



COLORADO
Oil & Gas Conservation
Commission
Department of Natural Resources

1120 Lincoln Street, Suite 801
Denver, CO 80203

Document #
2618738

November 29, 2017

Mr. Andrew M. Ross
Senior Water Quality Scientist
Colorado Department of Public Health and Environment
Water Quality Control Division - Watershed Section
WQCD-WS-B2
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

Regarding: Aquifer Exemption Request: D-Sandstone
Foundation Energy Management LLC
UIC Facility Name: Greasewood North
Well Name: Behring #23-7 (API: 05-123-21830)
Weld County, Colorado
SWNE Section 23, Township 6 North, Range 61 West, 6th Prime Meridian

Dear Mr. Ross,

This letter is a request to get Colorado Department of Public Health and Environment's concurrence for approval of an aquifer exemption for the D-Sand in the area of the Foundation Energy Management LLC Behring 23-7 well in Weld County, Colorado.

Foundation Energy Management LLC ("Foundation") received Colorado Oil and Gas Conservation Commission ("COGCC") approval for an enhanced recovery unit, the "Greasewood Unit", in Weld County, Colorado (see map Enclosure #1). Foundation has since filed an application for an Enhanced Recovery Underground Injection Control ("UIC") Facility called "Greasewood North". The Greasewood North application has one well, the Behring 23-7. The Behring 23-7 well is being converted from a Cretaceous D-Sand production well to a D-Sand injection well. Injection perforations are proposed from 6712 to 6730 feet ("ft") below the surface in this vertical well. Produced water from the D-Sand in this area has a Total Dissolved Solids ("TDS") concentration of 5,400 ppm*. Because the TDS concentration is less than 10,000 ppm the D-Sand as an injection zone needs an Aquifer Exemption.

Foundation filled out the EPA Aquifer Exemption Evaluation with supplemental information that is enclosed here (Enclosure #2). This is one of the better attempts to fill out the Evaluation that I have received. I added comments and explanations that I felt would help. The Evaluation was sent to the EPA on October 31, 2017. A public notice of aquifer exemption was published in the Greeley Tribune on November 5, 2017. To date COGCC has not received any comments regarding the proposed exemption. The EPA has stated that they

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Mr. Andrew M. Ross

November 29, 2017

Page 2

are waiting 45 days for the public comment period to expire on or about December 19, 2017 before issuing the aquifer exemption.

The D-Sand qualifies as an exempt aquifer because:

The D-Sand in this area does not currently serve as an aquifer. In general water wells in the area TD at about 300 ft and water is sourced from alluvium. Surface Casing in the Behring 23-7 was set at 307 ft and cemented to surface. There is one water well that TD's at 232 ft one half mile east of the area to be exempted (Enclosure #1). Another water well a quarter mile to the west was permitted to 300 ft in 2014 but Division of Water Resources records do not contain evidence of construction. The lack of population in this area, Wiggins is 17 miles south, Kersey 21 miles west, and Raymer 19.5 miles north east, suggests that the alluvial water is sufficient for current and foreseeable future needs in the Behring 23-7 area.

As shown in COGCC production reports the Behring 23-7 was a D-Sand production well between May 2004 and May 2015 (see Page 6 of Enclosure #2.) . Therefore it is contaminated by hydrocarbons.

Water from the D-Sand is too deep and contaminated to make a practical and economic source of water. The operator estimates that a comparable water well drilled to 7000 ft in this area would cost about \$750,000 and that a pipeline to Wiggins for example would cost about \$875,000. These costs, the cost to pump water from the well, and the cost of treatment to remove residual salts (i.e. lower TDS) and hydrocarbons and availability of cheaper-cleaner alluvial water make it unlikely that the D-Sand in this area would be used for drinking water.

Note that the area of the proposed aquifer exemption extends beyond the area of the enhanced recovery Greasewood Unit (Enclosure #1). The Aquifer Exemption for the Greasewood North UIC Facility is based on a quarter mile circle around the Behring 23-7. This circle intersects 2 additional quarter/quarter sections that were not included in the Greasewood Unit.

Please review the enclosed Evaluation form and associated documents let COGCC know whether CDPHE concurs with granting an aquifer exemption around the Behring 23-7 well as indicated. To date COGCC has not received any protests base on the published notice for the proposed aquifer exemption. Unless a protest is received the U.S. Environmental Protection Agency appears ready to grant the exemption.

Thank you for your attention and please feel free to contact me if you have any questions.

Sincerely,

Robert P. (Bob) Koehler
UIC Lead - Geology Advisor

Telephone: 303-894-2100 x5147

Email: Bob.Koehler@state.co.us

*COGCC used the individual cation and anion concentrations found on the enclosed lab analyses sheets to check TDS values. This check was performed because the TDS results derived from specific gravity, 1.004 (dimensionless), on both sheets gave the same TDS values, 5400 ppm, despite significantly different anion and cation concentrations. Using cation and anion concentrations TDS was found to range between 7158 and 7515 ppm.

Enclosures:

1. Over all map of the "Greasewood Unit"-Production and "Greasewood North" UIC-ER Facility
2. USEPA Aquifer Exemption Evaluation Form filled out by Foundation Energy Management with comments by COGCC. Includes Map, TDS analysis sheets, Answers to questions by Foundation (red font), and COGCC comments (blue font).

Map showing the Greasewood Field Unit and surrounding areas. The map includes a north arrow and a scale bar (1" = 1200 Feet).

Requested Area for Aquifer Exemption Boundary of Greasewood North UIC-ER Facility

Greasewood Field Unit Boundary-COGCC

Greasewood Unit

23-6N-61W Weld County, CO. Behring 23-7 API: 123-21830

Well locations and names:

- FOSTER 14-2
- BABB 14-2
- TAYLOR 15-2
- FOSTER 14-3
- TAYLOR 15-1
- FRANK 14-14
- BABB 14-14
- BABB 14-1
- BABB 15-4
- JOHNSON-JUHL 1
- JSD 1
- BRIGGS 2
- GREASEWOOD SOUTH UNIT 1
- NILES-EIS
- KETTL 22-1
- KETTL 22-2
- KETTL 4-23
- KETTL 23-3
- BEHRING 2-23
- DOC KETTL 23-6
- BEHRING 23-7
- BEHRING 23-10
- BEHRING 23-15
- FURROW 23-16
- ESTHER 13-24
- GADBOIS 1
- GREASEWOOD SOUTH UNIT 3
- PATTERSON 1
- GREASEWOOD SOUTH UNIT 2
- SCHETTLER 12-24
- FURROW SCHETTLER 14-24
- GREASEWOOD SOUTH UNIT 1

Proposed horizontal wellbores with approved drilling permits, bottomholes to south, target Niobrara.

Water Well permitted but never completed.

Permitted to 300', drilled? Alluvial Sands

Drilled to 232' Alluvial Sands

1/4-Mile

Aquifer Exemption Evaluation

Regulatory Agency: Colorado Oil and Gas Conservation Commission (COGCC) 1425 Program

Date of Aquifer Exemption Request: 10/31/2017

Substantial or Non-Substantial Program Revision: Non-Substantial

Basis for Substantial or Non-Substantial Determination: This AE request is considered non-substantial, consistent with EPA Guidance 34.

Operator: Foundation Energy Management

Well Class/Type: Class II SWD Well

Well/Project Name: Behring 23-7 (Greasewood North Unit)

Well/Project Permit Number: N/A

Well API number: 05-123-21830

Field: Greasewood North Unit

Tribal Reservation: NA

Well/Project Location: Qtr: SW NE Section: 23 Township: 6N Range: 61W

Footage Call: 1980 feet from (N) line 1980 feet from (E) line

County: Weld **State:** CO

Latitude: 40.47566 **Longitude:** -104.17332 (decimal degree, 5-decimals)

DESCRIPTION OF PROPOSED AQUIFER EXEMPTION (depths are approximate values at the well bore)

Aquifer to be Exempted: D Sand **Top:** 6,709 feet **Bottom:** 6,722 feet

Lithology: Sandstone

Water Quality – TDS (mg/L): 5,400 ppm **Source of WQ Data:** 2014 Basic Energy water analysis in lab from Babb 14-14 (API: 123-22254, 0.5 miles NW) and Behring 23-7 itself.

COGCC COMMENT: Values for both wells using specific gravity are 5,400 ppm (see pages 13-14). COGCC used web based calculator (“LennTech”) to get 7100-7500 ppm from analyzed anion and cation concentrations.

Areal Extent and Description of Exempted Aquifer (i.e. radial distance, encompassed TSR)

Total Area of Aquifer to be Exempted: 440 Acres

COGCC COMMENT: See enclosed map (page 15): “Foundation: "Greasewood Unit"-Production and "Greasewood North" UIC-ER Facility Aquifer Exemption Boundary”. The 440 acres cited refers to the Greasewood Field Unit a production unit approved by COGCC. The area required for the aquifer exemption is 2 quarter/quarter sections (80 acres) larger, a total of 520 acres than the production unit. A circle with a quarter mile radius centered on the Behring #23-7 well intersects 2 additional quarter/quarter sections not included in the Greasewood Field Unit. These quarter/quarters are the NE/4SW/4 and NE/4SE/4 of section 23. The UIC-ER Facility is to be called “Greasewood North”.

Description: QtrQtr Section, T S/N, R E/W

Township 6 North, Range 61 West, 6th P.M.

Section 14: SE/4SW/4, SW/4SE/4

Section 23: NW/4, NE/4, NW/4SE **COGCC adds NE/4SW/4 and NE/4SE/4**

Confining Zone(s):

Upper: Graneros Shale **Lithology:** Shale **Top:** 6,435 feet **Bottom:** 6,708 feet

Lower: Mowry Shale **Lithology:** Shale **Top:** 6,723 feet **Bottom:** 6,784 feet

BACKGROUND

USDW(s): none

Injectate Characteristics: Natural Gas (51% methane, 20% ethane, 16% propane, 5% N-Butane, 3% CO₂)
Produced D Sand water (TDS = 5,400 ppm)

BASIS FOR DECISION

Regulatory Criteria under which the exemption is requested

146.4: ☒ (a) Not currently used as a drinking water source and:

- How far from the AE boundary to review drinking water wells and how was this determined?

There is one well within ¼ mile radius of the Greasewood North unit boundary. This was determined by showing the water wells layer under the Water Resources (DWR) tab on the COGCC GIS map.

- Identify drinking water wells in area of review, their depths, and provide source of information.

Only one well within ¼ mile radius of AE was drilled to 300' and produces from alluvial sands. This was determined by clicking on the well on the GIS map and being directed to the Colorado Division of Water Resources (CDWR) and reading the log and history from for the water well.

- Identify any source water assessment and/or protection areas and designated sole source aquifers

None within 5 miles.

- Identify nearest public water supply (PWS).

The town of Wiggins, CO is 17.5 mi away.

- What is the distance of the nearest drinking water well utilizing the aquifer proposed for exemption. If so, is it in close enough proximity to require a capture zone analysis?

No D Sand drinking water wells. Only water well both wells within ½ mile of AE boundary are used for livestock and produced from shallow alluvial sands <300'. Surface casing on proposed injection well covers that depth.

- Provide map of AE boundary and location of drinking water wells.

See picture 1. **COGCC COMMENT: See COGCC map page 15.**

☒ (b)(1) It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or Class II operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible; or

- Projections on future use of the proposed aquifer.

Plan to inject previously produced D Sand natural gas and water into D Sand to re-pressurize the D Sand .for enhanced oil recovery. Water will not be injected into any other poorer-quality water zones outside the D Sand, because it would not help re-pressurize.

Hydrocarbon Production Data:

- Demonstrate historical production having occurred in the project area or field.

See figure 2 below. There are 3 hydrocarbon producing wells producing from the AE zone within the AE boundary. The cumulative production as of Oct 1st 2017 has totaled 280,000 bbl of oil and 1,302,000 mcf of gas.

- Demonstrate existence hydrocarbon (logs, core data, etc) and estimation of the quantity of the hydrocarbon potential.

Please see figure 3 below. Figure 3 shows the resistivity logs of the 3 producing wells within the AE boundary. The 3 producing wells from the AE zone have an average resistivity of 50 ohm-m indicating the presence of a resistive hydrocarbon, compared to conductive water would show a lower 10 ohm-m resistivity in this case.

Mineral Resources Available:

- A summary of logging which indicates that commercially producible quantities of minerals are present, a description of the mining method to be used, general information on the mineralogy and geochemistry of the mining zone, and a development timetable.

N/A

☐ (b)(2) It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical; or

- Projections on future use of the proposed aquifer.

Plan to inject previously produced D Sand natural gas and water into D Sand to re-pressurize the D Sand for enhanced oil recovery. Water will not be injected into any others poorer-quality water zones outside the D Sand, because it would not help re-pressurize.

- Current sources of water supply in the area of the proposed exempted aquifer.

All nearby fresh water wells are drilled to 150-300' depth and produce from alluvial sands. There are no drinking water wells that produce from the D Sand in the area.

- Availability, quantity and quality of alternative water supply source(s) to meet present and future needs.

There are no nearby cities or town to the proposed AE. The nearest town of Wiggins, CO is 17.5 mi away. Choosing this location for drinking water would be impractical due to the distance needed to get the water to the public.

- Population trends in the area and analysis of future water supply needs within the general area.

There are no nearby cities or town to the proposed AE. The nearest town of Wiggins, CO is 17.5 mi away. Choosing this location for drinking water would be impractical due to the distance needed to get the water to the public.

- Well construction and water transportation and/or treatment costs to develop aquifer proposed for exemption compared to costs to develop alternative resource(s).

To drill 7,000' and complete a new drinking water well in the D Sand would cost \$750,000. Constructing a water line costs roughly \$50,000/mile, therefore it would be another \$875,000 to lay a line from the proposed AE boundary to the nearest town.

To drill a 300' drinking water well in alluvial sands would cost only \$7,000 then another \$8,000 for a constant pressure pump system for a total of \$15,000. Alluvial sands are continuous throughout this area of Weld County and could be drilled closer to the nearest town.

☐ (b)(3) It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

- Projections on future use of the proposed aquifer.

Plan to inject previously produced D Sand natural gas and water into D Sand to re-pressurize the D Sand for enhanced oil recovery. Water is not wanted to be injected into any others poorer quality water zones outside the D Sand, because it would not help re-pressurize.

- Concentrations, types, and source of contaminants in the aquifer.

Total fluids pumped to surface within the AE boundary consists of (by volume) 51% oil, 43 % natural gas, and 6% water.

- If contamination is a result of a release, extent of contaminated area and whether contamination source has been abated.

There is no contamination source. The AE zone has a very low water saturation and therefore water only accounts for 6% off the total fluid production at the surface.

- Ability of treatment to remove contaminants from ground water.

At the surface, the water from the AE zone is in an emulsion with the oil. To break the emulsion, it requires heat and chemical. This adds roughly \$0.15/gal to treat the emulsion. **COGCC COMMENT: This statement refers to cleanup with respect to selling the hydrocarbons. It does not refer to cleanup to drinking water standards.**

- Current sources of water supply in the area of the proposed exempted aquifer.

There are no current sources of water supply in the area of the proposed exempted aquifer.

- Availability, quantity and quality of alternative water supply source(s) to meet present and future needs.

D Sand is not viable options for drinking water. It is a proven oil and gas formation throughout northeastern Colorado. Drinking water aquifers in the same area consist of shallow alluvial sands, Fox Hills, and Ogallala aquifer.

- Population trends in the area and analysis of future water supply needs within the general area.

N/A

- Well construction and water transportation and/or treatment costs to develop aquifer proposed for exemption compared to costs to develop alternative resource(s).

As mentioned above, it would require an initial investment of \$1.6 million to deliver water at a rate of .03 gal/min to the nearest public space, assuming the project of drilling and laying a line from the proposed AE boundary. Compared to drilling a 300' well into alluvial sands closer to the demand of water and spending \$25,000 to drill, install a pump, and lay a line and delivering 5 gal/min of water.

COGCC COMMENT: These figures do not include the cost to treat D-Sand water to drinking standards. Cleanup to drinking water would require removal of TDS and residual hydrocarbons.

☒ (c) TDS is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

- Projections on future use of the proposed aquifer.

Plan to inject previously produced D Sand natural gas and water into D Sand to re-pressurize the D Sand for enhanced oil recovery. Water will not be injected into any others poorer quality water zones outside the D Sand, because it would not help re-pressurize.

- Include information about the quality and availability of water from the aquifer proposed for exemption.

The water produced from the proposed AE zone has TDS of 5,400 ppm. At the surface it is an emulsion with the produced crude oil, which requires heat and chemical to separate the water from the oil. The current AE zone has the ability to deliver water at .03 gal/min.

- Analysis of the potential for public water supply use of the aquifer. This may include: a description of current sources of public water supply in the area, a discussion of the adequacy of current water supply sources to supply future needs, population projections, economy, future technology, and a discussion of other available water supply sources within the area.

The majority of the water in the area is produced from shallow alluvial sands for the purpose of watering livestock and domestic use. Permitting of these water wells allow for 3-15 gal/min to be extracted. Far higher capabilities than proposed AE zone. The alluvial sands are continuous in the area, meaning spacing and development for future wells would not be an issue.

Describe what assurance exist to confine fluids within the AE boundary:

- Discuss injection rate or volume limitation

The fracture gradient of the AE zone is .65 psi/ft, therefore injection rate will be limited by the surface injection pressure, as to not exceed the fracture pressure of the AE zone and risk propagating fractures into anything outside the AE zone. When injecting natural gas (400 psi), the max allowable surface pressure will be 5,000 psi since natural gas has a hydrostatic pressure of .0125 psi/ft. When injecting water, the max allowable surface pressure will be 2,040 psi since water has a hydrostatic pressure gradient of .433 psi/ft.

- Discuss existence and quality of confining zone(s). (Is the confining zone continuous, are there known fractures?)

The D-Sand Unit is overlain by the Graneros Shale and underlain by the Mowry Shale. Both shale intervals are known to be laterally continuous and confining with respect to the D-Sand. There are no known fractures in the area. COGCC COMMENT: The Greasewood Field would not be present if the Graneros and Mowry Shales did not provide adequate seals.

Public Comment

Public Comment Conducted? ☐ Yes ☒ No

Results of Public Comment Process:

N/A

Checklist of Questions to Consider

- ☐ Are there deeper aquifers with poorer quality water that can be used for injection (disposal wells)?
- ☐ Proximity to other jurisdictional boundaries?
- ☐ Is seismicity a concern in the area?
- ☐ Will injection of fluids cause any original formation fluid or injectate to migrate to any known USDW?
- ☐ Are all wells within the AE boundary and AOR properly cemented to prevent preferential flow paths?

Provide other considerations to support aquifer exemption approval:

FIGURE 1

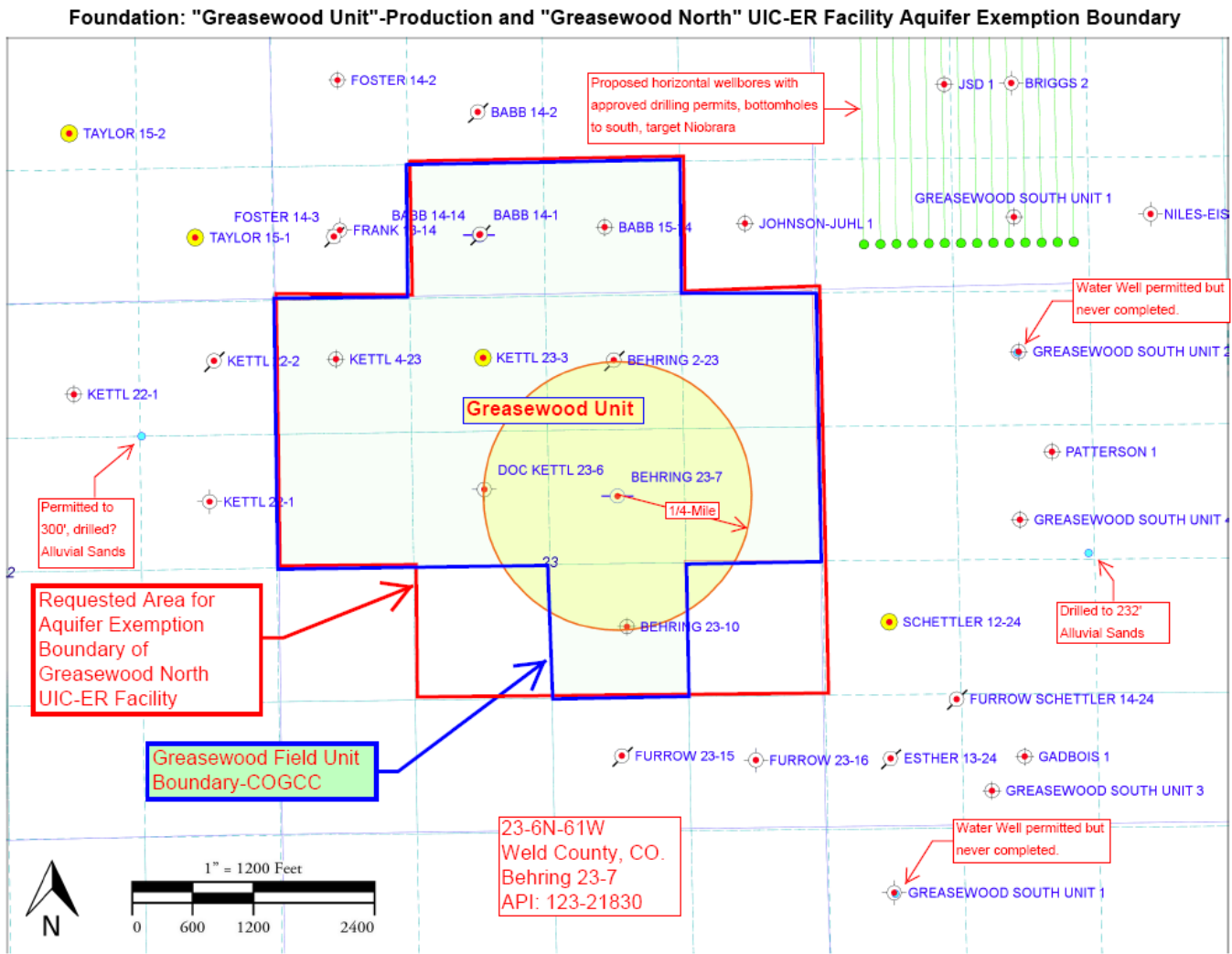
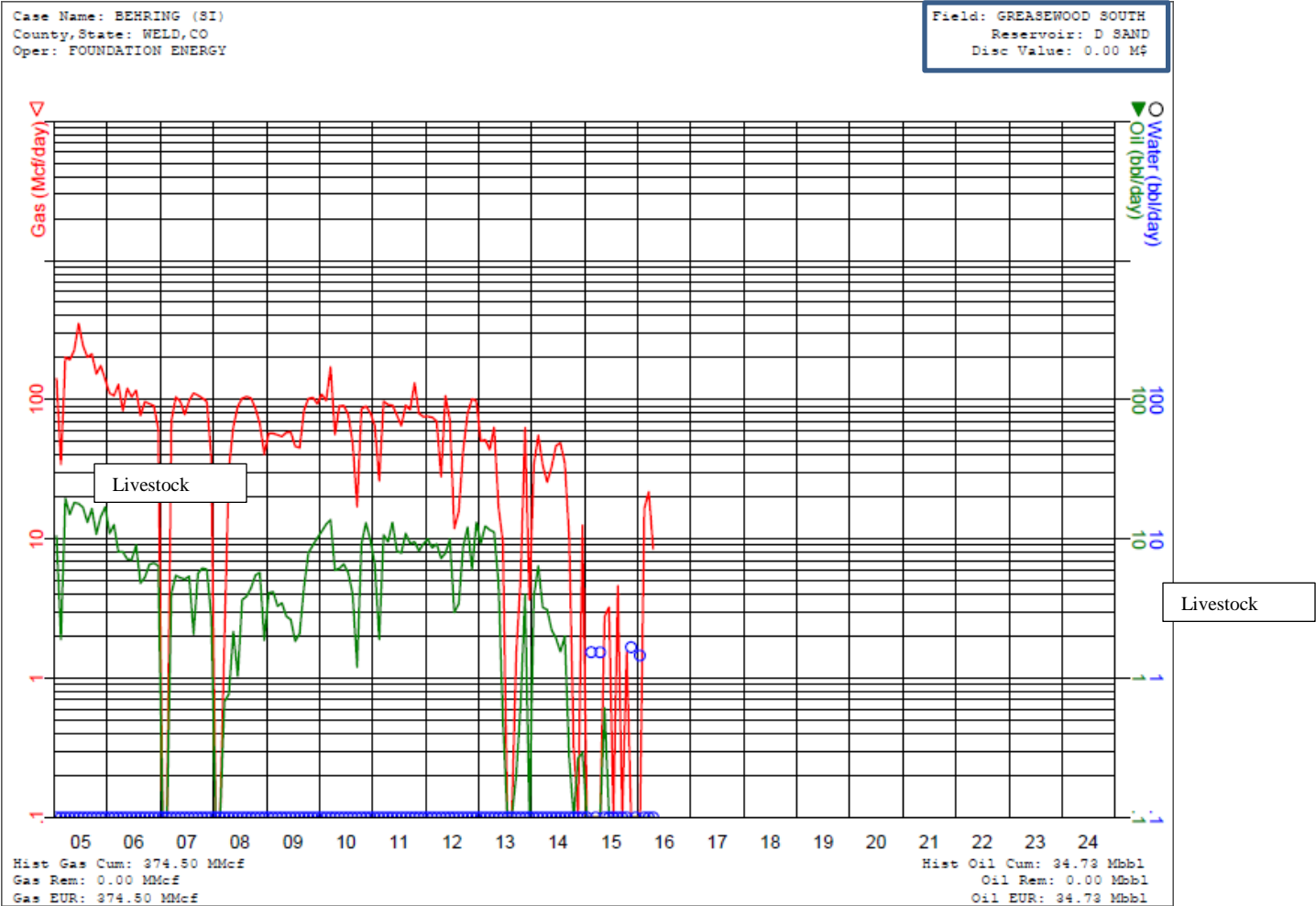


FIGURE 2

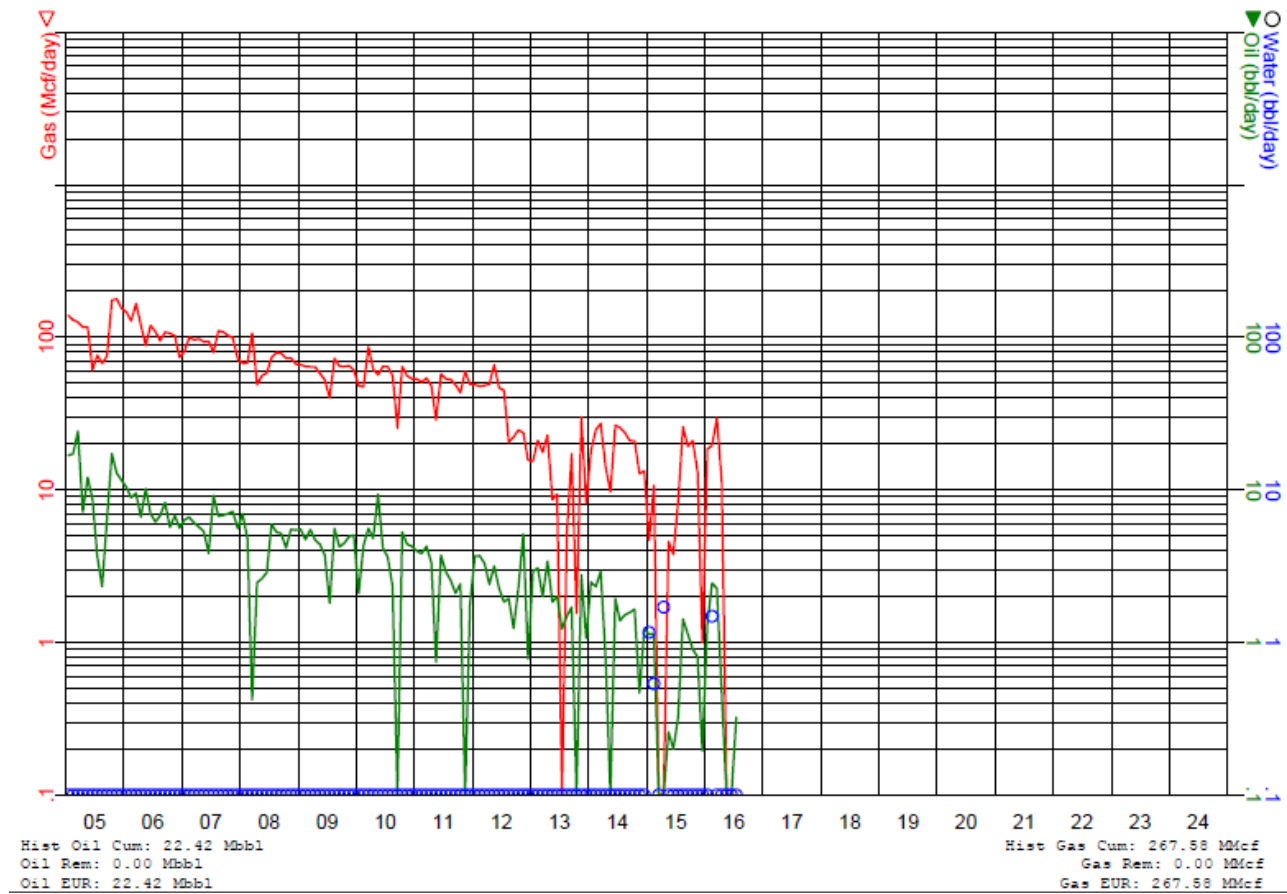
Behring 23-7 – Cumulative production = 35,000 bbl of oil / 374,000 mcf of natural gas



Babb 14-14 – Cumulative production = 22,000 bbl of oil / 267,000 mcf of natural gas

Case Name: BABB 14-14 (SI)
County, State: WELD, CO
Oper: FOUNDATION ENERGY

Field: GREASEWOOD
Reservoir: D SAND
Disc Value: 0.00 M\$



Kettl 23-3 – Cumulative production = 223,000 bbl of oil / 661,000 mcf of natural gas

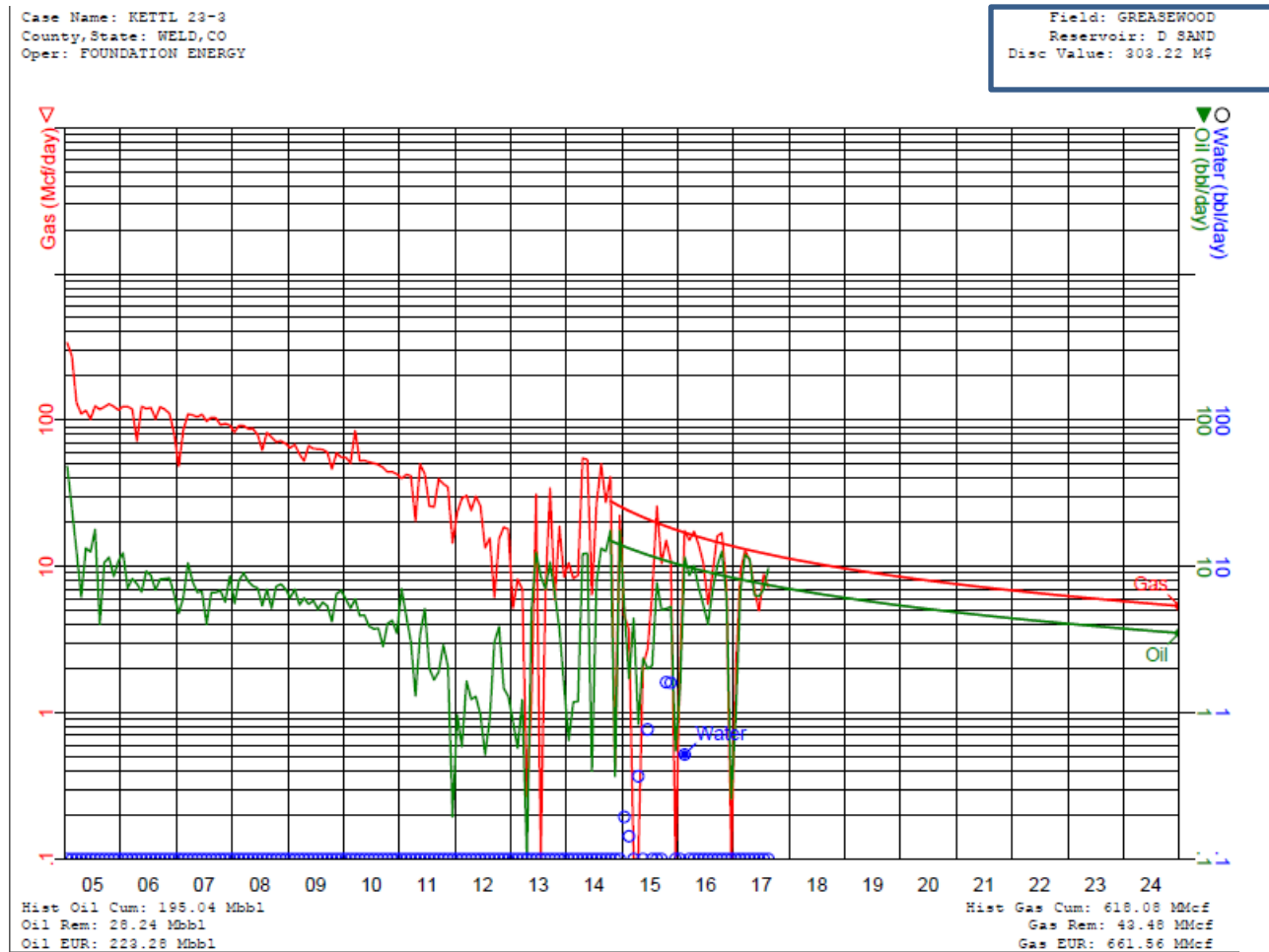
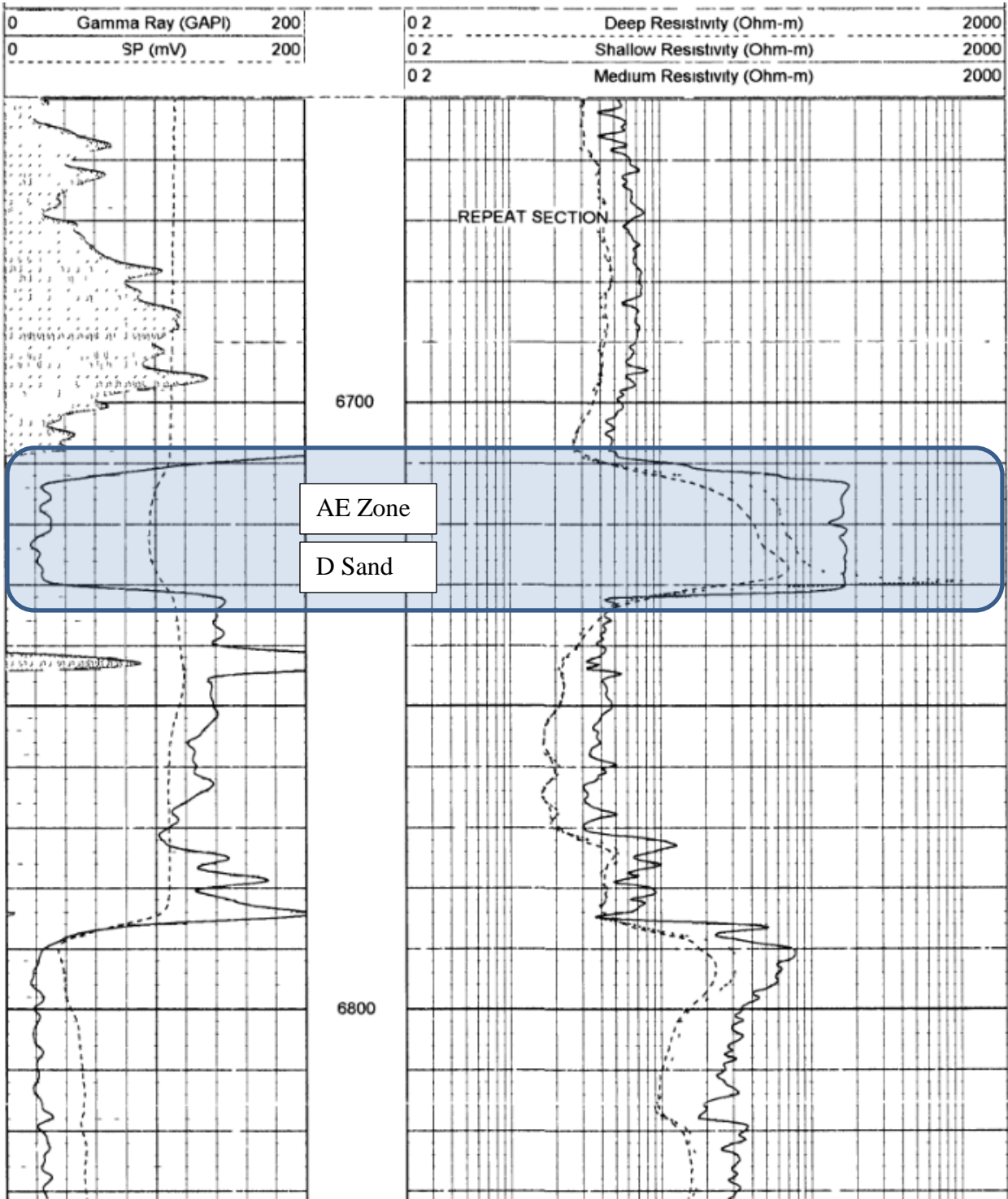
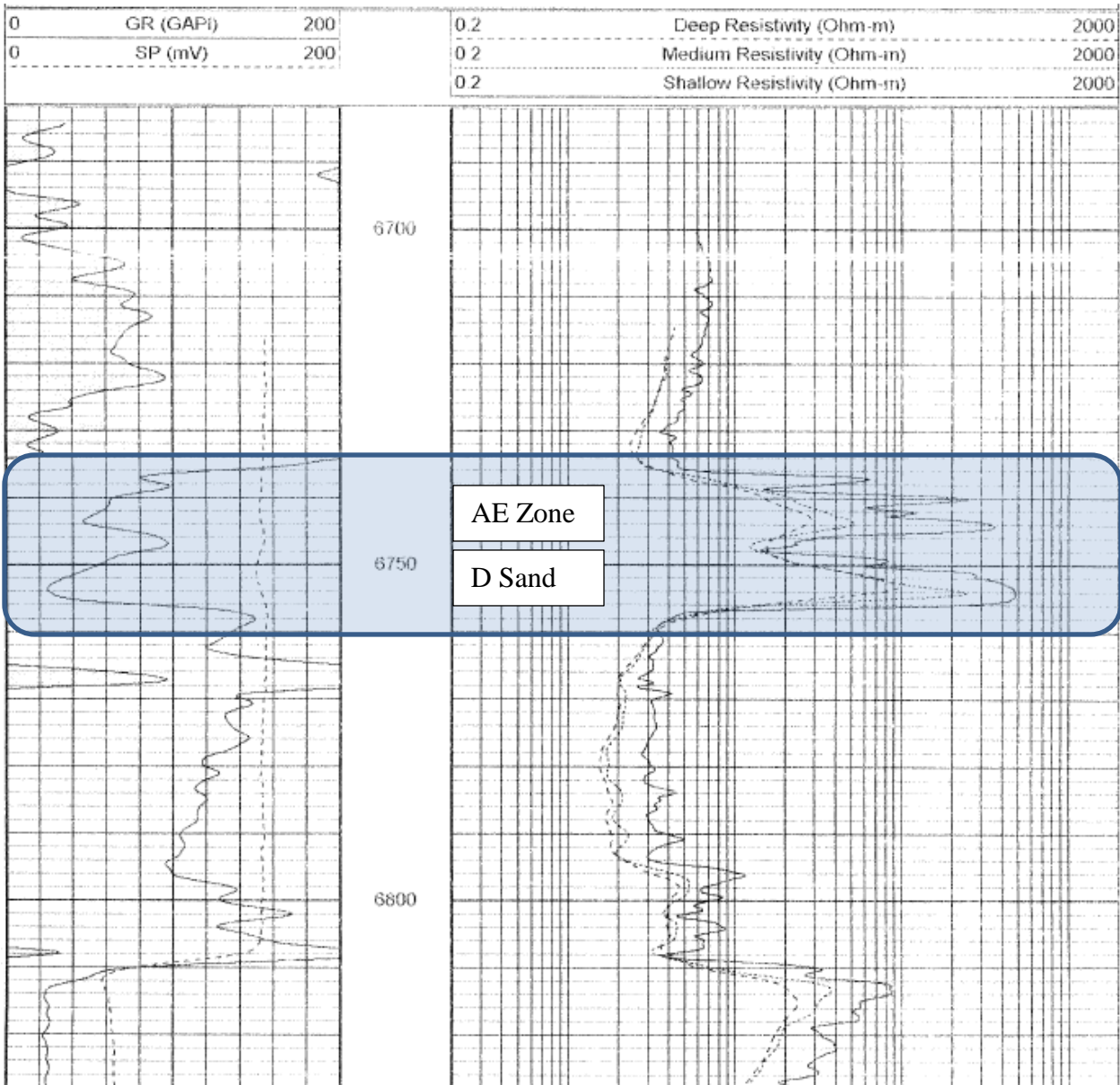


FIGURE 3

Behring 23-7 – Resistivity Log – Resistivity of 60 ohm-m indicates hydrocarbon bearing zone





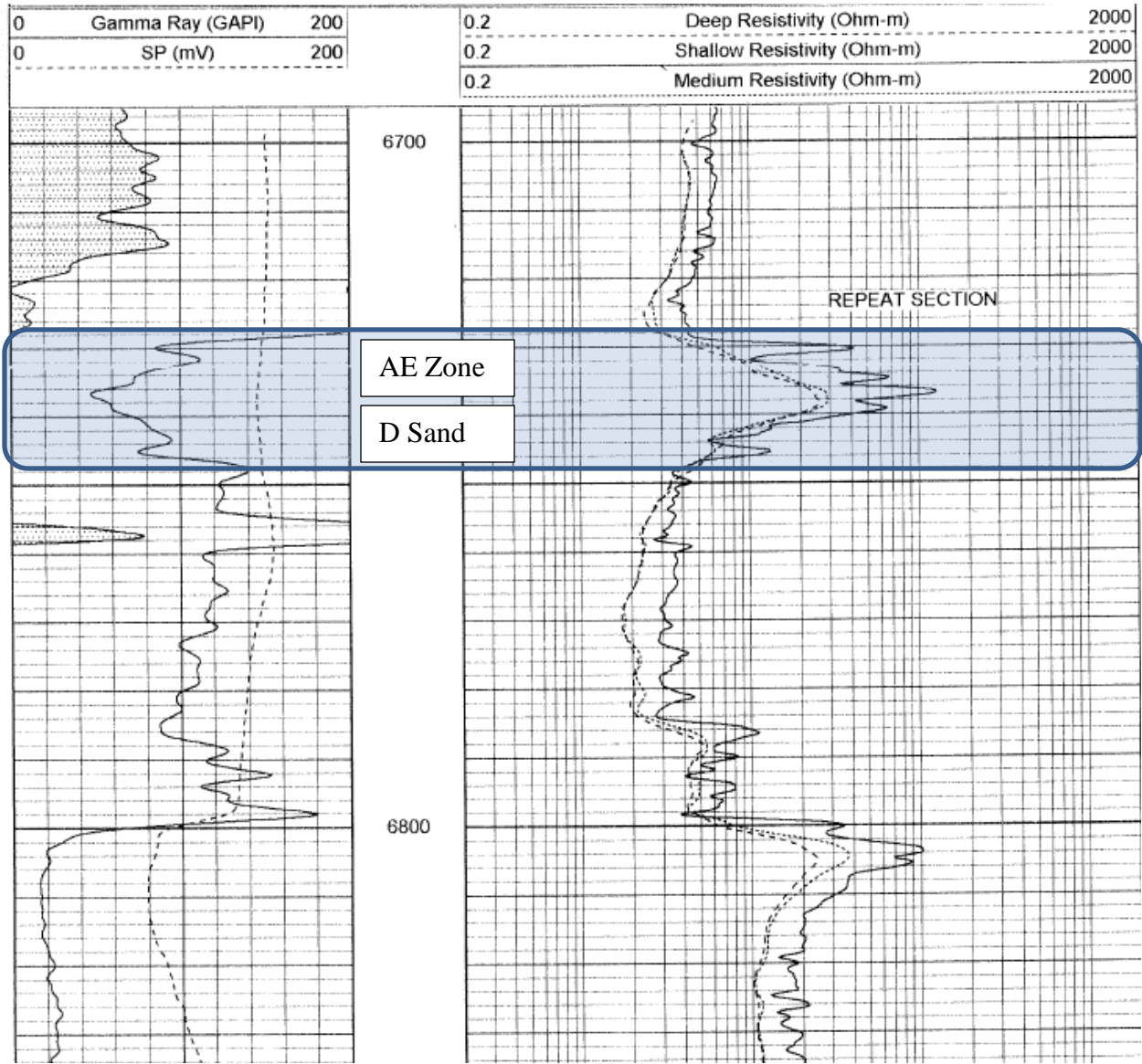




Figure 4

Water analysis – Babb 14-14 – TDS 5,400 ppm

| | | | |
|--|-------------------|---|-------------|
|  | | Using web based TDS and Electrical Conductivity calculator by LennTech result is 7158 ppm. BK – COGCC – 10/31/2017 | |
| <small>P.O. BOX 219 - 12701 ENERGY ROAD - FORT MORGAN CO. 80701 - PH (970) 867-2766 - FAX (970) 867-2766</small> | | | |
| WATER ANALYSIS | | | |
| COMPANY: | FOUNDATION ENERGY | LEASE: | BABB 14-14 |
| | | | |
| FAX: | | DATE: | 6/24/2014 |
| E-MAIL: | | | |
| | | SAMPLE NUMBER: | WS06241407 |
| <u>DISSOLVED SOLIDS:</u> | | <u>WELL DATA</u> | |
| <u>CATIONS:</u> | | Depth: _____ ft | |
| Sodium, Na (Calc) ppm: | 2,411 | Formation: | |
| Calcium, Ca, ppm: | 103 | Water BPD: | |
| Magnesium, Mg, ppm: | 102 | | |
| <u>ANIONS</u> | | <u>OTHER PROPERTIES</u> | |
| Chlorides, Cl ppm: | 3,700 | pH: | 7.0 |
| Sulfates, SO ₄ , ppm: | 49 | Specific Gravity: | 1.004 66 °F |
| Bicarbonates, HCO ₃ ppm: | 793 | Resisivity (Meter) ohm*M: | 1.2 66 °F |
| Carbonates, CO ₃ ppm: | | Total Hardness, ppm: | 205 |
| Total Dissolved Solids (Calculated) ppm: | | | |
| Derived from Specific Gravity, ppm: | 5,400 | | |
| Iron, Fe (Total) ppm: | 0 | | |
| Sulfide, as H ₂ S ppm: | 0 | | |
| <u>REMARKS AND RECOMMENDATIONS:</u> | | | |
| | | | |

| | | | |
|--|-------------------|---|--------------|
|  | | Using web based TDS and Electrical Conductivity calculator by LennTech result is 7514 ppm. BK – COGCC – 10/31/2017 | |
| <small>P.O. BOX 219 - 12701 ENERGY ROAD - FORT MORGAN CO. 80701 - PH (970) 867-2766 - FAX (970) 867-2766</small> | | | |
| WATER ANALYSIS | | | |
| COMPANY: | FOUNDATION ENERGY | LEASE: | BEHRING 23-7 |
| | | | |
| FAX: | | DATE: | 6/23/2014 |
| E-MAIL: | | | |
| | | SAMPLE NUMBER: | WS06231408 |
| <u>DISSOLVED SOLIDS:</u> | | <u>WELL DATA</u> | |
| <u>CATIONS:</u> | | Depth: _____ ft | |
| Sodium, Na (Calc) ppm: | 1,348 | Formation: | |
| Calcium, Ca, ppm: | 818 | Water BPD: | |
| Magnesium, Mg, ppm: | 204 | | |
| <u>ANIONS</u> | | <u>OTHER PROPERTIES</u> | |
| Chlorides, Cl ppm: | 3,000 | pH: | 6.5 |
| Sulfates, SO ₄ , ppm: | 125 | Specific Gravity: | 1.004 68 °F |
| Bicarbonates, HCO ₃ ppm: | 1,769 | Resisivity (Meter) ohm*M: | 1.3 68 °F |
| Carbonates, CO ₃ ppm: | | Total Hardness, ppm: | 1022 |
| Total Dissolved Solids (Calculated) ppm: | | | |
| Derived from Specific Gravity, ppm: | 5,400 | | |
| Iron, Fe (Total) ppm: | 250 | | |
| Sulfide, as H ₂ S ppm: | 0 | | |
| <u>REMARKS AND RECOMMENDATIONS:</u> | | | |
| | | | |