55 m^2/day (5.9 ft^2/day). The data also does not support the spatial variation of hydraulic conductivity in the model as shown on Figure 1.

C. Groundwater Modeling

The groundwater model was employed to simulate the effect of pumping three irrigation wells on heads in Layer 1 and on reach gain in Silver Creek. The irrigation wells are owned by Picabo Livestock, Inc. and their locations are indicated on Figure 2 (well numbers 41, 45, and 56). All wells are fully cased through the alluvium and into the lower basalt, thereby drawing only from the lower aquifer. The Picabo Livestock Wells were originally included in the calibrated model and extractions were modeled within layer 3 in the following model cells (row,column,layer): (525,235,3), (527,237,3), and (520,256,3).

To determine the impact of well pumping, the calibrated model results were obtained from a transient model run. The simulated Picabo Livestock wells were then removed from the model, and corresponding excess irrigation recharge was removed from the Picabo Livestock footprint. Excess irrigation was estimated to be approximately 45% of the water volume extracted from the wells, which is the same figure used in the Big Wood model. The transient model was then re-run and results from the modified model were compared to the calibrated model to determine the impact to local heads, river reaches, and underflow.

The simulated impact of the Picabo Livestock wells on the Big Wood River and Willow Creek is essentially zero (less than 0.00 cfs). The impact on Silver Creek above Sportsman's Access is an average of 1.95 cfs with a seasonal range from 0.23 cfs to 4.10 cfs as shown in Figure 4. As a percentage of gross well pumping, the reach gain impact is an average of 50%, but ranges from 27% to 80%, depending on the year.

The Big Wood model was not modified to reflect the actual nature of the separation between Layer 2 and Layer 3, as this would require significant effort to rework a major section of the model. Since the actual Layer 2 hydraulic conductivity appears to be two orders of magnitude lower than the average model-calibrated values, and the Layer 2 thickness is at least double the model-assumed value, Darcy's law would dictate that the effect of pumping of irrigation wells such as the Picabo Livestock wells on reach gain in Silver Creek must be at least two orders of magnitude less than the model simulations would suggest.

It is strongly recommended that for future updates and calibrations of the model, the groundwater modelers use actual field data in this and other areas of the domain to set a narrow range of hydraulic conductivities.

D. Conclusions

- The Big Wood River groundwater model includes three computational layers in area west of Picabo. From the top downward, Layer 1 is the upper alluvial aquifer which is hydraulically connected to the surface streams, Layer 2 is a low-permeability layer between the alluvium and the lower basalt, and Layer 3 is the lower basalt. In general, this configuration adequately reflects the observed vertical stratification.

- Pumping from wells completed in the lower basalt can affect the piezometric head in Layer 1, and subsequently the reach gain in Silver Creek, only to the extent there is vertical transmissivity between Layers 1 and 3. The magnitude of the vertical transmissivity depends on the hydraulic conductivity and thickness of Layer 2.

- The calibrated groundwater model hydraulic conductivity for Layer 2 ranges from 1 to 50 m/day in an area roughly east of Gannett. These values were not determined by actual scientific judgment, but were selected by an automated calibration algorithm known as PEST.

- Observational evidence based on real data from well drilling records indicates that the separating strata between water-bearing zones in the lower basalt and the upper alluvium averages 46 feet (14.0 m) in thickness and consists of material denoted by well drillers as "clay," "sandy clay," or "clay and gravel" and/or dense, unfractured basalt. Either of these types of materials have extremely low vertical hydraulic conductivity.

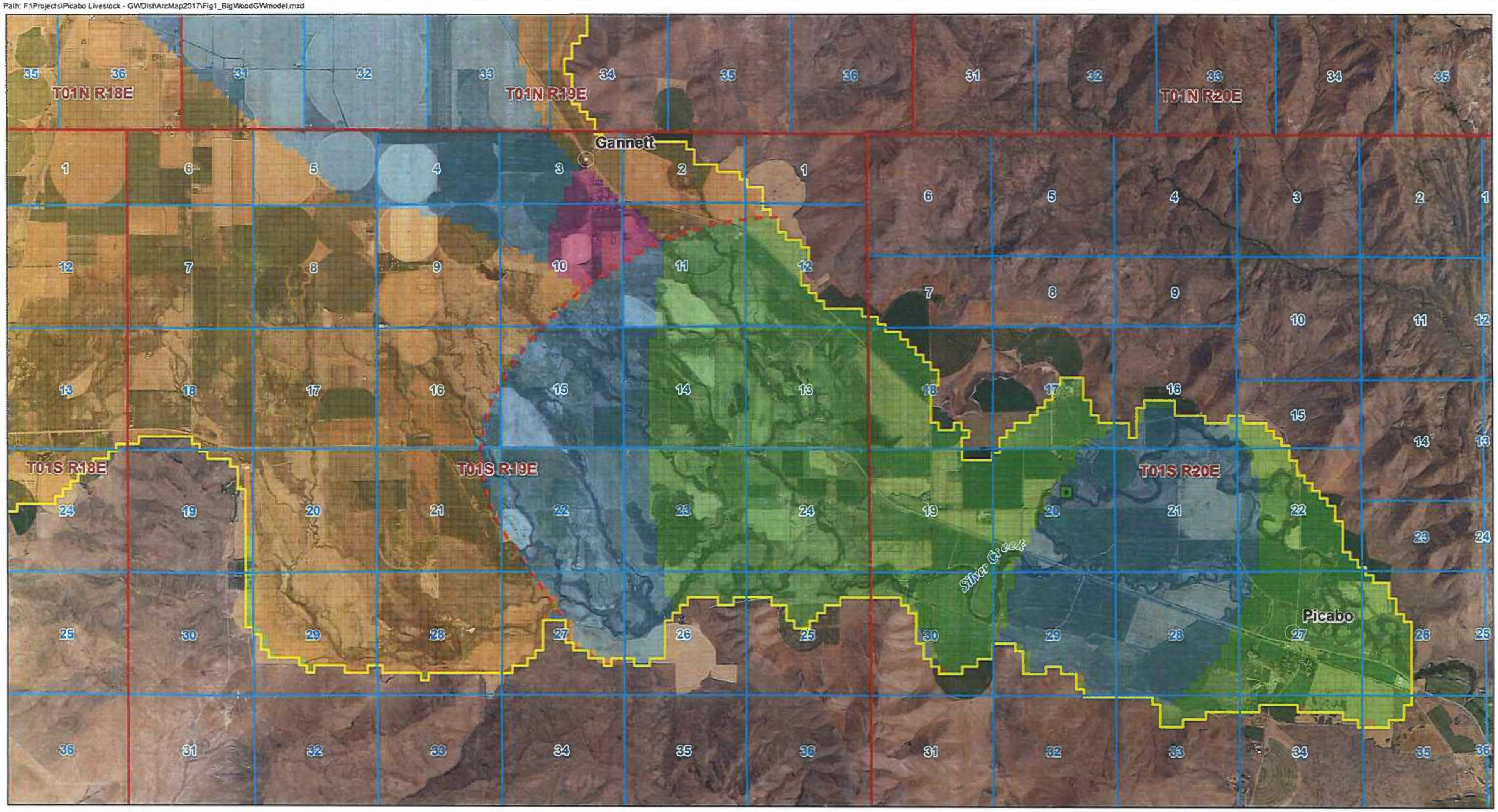
- Based on actual lithology, the estimated average vertical hydraulic conductivity of the separating layer is 0.039 m/day (0.13 ft/day) and the estimated average transmissivity is 0.55 m^2/day (5.9 ft^2/day). These values are two orders of magnitude less than the calibrated values. The estimated Layer 2 characteristics from the model calibration and from the evaluation of observed lithology are compared in Table 2.

Table 2. Comparison of Layer 2 characteristics from model calibration and from evaluation of actual lithologic data (all values expressed in English units).

Parameter	Source of Estimate	
	Model Calibration	**Evaluation of Lithology**
Thickness	16 ft	Average 46 ft Median 38 ft
Hydraulic conductivity	3.3 to 164 ft/d Average 31.3 ft/d	0.13 ft/d
Transmissivity	501 ft^2/d	5.9 ft^2/d

- As an example, the model-simulated impact of irrigation wells owned by Picabo Livestock, Inc. on reach gain in Silver Creek ranges from 0.23 to 4.10 cfs. Due to the overestimation of the hydraulic conductivity and underestimation of the thickness of model Layer 2, the actual impact will likely be at least two orders of magnitude less than the model would predict.

Path: F:\Projects\Picabo Livestock - GWDist\ArcMap2017\Fig1_BigWoodGWmodel.mxd



0 0.5 1 2 Miles

FIGURE 1. BIG WOOD GROUNDWATER MODEL LAYER 2 HYDRAULIC CONDUCTIVITY

Model boundary
Sportsman's access
Study area boundary

m/day
0-1
1-10
10-50
50-200

N

BROCKWAY ENGINEERING, PLLC.
ICB - Date: 9/6/2017

NAIP 2015 AERIAL

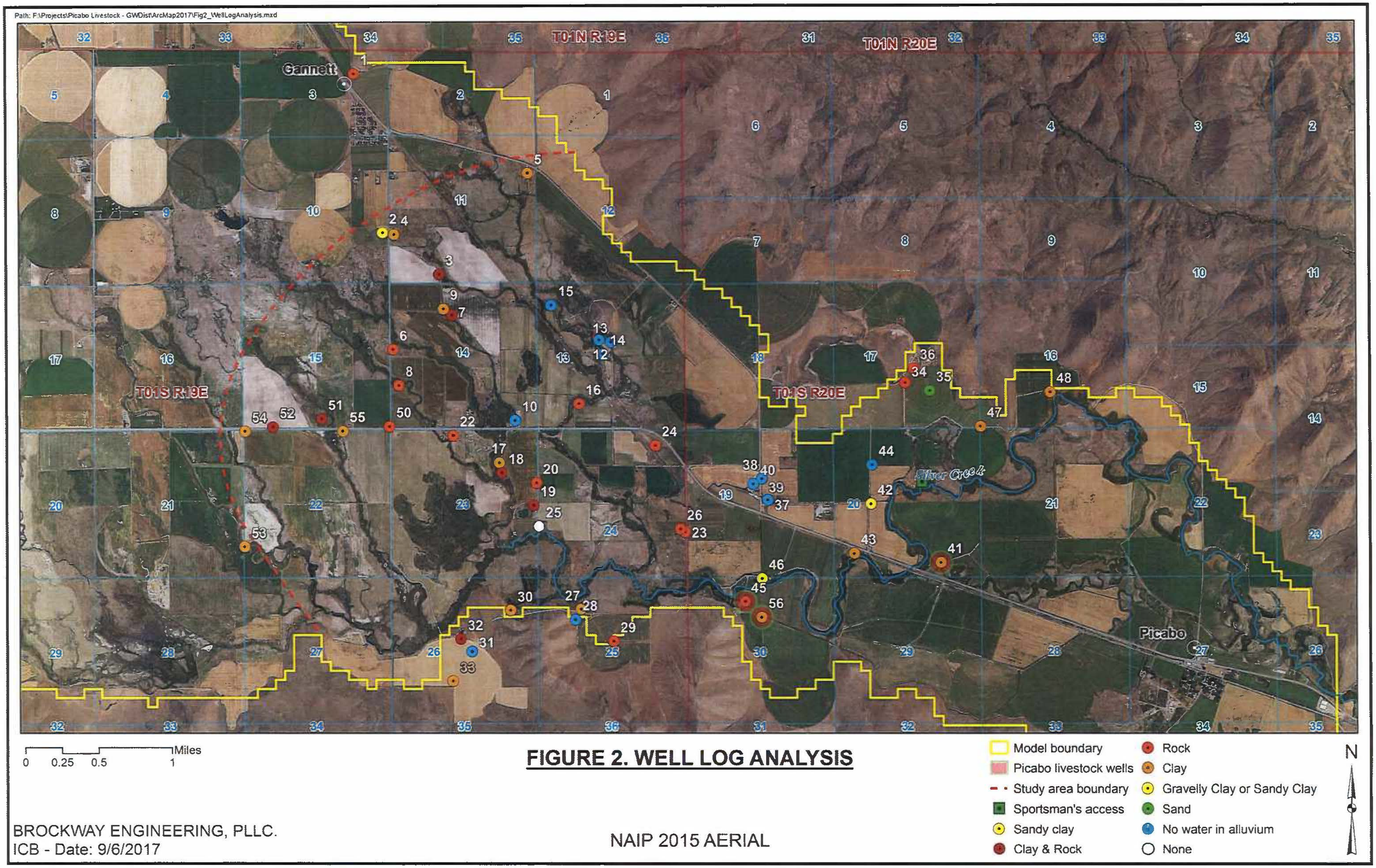


FIGURE 2. WELL LOG ANALYSIS

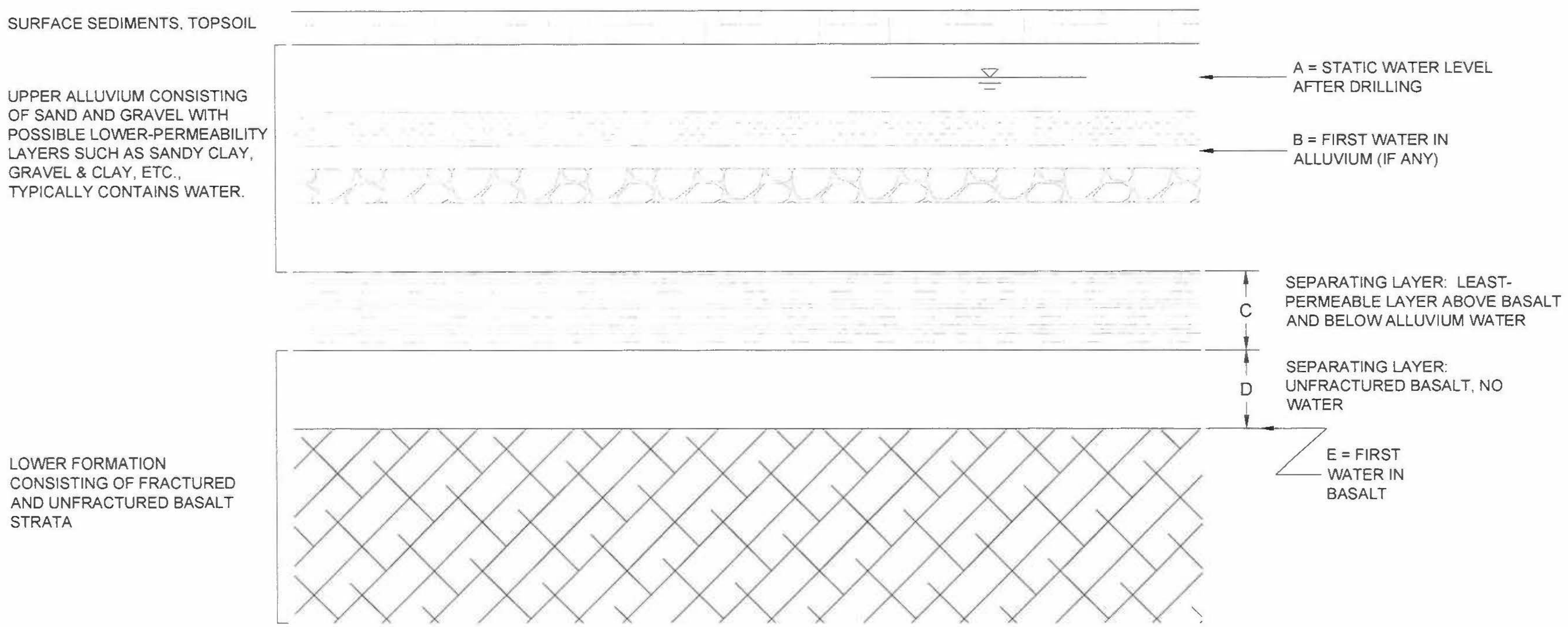


Figure 3. Generalized lithology in the study area, showing upper unconfined alluvial system and lower basalt system, with separating layers consisting of fine-grained sediments (typically clay or sandy clay), and/or dense, unfractured basalt. Labels "A" through "E" correspond to well information in Appendix A. Total thickness of separating layer is equal to C + D.

Figure 4. Model-Simulated Response of Picabo Livestock Groundwater Use on reach gain in the Silver Creek abv Sportsman's Access Reach