

**EWART UNIT NO. 5  
WATERFLOOD EOR PROJECT**

**ANNUAL REPORT FOR 2015**

**June 29, 2016**

**Tundra Oil and Gas Partnership**

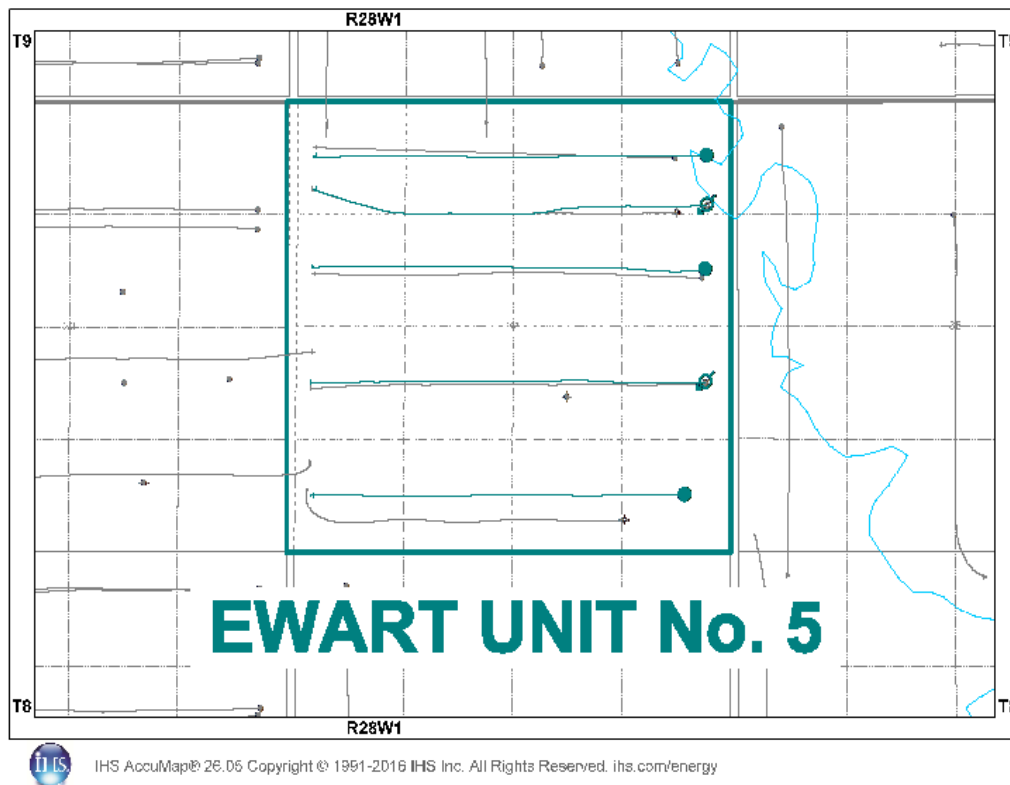
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## **INTRODUCTION**

Ewart Unit No. 5 Enhanced Oil Recovery (EOR) Scheme was approved under EOR Order No. 35 effective April 1, 2014 with Tundra Oil and Gas (Tundra) as Operator. The EOR project area contains 3 horizontal producing wells and 2 horizontal injection wells in Section 34 Township 8 Range 28 W1 as shown in the figure below.

**Figure 1: Ewart Unit No. 5 Area Outline**



In accordance with Section 73 of the Manitoba Drilling and Production Regulation, Tundra hereby submits the following 2015 Annual Progress Report for Ewart Unit No. 5.

## **DISCUSSION**

### **Production History**

For the wells included in Ewart Unit No. 5, production started in July 2008 with the 00/01-34-008-28W1 well. Average oil production peaked at 14.17 m<sup>3</sup>/d per well in December of 2009. This production was coming from 3 wells and totaled 42.52 m<sup>3</sup>/d for the Unit. In December 2015, the Unit was producing 4.02 m<sup>3</sup>/d of oil and 3.46 m<sup>3</sup>/d of water. Water injection commenced in Ewart Unit No. 5 in March 2015. Gas injection

commenced in September 2015 in the 02/16-34-008-28W1 location. The rates and WOR are presented in Figure 2.

**Figure 2: Ewart Unit No. 5 Production/Injection Rates and WOR vs Time**

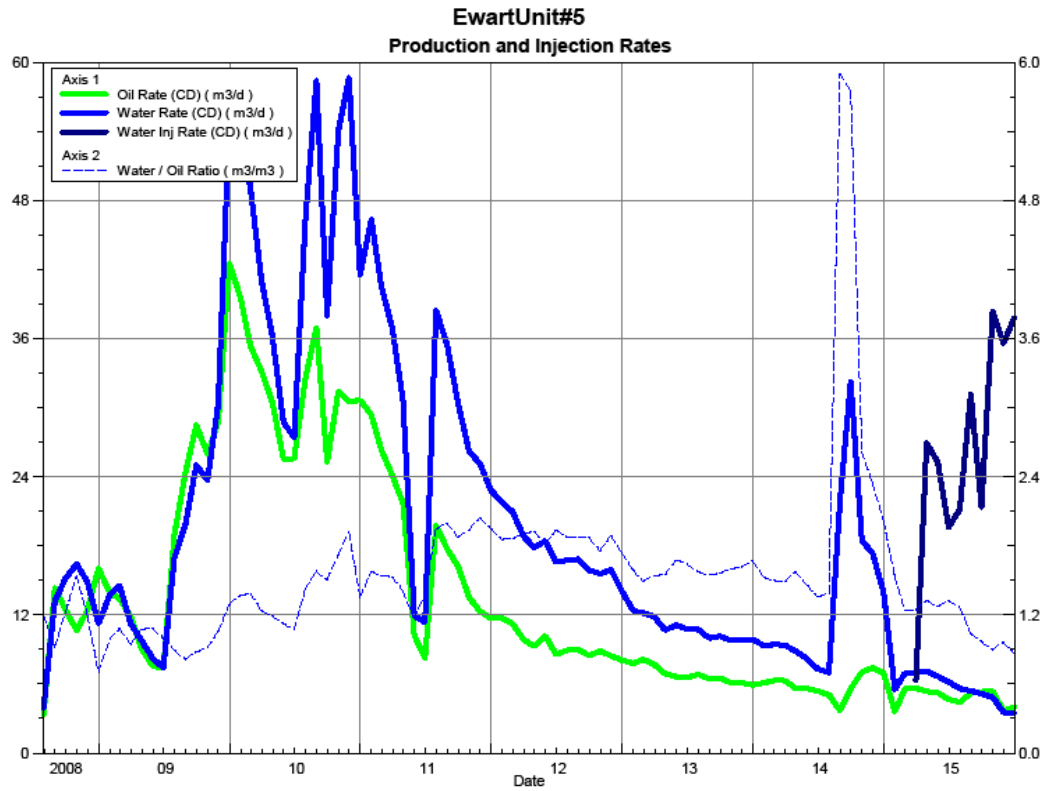
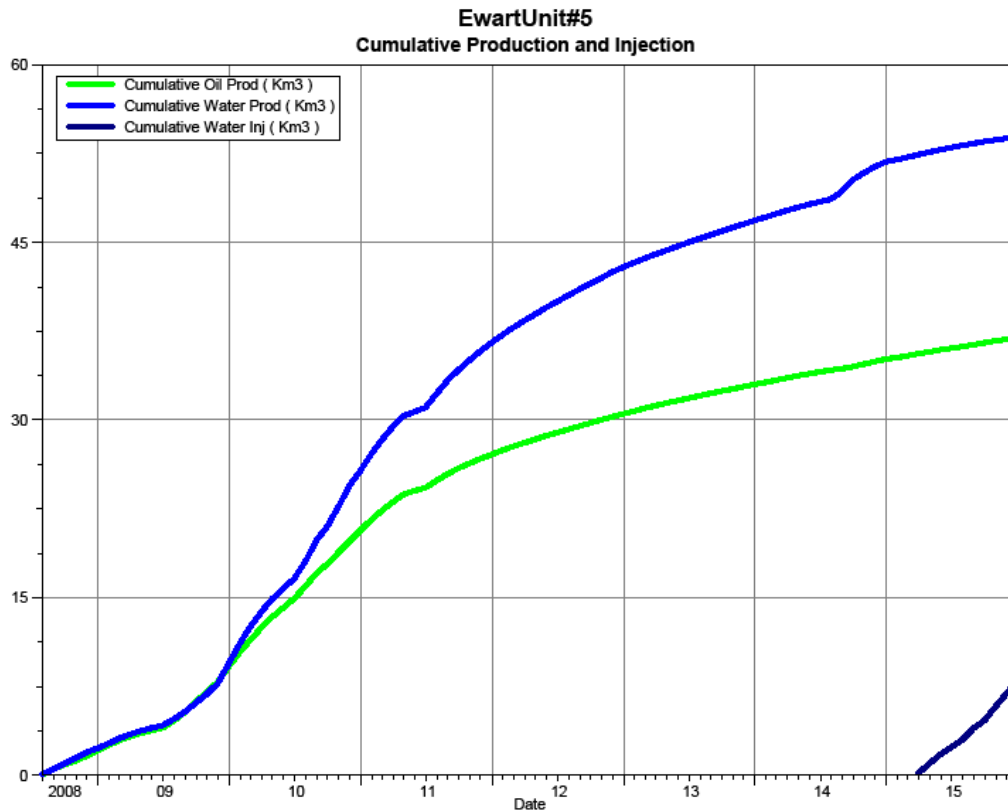


Figure 3 shows the cumulative production for Ewart Unit No. 5 to the end of December 2015 as 36.93 e³m³ of oil, and 53.87 e³m³ of water, representing an 8.3% recovery factor of the OOIP. The cumulative water injected is 8.07 e³m³ and the cumulative gas injected is 0.755 e³m³ (Table 2, Appendix A)

**Figure 3: Ewart Unit No. 5 Cumulative Oil, Water and Water Injected vs Time**



## **Waterflood Development Plan**

### **Ewart Unit No. 5 Waterflood (WF) Development Plan**

Ewart Unit No. 5 is still in the development phase at the end of 2015. The purpose of this Immiscible Gas Injection Pilot is to install gas injection in Section 34 and evaluate over a 5 year period whether water alternating gas (WAG) injection will result in improved oil recovery in areas where waterflooding and miscible gas flooding could be economically challenged due to poor reservoir quality.

Two injection wells are proposed for the unit. The 08-34-008-28W1 (08-34) is an existing producer that will be converted to an injector. In July 2014, the 02/16-34-008-28W1 (02/16-34) proposed horizontal injector was drilled between 09-34 and 16-34-008-28W1. The new horizontal well was not fracture stimulated unlike the 08-34 future injector.

Tundra plans to inject water prior to gas in both wells to allow the reservoir pressure to build up without the risk of early gas breakthrough. Due to 08-34 having spent several years as a producer, Tundra expects the voidage around this wellbore to take a bit longer

to fill up. Tundra plans to alternate water and gas injection in the two injection wells. The duration and frequency between the WAG cycles will depend on:

- the well's injectivity to each substance (water and nitrogen),
- production response from the offset producers, and
- the capacity of the nitrogen generating equipment being reached.

Water injection began in Ewart Unit No. 5 in March 2015, after the conversion of the 08-34 and 02/16-34 existing horizontal producers to injection wells. Tundra commenced gas injection in the 02/16-34 well in September 2015.

Production performance by injector pattern is summarized in Appendix A.

Any future revisions to the waterflood development or surveillance plan would be based on new production or performance response data, technical studies, or observed reservoir behavior and reserves recovery interpretations.

## **Waterflood EOR Operating Strategy and Performance**

### **N<sub>2</sub> Source**

The N<sub>2</sub> for this pilot will be generated on site through an N<sub>2</sub> PSA Generator. In general transporting liquid nitrogen is much more difficult than CO<sub>2</sub> due to its low boiling point temperature. This unit filters the N<sub>2</sub> from the atmosphere and compresses and stores it on site.

### **Water Source and Quality**

The injection water for Ewart Unit No. 5 will be sourced from the 16-32-007-29W1 well (Lodgepole formation). The water is treated at the 03-04-008-29W1 battery where it is filtered to 0.5 microns and has scale inhibitor added. The injection water is then distributed to the injectors through the dedicated infrastructure system.

### **Injection Wellhead Pressures**

Water injection started in this Unit in March 2015. The average monthly wellhead injection pressure for each injector is summarized in Appendix B. Since injection in this Unit is still in the early stages, the injectors are still building up to a target injection pressure of 7000 kPa.

### **Reservoir Pressure**

Where practical, Tundra is committed to collecting pressure data from newly drilled injection wells. For Ewart Unit No. 5, pressure data is currently available for the 02/16-34 location. A summary table is presented in Appendix C. Pressures are corrected to a common datum of -450 m SS for comparison with other units in the area.

### **Well Servicing**

The following table summarizes the well servicing performed within Ewart Unit No. 5 in 2015:

100.09-34-008-28W1.00	Pump Change	11/24/2015
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### **Waterflood Performance Discussion**

At the end of 2015, Ewart Unit No. 5 had 2 injection patterns in place. In 2015, the 2 horizontal producers, 08-34 and 02/16-34-008-28W1 were converted to injectors. This unit will have a combination of waterflood patterns at 20 acre and 40 acre spacing having utilized the existing horizontal wells in the area.

Tundra expects to alternate N<sub>2</sub> and water injection every 1-6 months to optimize the flood front and minimize gas channeling and breakthroughs. The initial Voidage Replacement Ratio (VRR) is expected to be approximately 1.25 to 3.00 within the patterns during the fill up period. As the cumulative VRR approaches 1, target reservoir operating pressure for waterflood operations will be 75-90% of original reservoir pressure.

A summary table of the injector pattern(s) is presented in Appendix A. Plots of the production are presented in Appendix D for each of the injection pattern(s).

**Table No. 1**

	<b>100/08-34</b>			<b>102/16-34</b>		
	<b>Avg Gas Inj (sm3/d)</b>	<b>Avg Gas Inj (rm3/d)*</b>	<b>Wtr Inj (rm3/d)</b>	<b>Avg Gas Inj (sm3/d)</b>	<b>Avg Gas Inj (rm3/d)*</b>	<b>Wtr Inj (rm3/d)</b>
<b>Feb-15</b>	0.00	0.00	0.00	0.00	0.00	0.00
<b>Mar-15</b>	0.00	0.00	6.10	0.00	0.00	2.47
<b>Apr-15</b>	0.00	0.00	18.17	0.00	0.00	8.79
<b>May-15</b>	0.00	0.00	19.35	0.00	0.00	5.90
<b>Jun-15</b>	0.00	0.00	15.23	0.00	0.00	4.40
<b>Jul-15</b>	0.00	0.00	20.65	0.00	0.00	0.48
<b>Aug-15</b>	0.00	0.00	26.71	0.02	0.00	4.48
<b>Sep-15</b>	0.00	0.00	21.37	252.14	3.74	0.00
<b>Oct-15</b>	0.00	0.00	38.35	319.49	4.73	0.00
<b>Nov-15</b>	0.00	0.00	35.60	613.62	9.09	0.00
<b>Dec-15</b>	0.00	0.00	37.84	485.16	7.19	0.00

\* 7.0 MPa @ 30 oC



**Table No. 2**

WELL	Date	Mth_Inj_N2 (kgs)	Mth_Inj_N2* (rm3)	Mth_Inj_Water (rm3)	Avg_WH_Inj_Pressure (kPa)
02/16-34-008-28W1/2	03/01/2015	0	0	7	1
02/16-34-008-28W1/2	04/01/2015	0	0	264	2180
02/16-34-008-28W1/2	05/01/2015	0	0	183	3179
02/16-34-008-28W1/2	06/01/2015	0	0	132	3221
02/16-34-008-28W1/2	07/01/2015	0	0	15	109
02/16-34-008-28W1/2	08/01/2015	0	0	139	3969
02/16-34-008-28W1/2	09/01/2015	8926	112	0	6702
02/16-34-008-28W1/2	10/01/2015	11687	147	0	6540
02/16-34-008-28W1/2	11/01/2015	21722	273	0	6913
02/16-34-008-28W1/2	12/01/2015	17747	223	0	6696
00/08-34-008-28W1/0	03/01/2015	0	0	189	19
00/08-34-008-28W1/0	04/01/2015	0	0	545	-77
00/08-34-008-28W1/0	05/01/2015	0	0	600	-81
00/08-34-008-28W1/0	06/01/2015	0	0	457	-80
00/08-34-008-28W1/0	07/01/2015	0	0	640	-78
00/08-34-008-28W1/0	08/01/2015	0	0	828	-79
00/08-34-008-28W1/0	09/01/2015	0	0	641	-81
00/08-34-008-28W1/0	10/01/2015	0	0	1189	432
00/08-34-008-28W1/0	11/01/2015	0	0	1068	1124
00/08-34-008-28W1/0	12/01/2015	0	0	1173	2025

\*7.0 MPa @ 30 oC

## **List of Appendices**

Appendix A: Injection Pattern Summary

Appendix B: Injection Pressure Summary

Appendix C: Reservoir Pressure Summary

Appendix D: Injector Pattern Production/Injection Rates, Cumulative and VRR Plots for  
the following injectors:

00/08-34-008-28W1/0

02/16-34-008-29W1/2

## Appendix A

### Ewart Unit No. 5 Injection Pattern Summary as of December 2015

[illegible]

## Appendix B

### Average Monthly Injection Pressure (kPag)

Month	100/08-34	102/16-34
Jan-15	-	-
Feb-15	0	0
Mar-15	19	1
Apr-15	-77	2180
May-15	-81	3179
Jun-15	-80	3221
Jul-15	-78	109
Aug-15	-79	3969
Sep-15	-81	6702
Oct-15	432	6540
Nov-15	1124	6913
Dec-15	2025	6696

## APPENDIX C

### Ewart Unit No. 5 - Pressure Summary

Location	Test Date	Final Pressure (kPaa)	MPP (mTVD)	KB	Datum Depth	Gradient	Pressure @ -450 masl
102/16-34-008-28W1/02	July 29th - Sept 7th, 2014	3402.9	874.9	484.5	-450	8.25	3895

## **Appendix D**

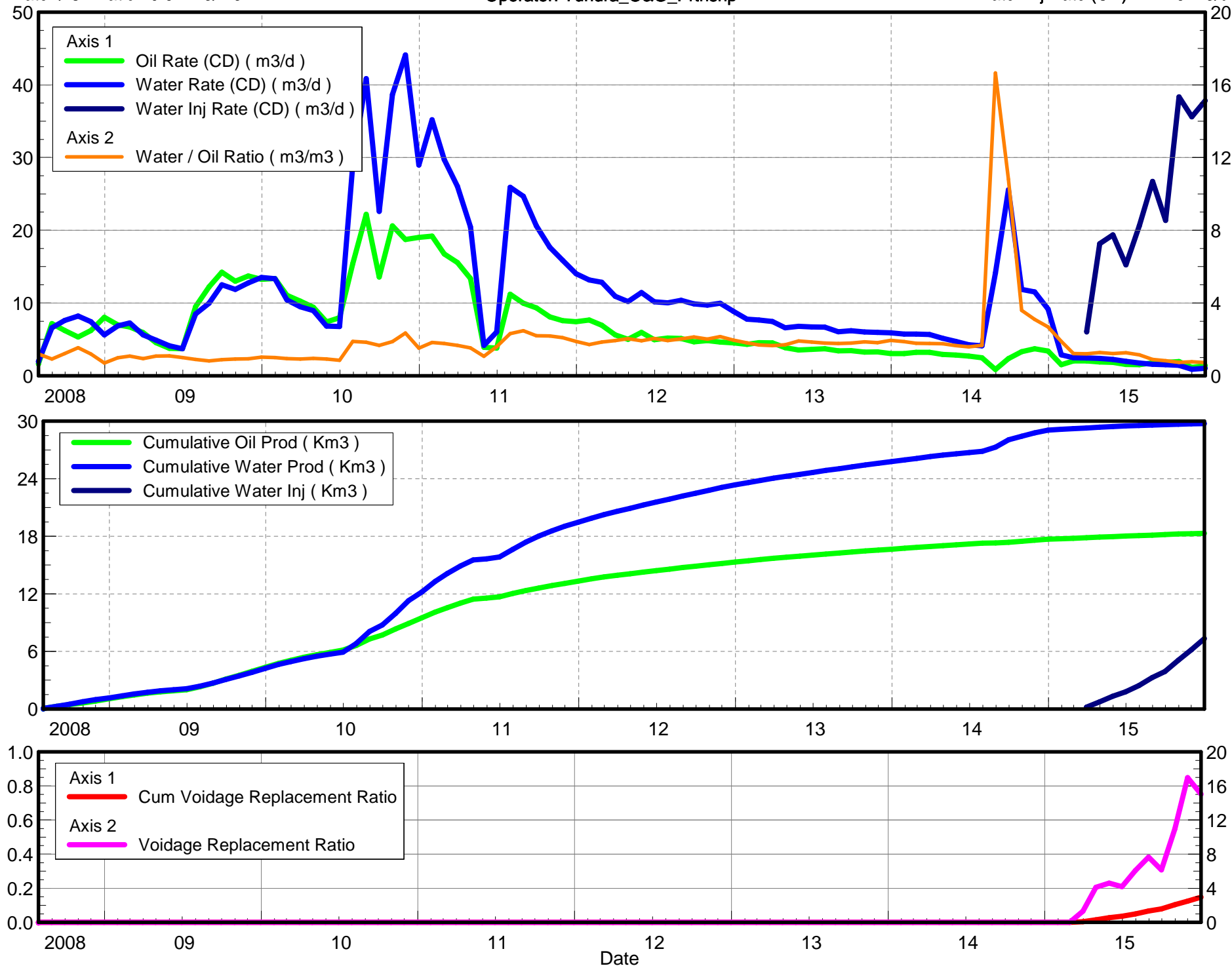
### **Rates and VRR Plots**

Oil Formation Vol Factor : 1.07100 m3/m3  
Water Formation Vol Factor : 1.00150 m3/m3  
Water / Oil Ratio : 0.52 m3/m3

Pattern: 00/08-34-008-28Inj Set: EwartUnit#5

June 29, 2016  
Operator: Tundra\_O&G\_Prtshp

Oil Rate (CD) : 0.92 m3/d  
Water Rate (CD) : 0.48 m3/d  
Water Inj Rate (CD) : 11.45 m3/d



Oil Formation Vol Factor : 1.07100 m3/m3  
Water Formation Vol Factor : 1.00150 m3/m3  
Water / Oil Ratio : 0.30 m3/m3

Pattern: 02/16-34-008-28Inj Set: EwartUnit#5

June 29, 2016

Operator: Tundra\_O&G\_Prtshp

Oil Rate (CD) : 1.27 m3/d  
Water Rate (CD) : 0.39 m3/d  
Water Inj Rate (CD) : 4.48 m3/d

