FREEPORT-McMoRAN OIL & GAS

April 28, 2016

Mrs. Pat Abel
District Deputy, Coastal District
California Division of Oil, Gas, & Geothermal Resources
195 S. Broadway, Suite 101
Orcutt, CA 93455-4655

RE: Arroyo Grande Aquifer Exemption Boundary Update – USEPA Supplemental Data Request

Dear Mrs. Abel:

Freeport-McMoRan Oil & Gas (FM O&G) has reviewed the supplemental data request submitted to DOGGR dated April 19, 2016. Pursuant to the questions posed in the letter, FM O&G has contracted with an outside consultant to conduct a water capture analysis of the groundwater supply wells situated in closest proximity to the proposed modified exemption boundary. The results of the analysis and supporting material are enclosed with this letter for your review and validate that the entirety of the area proposed for exemption does not currently provide a source of drinking water.

The analysis also involved a field level survey to verify information submitted by the Center for Biological Diversity (CBD) asserting the presence of groundwater supply wells that were not identified in the initial application materials. As evidenced by the results of the on the ground work of the independent consultants, CBD's submittal to the EPA included a number of factual errors, including mistakenly identifying agricultural frost prevention units as groundwater supply wells.

FM O&G has also reviewed the EPA's supplemental questions related to the application's demonstration of hydraulic isolation. While it should be noted that the federal criteria for making aquifer exemption related determinations do not require an aquifer to be fully contained or isolated, we believe the fact that such geologic features exist at the Arroyo Grande Oil Field (AGOF) is relevant for the record, and strengthen the evidence submitted relative to the core determination criteria.

Hydraulic Isolation

Q1a. Provide additional information demonstrating how the fault acts as a barrier to fluid migration.

A1a. Data contained in a 2008 groundwater study conducted by Cleath-Harris Geologists Inc. (CHG) for PXP covering the Price Canyon Unit property contains additional evidence that the fault acts as a barrier to fluid migration. The reported is titled, "Groundwater Resources Study For PXP, Arroyo Grande Oilfield, December 2008 By Cleath-Harris Geologist Inc."

A relevant excerpt from the base flow survey conducted by CHG follows below and is further bolstered by Figure 1:

"Pismo Creek is gaining stream between the railroad crossing Price Canyon Road and station 8. The contributions to stream flow are interpreted to come from surfacing ground water. Most of the increase in base flow occurs between Station 4 and Station 6. Station 6 is where the Indian Knob fault is inferred to cross beneath the alluvial deposits. The fault is likely a ground water barrier, where ground water flow backs up and pressure builds, forcing flow up into overlying alluvial deposits, which drain into Pismo Creek. At station 8, all underflow surfaces as stream flow. Station 8 is at the upstream end of the oilfield."

"The salinity of Pismo Creek increases without an apparent increase in surface flow downstream of Station 8..."

The Station 8 reference above is located in the Arroyo Grande Fault Zone (AGFZ). The CHG base flow survey demonstrates quantitatively that the Arroyo Grande Fault Zone is the final barrier to fluid flow in Price Canyon north of the AGOF. The AGFZ is not unique as a barrier to fluid flow in Price Canyon as the Indian Knob and the Enda Faults are also barriers to fluid flow as described in the CHG survey. In addition, the base flow survey noted an increase in salinity in samples measured in the AGOF south of Station 8 in the AGFZ. The CHG base flow survey is completely consistent with the evidence presented in the aquifer exemption proposal including:

1. The AGFZ main fault and fault splays are identified as liniments on aerial photos and by offset formations in the subsurface as evidenced by well log data.
2. Fault gouge identified on the Silva 1 well mudlog in the fault zone is solid evidence of a fault sealing mechanism in the AGFZ
3. High oil saturation values from core samples south of the AGFZ in the AGOF versus very low oil saturations north of the AGFZ. If oil could migrate north across the AGFZ then there would be high oil saturations north of the AGFZ and there are not.
4. Eight uneconomic wells drilled over a wide area of Price Canyon north of the AGFZ versus hundreds of economic wells drilled in the AGOF south of the AGFZ demonstrating that oil has not migrated across the AGFZ.
5. Multiple drinking water well completions in Pismo Fm. sands north of the AGFZ at higher elevations than the AGOF. If the AGFZ was not a barrier to fluid flow then oil would have migrated across the fault zone to the highest elevation making the existing drinking water wells an impossibility.

The five lines of evidence from the aquifer exemption proposal combined with the flow and salinity measurement data from the CHG base flow survey clearly and consistently demonstrate that the AGFZ is a barrier to fluid flow.

Q1b. Provide additional information as to how the facies change acts as a barrier to fluid migration.

A1b. Data about the SW area between the west ends of cross-sections E to the south and B to the north can be derived from previously conducted drill striplogs (lithology from drill cuttings) and a wireline electric log. The data from these records can be correlated to identify the basic formations in the area including the Pismo Formation Edna and Miguelito Members and the Monterey Formation with wells in the area with much more data like well Guidetti A 4 at the west end of cross-section B-B'. The area where these wells are located is considered part of the Indian

Knob area which was an uneconomic heavy oil drilling area in the past and contains no drinking water wells. The well data indicates similar formation relationships to the Guidetti A 4 well with Edna Member sands from near surface to a depth of around 600' MD underlain by the Miguelito siltstones and claystones that is underlain by the Monterey Formation. The Edna Member sands in this area are water sands containing tar. This area is west of the black dashed line on the proposed aquifer exemption map which is the approximate boundary where there is no mobile oil, only immobile tar that fills the pore space of the Edna Member sands. It is the tar that blocks migration of mobile oil further up structure out of the syncline forming a tar seal.

The facies change on the southern end of the AGOF is the transition from Edna Member sands to the north to Miguelito Member basin ward siltstone and claystones to the south. The reason this transition from sand to siltstone and claystone forms an effective seal is due to the change in permeability. The Edna Member sands typically have permeability in the range of several hundred millidarcys to well over a darcy. The Miguelito Member siltstone and claystone have permeability of less than 10 millidarcys. This data comes from lab measurements of permeability on core samples taken at the time wells were drilled in the area of the facies transition. In addition, the siltstone and claystone don't have significant oil saturations further showing they provide a seal to oil migration out of the AGOF.

Q1c. Provide additional information as to how the presence of tar seals act as a barrier to fluid migration.

A1c. Oilfields defined by tar seals like the AGOF are well known around the world. Within California there are a number of oilfields which have tar seals as prominent geologic features including: San Ardo, King City, Santa Paula, Los Angeles City, McKittrick, South Belridge and Coalinga. In specific regards to the AGOF a 1980 report by DOGGR found that "the Edna [includes the AGOF] deposit of San Luis Obispo County is probably the largest surface occurrence of tar sand in California." (DOGGR, Unconventional Petroleum Resources, by Fred O. Hallmark, Pub. No. TR25, 1980).

The original saline formation waters in the marine sediments of the Pismo Formation at the AGOF have largely been replaced by sub-3000 ppm TDS waters as is evidenced by numerous water samples taken from around the oilfield at various depths. The transition to lower TDS formation waters occurred as the Pismo Formation sands were uplifted and exposed to meteoric water. Contact between the hydrocarbons already in place in the Pismo Formation and the meteoric waters resulted in contamination of the oil reservoir by anaerobic bacteria, which biodegraded the once light-oil hydrocarbons into heavy-oil and/or bitumen (tar, asphalt). The hydrocarbons at the surface, or in contact with groundwater in the subsurface, would have been the most biodegraded and, accordingly, formed bitumen with API gravities typically less than 10 degrees and viscosities greater than 10,000 cp to over 100,000 cp at ambient temperatures (Figure 2). Bitumen owes its density and viscosity to its chemical composition—mainly large hydrocarbon molecules known as asphaltenes and resins, which are present in lighter oils but are highly concentrated in bitumen. In addition, bitumen frequently has a high content of metals, such as nickel and vanadium, and nonmetallic inorganic elements, such as nitrogen, oxygen, and sulfur.

The interior of the reservoir, being insulated from such degradation, contains primarily heavy oil with a consistency of approximately 13 degrees API gravity and a viscosity in the range of 2500 – 3500 cp. Thus, it is the immobile bitumen, with very high viscosity and very low mobility at ambient conditions that blocks liquids fluid flow into (and/or out of) the otherwise porous Pismo Formation sands (Dollie Sands), and that forms the seal (tar seal) surrounding the heavy oil reservoir. This geologic description is validated by the mudlog for well Guidetti A 4, which is located at the west end of cross-section B-B' from the aquifer exemption proposal. The mudlog shows multiple occurrences of tar in the subsurface (Figure 3).

While the graphic diagrams contained in the original application depict the seals as single lines for brevity, in reality the seals encompass wide areas and contain significant thickness around the perimeter. The effectiveness and integrity of the seals as containing features is enhanced by prudent operations at the limits of the field such as maintenance of low reservoir pressure, and site specific placement of temperature monitoring wells. To date, none of the monitoring wells that have been installed have recorded any increase in temperature above background levels. Robust background temperature monitoring will continue to be utilized going forward.

Q2. Provide additional information to address the hydraulic isolation of the Dollie Sands from surrounding aquifers.

A2. The six cross-sections (A – A' through E – E') that accompany the proposed aquifer exemption boundary (PAEB) map all show the Miguelito stratigraphically below the AGOF Edna Member (Dollie) sands throughout the area within the boundary. The low permeability Miguelito Member siltstones and claystones (< 10 md) form a consistent lower confining zone throughout the PAEB. However, some of the Edna Member (Dollie) sands continue latterly to the southeast into Oak Park Basin (OPB) as shown in PAEB cross-section E-E'. Of all the sands that cross in to the OPB only the M-12 basal Edna Member sand has ever been productive. The sands that extend into the Oak Park Basin are separated by a structural ridge between the AGOF and OPB (figures X & Y). The historically productive OPB wells are also separated by more than 2000' laterally from AGOF operations.

The upper confining zone at the AGOF is 250'. This is the minimum depth at which wells are completed down from surface. Above 250' are shallow tar sands that form the upper seal throughout the oil reservoir. Shallow tar sands at the AGOF have been recognized in the 1944 USGS "Oil and Gas Investigations Preliminary Map 16", the 1958 and 1989 DOGGR Gold Book cross-sections, in the many shallow core holes, numerous mud logs, strip logs and cores and outcrops.

Q3a. Provide additional technical information for selecting the spill point elevation.

A3a. A hydraulic analysis was conducted (Aug 2015) using the most conservative spill point elevation to determine if fluids would pass over the spill point and outside the Arroyo Grande syncline under operating conditions. It was determined that the injected fluids would remain below the spill point elevation and thus not move outside the syncline. Operations to date have continued to increase the offtake vs injection thus continuing to reduce reservoir pressure and provide additional margin for fluids not passing over the spill point.

The spill point elevation and location was based on available well data from a half dozen wells and mapped sands on the west side of the field. It was determined that the west side location provided the most conservative area of the field to establish a spill point elevation since other areas around the syncline are higher in elevation and water injection is confined to the west side. Utilizing cross sections in the western edge, a 275' spill point elevation was determined for the hydraulic analysis.

To date, the WESP and water plant have been in continuous operation since August 2015. Gas injection has further declined, water injection has remained approximately the same, steam injection has reduced, and produced fluids have increased. Therefore, the offtake vs injection volume has increased, which continues to effectively reduce the reservoir pressure. Continued reduction in reservoir pressure will provide greater ability to inject fluids into the reservoir and add additional margin in the spill point hydraulic analysis determination. For every 20 psi decrease in reservoir pressure adds approximately 15% margin versus the spill point hydraulic head. Please also see the original aquifer exemption application, Section 2.1.3, page 9-14.

Q3b. Provide additional site specific groundwater flow information.

A3b. The area of the requested aquifer exemption has been recognized by the California Department of Water Resources and other geologic and hydrogeologic authorities as being separated from the Edna Valley groundwater basin by geologic formations and faulting. As such, continuity and rate measurement for groundwater flow through the area is incongruous with the physical nature of the site.

The California Department of Water Resources (1) limits the extent of the San Luis Obispo Valley Groundwater Basin and does not include any of the area in the aquifer exemption, recognizing that these are distinctly separate areas that do not have significant groundwater connectivity. This is supported by the findings in a Balanced Hydrologics report from 2008 (2). This report details how groundwater, when present in sufficient quantities, undergoes upwelling along the various fault traces that cross Pismo Creek up-gradient of the aquifer exemption area. This upwelling water feeds into Pismo Creek as surface water precisely because it cannot continue to flow as groundwater across the fault traces. This presupposes what other research has found (3), which is that general groundwater flows are from the northeast to southwest, but illustrates that the groundwater does not flow significantly in a subsurface manner across the various faults. It flows as a surface water when there is sufficient water to support upwelling into Pismo Creek, but when groundwater is insufficient to support upwelling, the fault traces act as a dam, holding back groundwater from flowing into the area of the aquifer exemption. This is consistent with the interpretation from the technical document from Cleath-Harris Geologists (4) in Appendix G 1-1 of our aquifer exemption application package which states, "The subsurface hydraulic connection between the Edna subbasin and Price Canyon water-bearing zones is restricted by faulting and folding, which act as barriers to groundwater flow."

Likewise, little to no groundwater flow can be expected through the area of the proposed aquifer exemption in a downstream direction. A 2007 report by WZI, Inc. (5) states, "...the Pismo Creek drainage was observed to be incised directly into the Edna Member of the Pismo Formation bedrock." It goes on to state that "...no extensive or continuous alluvial deposits are present along the Pismo Creek drainage through the PXP property." Since no extensive or continuous alluvial deposits exist in the area, the only possibility for groundwater flow would be through fractures in the bedrock. Since the bedrock in the area is saturated with oil, any groundwater flowing from the area of the aquifer exemption to the south would be accompanied by crude oil, but this has not been observed in any down gradient wells.

These multiple references from respected sources all indicate that water flow across the various fault zones separating the Edna subbasin of the San Luis Obispo Valley Groundwater Basin is insignificant under average conditions, and that there is insignificant groundwater flow within the area of the aquifer exemption and no groundwater flow out of this area to the south. Instead, all flows into and out of the area of the aquifer exemption are limited to the surface flows in Pismo Creek.

1. California Department of Water Resources (DWR). 2004. California's Groundwater Bulletin 118. San Luis Obispo Valley Groundwater Basin 3-9.
2. Balance Hydrologics, Inc. 2008. Hydrology and Geology Assessment of the Pismo Creek Watershed, San Luis Obispo, California. August 2008.

3. Fugro West, Inc. 2008. Water Resources Assessment for the Cold Canyon Landfill Expansion, Environmental Impact Report.
4. Cleath-Harris Geologists, Inc. 2015. Review of DWR Well Completion Reports for Wells Within One-Mile Radius of the Freeport-McMoRan Arroyo Grande Oil Field.
5. WZI, Inc. 2007. Pismo Creek Alluvial Evaluation, Arroyo Grande Oil Field, San Luis Obispo County, California.

Q3c. Provide additional information concerning the potential for future saturation in the aquifer.

A3c. Continued dewatering of the reservoir will further reduce water saturation and reservoir pressure, thus keeping the fluids contained in the syncline. Furthermore, over time, the water cut ratio per barrel of fluid produced will be reduced as the dewatering operations continue. Buoyancy-driven fluid movement is not evident or expected as the heavy oil and water remain interspersed and in emulsions.

Q3d. Provide additional supportive data relative to hydraulic containment

A3d. See attached Exhibit A for field wide production and injection volumes for January 2015 – March 2016. The data contained in this spread sheet supports the response provided to question 3a.

Current Source Analysis

Q4. Provide additional information concerning nearby groundwater supply wells.

A4. See analysis and supporting materials by Cleath Harris Geologists.

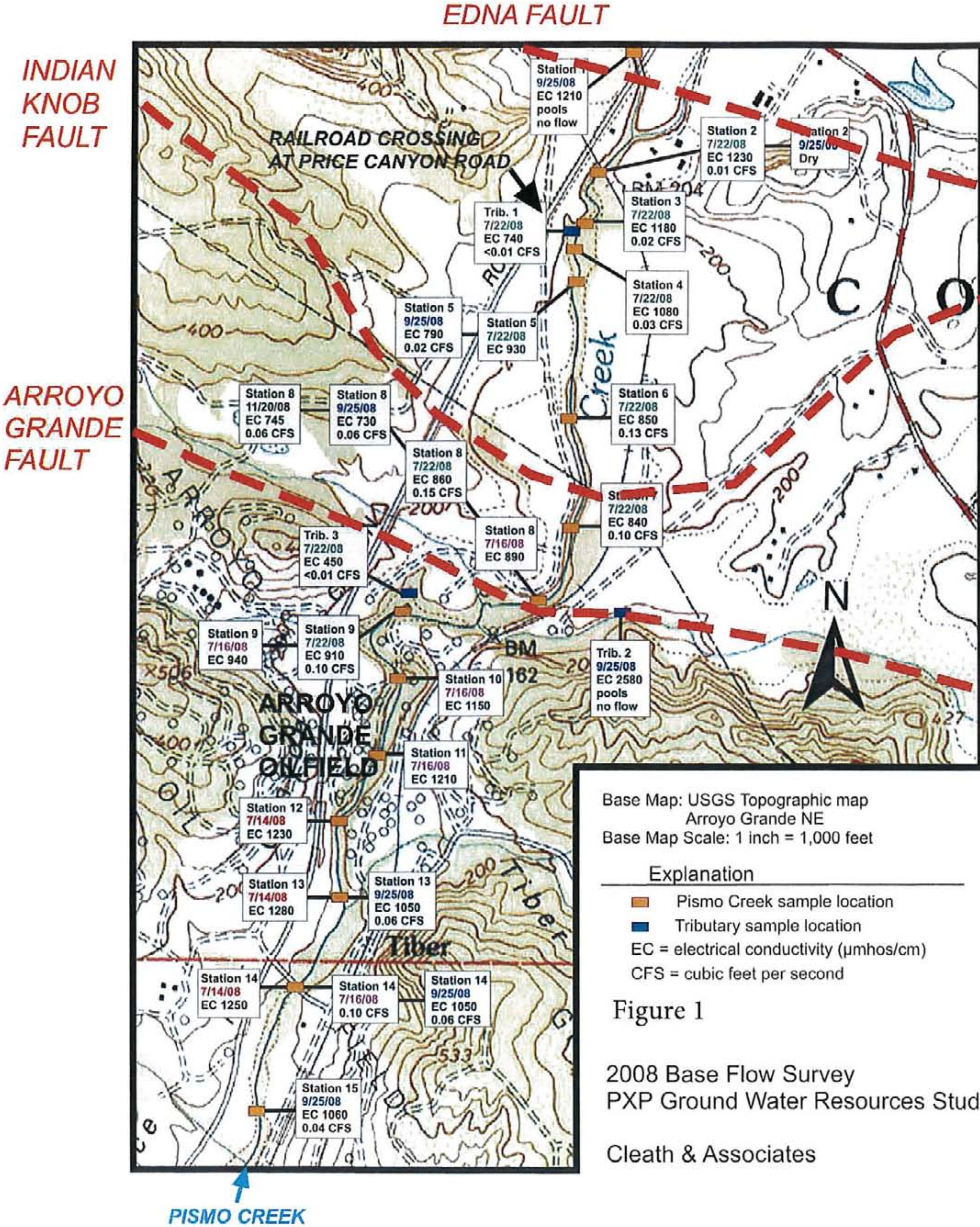
Thank you in advance for your consideration of this supplemental material in response to the questions posed by the EPA. As always, please do not hesitate to contact us should you have questions regarding the enclosed material.

Sincerely,

Patrick Vowell
EH&S Advisor
Freeport-McMoRan Oil & Gas

CC: Ken Harris, State Supervisor, DOGGR
Jason Marshall, Deputy Director, California Department of Conservation
John Borkovich, State Water Resources Control Board
Janice Zinky, State Water Resources Control Board
John Robertson, Central Coast Regional Water Quality Control Board
Aaron Katona, Central Coast Regional Water Quality Control Board
David Rose, EH&S Manager, FM O&G

Figures and Exhibits



Base Map: USGS Topographic map
Arroyo Grande NE
Base Map Scale: 1 inch = 1,000 feet

Explanation

- Pismo Creek sample location
- Tributary sample location

EC = electrical conductivity (μmhos/cm)
CFS = cubic feet per second

Figure 1

2008 Base Flow Survey
PXP Ground Water Resources Study

Cleath & Associates

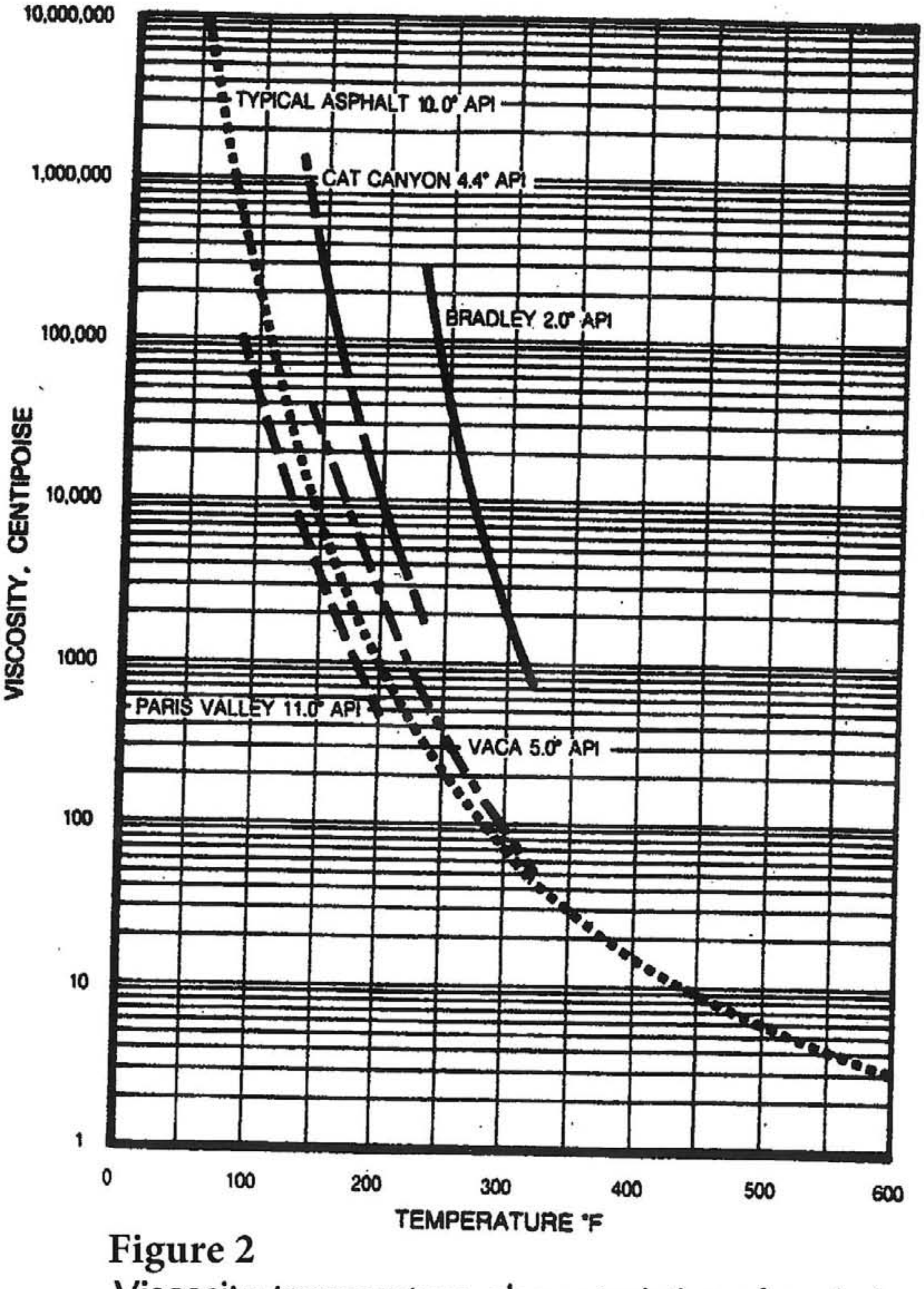
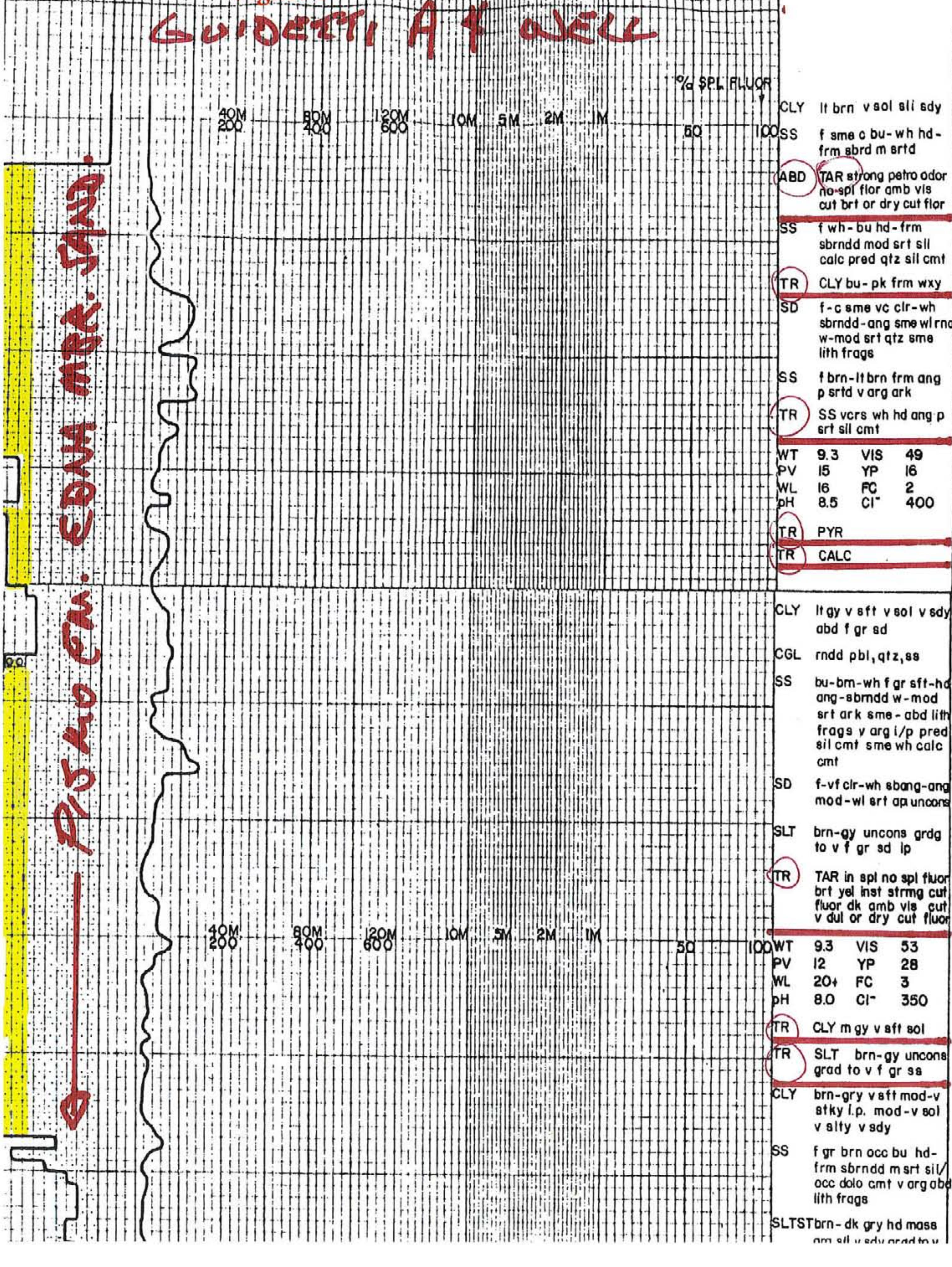


Figure 2
Viscosity temperature characteristics of asphaltic crude oils.

CALIFORNIA DIVISION OF OIL AND GAS

Figure 3



GUIDETTI A 4 WELL
EDNA MBR. SAND
PISMO FM.
% SPL FLUOR
40M 200
80M 400
120M 600
10M
5M
2M
1M
50
100
CLY lt brn v sol sli sdy
SS f sme c bu-wh hd-frm sbrd m srtd
ABD TAR strong petro odor no spl flor amb vis cut brt or dry cut flor
SS f wh-bu hd-frm sbrndd mod srt sil calc pred qtz sil cmt
TR CLY bu-pk frm wxy
SD f-c sme vc clr-wh sbrndd-ang sme wl rnd w-mod srt qtz sme lith frags
SS f brn-lt brn frm ang p srtd v arg ark
TR SS vcrs wh hd ang p srt sil cmt
WT 9.3 VIS 49
PV 15 YP 16
WL 16 FC 2
pH 8.5 Cl⁻ 400
TR PYR
TR CALC
CLY lt gy v sft v sol v sdy abd f gr sd
CGL rndd pbl, qtz, ss
SS bu-brn-wh f gr sft-hd ang-sbrndd w-mod srt ark sme-abd lith frags v arg i/p pred sil cmt sme wh calc cmt
SD f-vf clr-wh sbang-ang mod-wl srt ap uncons
SLT brn-gy uncons grdg to v f gr sd ip
TR TAR in spl no spl fluor brt yel inst strmg cut fluor dk amb vis cut v dul or dry cut fluor
40M 200
80M 400
120M 600
10M
5M
2M
1M
50
100
WT 9.3 VIS 53
PV 12 YP 28
WL 20+ FC 3
pH 8.0 Cl⁻ 350
TR CLY m gy v sft sol
TR SLT brn-gy uncons grad to v f gr ss
CLY brn-gry v sft mod-v stky i.p. mod-v sol v slty v sdy
SS f gr brn occ bu hd-frm sbrndd m srt sil/occ dolo cmt v arg abd lith frags
SLTST brn-dk gry hd mass

Exhibit A

Arroyo Grande Production and Injection Data (1/2015 - 3/2016)

	Production			Injection		
	Oil	Gas	Water	Steam	Water	Gas
Mo/Yr	BOPD	MCFPD	BWPD	BSPD	BWPD	MCFPD
1/1/2015	1355	2538	30073	7613	4375	2538
2/1/2015	1364	2398	31189	8065	4620	2398
3/1/2015	1368	2588	30098	8402	4475	2588
4/1/2015	1316	2641	29182	8414	3988	2641
5/1/2015	1328	2793	28643	8434	4121	2793
6/1/2015	1138	1912	26605	8650	3598	1912
7/1/2015	1291	2765	27167	9759	3498	2765
8/1/2015	1307	2715	25418	10233	2242	2715
9/1/2015	1369	2749	25802	9599	3056	1868
10/1/2015	1494	2894	28711	10528	3610	806
11/1/2015	1493	2980	29235	11133	3570	871
12/1/2015	1550	3101	29442	11533	3790	800
1/1/2016	1496	2826	27597	10983	2721	1308
2/1/2016	1564	2938	26698	9656	4769	952
3/1/2016	1607	2915	27770	10825	3579	625