Technical Analysis

Montalban Oil and Gas Operations Jody Field 34-1

The Montalban Oil and Gas Operations Inc. (MOGO) permit MT52443, Jody Field well 34-1, was initially authorized to inject into the Madison formation under a Montana Board of Oil and Gas Commission (MBOGC) Class II well. With this permitting action, the Class II well will be converted to a Class V well. The modification will allow MOGO to inject associated with oil and natural gas production and municipal fluids from processed renewable feedstocks, such as seed oils, used cooking oil and tallow. The change from a Class II well to a Class V well was required in order to expand the type of injectate, Class II wells are limited to wastes from oil and gas production.

The well is being permitted as a Class V rather than Class I well because it is constructed above the Devonian Duperow Aquifer, which is considered a USDW in some areas of the basin. However, there is limited data on the Devonian Duperow Aquifer in this area. Well logs drilled into the Duperow Formation approximately 5 to 6 miles east of the AOR indicate that the Sun River Dolomite is separated from the underlying Duperow Formation by approximately 1,300 feet of confining zone (Mississippian Mission Canyon and Lodgepole Limestone and Upper Devonian Three Forks and Potlatch Formations). A water quality sample from the Devonian Duperow Aquifer was observed to have a calculated TDS under 10,000 mg/L (API #25-073-21523). To be conservative, the EPA decided to classify Jody Field 34-1 as a Class V well. This permit will be written to Class I standards.

The well injects into the Madison Formation, which is considered a USDW, and MBOGC previously submitted an Aquifer Exemption for the Madison Formation for the Jody Field 34-1 well to the EPA. On August 15, 2011, the EPA reviewed and concurred on this aquifer exemption for the Madison Formation in accordance with 40 CFR §§144.7 and 146.4 of the Safe Drinking Water Act

A workover to acidize and deepen the well was approved by the Montana Board of Oil and Gas Conservation in August 2022 and the workover was conducted in September 2022. Jody Field 34-1 was deepened by 42 feet for a total of 110 feet across the Madison. No injection has occurred since the well was deepened, except for the injection of clean water used to conduct the step rate test.

The well workover revealed that there was not a confining zone of less permeable layers directly beneath the bottom of the original well depth, as previously assumed in the first aquifer exemption. Since the Madison formation is most likely hydraulically connected and there is not sufficient evidence of less permeable layers within the lower Madison formation, an aquifer exemption and injection zone expansion of the entire Madison Aquifer to a depth of approximately 3,700 feet has been requested for continued injection. The extent of the exempted aquifer is horizontally within a radius of 1/4 mile from the Jody Field 34-1 well.

The aquifer exemption expansion was extended to the approximate bottom of the Madison Formation (approximately 3,700 ft), as there are no confining zones within the Madison to prevent the injectate from travelling below the bottom of the well. Therefore, the entire Madison Formation must be exempted so that the Permittee can comply with the permit and AE.

The parameters below are the values used to calculate the initial maximum cumulative injection volume issued with this Permit. See spreadsheet "Well Calculations.xlsx" for more details.

Aquifer Exemption Radius (miles)	Perforated Zones (ft)	Porosity (%)	Injection Zone Top Depth (ft)	Previously Injected Volume (bbls)	Cumulative Injection Volume Limitation (bbls)
0.25	100	9.4	3,428	352,455	8,811,350

The maximum cumulative injection volume limitation is calculated using the equation below.

$$\boldsymbol{Volume} = (\pi * \boldsymbol{radius}^2 * \boldsymbol{height} * \boldsymbol{porosity}) - \boldsymbol{Previously\ Injected\ Volume}$$

Radius (ft) is the radius of the aquifer exemption.

Height (ft) is the total thickness of the perforated zones.

Porosity (unitless) is the porosity of the injection zone.

Previously Injected Volume (ft^3) accounts for the volume of injectate that has already been injected into the well. Please see additional explanation below.

The Permittee reported a cumulative injected volume of 179,752 bbls for Jody Field 34-1 on December 31, 2022 to MBOGC. Based on past injection through 51 feet of perforations, the radius of injected volume is estimated to have traveled 281 feet. To ensure that the fluids remain within the proposed exemption area of the Madison Formation, we must assume that the volume was injected uniformly across the entire "height" for the calculation, including the interval that is newly proposed for exemption, for a total of 100 feet. Therefore, the previously injected volume is assumed to be 352,455 bbls and the initial maximum cumulative injection volume is set at 8,811,350 bbls.

A compensated neutron-formation density log was run at the Jody Field 34-1 well by Schlumberger for the purpose of identifying hydrocarbon bearing zones. The compensated neutron-formation density log is a combination of density and neutron porosity logs and provides a good source of porosity data. The final porosity value utilized for the cumulative volume calculation was set at 9.4%. The estimated porosity falls within the range found in the literature[1].

Local Stratigraphy

Formation Type	Formation	Top (ft)	Bottom (ft)	Lithology
USDW	Two Medicine	0	484	Fine to medium grained quartzose sandstone that coarsens upward with good porosity in the upper sections of the formation
USDW	Eagle/Virgelle	484	674	Medium grained sandstone and mudstone
Confining Zone	Colorado Shale	674	1,780	Dense, non-calcareous shale with interbedded bentonite
Confining Zone	Blackleaf	1,780	1,878	Very fine-grained sandstone with units of hard, dense, noncalcareous shale and bentonite
Confining Zone	Bow Island	1,878	2,544	Very fine grained, very dense quartzose sandstone interbedded with shale, bentonite and siltstone
USDW	Dakota	2,544	2,586	Interbedded units of firm, dense shale and very fine grained bentonitic sandstone
USDW	Kootenai	2,586	3,081	Interbedded units of very fine-grained to fine grained sandstone and firm, dense shale
USDW	Sunburst	3,081	3,207	Interbedded units of very fine-grained to fine grained sandstone and firm, dense shale

[1] The Sun River Dolomite has been studied extensively for its hydrocarbon production potential and was determined to have an average porosity of 8 to 14% and average permeability of 10 to 82 millidarcy with the highest values observed in the Pondera Field (Pasternack 1988).

Confining Zone	Swift	3,207	3,327	Interbedded very fine grained to fine grained quartzose sandstone and firm, dense shale
Confining Zone	Rierdon	3,327	3,404	Firm to hard, dense marlstone
Confining Zone	Sawtooth	3,404	3,428	Firm to hard, dense siltstone interbedded with very find grained quartzose sandstone
USDW (partially exempted)	Madison	3,428	3,700	Fine grained dolomite with good vuggy and intergranular porosity
Confining Zone	Mississippian Mission Canyon and Lodgepole Limestone	3,700	4,700	Dense, cherty, hard, tight limestone with crypto to microcrystalline grains. No porosity observed
Confining Zone	Upper Devonian Three Forks and Potlach Formations	4,700	4,900	Dense, tight limestone and shale (approx. 60 ft underlain by interbedded shale and anhydrite)
USDW	Devonian Duperow Aquifer	Approx. 4,900	Approx. 5,600	Dense, tight crypto to microcrystalline dolomite with poor to fair porosity

USDWs

Formation Name or Stratigraphic Unit	Top (ft)*	Base (ft)*	TDS (mg/l)	Lithology
Two Medicine	0	484	<3,000 mg/L	Fine to medium grained quartzose sandstone that coarsens upward with good porosity in the upper sections of the formation
Eagle/Virgelle	484	674	<5,000 mg/L	Medium grained sandstone and mudstone
Dakota	2,544	2,586	Ranges depending on location – observed at 7,000 to 12,000 mg/L (Well MT51141-07750)	Interbedded units of firm, dense shale and very fine grained bentonitic sandstone
Kootenai	2,586	3,081		Interbedded units of very fine-grained to fine grained sandstone and firm, dense shale
Sunburst	3,081	3,207		Interbedded units of very fine-grained to fine grained sandstone and firm, dense shale
Mississippian Madison Aquifer**	3,428	3,700	5,440 mg/L (API # 25-073-21740) to 9,000 mg/L	Fine grained dolomite with good vuggy and intergranular porosity
Devonian Duperow Aquifer	Approx. 4,900	Approx. 5,600	9,470 to 13,800 mg/L (API# 25-073-21523)	Dense, tight crypto to microcrystalline dolomite with poor to fair porosity

<u>API #25-073-21523, Powers Farm 29-1, TD= 5,800 ft</u>

- 4.8 miles northeast from Jody Field 34-2
- Describes Madison as having good vuggy porosity and good intergranular porosity from the top of the Sun River (3092 feet) to 3125 feet, for a total of 33 feet. At 3125 feet, the geology changes to a micro to very fine

crystalline, dense, tight, hard Dolomite for 5 feet. Then from 3130 feet to 3135 feet, the Dolomite has very finely granular, dense, some fair intergranular porosity.

- Describes Mission Canyon Limestone as crypto to microcrystalline, dense, tight, and hard with poor interfragmental porosity and chalky infill of any porosity (page 54 of Well_API_2507321523.pdf).
- In the PDF on Page 87, there is a report that lists Permeability at depth. The permeability for the Madison formation is relatively high (up to 47.9 md) and stays above 1.0 md. The Permeability drops to 0.1 md at the Mission Canyon Limestone depth and generally remains 0.1 md permeability throughout the formation.

This geologic log and permeability report show that the Mission Canyon Limestone is an adequate lower confining zone for the injection zone. There is not enough evidence here to classify the lower Madison as a low permeability confining zone.

Injection Zone/Confining Zone

The injection zone is completed within the Sun River Dolomite, the uppermost section of the Mississippian Madison Formation. The proposed UIC area is located on the western edge of the Great Plains, west of the Sweetgrass Arch and east of the Intermountain Seismic Belt. The proposed UIC area is located several miles east of mapped faults in an area with low earthquake risk. No mapped or known faults lie within the AOR.

Formation Name or Stratigraphic Unit	Top (ft)*	Base (ft)*	Porosity	Proposed Exemption
Madison Formation	3,428	approx 3,700*	9.4%	Montana Board of Oil and Gas Conservation (MBOGC) submitted an Aquifer Exemption (AE) for the Madison Formation for the Jody Field 34-1 well to the EPA. On August 15, 2011, the EPA reviewed and concurred on this aquifer exemption for the Madison Formation within a one-quarter (1/4) mile radius from the wellbore between the depths of 3,428 to 3,493 feet, in accordance with 40 CFR §§144.7 and 146.4 of the Safe Drinking Water Act. An aquifer exemption expansion is proposed for the Madison formation from a depth of 3,493 to approximately 3,700* feet.

*Depth is approximate and projected, based on nearby wells (API Numbers 25-073-05439, 25-073-05440 and 25-073-21523).

AOR

The initial permit application was submitted for an area-wide permit. The EPA determined that individual permits for these wells was more appropriate. EPA established the AOR for the Jody Field 34-1 permit based on a delineated radius of ¼ mile from the well location. The Permittee provided figure (below) indicating the location of the current injection wells, Jody Field 34-1 and 34-2, and other wells located within the AOR and operated by MOGO. These wells were completed in Madison Formation and include; Jody Field 14-34, Jody Field 4-1, and Jody Field 4-1A. The Field C.W. JR indicated in the figure is a shallow water well at a depth of 109 feet.

Construction data from AOR wells was reviewed to determine the integrity of the wells and possibility of fluid migration beyond the injection zone due to injection at Jody Field 34-1 and Jody Field 34-2. All wells within the AOR are cemented from the well bottom to above Sawtooth Formation and thus isolate the injection zone. The operator volunteered to monitor the nearby shut-in wells (Jody Field 14-34 and Jody Field 4-1A) in the Response to Comments dated December 21, 2021. In both shut-in wells, the wellbore provides an isolated pathway for pressure and fluid from the injection zone to surface. The surface "shut in" status prevents fluid movement but allows the wellbore to be used as a means of monitoring the injection zone pressures.

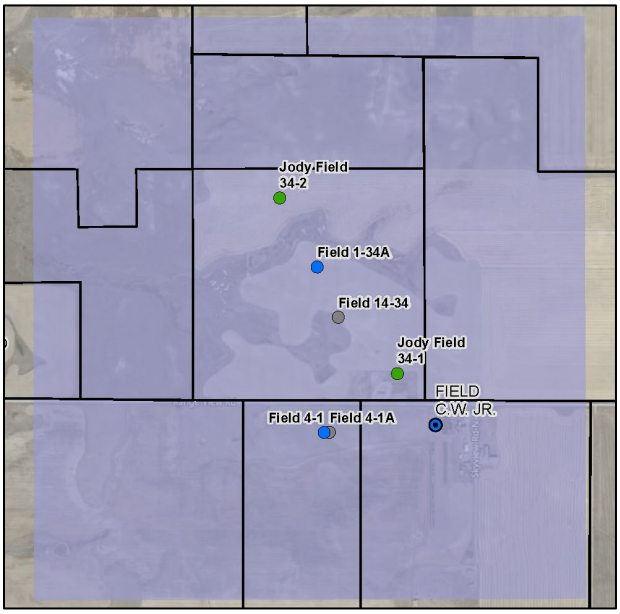

Figure 01

The following features were not found, or known to be within, the mapped AOR:

- outcrops of injection and confining formations;
- surface water intake and discharge structures;
- hazardous waste treatment, storage, or disposal facilities;
- mines (surface and subsurface) and quarries; or
- residences, schools, and hospitals.

Corrective Action

N/A

Fracture/faults/seismicity

There are no known faults or fractures surrounding this well that would compromise the confining zones. Geologic records from the wells indicate that the overlying and underlying confining zones are dense, tight, with low porosity and do not exhibit any fracturing (Montana BOGC logs (Wells Jody Field 4-1/API No. 25-073-21824, Jody Field 4-1A/API No. 25-073-21842, Stanwald Sahara No. 1/API No. 25-073-05440, Powers Farm No. 29-1/API No. 25-073-21523, Federal Land Bank of Spokane Well No. 1/API No. 25-073-05439).

Well Construction

Casing Type	Hole Size (in)	Casing Size (in)	Cased Interval (ft)	Cemented Interval (ft)
Production	6.25	4.5	675-3,540	2,750-3,538
Surface	8.5	7	0-675	0-675

The well is constructed as

- 7" LTD 17#/ft surface casing set in a 8 ¾" hole to a depth of 679' below ground level and cemented with w/175 sacks Class G Cement to the surface.
- 4 ½" J-55 10.5#/ft long string casing set in a 6 ¼" hole from 679' – 3540' KB w/100 sacks Class G Cement.
- Float collar @ 3495.42 KB
- Original perforations were made at 3 intervals between 3,432' and 3,446' TD
- Reperforated from 3,448'-3,538', Total Depth: 3,540' Driller 3,539' Logger

Evaluation of the cement bond log and amplitude at 80% bond (mV) calculation yielded an A_{80} = 2.2mV. Guidance 34 recommends a continuous 15' section with 80% cement bond index (CBI) for a 4.5" pipe across the confining zone. The vast majority of the CBL from cement top to the top perforation has an 80% CBI. Starting from the upper perf and moving up, at 3428', there is a 20' section from 3404-3424'. The next continuous section is a 108' section from 3278-3386'.

Operation Conditions

A SRT was completed in April 2023 and the MAIP was calculated utilizing the data submitted (see Jody Field 34-1_SRT Analysis.xlsx).

The table below provides the initial values used to calculate the initial MAIP:

Fracture Gradient	Specific Gravity	SG Fluctuation Factor	Injection Zone Top Depth (ft)	Friction Loss (psi)	Authorized MAIP (psi)
0.777	1.004	0.05	3,428	385	1,484

Based on current SRT data, the Jody Field 34-1 MAIP will be initially set to 1,484 psi. This value may change after the specific gravity of the injectate is measured, which is a permit condition prior to authorization to inject. A water quality sample of the wastewater from Montana Renewables feedstock pretreatment unit was taken on May 15, 2023. The TDS in this sample was observed to be 5,080 mg/L. A specific gravity value was calculated from the measured TDS (Collins 1987). Once the Permittee provides a measured specific gravity value of the injectate, the MAIP will be updated.

Logging and Testing

- In discussion with ECAD, the MIT Standard Annulus Pressure tests submitted to MBOGC are not consistent with R8's testing protocol. The operator must conduct an MIT prior to authorization to inject to ensure they meet EPA's test requirement standards. MOGO must follow the R8 Guidance 39.
- Noise log are required prior to receiving authorization to inject.*

* A noise log must be performed to assess the presence of fluid movement between the exposed upper USDWs (Dakota, Kootenai, and Sunburst) and adjacent formations. Based on the calculated top of cement, the existing cement does not appear to prevent movement of fluids between the upper USDWs and the confining layers. The noise log must be conducted between the top of cement behind the 4.5-inch casing and the base of the 7-inch surface casing. If the noise log shows fluid movement, casing perforation and squeeze cementing will be required to isolate the USDWs.

P&A Plan

MOGO submitted an updated P&A plan that was approved by EPA. MOGO submitted a Letter of Credit for the well. Concurrence on the financial assurance was provided, via email by Ben D'Innocenzo on 6/28/2023.

Environmental Justice

The EPA considered its obligations under Executive Order 12898 and concluded that there may be potential EJ communities proximate to the Authorized Permit Area. The primary potential human health or environmental effects to these communities associated with injection well operations would be to local aquifers that are currently being used or may be used in the future as USDWs. EPA's UIC program authority under the Safe Drinking Water Act is designed to protect USDWs through the regulation of underground injection wells. EPA has concluded that the specific conditions of UIC Permit MT52443-12513 will prevent contamination to USDWs, including USDWs which either are or will be used in the future by communities of EJ concern.

Historical Property

EPA considered its obligations under the National Historic Preservation Act and found no impacts related to Historical Property. The National Park Service National Register of Historic Places database was searched for historic properties located in Pondera County. Four locations were found, however none of the locations were in the vicinity of the Jody Field 34-1 well. The Jody Field 34-1 well is already constructed, has been operated for injection, and may require workover activities that will not impact surrounding areas. All roads are in place, and injection fluid will be transported to the site via existing infrastructure. Based on this information, the EPA is proposing to find that no historic properties will be affected as a result of issuing this UIC Permit.

Endangered Species

EPA considered its obligations under Endangered Species Act and utilizing the U.S. Fish & Wildlife Service, Information for Planning and Conservation (IPaC) website (https://ipac.ecosphere.fws.gov), made the following determination.

The federally listed endangered species found in the area of the Facility include:

	Species	**Status**
Mammals	Grizzly Bear (*Ursus arctos horribilis*)	Threatened
	North American Wolverine (*Gulo gulo luscus*)	Proposed Threatened
Insects	Monarch Butterfly (*Danaus plexippus*)	Candidate

(No critical habitats are located in the project area)

The EPA has determined this Permit issuance will have No Effect on any of the species listed by the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act within Pondera County. The finding is based upon the following:

There is no new construction or facility size increase that would result in ground disturbance or vegetation removal with the reissue of this permit.

In addition to IPAC, the Montana Sage Grouse Habitat Conservation Program database (https://sagegrouse.mt.gov/ProgramMap) was utilized to ensure the Jody Field 34-2 well is not in or close to designated sage grouse habitat. Results from this review "Not In EO Area".

Tribes

EPA considered its obligations under the 1984 EPA Policy for the Administration of Environmental Programs on Indian Reservations. Due to the location of the well within Tribal Cession Boundaries, during public notice the Blackfeet Tribe of the Blackfeet Indian Reservation of Montana; Crow Tribe of Montana; and Fort Belknap Indian Community of the Fort Belknap Reservation of Montana will all be notified to ensure awareness of the project and scope.

References

Pasternack, Ira, Nature and Distribution of Mississippian Sun River Dolomite Porosity, West Flank of the Sweetgrass Arch, Northwestern Montana, August 16, 1988

Collins, A., G., 1987, Properties of produced waters, in Bradley, H., B., eds., Petroleum Engineering Handbook: Dallas, SPE, p. 24-15.