TORC
Oil & Gas Ltd
Suite 1800 Eighth Avenue Place, 525 – 8th Avenue SW, Calgary, AB
T2P 1G1 | p. 403.930.4120 | f. 403.930.4159

Proposed East Manson Unit No. 9

Application for Waterflood EOR Manson, Manitoba

January 2019

Table of Contents

Introduction

In accordance to Section 71 of the Drilling and Production Regulations of Manitoba, TORC Oil & Gas Ltd (TORC) is requesting the board's approval of a newly proposed East Manson Unit No.9 (EMU No.9). The unit will be located in the Northeast quarter of section 16-013-28W1 and Northwest quarter of section 15-13-28W1 with the intent of further extending a waterflood in the Bakken pool.

Since the first vertical discovery well in August 2010, a total of 141 horizontal and 44 vertical wells have been drilled targeting the Bakken in the Manson area. The large Middle Bakken pool trends southeast to northwest from section 31-12-27W1 to section 14-14-29W1 respectively. A low pool-wide estimated ultimate recovery (EUR) of 7.2% is expected due to negligible solution gas and low initial pressure. The proposed waterflood and unit area will further expand the waterflood.

The proposed EMU#9 waterflood area is currently developed with 6 horizontal wells. Following approval of the proposed unit, 2 existing wells will be converted to injectors and an additional 2 horizontal wells will be drilled in order to complete the waterflood scheme outlined in *Appendix D, figure 3.* Results to date from offsetting Manson waterflood units demonstrate that recovery factors of over 20% can be attained, see *Appendix E, figure 1.*

If you have any questions or concerns about the application, please contact the undersigned.

Sincerely,

Jarrad Freadrich, P.Eng
Exploitation Engineer
TORC Oil & Gas Ltd
ph (403) 930-4181
jfreadrich@torcoil.com

Summary

1. The Proposed East Manson Unit No.9 will include 8 legal subdivisions (LSD's) in Section 15 and 16-13-28W1, where 6 horizontal wells are completed in the Middle Bakken formation. A map of EMU No.9 is attached in *Appendix A, figure 1*.

2. *Appendix C, figure 2* show oil production from the proposed East Manson Unit No.9 of 12.5 m3/d as of October 31, 2018.

3. Original oil in place (OOIP) for the proposed unit is 366 e $^3m^3$ or 45.8 e $^3m^3$/ LSD. (see *Appendix C, figure 1*)

4. Cumulative oil production from the proposed unit as of October 31, 2018 is 20.4 e $^3m^3$, giving a current recovery factor (RF) of 5.6% within the unit boundary.

5. Declines for the 6 current producing wells show an estimated ultimate recovery (EUR) of 52 e $^3m^3$ and remaining recoverable oil in place as of October 31, 2018 of 325 e$^3m^3$. This gives an ultimate recovery factor of 14% under primary depletion. Under full development (2 additional wells) the ultimate recovery factor increases to 17% under primary depletion.

6. Initial reservoir pressure (Pi) of the Middle Bakken reservoir was 5500 kPa. This value was consistent with four different static gradients taken in SEC 12 TWP 14 RNG 29 and 20, 29, 28 TWP 13 RNG 28W1. Current reservoir pressure (Pr) is estimated to be approximately 2900 kPa based on recent Pressures and Fluid Levels taken from 00/13-16-013-28W1.

7. Results from offsetting units under waterfloods show good response in very little time. The waterflood response in East Manson Unit No. 1 is shown in *Appendix E, figure 1*.

8. Upon approval, 2 horizontal well will immediately be converted to injection. An additional 2 horizontal wells will be converted to injection in the future once TORC drills the remaining 2 wells in section 15. The incremental recovery factor due to waterflood is expected to be 4.7% or 17.4e3m3. A fully developed injection pattern is shown *Appendix D, figure 3*, with a target water injection date of June 1, 2019.

Geological Discussion

Stratigraphy

The stratigraphy in EMU No. 9 is defined by the cross section A-A` seen in *Appendix B, Figure 6.* Cross section A-A` can be observed on each of the Appendix B maps running from the Northwest to the Southeast. The structural cross section is from the lower Madison to the Birdbear and displays the stratigraphy of the Manson Bakken oil pool. The oil is contained within a fining upwards Middle Bakken sandstone (yellow) that unconformity overlies the dolomitic siltstones and shales of the Three Forks / Torquay formation (brown). This Bakken sand is in turn is overlain by a regional Bakken shale (black). The Bakken oil reservoir consists of a NW-SE trending sand body that transitions to non-reservoir in the updip direction to the NE. It is this updip truncation of the Bakken sand and the vertical seal provided by the Bakken shale that allows for trapping of the Manson Bakken oil pool (*Appendix B, Figures 1-4).*

Reservoir Sedimentology

The Middle Bakken reservoir is a fining upwards clastic unit that ranges in grain size from a fine grained sand just above the unconformity with the Three Forks / Torquay to a bioturbated medium to coarse silt just below the upper boundary with the Bakken shale. The transition from a fine grained, ripple laminated, and well sorted sandstone at the base of the Middle Bakken to a bioturbated, medium to coarse grained silt at top represents a transition from a nearshore shallow water environment to a deeper water offshore setting. This gradual increase in water depth continues above the Middle Bakken with the deposition of the anoxic, deep water Upper Bakken shale.

The net effect of the fining upwards sequence in the Middle Bakken on the Manson oil pool is that the best reservoir is located at the base of the Middle Bakken and overall reservoir quality will decrease as one moves vertically through the Middle Bakken.

Structure

Structure maps for the Middle Bakken (top Bakken reservoir) and Three Forks / Torquay (base of the Middle Bakken reservoir) are provided in *Appendix B, Figures 1 & 2*. Overall both beds have a gentle dip down to the SW with local variations most likely due to dissolution of prairie evaporates lower in the section. It is important to note that the present day structure is due to events that occurred after deposition of the Middle Bakken reservoir. As such, these structural elements do not influence the distribution and quality of the reservoir.

Reservoir Continuity and quality

In a pool analysis, a proper understanding of appropriate cutoff value is critical when one sets out to make maps that define the limits and quality of the reservoir being mapped. To facilitate this, a porosity – permeability cross plot of all the core analysis over the Middle Bakken from Townships 12-15 and Ranges 27-30W1 was constructed (*Appendix B, Figure 5 & 6*). From this analysis, one can see that for a given porosity value, the permeability can vary greatly. As a result, if too high of a cutoff value is used, the overall quantity of reservoir will be underestimated. To best capture all of the pore space that will contribute to production over the life of the pool, a 12% density porosity cutoff was used. Using this cutoff, Phi x h and K x h maps (*Appendix B, Figure 3 & 4)* were constructed. When viewed in conjunction with the NW-SE structural cross section (*Appendix B, Figure 7*), it is apparent that in addition to being continuous across that proposed waterflood unit, the Middle Bakken reservoir has similar reservoir properties to offsetting parts of the pool that are undergoing active waterflood.

Fluid Contacts

The oil-water contact of the Middle Bakken Reservoir has been interpreted from logs to be at approximately -195m subsea. Based on the structural mapping done, this contact is substantially downdip from the proposed unit. Fluid contacts pose no risk to this reservoir.

Reservoir Characteristics and Current Recovery

Original Oil in Place

Porosity and water saturation values were taken from a combination of neutron- density logs and core samples where stratigraphic test holes are present. Volumetric original oil in place (OOIP) was calculated for the proposed waterflood area using the Bakken reservoir 12% phi*h map *(Appendix B, figure 3)*. Combining the phi*h with an average initial Sw of 35% and a B_o 1.1 of over the NW ¼ of sec.15 and NE ¼ of sec.16 ½ Twp.13 Rge.28 W1 equated to an OOIP of 366 e3m3. OOIP per quarter section can be seen *in Appendix C, figure 1*.

Reservoir and Fluid Properties

Applicable reservoir and fluid properties are outlined in the following table. All information supporting the following values such as fluid analyses and static gradients can be submitted upon request.

Torquay Reservoir and Fluid Properties

Reservoir:		**Comments**
Initial Reservoir Pressure (Pi)	5.5 MPa	From static Gradient
Current Reservoir Pressure (Pr)	2.9 MPa	November 2019 Static shot
Formation Breakdown Pressure (Pfrac)	14 MPa	Average from fracs
Average Water Saturation (Sw)	0.23	From Core Samples
Core Wettability	Moderate water wet	From 15-20 Rel perms
Fluid:		
Oil API Gravity @ 15 C	37.9	From 13-29BT Oil analysis
Total Sulphur Mass Fraction	0.00258	From 13-29BT Oil analysis
Absolute Viscosity @ 25 C (cP)	3.8	From 13-29BT Oil analysis
Formation Water Salinity (ppm)	58,000	From 16-04BT Water analysis
Formation Water Resistivity @ 25 C	0.119 Ohm*m	From 16-04BT Water analysis

Historical Production

The proposed unit has been developed with 6 East-West horizontal wells. Spacing between horizontal wells is about 200m as seen in *Appendix A, figure 1*. To date, 20.4 e3m3 of oil has been recovered from proposed unit with production beginning in October 2011 and peaking in December 2011 at 21.2 m3/d oil and 23.4 m3/d water. A daily rate group plot showing historical oil production can be seen in *Appendix C, figure 2*.

Primary Depletion

Estimated ultimate oil recovery (EUR) for the proposed unit is 52 e3m3 using decline analysis on individual wells currently on production. Under a fully developed scenario (2 additional wells), the EUR for the proposed unit increases to 62 e3m3. The spud dates for the 2 additional horizontal wells are the following:

UWI	Estimated Spud date
(9-16) 102/11-15-13-28W1 HZ	January 2020
(9-16) 102/14-15-13-28W1 HZ	January 2020

A group plot of declines for all proposed unit wells can be seen in *Appendix C, figure 3*, where horizontal wells have fitted to a hyperbolic decline with a hyperbolic exponent b of 0.7. An average yearly decline of 25% is expected in middle and later production periods.

No extensive PVT analysis has yet been conducted on reservoir fluids. Surface gas to oil ratio (GOR) has been measured to be between 2 and 5 m3/m3. It is believed that due to the low GOR, all gas can be considered solution gas. Current reservoir pressure conditions are expected to be undersaturated or near bubble point where reservoir drive is largely limited to fluid and rock expansion.

This was demonstrated with the pilot SEC 29 waterflood, where response was seen in approximately 15 days in producers 200m from a pilot injector. Rapid response is seen primarily due low reservoir gas saturation, see *Appendix E, figure 1.* This dictates fluid volume considered for the voidage replacement ratio (VRR) seen in the 'Waterflood Operating Strategy' portion of this application.

Unitization

Unit name: TORC Oil & Gas Ltd. proposes that the name of the new unit will be East Manson Unit No.9 (EMU No.9).

Unit Operator: TORC Oil & Gas Ltd. will assume operatorship of East Manson Unit No.9.

Unitized Zone(s): The proposed unitized zones will be the Bakken and Torquay (Three Forks) formations.

Unit Lands: NW/4 of Sec 15-13-28W1 and NE/4 of Sec 16-13-28W1 will be included in the proposed Manson Unit No.9 as outlined in *Appendix A, figure 1.*

Unitized wells: East Manson Unit No.9 will initially consist of 2 injectors and 4 producing wells. The proposed injectors (102/10-16-013-28W1/00 & 100/15-16-013-28W1/00) will be immediately converted upon approval of the unit and according to the proposed development plan outlined in *Appendix D, figure 3*. The 100/14-15-013-28W1/00 well will be converted to injection once offsetting horizontal producers are drilled. The following is a list of wells within the unit area:

License #	UWI	Proposed Status
010906	102/10-16-013-28W1/00 HZ	Injector (conversion)
010888	100/15-16-013-28W1/00 HZ	Injector (conversion)
010555	100/14-15-013-28W1/00 HZ	Producer
010352	100/11-15-013-28W1/00 HZ	Producer (future conversion)
010887	100/10-16-013-28W1/00 HZ	Producer
008234	100/16-16-013-28W1/00 HZ	Producer
TBD	102/14-15-013-28W1/00 HZ	Producer (new drill – future conversion)
TBD	102/11-15-013-28W1/00 HZ	Producer (new drill)

Tract Factors: as shown in *Appendix A, figure 3.*

The proposed East Manson Unit No.9 will consist of 2 tracts based on the two quarter sections comprising the proposed unit area.

The Tract Factor contribution for each quarter section was calculated as follows:

- Gross OOIP by quarter section minus cumulative production to date from the wells on each quarter (as distributed by specific Production Allocation Agreements where applicable) to yield remaining gross OOIP.

Waterflood Project Development

Proposed Water Injection Well Conversions and Timing

TORC proposes to convert a total of 4 horizontal wells to Middle Bakken Injectors. The first 2 conversions will take place in Q2-2019 or upon the board's approval. The final 2 conversions will not be until Q3-2021. A typical injector well schematic can be seen in *Appendix D, figure 1*.

Total daily injection demand for EMU#9 is expected to be approximately 40-60 m3/d, as outlined in the following table. Source water injection demand for EMU #9 will be met from existing pool-wide Manson production.

Produced injection water will be treated and separated at the TORC 16-04-013-28W1 battery then filtered and pumped to the proposed injection wells. Fiber reinforced polyethylene lines will be utilized for injection. A flow diagram of the proposed injection system and addition to the current 16-04-13-28W1 battery can be seen *in Appendix D, figure 2.* Corrosion mitigation measures will also be implemented throughout the duration of the proposed water flood and are outlined in *Appendix D, figure 4.* A schedule of injectors and anticipated injection rates can be seen below:

License #	UWI	Conversion Timing	Anticipated Initial Injection Rate
10906	(12-15) 102/10-16-013-28W1	June 2019	10-15 m3/d
10888	(13-15) 100/15-16-013-28W1	June 2019	10-15 m3/d
10352	(09-16) 100/11-15-013-28W1	July 2021	10-15 m3/d
TBD	(09-16) 102/14-15-013-28W1	July 2021	10-15 m3/d

Anticipated injection rates are based on historical fluid production for each well and will vary according to the following injection parameters:

Formation Fracture Pressure	14 MPa
Formation Fracture Wellhead Pressure	7.5 MPa
Requested Maximum Wellhead Pressure (90% of above)	6.8 MPa

Formation fracture pressure was determined from extensive hydraulic fracture data throughout sections 20, 21 and the Manson field. TORC requests a maximum injection pressure of 90% of the Formation Fracture Wellhead pressure = 6.8 MPa.

Waterflood Operating Strategy

The first injector conversion is proposed to occur in in June 2019. A fill-up period of approximately 1 month is expected due to negligible gas saturation (Sg), and has been seen in other Manson waterfloods. Target reservoir pressure will be 5.5 MPa, while maintaining a voidage replacement ratio (VRR) between 1 and 1.5. Some out of zone thieving to the Lower Lodgepole is expected as some natural fractures are believed to have reached porosity in the Lodgepole. Voidage replacement will be monitored and modeled throughout the injection process to maximize reserve recovery.

The following surveillance data and calculations will be acquired throughout the duration of the waterflood:

- Short-term pressure build-ups on both producers and injectors to monitor reservoir pressure.
- Wellhead flow meters on all wells to acquire daily rates
- Continuous wellhead injection pressure monitoring
- Weekly water cuts on all wells
- The use of fractional flow and Hall plots
- Analysis of acquired data and observation of trends in: water oil ratio (WOR), reservoir pressure (Pr), production rate, injection rate, cumulative production, etc.

In accordance to Section 73 of the Drilling and Production Regulations, an annual EOR report outlining the above data and calculations will be submitted within 60 days of initial injection and within 60 days after the end of each calendar year.

Secondary Recovery and Production Forecast

TORC believes that incremental recovery upwards of 5% can be forecasted in EMU #9 with the proposed injection scheme where horizontal injectors will allow for uniform lateral sweep from well paths. Furthermore, liner systems with closable sleeves will enable adaptable injection patterns by isolating chosen injection intervals and known heterogeneity or fractured areas can subsequently be avoided.
Selective intervals can also be mirrored in the horizontal producers to isolate or delay breakthrough.

Recovery has been calculated for the WF area based on forecasted individual well declines under pressure support. The resultant post flood EUR is 79.4 e3m3 which yields an incremental and ultimate post flood recovery factors of 4.7% and 21.7% respectively. Forecasted production profiles for both primary and waterflood can be seen in *Appendix C, figure 4*.

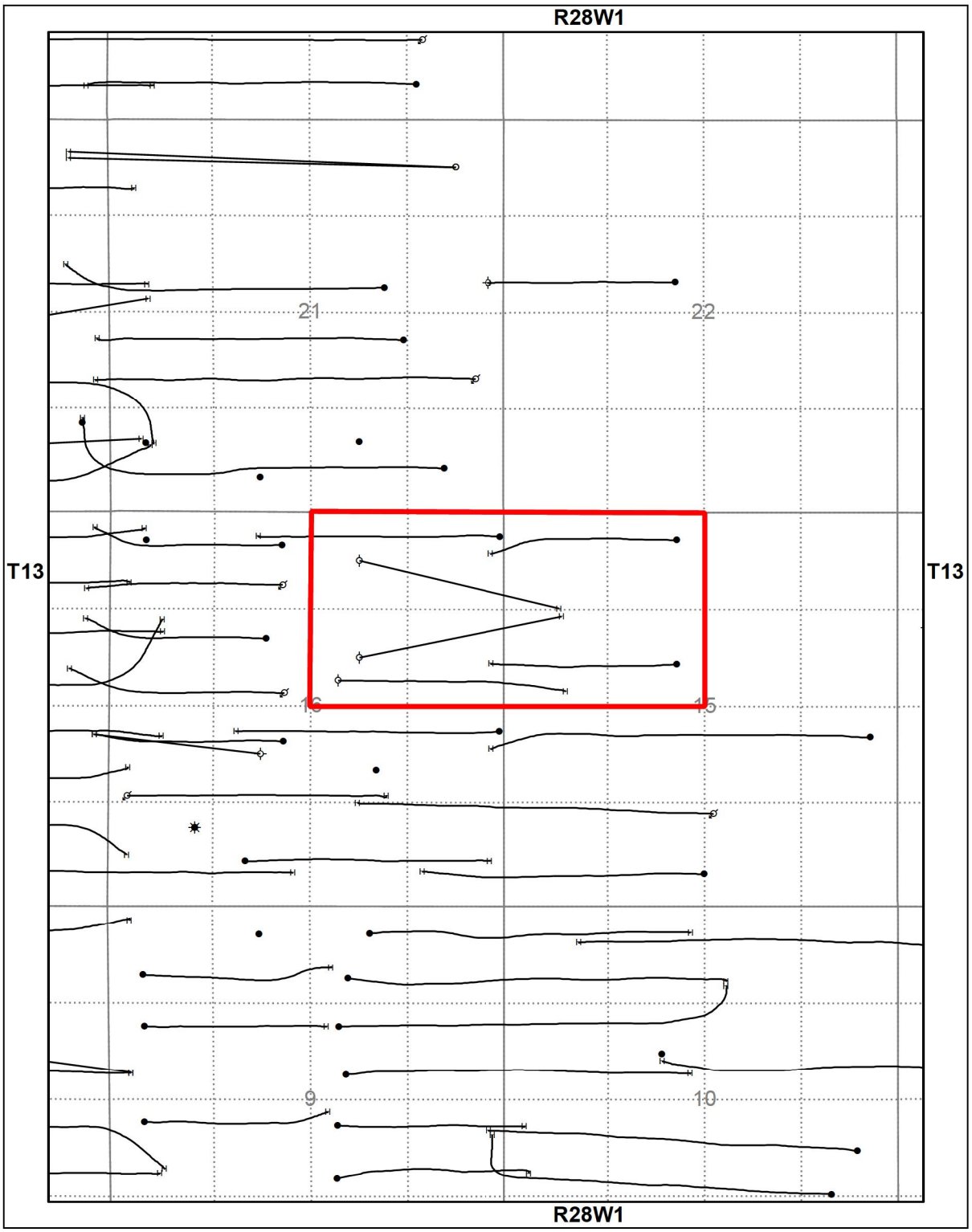
Incremental recovery of 5% is consistent with other units within the Manson area. Pressure response and increased production is almost instantaneous. The waterflood response in East Manson Unit No. 01 can be seen in *Appendix E, figure 1*.

After water flood implementation, project success will be evaluated by:

- Recording continuous incremental recovery
- Recovery comparisons with adjacent sections, forecasted recovery and Sinclair analogues

Appendix A: Unit & Notification

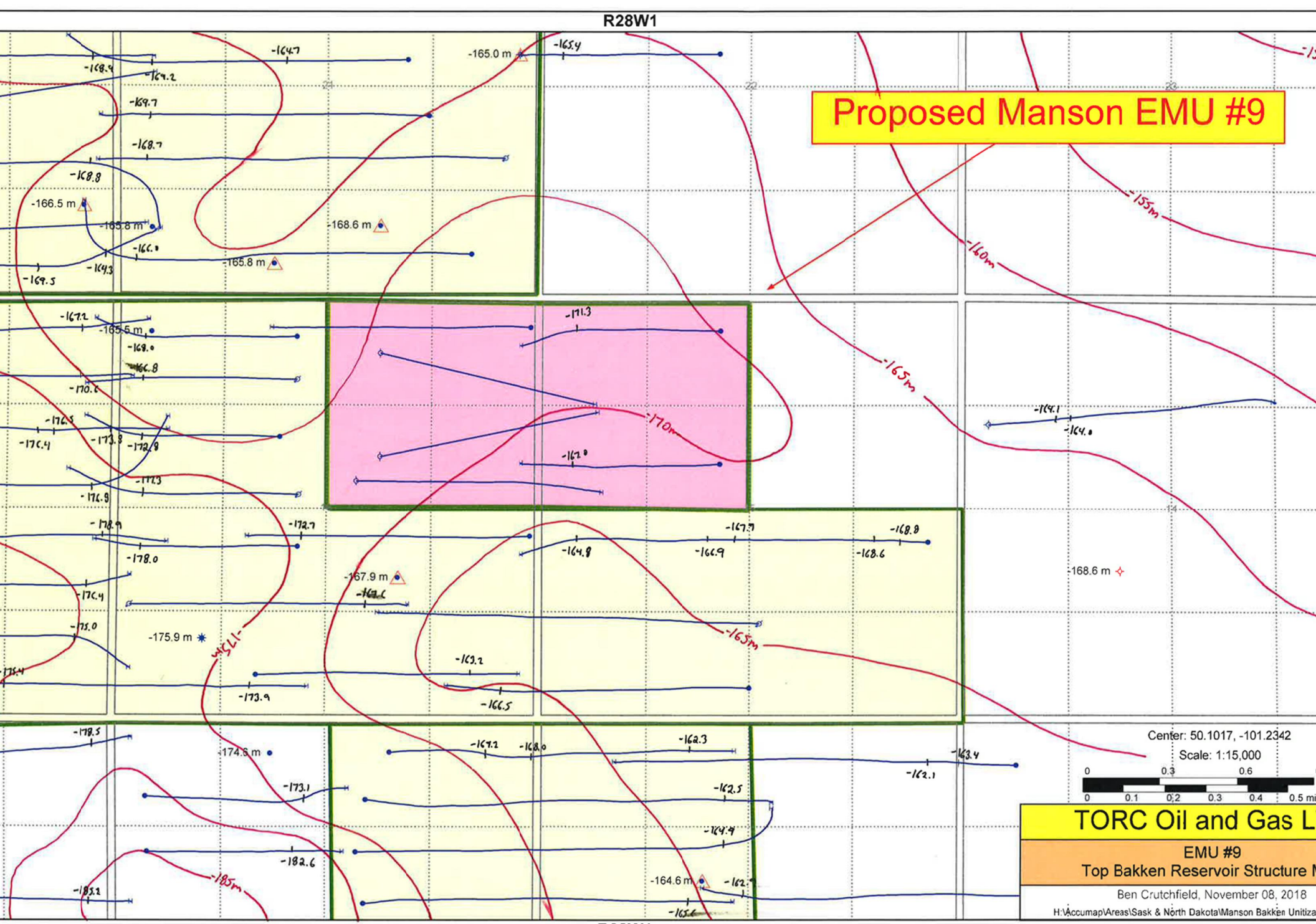
Appendix A, Figure 1: East Manson Unit No.9 Map

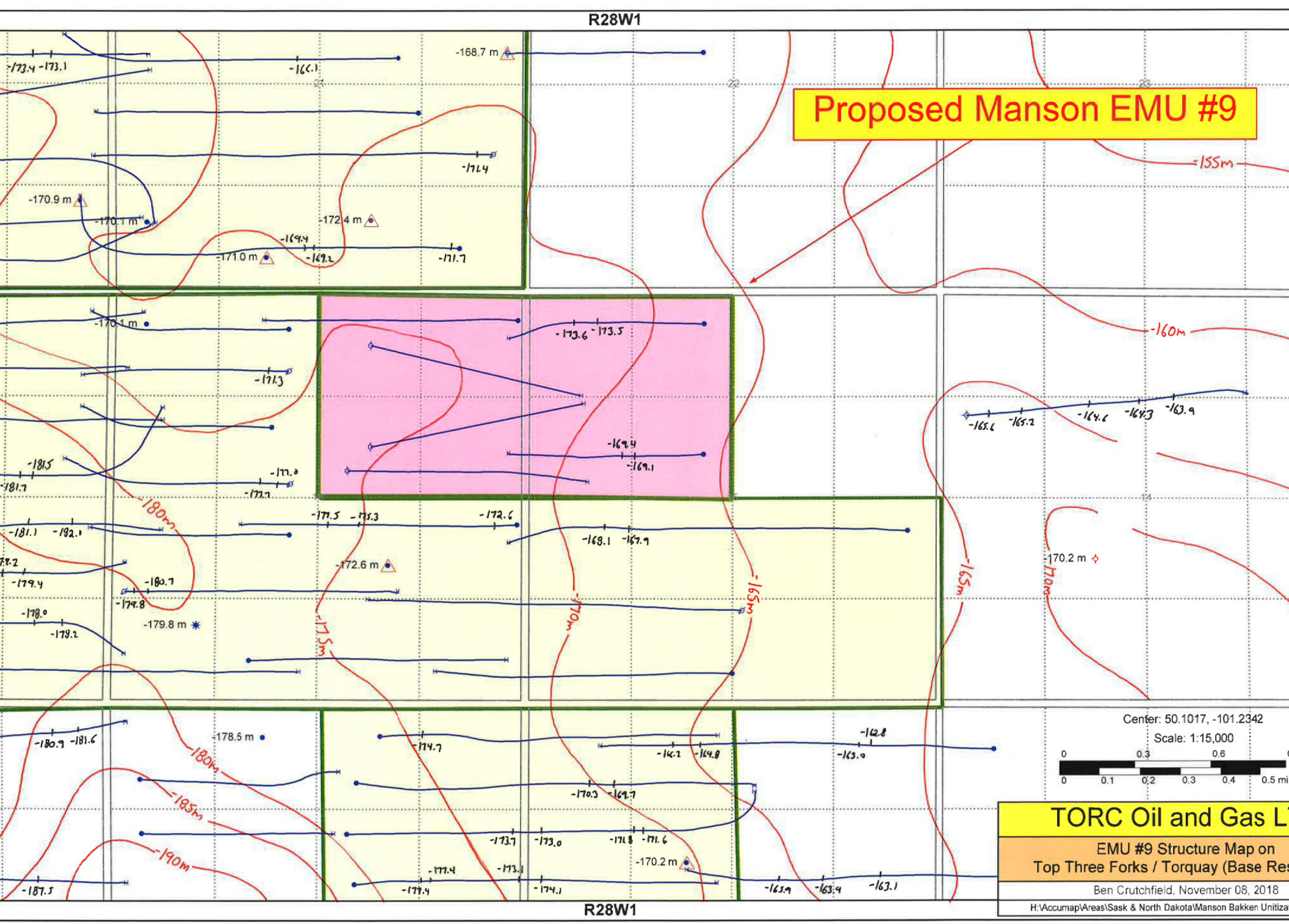


Appendix A, Figure 3: Tract Factors - EMU#9

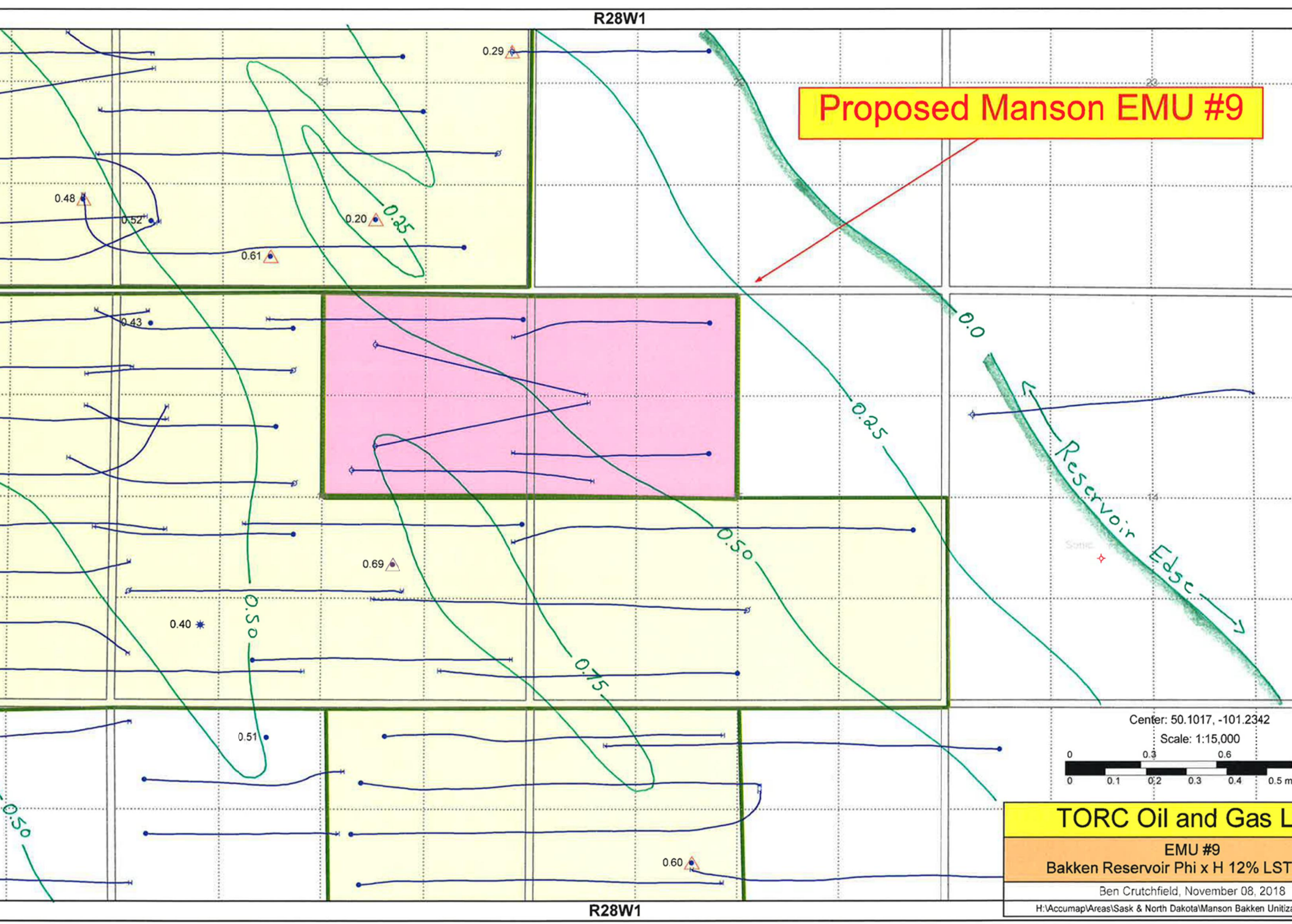
East Manson Unit No. 9							
			Oil Production				
Tract Number	Legal Description	Working Interest	OOIP (mbbl)	Cum production per Well (mbbl)	production allocation	Gross Remaining OOIP (mbbl)	Tract Factor
1	lsd 11 Sec 15-13-28W1	TORC Oil & Gas Ltd. 100%	226	43.81	50.0000000%	204	9.401811742%
2	lsd 12 Sec 15-13-28W1	TORC Oil & Gas Ltd. 100%	226	43.81	50.0000000%	204	9.401811742%
3	lsd 13 Sec 15-13-28W1	TORC Oil & Gas Ltd. 100%	226	5.348	50.0000000%	219.24124	10.099536285%
				76.059	5.3705159%		
4	lsd 14 Sec 15-13-28W1	TORC Oil & Gas Ltd. 100%	226	5.348	50.0000000%	223.32600	10.287704300%
5	lsd 9 Sec 16-13-28W1	TORC Oil & Gas Ltd. 100%	348	1.541	50.0000000%	346	15.958503825%
				2.103	50.0000000%		
6	lsd 10 Sec 16-13-28W1	TORC Oil & Gas Ltd. 100%	348	1.541	50.0000000%	346	15.958503825%
				2.103	50.0000000%		
7	lsd 15 Sec 16-13-28W1	TORC Oil & Gas Ltd. 100%	348	2.726	50.0000000%	314	14.473981701%
				76.059	42.9733241%		
8	lsd 16 Sec 16-13-28W1	TORC Oil & Gas Ltd. 100%	348	2.726	50.0000000%	313	14.418146581%
				76.059	44.5669180%		
TOTAL			**2,297**			**2,171**	**100.000000000%**

Appendix B: Geological Maps

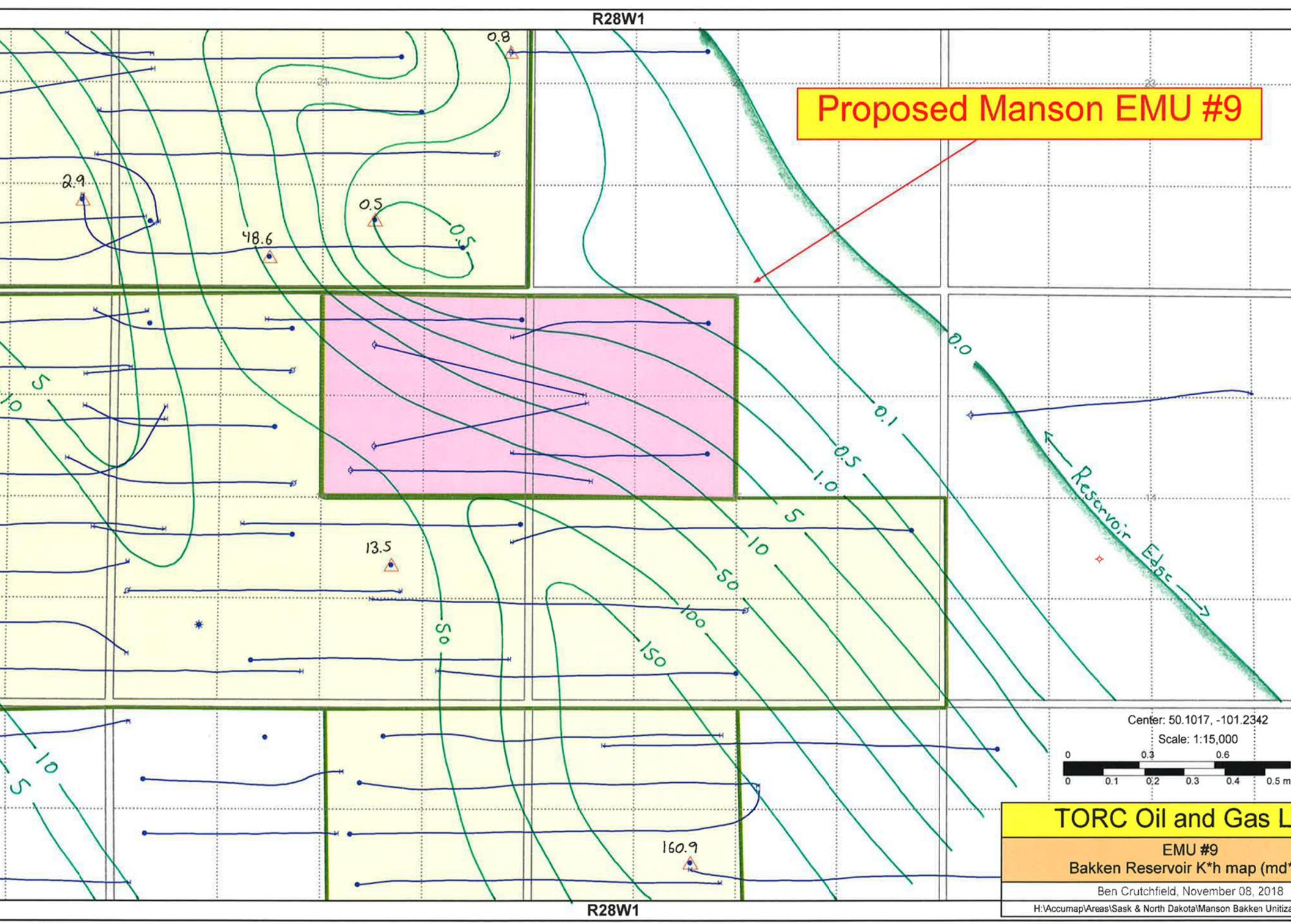




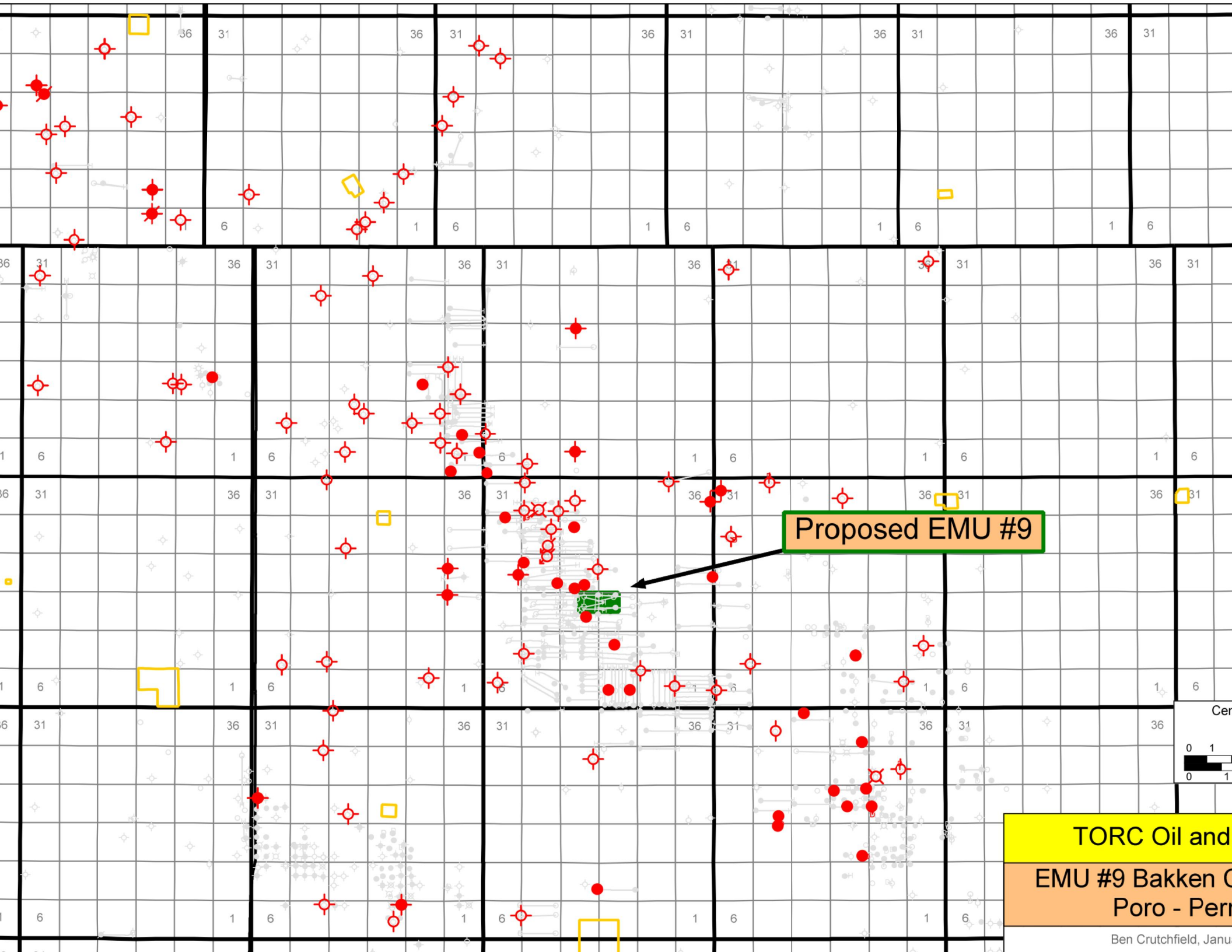
Datum: NAD27 Projection: Stereographic DLS Version AB: ATS 2.6, BC: PRB

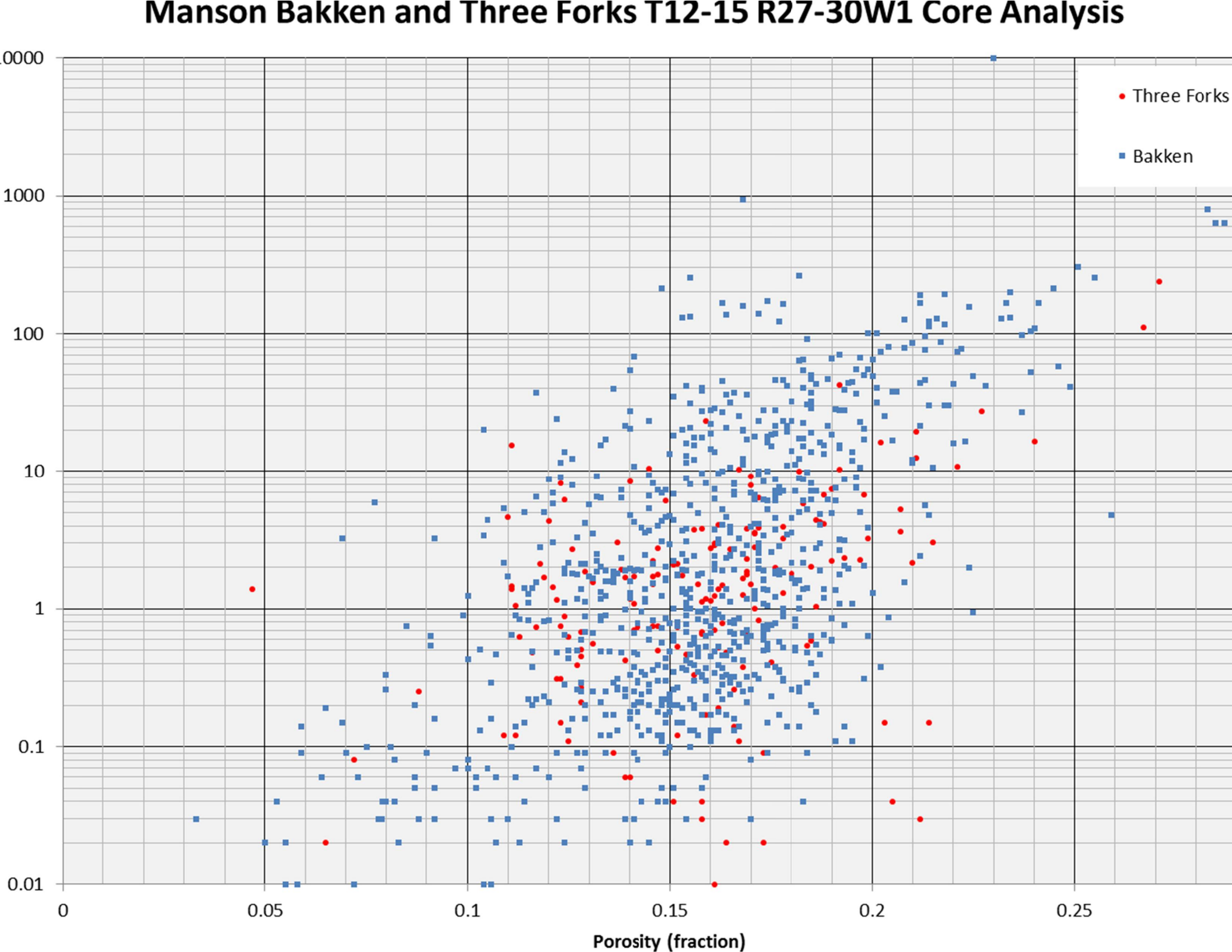


Datum: NAD27 Projection: Stereographic DLS Version AB: ATS 2.6, BC: PRE

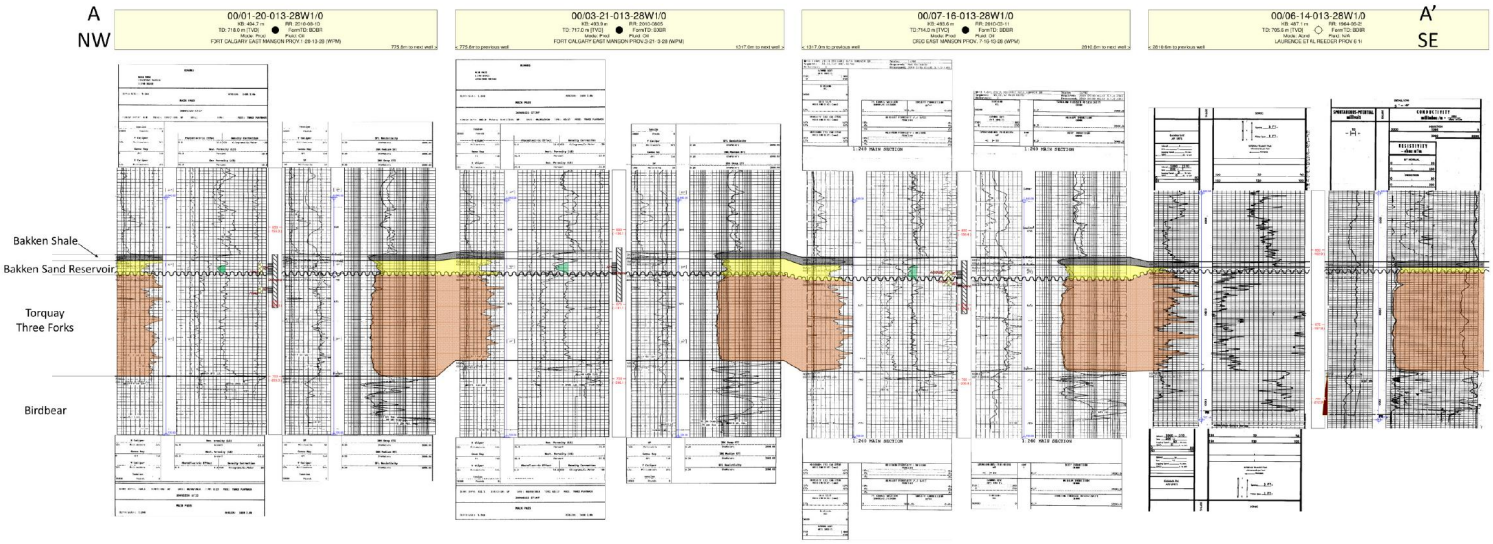


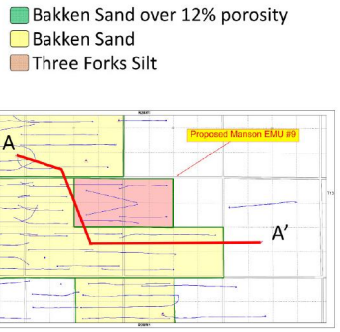
Datum: NAD27 Projection: Stereographic DLS Version AB: ATS 2.6, BC: PRB


Proposed EMU #9
TORC Oil and
EMU #9 Bakken C
Poro - Perm
Ben Crutchfield, Janu


Manson Bakken and Three Forks T12-15 R27-30W1 Core Analysis
10000
1000
100
10
1
0.1
0.01
0
0.05
0.1
0.15
0.2
0.25
Porosity (fraction)
Three Forks
Bakken

Appendix B, Figure 7: Stratigraphic Cross Section A-A' (West to East) across EMU No.9





NW – SE Structural Cross Section from the Madison to Birdbear of the Bakken Reservoir

Appendix C: Reservoir Characteristics & Recovery

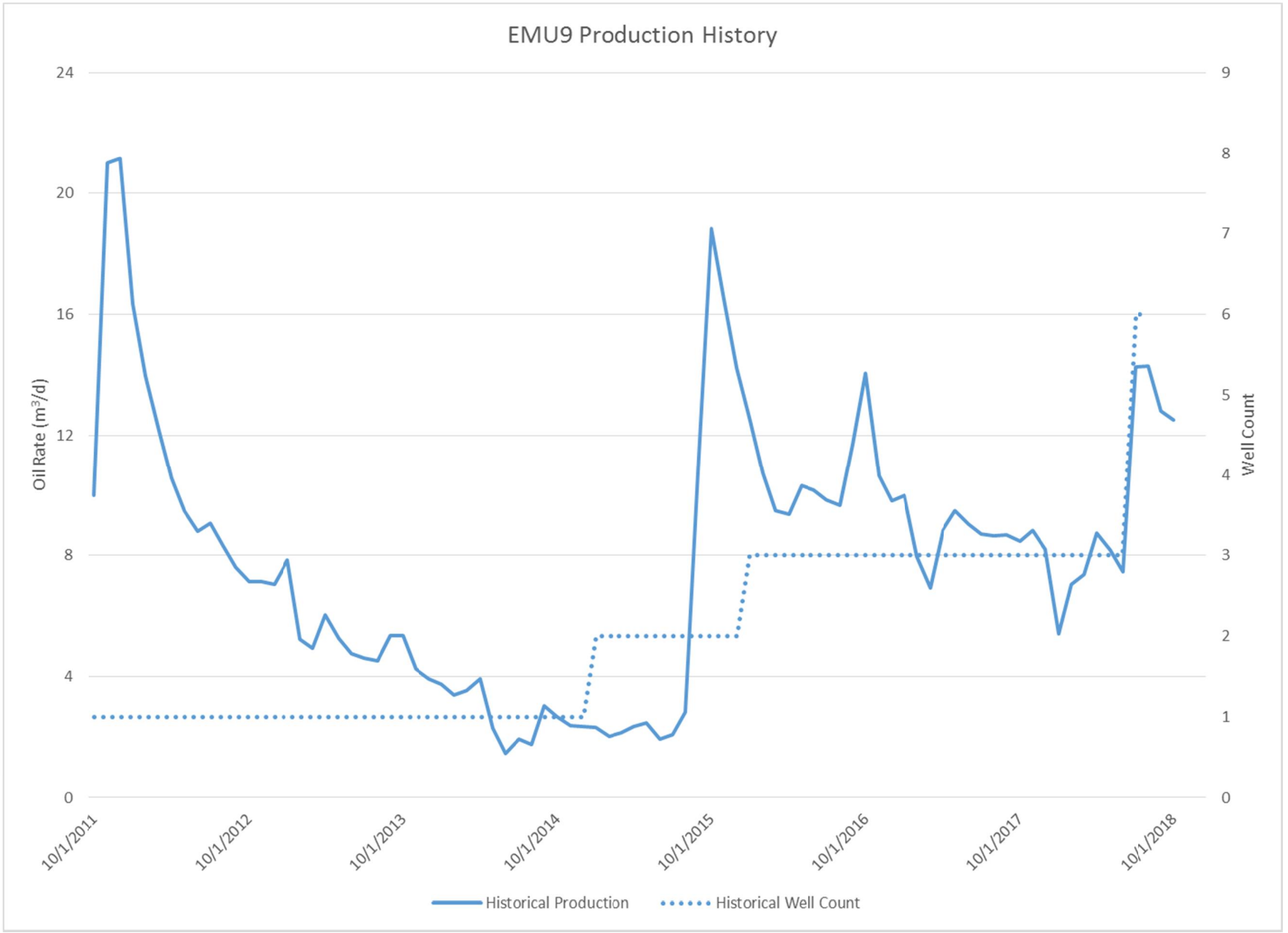
Appendix C, Figure 1: East Manson Unit No.9 OOIP

East Manson Unit No. 9		
Legal Description	**OOIP (e3m3)**	**OOIP (mbbl)**
NE/4 Sec 16-013-28W1	222	1,393
NW/4 Sec 15-013-28W1	144	904
EMU 9 Total OOIP	366	2,297

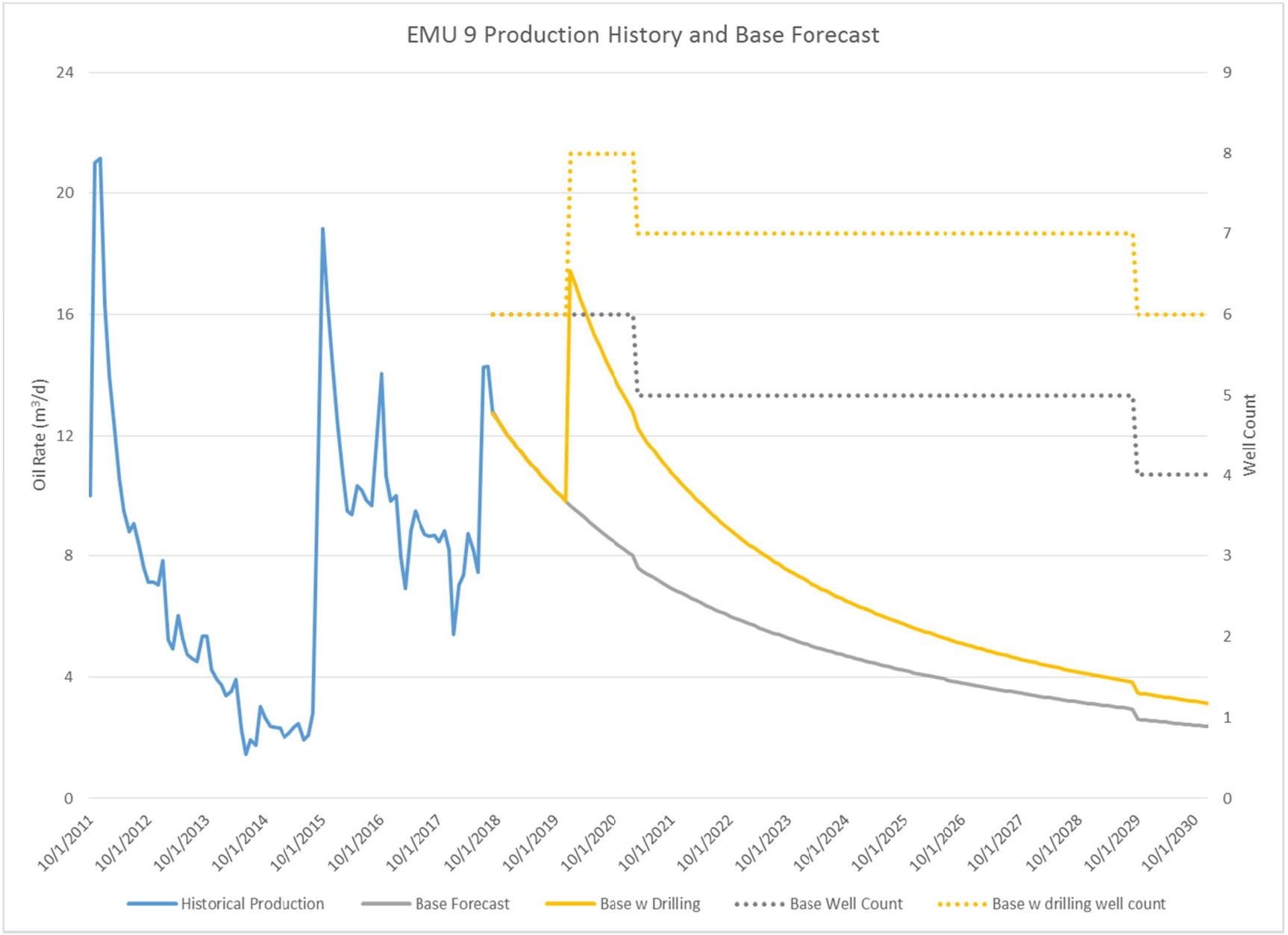
Sw = 35%

Bo (Res bbl/STB) = 1.1

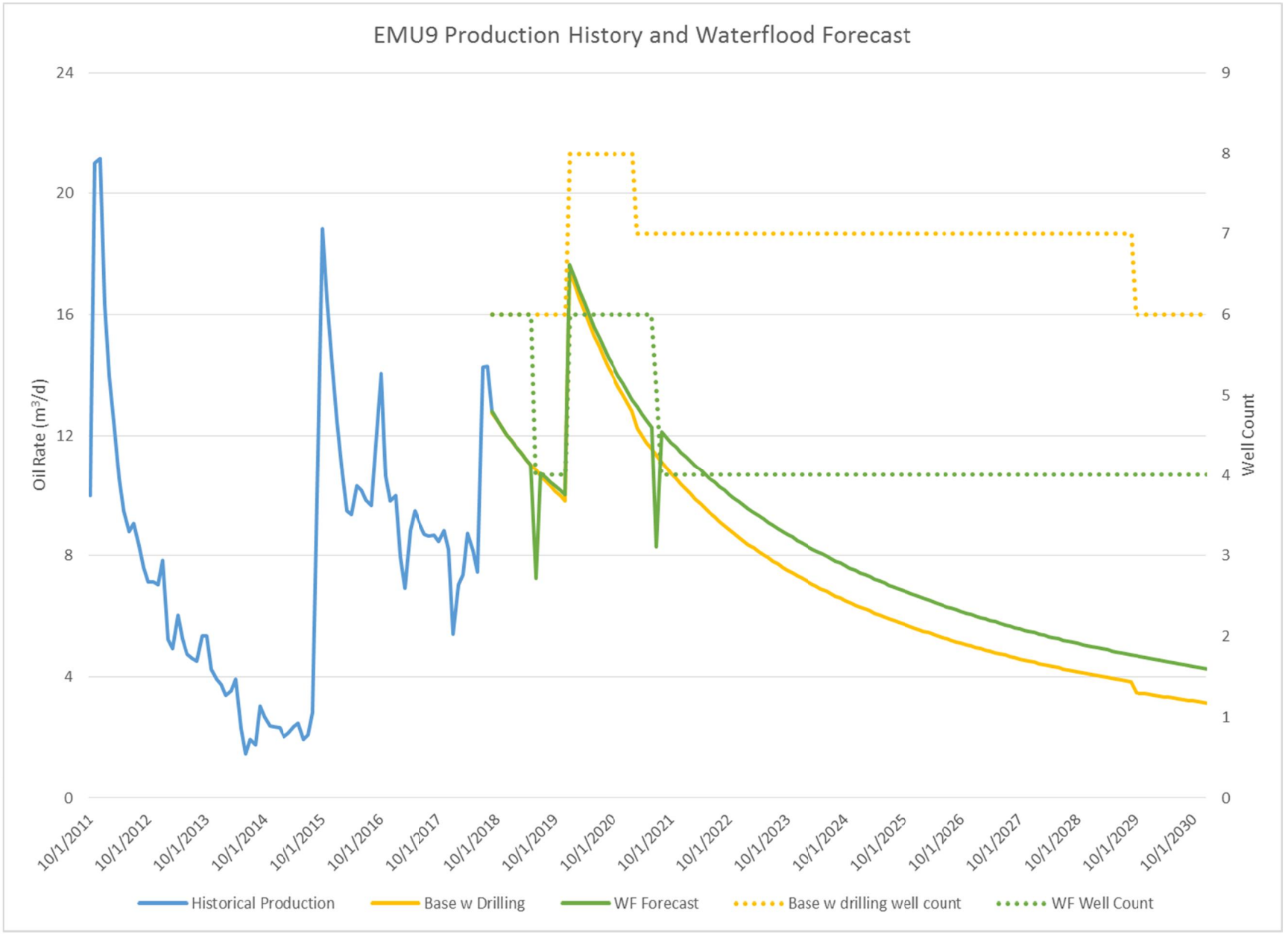
Appendix C, Figure 2: East Manson Unit No.9 Production Hist



Appendix C, Figure 3: East Manson Unit No.9 Production Base Forecasts

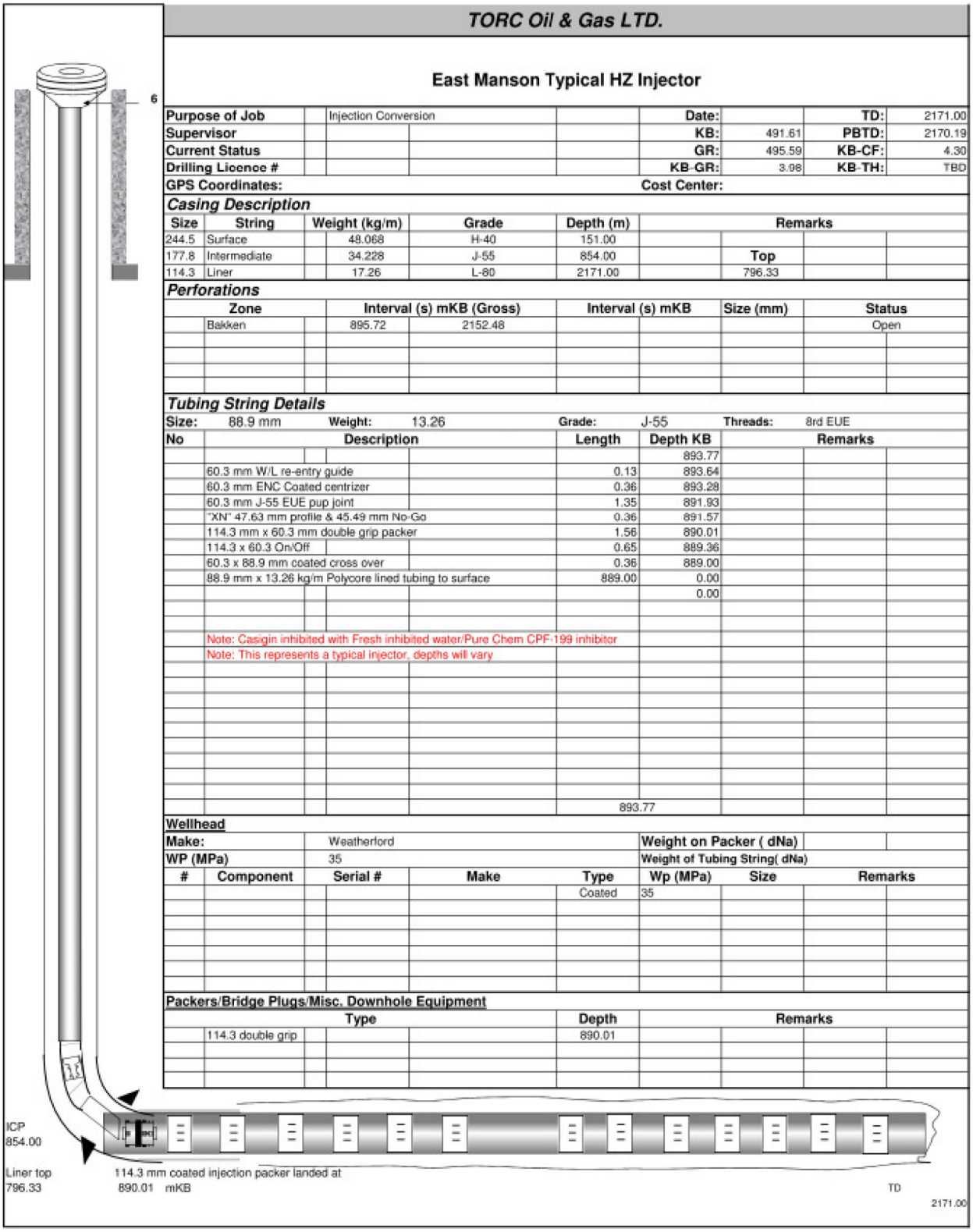


Appendix C, Figure 4: East Manson Unit No.9 Waterflood Forecast



Appendix D: Proposed Waterflood Design

Appendix D: Figure 1 Typical Horizontal Injector Schematic



TORC Oil & Gas LTD.

East Manson Typical HZ Injector

Purpose of Job	Injection Conversion		Date:		TD:	2171.00	
Supervisor			KB:	491.61	PBTD:	2170.19	
Current Status			GR:	495.59	KB-CF:	4.30	
Drilling Licence #			KB-GR:	3.98	KB-TH:	TBD	
GPS Coordinates:			Cost Center:				

Casing Description

Size	String	Weight (kg/m)	Grade	Depth (m)	Remarks	
244.5	Surface	48.068	H-40	151.00		
177.8	Intermediate	34.228	J-55	854.00	Top	
114.3	Liner	17.26	L-80	2171.00	796.33	

Perforations

Zone	Interval (s) mKB (Gross)		Interval (s) mKB	Size (mm)	Status
Bakken	895.72	2152.48			Open

Tubing String Details

Size: 88.9 mm Weight: 13.26 Grade: J-55 Threads: 8rd EUE

No	Description	Length	Depth KB	Remarks
			893.77	
	60.3 mm W/L re-entry guide	0.13	893.64	
	60.3 mm ENC Coated centrizer	0.36	893.28	
	60.3 mm J-55 EUE pup joint	1.35	891.93	
	"XN" 47.63 mm profile & 45.49 mm No-Go	0.36	891.57	
	114.3 mm x 60.3 mm double grip packer	1.56	890.01	
	114.3 x 60.3 On/Off	0.65	889.36	
	60.3 x 88.9 mm coated cross over	0.36	889.00	
	88.9 mm x 13.26 kg/m Polycore lined tubing to surface	889.00	0.00	
			0.00	
	Note: Casigin inhibited with Fresh inhibited water/Pure Chem CPF-199 inhibitor			
	Note: This represents a typical injector, depths will vary			
		893.77		

Wellhead

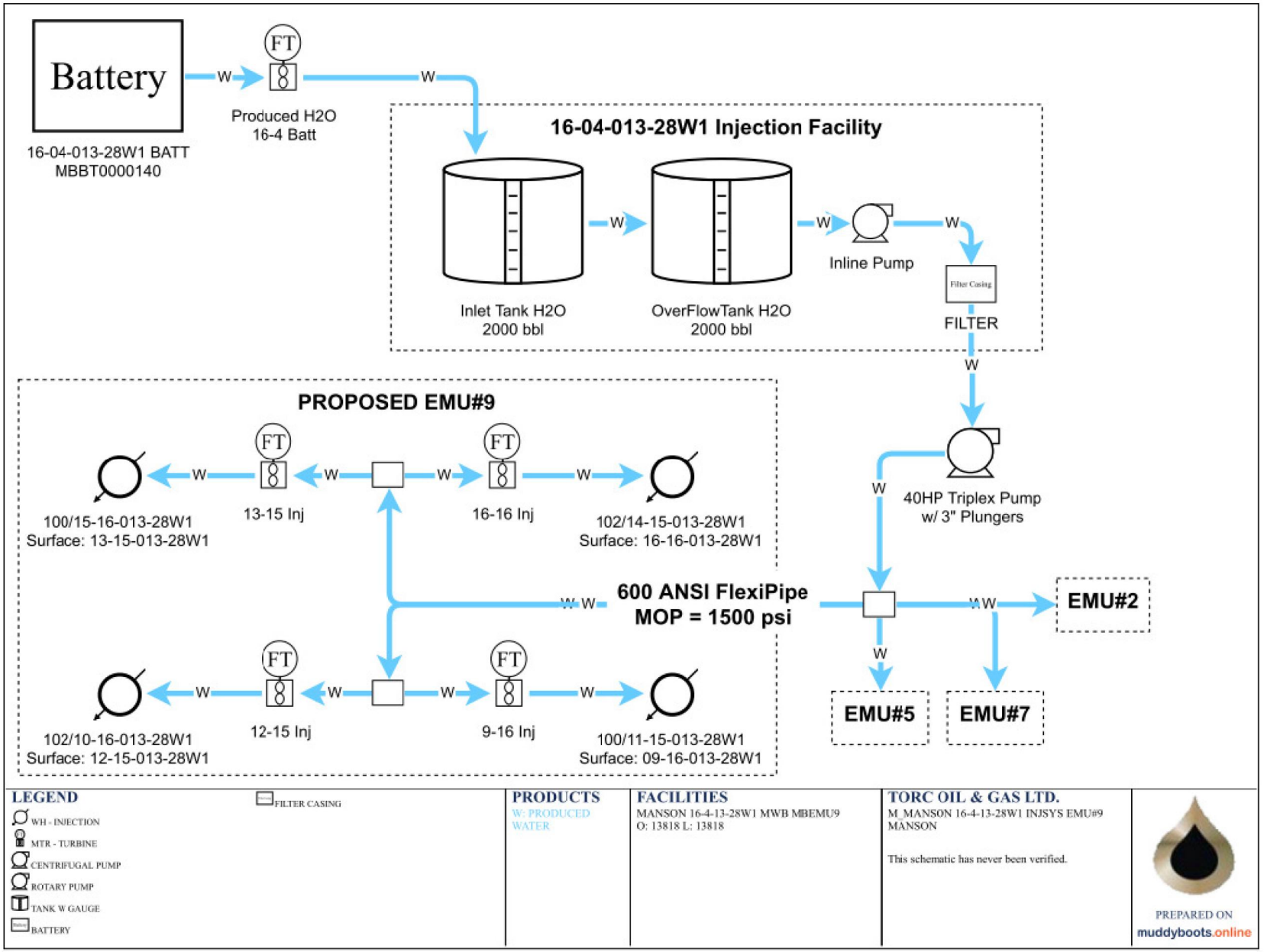
Make:	Weatherford	Weight on Packer (dNa)	
WP (MPa)	35	Weight of Tubing String(dNa)	

#	Component	Serial #	Make	Type	Wp (MPa)	Size	Remarks
				Coated	35		

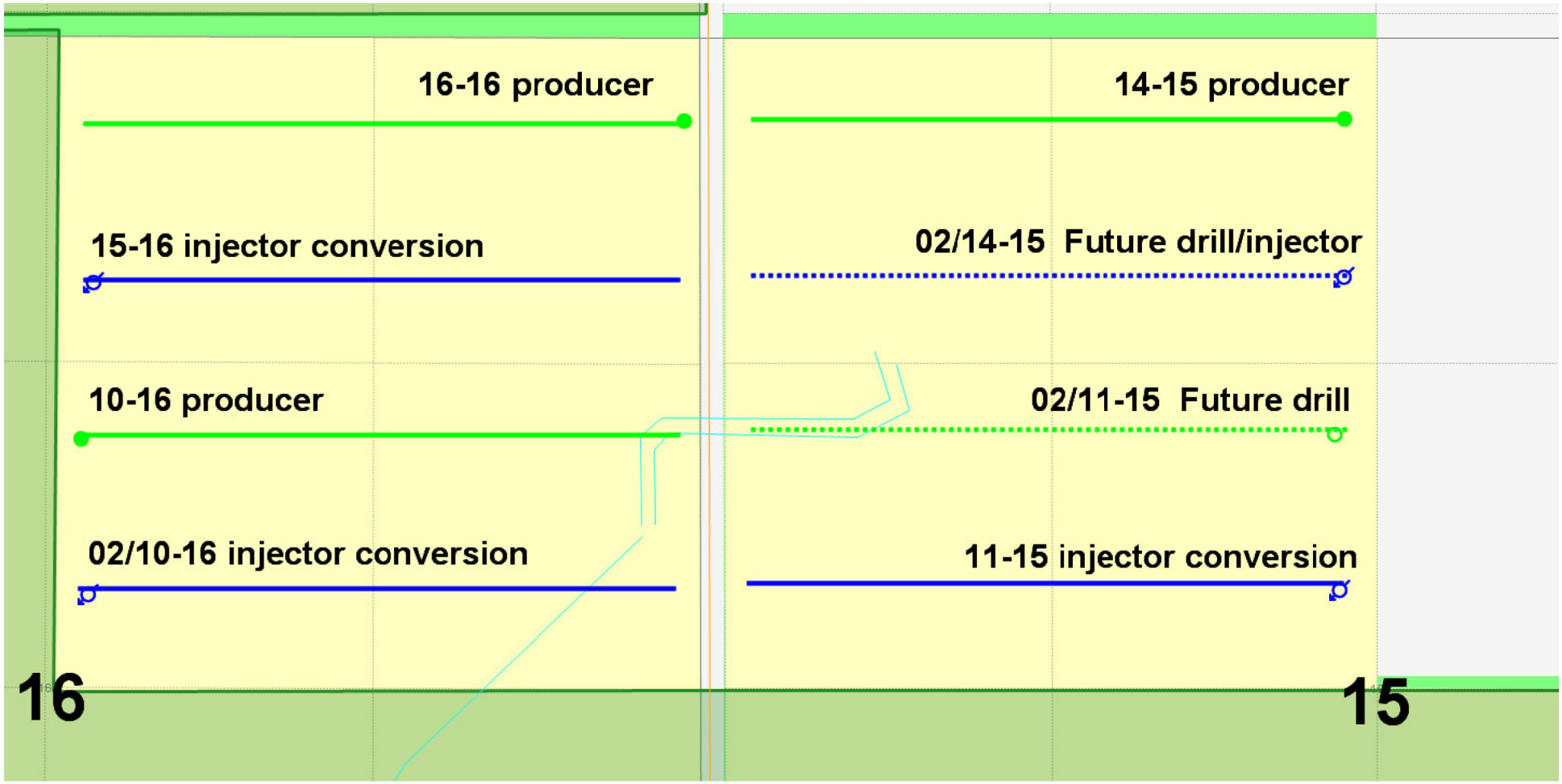
Packers/Bridge Plugs/Misc. Downhole Equipment

Type	Depth	Remarks
114.3 double grip	890.01	

Appendix D, Figure 2: Injection Diagram



Appendix D, Figure 3: Injection Scheme



Appendix D, Figure 4: Corrosion Control

East Manson Unit No.9 Corrosion Control Program

Surface Lines:

- All surface flow lines will consists of Flexpipe reinforced polyethylene pipe and/or fiberglass, both of which are corrosion resistant.
- Surface lines to injection wells will have a maximum allowable pressure of 1500 psi
- Stainless steel and aluminum bronze valves/fittings
- Isolation valves at wellheads, injection facility and camelback risers
- High and low pressure shut-down

Injection Facilities

- Internally coated storage tanks
- Stainless steel filtration system w/ 10 micron filter socks
- Pump unit consisting of tungsten carbide plungers and Delrin valves

Injection Wells

- Injector tubing will be fusion epoxy coated (FBE)
- Casing, tubing and wellhead cathodic protection
- Corrosion resistant surface lines (stainless steel or fiberglass) and aluminum bronze master valves
- Inhibited water in annular space

Producing and Source Wells

- Downhole corrosion inhibitor batch treatments and/or continuous injection of corrosion inhibitor
- Cathodic protection

Appendix E, Figure 1: EMU No. 1 Waterflood Response

Appendix E, Figure 1: EMU No. 1 Waterflood Response