

**Proposed East Manson Unit No. 7**  
**Application for Enhanced Oil Recovery Waterflood Project**  
**Middle Bakken**  
**East Manson, Manitoba**

**August 26, 2015**  
**Crescent Point Resources Partnership**

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## Introduction

The East Manson Field, which is located in Township 13 and Range 28W1, first produced in 2010 from 00/14-09-013-28W1/0 targeting the Middle Bakken formation. The field has been primarily developed with horizontal wells. Crescent Point Resources Partnership (CPG) drilled the first well in the proposed unit at 00/09-01-013-28W1/2 and is the operator of the East Manson lands in the proposed unit.

CPG is proposing a unit be created in sections 35 and 36, Township 12 and Range 28W1 and section 1 and the east half of section 2, Township 13 and Range 28W1 and believes potential exists for incremental production and reserves from a waterflood EOR project in the Middle Bakken formation. Currently, there are 9 producing horizontal wells in the proposed unit. In the third quarter of 2015, CPG drilled another 6 horizontal wells that are waiting to be tied-in. CPG plans to drill 12 more horizontal producers in 2016. A total of 12 horizontal wells will be converted to injection and CPG plans to produce the horizontal wells for a year before converting them to injectors. CPG hereby submits an application to establish East Manson Unit No. 7 and implement an Enhanced Oil Recovery Waterflood Project within the Middle Bakken Formation (Figure 1).

The proposed East Manson Unit No. 7 falls within the Manson Bakken –Three Forks pool – 17-62B (Figure 2).

## Summary

1. The proposed East Manson Unit No. 7 is to include 9 existing producing wells within 56 legal subdivisions (LSD) that were completed in the Middle Bakken formation (Figure 1).
2. The original oil in place (OOIP) for the proposed East Manson Unit No. 7 is  $1,536.6 \text{ e}^3\text{m}^3$  (9,669.9 mbbbl) for an average of  $27.4 \text{ e}^3\text{m}^3$  (172.7 mbbbl) per LSD.
3. Cumulative production in the proposed East Manson Unit No. 7 up until the end of June 2015 is  $47.2 \text{ e}^3\text{m}^3$  (296.9 mbbbl) of oil. This represents a 3.1% recovery factor of the total OOIP.
4. The expected ultimate oil recovery (EUR) of oil on primary production within the proposed East Manson Unit No. 7 using decline analysis and a horizontal type well for the 18 remaining locations is  $241.1 \text{ e}^3\text{m}^3$  (1,516.5 mbbbl) with  $193.9 \text{ e}^3\text{m}^3$  (1,219.6 mbbbl) remaining as of June 2015. The expected recovery factor would be 15.7% of the OOIP.
5. In January 2015, production from the proposed East Manson Unit No. 7 peaked at  $106.5 \text{ m}^3/\text{d}$  (669.9 bbl/d) or  $11.8 \text{ m}^3/\text{d}$  (74.4 bbl/d) per well with a 16% watercut (Figure 3).

6. Initial pressure of the Middle Bakken reservoir within the proposed East Manson Unit No. 7 is 6.2 MPa. Current pressure ranges from 2.7 MPa to 5.7 MPa.
7. East Manson Unit No. 1, located in section 29-13-28W1, was used as an analogy to predict the recovery factor under waterflood. With the implementation of a waterflood, an incremental reserves of  $161.8 \text{ e}^3\text{m}^3$  (1,017.7 mbbl) for a total EUR of  $402.9 \text{ e}^3\text{m}^3$  (2,534.2 mbbl) is expected. The incremental recovery factor is expected to be 10.5% for a total recovery factor of 26.2%.
8. The development plan includes drilling 12 additional horizontal producing wells. 12 horizontal wells will be converted to injection (Figure 4).

## **Geology**

### Stratigraphy

The stratigraphy of the Bakken Formation in East Manson Unit No. 7 is shown on the type log 9-2-13-28W1 in Appendix 1. The Bakken Formation in the 9-2-13-28W1 well consists of the Upper Bakken Shale and the Middle Bakken Sandstone. Underlying the Middle Bakken is the Torquay Formation with the contact between the two being an unconformable surface which CPG refers to as the Three Forks Unconformity. Overlying the Upper Bakken is the Basal Limestone of the Lodgepole Formation. The Middle Bakken Sandstone forms the reservoir for the East Manson pool. The cross-section (Appendix 2) shows the continuous reservoir across the proposed East Manson Unit No. 7.

### Sedimentology

The Middle Bakken in the proposed East Manson Unit No. 7 normally consists of a fine-grained sandstone to a siltstone. The upper portion of the Middle Bakken is often referred to as the “Brachiopod zone” and normally consists of an oxidized fine grained quartz siltstone. It often contains common thin walled Brachiopods and is usually quite bioturbated. This zone is indicative of a Middle Bakken shoreface type deposit and does not normally form reservoir in the East Manson area. The lower portion of the Middle Bakken consists of a fine-grained sandstone characterized by cross laminations, rip up clasts, and scouring. This zone is indicative of a higher energy environment likely representing the upper shoreface to beach facies. This zone is the main Middle Bakken producing reservoir. Permeability in the Bakken Sand within the proposed East Manson Unit No. 7 ranges anywhere from approximately 1 md to over 100 md as is demonstrated in the 9-2-13-28W1 well (Appendix 3). Porosity in this zone ranges from 16 to 23 percent.

### Structure

The Upper Bakken Structure Map in Appendix 4 shows the dip of the beds from northeast to southwest across the area from a high of -165 m to -190 m. The Torquay



Unconformity Map in Appendix 5 also shows the dip of the beds from the northeast to southwest from a high of -170 m to -195 m.

#### Reservoir

Porosity ( $\phi$ -h), permeability (k-h), and net pay maps are provided in the Appendices 6, 7, and 8. These maps were generated using the open hole logs and core data. The net pay map in Appendix 6 shows a maximum net pay thickness of 3 m. The porosity ( $\phi$ -h) map in Appendix 8 demonstrates porosity and pay thickness varies throughout with higher average porosity and net pay thickness trends northwest-southeast. The permeability (k-h) map in Appendix 7 demonstrates the variability of permeability through the area and that the higher permeability is trending northwest-southeast as well.

### **Reservoir Properties and Technical Discussion**

#### Original Oil in Place (OOIP)

The OOIP for the Middle Bakken within the proposed East Manson Unit No. 7 based on volumetrics is estimated to be  $1,536.6 \text{ e}^3\text{m}^3$  (9,669.9 mbbl) for an average of  $27.4 \text{ e}^3\text{m}^3$  (172.7 mbbl) per LSD. OOIP values were calculated using a 9% porosity net pay cutoff, which can be found in Figure 10. The OOIP was calculated internally from mapping created by Dave Sandy and Greg Anderson, who are both Professional Geologists with a number of years of experience.

PVT analysis was obtained from 00/03-16-013-28W1/0 and relative permeability analysis was obtained from a core at 00/07-16-013-28W1/0. The formation rock and fluid properties for the Middle Bakken have been summarized in Appendix 9.

#### Historical Production

The first well that was drilled was 00/09-01-013-28W1/2 and was placed on production in March 2013 and a second was drilled in August 2013. In 2014, development continued with the drilling of 4 wells. In 2015, 9 wells were drilled. Production peaked in January 2015 at  $106.5 \text{ m}^3/\text{d}$  (669.9 bbl/d) or  $11.8 \text{ m}^3/\text{d}$  (74.4 bbl/d) per well with a 16% watercut (Figure 3). In 2016, CPG plans to drill the last 12 wells.

#### Primary Recovery

Cumulative production in the proposed East Manson Unit No. 7 up until the end of June 2015 is  $47.2 \text{ e}^3\text{m}^3$  (296.9 mbbl) of oil and  $22.1 \text{ e}^3\text{m}^3$  (139.1 mbbl) of water. This represents a 3.1% recovery factor of the total OOIP. Based on decline analysis and a  $5.0 \text{ e}^3\text{m}^3$  (31.4 mbbl) type well for the future horizontal locations, the EUR on primary production is  $241.1 \text{ e}^3\text{m}^3$  (1,516.5 mbbl) with  $193.9 \text{ e}^3\text{m}^3$  (1,219.6 mbbl) remaining as of June 2015 (Figures 8 and 9). The expected recovery factor would be 15.7% of the total OOIP (Figure 10).

### Secondary Recovery

East Manson Unit No. 1, located in section 29-13-28W1, was used as an analogy to predict the recovery factor under waterflood (Figures 5, 6 and 7). Based on  $882.6 \text{ e}^3\text{m}^3$  (5,551.6 mbbbl) OOIP, the total recovery factor with waterflood is 28.0%.

With the implementation of a waterflood in the proposed East Manson Unit No. 7, the incremental reserves would be  $161.8 \text{ e}^3\text{m}^3$  (1,017.7 mbbbl) for a total EUR of  $402.9 \text{ e}^3\text{m}^3$  (2,534.2 mbbbl) (Figures 8 and 9). The incremental recovery factor is expected to be 10.5% for a total recovery factor of 26.2%, which matches the analog in East Manson Unit No. 1 (Figure 10).

### **Unitization**

The basis for unitization is to implement a waterflood is to increase the overall recovery of the OOIP from the proposed project area.

### Unit Name

CPG proposes that the official name of the new unit shall be East Manson Unit No. 7.

### Unit Operator

CPG will be the Operator for East Manson Unit No. 7.

### Unitized Zones

The unitized zone to be water flooded in the East Manson Unit No. 7 will be the Middle Bakken/Torquay Formation.

### Unit Wells

The 9 producing wells, 6 standing wells (waiting on tie-in) and 12 locations in the proposed East Manson Unit No. 7 are outlined in Appendix 10 with their current status. The projected timing of the new drills and injector conversions is also included.

### Unit Lands

The East Manson Unit No. 7 will consist of all 56 LSDs in sections 35 and 36, Township 12 and Range 28W1 and section 1 and the east half of section 2, Township 13 and Range 28W1. The lands included in the 40 acre tracts are outlined in Appendix 11.

### Tract Factors

The proposed East Manson Unit No. 7 will consist of 56 tracts based on remaining OOIP using maps created internally by CPG per LSD, as of June 2015. The production from the horizontal wells was divided according to the existing production allocation agreement. The calculation of the tract factors are outlined in Appendix 12.

### Working Interest Owners

Appendix 11 outlines the working interest for each recommended tract within the proposed East Manson Unit No. 7. CPG will have a 100% WI across all tracts.



## **Waterflood Development**

The 6 standing wells drilled in 2015 will be tied in during the third quarter and the remaining 12 locations will be drilled and placed on production in 2016. There will be a total of 12 horizontal wells converted to injection in 2016 after being produced for one year (Figure 4). After full development and the implementation of the waterflood, there will be 15 horizontal producers and 12 horizontal injectors.

### Waterflood Operating Strategy

The proposed East Manson Unit No. 7 will be tied into CPG's battery at 16-4-13-28W1. Injected water will be a combination of Middle Bakken produced water and Lower Lodgepole water from a future source well located at 00/01-09-013-28W1/0. Production is sent to the battery at 16-4-13-28W1, where the water is separated, filtered and distributed to the injection system. A simplified process flow diagram of the system from the 16-4-13-28W1 to the injectors is located in Figure 15.

Compatibility testing will occur once the source well at 00/01-09-013-28W1/0 has been drilled. All potential mixture ratios between the source water and produced water will be simulated and evaluated for scaling and precipitate producing tendencies.

The injector wells will be equipped with injection volume metering and rate/pressure control (Figures 12 and 13). Water injection volumes and metre balancing will be utilized to monitor the entire system measurement and integrity on a daily basis.

The corrosion control program outlining the planned system design and operational practices to prevent corrosion is located in Figure 14.

### Reservoir Pressure

The initial pressure taken at 00/08-36-012-28W1/0 was measured to be 6.2 MPa. Current pressure ranges from 2.7 MPa to 5.7 MPa (Appendix 9). The saturation pressure from PVT analysis done on 00/03-16-013-28W1/0 is 3.6 MPa. The PVT analysis has indicated a low solution GOR of  $6 \text{ m}^3/\text{m}^3$ . The combination of the drop below the bubble point with almost no gas in solution means that there is very little energy in the reservoir. CPG believes a waterflood is required to provide energy for the reservoir and increase oil recovery. Reservoir pressure will be increased back to original reservoir pressure by maintaining a monthly voidage replacement ratio (VRR) of 1.3-1.5 until a cumulative VRR of 1.0 is reached.

### Waterflood Surveillance and Optimization

The response and waterflood surveillance of East Manson Unit No. 7 will consist of the following:

- Regular production well testing to monitor fluid rate and water cut to watch for waterflood response
- Comparison of daily injection rates and pressure monitoring to targets

- Monitor monthly and cumulative voidage replacement ratio by pattern and overall unit
- Evaluation of Hall plots
- New injection targets will be sent to the field on a regular basis

#### Injector Conversions

The producing wells that will be converted to injection will be produced for a full year before conversion and will take place in 2016. The tubing and rods will be removed and replaced with internally coated tubing. A typical injector schematic for a horizontal injector is shown in Figure 11.

#### Injection Rates and Pressures

CPG plans to inject water into the Middle Bakken to re-pressurize and add energy to the reservoir. Initial instantaneous VRR targets will be between 1.3 and 1.5 until a cumulative VRR of 1.0 is reached. Initial forecasts suggest the injection requirements will be between 250 m<sup>3</sup>/d (1,573 bbl/d) and 300 m<sup>3</sup>/d (1,887 bbl/d) or 21 m<sup>3</sup>/d (131 bbl/d) and 25 m<sup>3</sup>/d (157 bbl/d) per injector.

Completion data from wells that have been stimulated by hydraulic fractures in the East Manson area indicates a fracture gradient of 20.0 kPa/m. This works out to a fracture pressure at the sandface 13,400 kPa or 6,700 kPa at the wellhead. The requested maximum wellhead injection pressure will be 90% of the fracture pressure which is 6000 kPa.

#### Economic Limit

The economic limit will be when the net oil rate and net oil price revenue stream becomes less than the current producing operating costs. Based on current price forecasts, the economic limit for the project would be 5 m<sup>3</sup>/d.

#### **Notifications**

CPG has notified all surface and mineral owners within the proposed unit and the surrounding 500 m of the unit boundary about the application for unitization and waterflood of sections 35 and 36-12-28W1 and section 1 and the east half of section 2-13-28W1 (Appendices 13-17). Copies of receipts and delivery notifications to all stakeholders are attached in Appendix 18.

East Manson Unit No. 7 unitization and execution of the formal East Manson Unit No. 7 agreement by affected mineral owners will occur once the Petroleum Branch has reviewed the tract factors. Copies of the agreement will be forwarded to the Petroleum Branch to complete the East Manson Unit No. 7 application.

Please contact Jeff [REDACTED] at 403-767-6946, by email at [jsmith@crescentpointenergy.com](mailto:jsmith@crescentpointenergy.com) or at Suite 2000, 585-8<sup>th</sup> Ave SW, Calgary, Alberta, T2P 1G1 for any other questions or clarification.



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## **Proposed East Manson Unit No. 7**

### **Application for Enhanced Oil Recovery Waterflood Project**

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## **Proposed East Manson Unit No. 7**

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