

**SINCLAIR UNIT NO. 5**  
**WATERFLOOD EOR PROJECT**  
**ANNUAL REPORT FOR 2016**

**May 31, 2017**

**Tundra Oil and Gas Partnership**

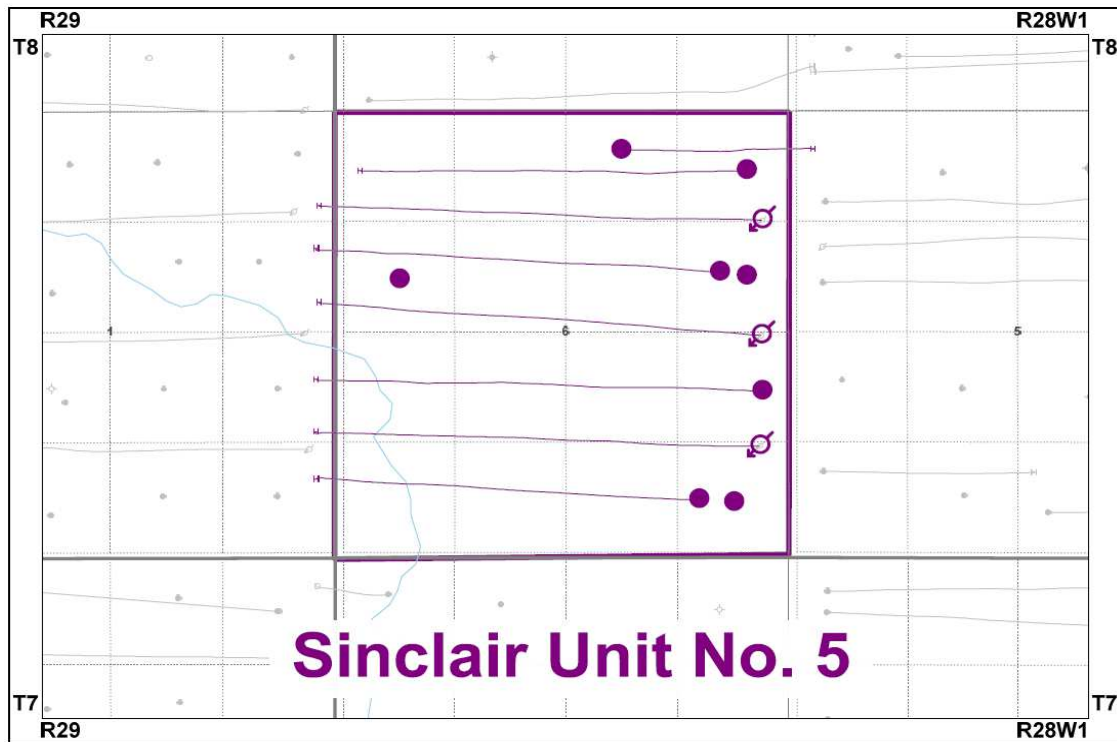
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02/01-06-008-28W1	
02/08-06-008-28W1	
02/16-06-008-28W1	

## **INTRODUCTION**

Sinclair Unit No. 5 Enhanced Oil Recovery (EOR) Waterflood Project was approved under Waterflood Order No. 21 effective October 1, 2010 with Tundra Oil and Gas (Tundra) as Operator. The EOR project area, outlined in yellow on Figure 1, contains 8 producing wells and 3 injection wells within Section 6 in Township 8, Range 28 W1.

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



In accordance with Section 73 of the Manitoba Drilling and Production Regulation, Tundra submits the following 2016 Annual Progress Report for Sinclair Unit No. 5 as required by Waterflood Order No. 21.

## **DISCUSSION**

### **Production History**

For the wells included in Sinclair Unit No. 5, production started in March 2005 with 00/09-06-008-28W1. Oil production peaked at 76.0 m<sup>3</sup>/d in March of 2009, just after the four horizontal wells were brought on production. Water injection started in Sinclair Unit No. 5 in April 2012. In December 2016, the Unit was producing 13.94 m<sup>3</sup>/d of oil and 33.61 m<sup>3</sup>/d of water and had an average WOR of 2.14 m<sup>3</sup>/m<sup>3</sup> in 2016. The rates and WOR are presented in Figure 2.

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

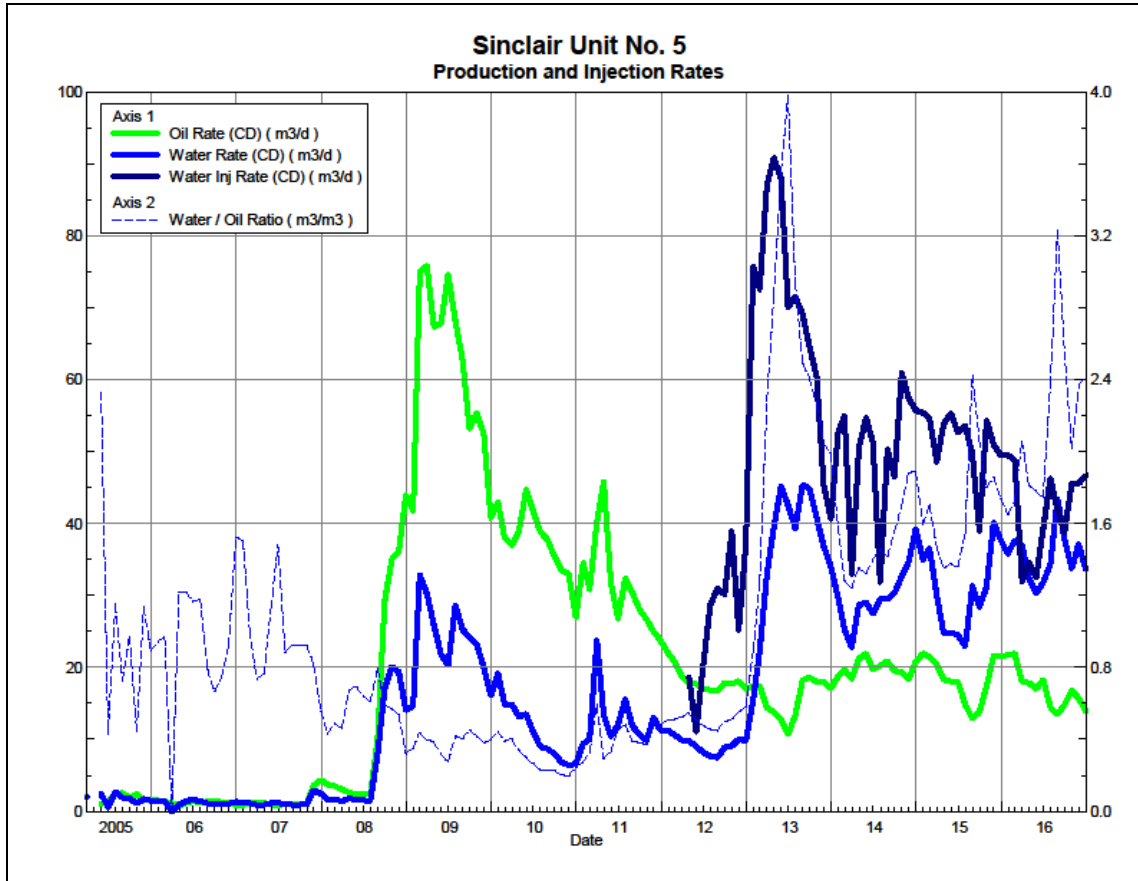
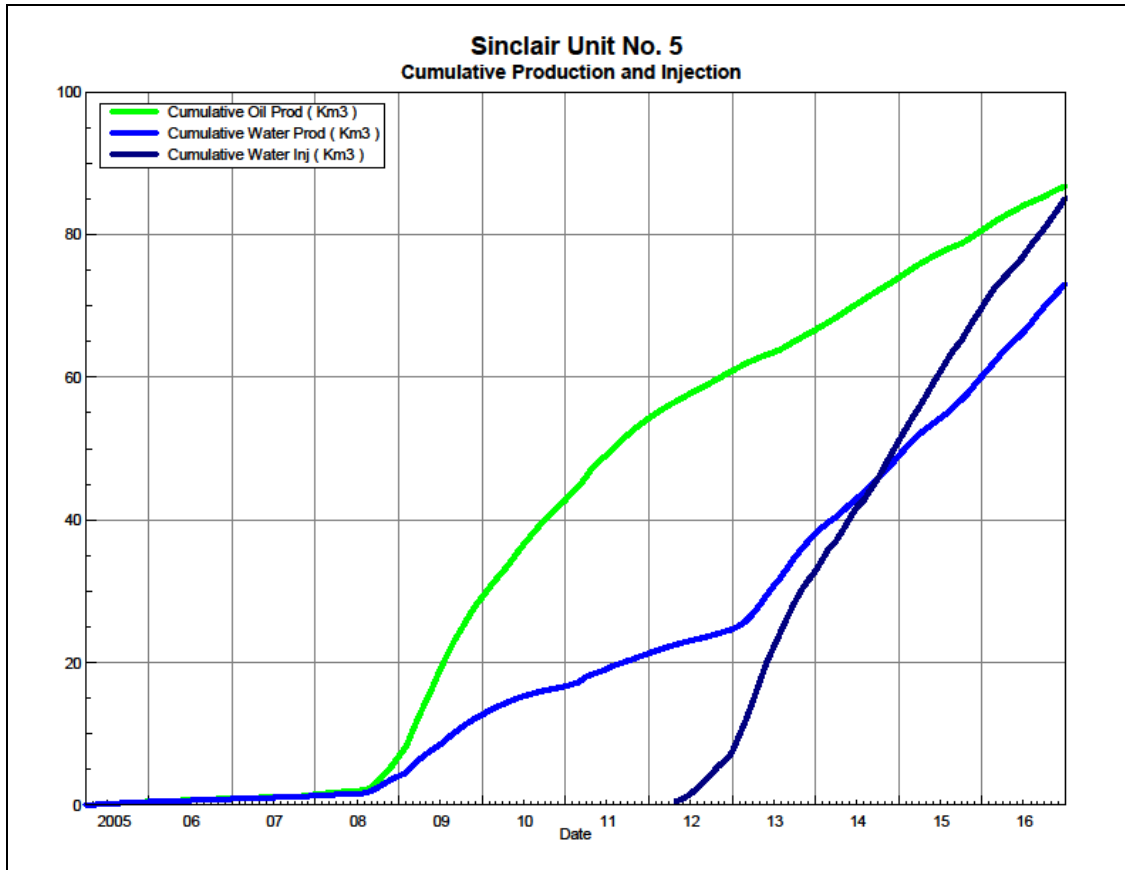


Figure 3 shows the cumulative production for Sinclair Unit No. 5 to the end of December 2016 as 86.79 e³m³ of oil, and 73.08 e³m³ of water, representing a 27.6% recovery factor of the OOIP. The cumulative water injected is 85.07 e³m³.

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



## **Waterflood Development Plan**

### **Sinclair Unit No 5 Waterflood (WF) Development Plan**

Injectors were drilled at the end of 2010 and were openhole fracture stimulated to improve the injection rates. After having produced the injectors for over a year, to create voidage and improve recovery, water injection commenced in Sinclair Unit No. 5 in April 2012. As of December 2016, Sinclair Unit No. 5 had 3 injection patterns in place.

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**

### **Water Source and Quality**

The injection water for Sinclair Unit No. 5 was sourced from the 02/16-32-007-29W1 well (Lodgepole formation) until June 2016 when it was switched over to the newly recompleted source water well at 02/14-30-007-28W1 (Mannville formation). The water is treated at the 04-01-008-29W1 filtration plant where it is filtered to 0.1 microns and has scale inhibitor and biocide added. The injection water is then distributed to the injectors through the dedicated infrastructure system.

### **Injection Wellhead Pressures**

Injection started in this Unit in April 2012. The monthly wellhead injection pressure for each injector is summarized in Appendix C. Since injection in this Unit is still in the early stages, the injectors are still building up to a target injection pressure of 6300 kPaa.

### **Reservoir Pressure**

Tundra undertook to collect pressures from every new injection well drilled in 2010. In addition to the three initial pressures in 2010 from the new drills in Sinclair Unit No. 5, the well at 00/12-06-008-28W1/0 was shut-in from April to October 2011. Prior to start up, Tundra obtained a build-up fluid level shot via AWS. The pressure was interpreted to be approximately 1.2 MPaa. This pressure data is low due to the nature of the reservoir (tight, low porosity and permeability) and this value does not represent the current reservoir pressure as a much longer time is required to obtain a stabilized reservoir pressure. Tundra is endeavored to obtain reservoir pressures as required in order to monitor and optimize its waterfloods.

### **Well Servicing**

No maintenance was required on the 11 wells in Sinclair Unit No. 5 in 2016.

### **Voidage Replacement**

Tundra intends to inject water to re-pressurize the reservoir due to cumulative primary production and corresponding pressure depletion. During the initial fill-up period, the instantaneous voidage replacement ratio (VRR) is expected to average approximately 1.25 to 2.0 by individual pattern. The injector pattern VRRs will be discussed in the waterflood performance section of the report.

## **Waterflood Performance Discussion**

At the end of 2016, Sinclair Unit No. 5 waterflood area had 3 injector patterns in place. The patterns consist of an east-west horizontal injector placed between two horizontal producers, one to the north and one to the south. An overall summary for each injector pattern is presented in Appendix B.

In early 2013, the horizontal producers at 00/08-06 & 02/09-06 had indications of premature breakthrough. On December 18, 2013, a fiber optic temperature log was ran in the 02/08-06 injector. With the log results, a packer was set to isolate the toe and heel sections of the horizontal injector. Both affected producers responded positively with reductions in water volumes and an increase in oil volumes.

A well review in 2014, showed potential for improving the recovery from this unit. In 2015, Tundra drilled a short horizontal well in LSD 15 and 16 (100/15-06-008-28W1/0) and a vertical well (103/01-06-008-28W1/0) to improve oil recovery in those portions of the unit.

Plots of the production and injection data along with the VRR information are presented in Appendix D for each of the injector patterns.

## List of Appendices

Appendix A: Well Name and Status Table

Appendix B: Injection Pattern Summary

Appendix C: Average Monthly Injection Pressures

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

02/01-06-008-28W1

02/08-06-008-28W1

02/16-06-008-28W1



## ***Appendix A***

<b><i>UWI</i></b>	<b><i>Surface Hole Location</i></b>	<b><i>Well Status</i></b>	<b><i>Type</i></b>
100/01-06-008-28W1/0	100010100829W100	Capable of OIL Production	Horizontal
102/01-06-008-28W1/0	102080100829W100	Water Injection	Horizontal
103/01-06-008-28W1/0		Capable of OIL Production	Vertical
100/08-06-008-28W1/0	100080100829W100	Capable of OIL Production	Horizontal
102/08-06-008-28W1/0	103090100829W100	Water Injection	Horizontal
100/09-06-008-28W1/0		Capable of OIL Production	Vertical
102/09-06-008-28W1/0	102090100829W100	Capable of OIL Production	Horizontal
100/12-06-008-28W1/0		Capable of OIL Production	Vertical
100/15-06-008-28W1/0	100130500828W100	Capable of OIL Production	Horizontal
100/16-06-008-28W1/0	100130600828W100	Capable of OIL Production	Horizontal
102/16-06-008-28W1/0	102160100829W100	Water Injection	Horizontal

## Appendix B

## Sinclair Unit No. 5 Injection Pattern Summary as of December 2016

[illegible]

## Appendix C

Month	Average Monthly Injection Pressure (kPag)		
	102/01-06	102/08-06	102/16-06
Jan-12	0	0	0
Feb-12	0	0	0
Mar-12	0	0	0
Apr-12	0	0	0
May-12	0	31	0
Jun-12	0	790	0
Jul-12	2	1609	0
Aug-12	0	2313	0
Sep-12	88	2398	0
Oct-12	1337	3050	0
Nov-12	1047	1820	0
Dec-12	1577	1349	2
Jan-13	3000	3573	-45
Feb-13	3387	3978	-66
Mar-13	3795	4497	-71
Apr-13	4116	4708	26
May-13	4246	4959	1186
Jun-13	4319	4719	1402
Jul-13	4572	4904	1719
Aug-13	4750	5014	1975
Sep-13	4835	4976	2309
Oct-13	5006	4985	2411
Nov-13	4990	2408	2821
Dec-13	4998	1305	2945
Jan-14	4741	3131	2748
Feb-14	4985	4892	2974
Mar-14	4377	1596	2330
Apr-14	4973	3640	2627
May-14	5006	4753	2798
Jun-14	5038	4932	3028
Jul-14	4912	2257	2060
Aug-14	5411	2649	3001
Sep-14	5545	1046	3294
Oct-14	5633	4684	3452
Nov-14	5654	4979	3313
Dec-14	5723	4995	3212

	Average Monthly Injection Pressure (kPag)		
Month	102/01-06	102/08-06	102/16-06
Jan-15	5791	5000	3404
Feb-15	5897	5004	3628
Mar-15	5625	4898	3559
Apr-15	5808	4938	4055
May-15	5838	5077	4332
Jun-15	5883	4895	4460
Jul-15	5809	5427	4053
Aug-15	5666	5443	3756
Sep-15	5036	5048	3488
Oct-15	5666	5477	4702
Nov-15	5614	5475	4853
Dec-15	5680	5504	4935
Jan-16	5771	5472	4967
Feb-16	5737	5617	4915
Mar-16	5019	4899	3719
Apr-16	5218	5103	2163
May-16	5180	5149	1798
Jun-16	5746	5708	1693
Jul-16	6182	5906	925
Aug-16	6153	5853	179
Sep-16	6103	5608	-70
Oct-16	5985	5556	12
Nov-16	5349	5570	-61
Dec-16	5533	5700	-64

## **Appendix D**

### **Rates and VRR Plots**

Oil Formation Vol Factor : 1.07100 m3/m3

Pattern: 02/01-06-008-28Inj Set: SinclairUnit#5

Oil Rate (CD) : 5.04 m3/d

Water Formation Vol Factor : 1.00150 m3/m3

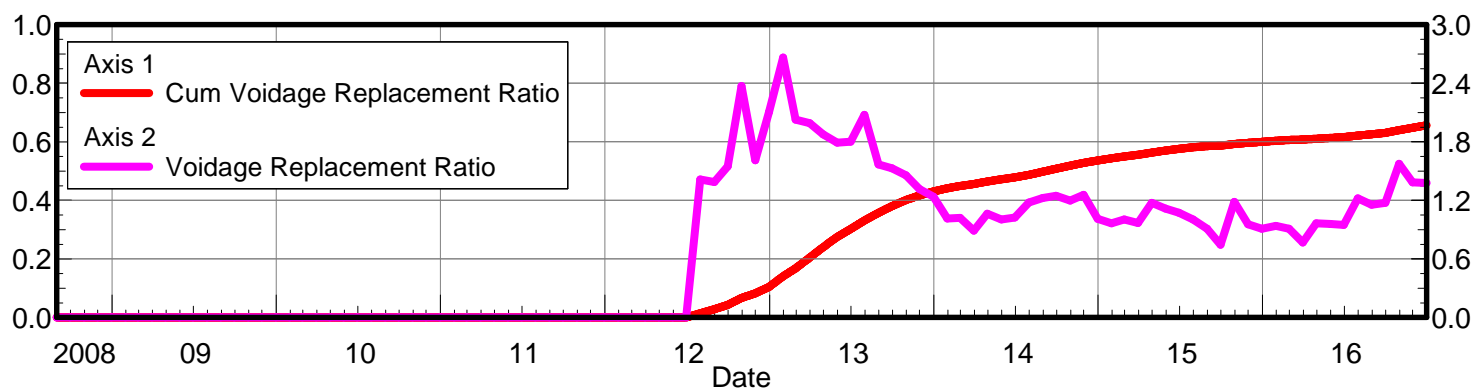
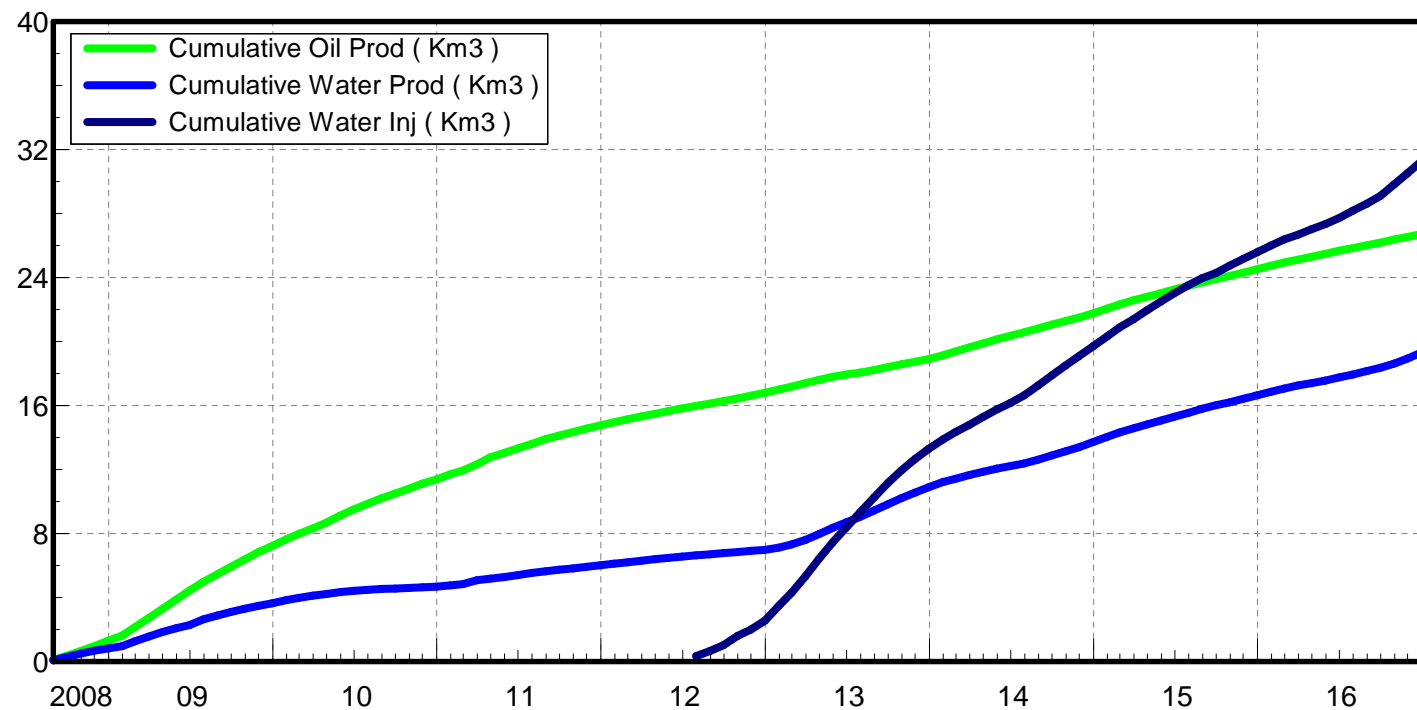
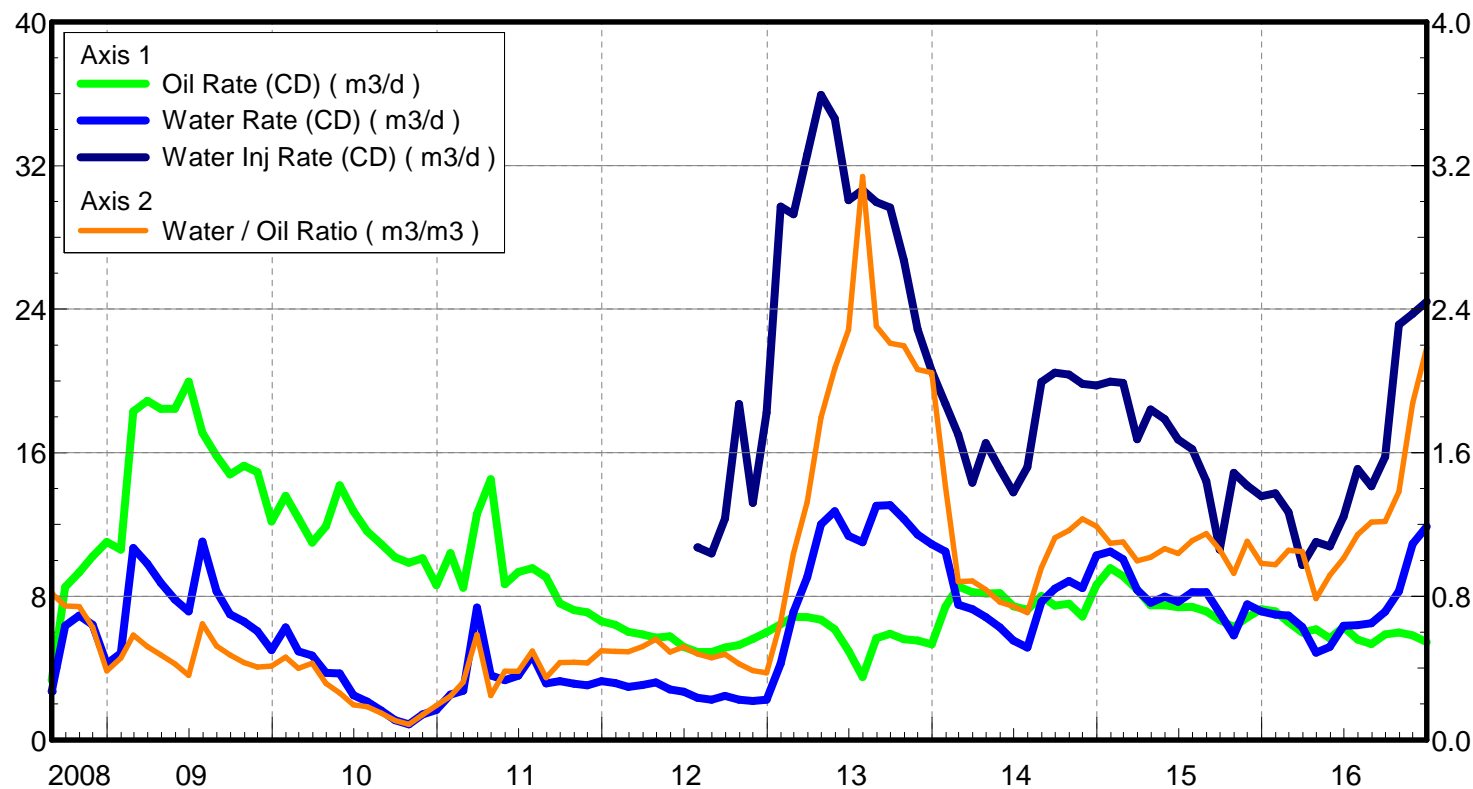
May 30, 2017

Water Rate (CD) : 13.26 m3/d

Water / Oil Ratio : 2.16 m3/m3

Operator: TUNDRA\_OIL\_&\_GAS\_LIMITED

Water Inj Rate (CD) : 23.79 m3/d



Oil Formation Vol Factor : 1.07100 m3/m3

Pattern: 02/08-06-008-28Inj Set: SinclairUnit#5

Oil Rate (CD) : 2.82 m3/d

Water Formation Vol Factor : 1.00150 m3/m3

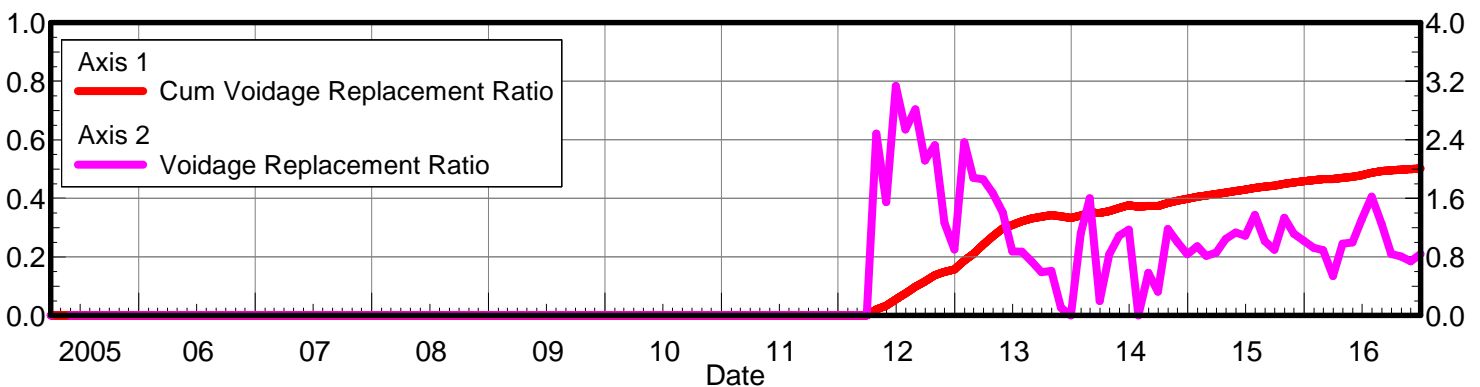
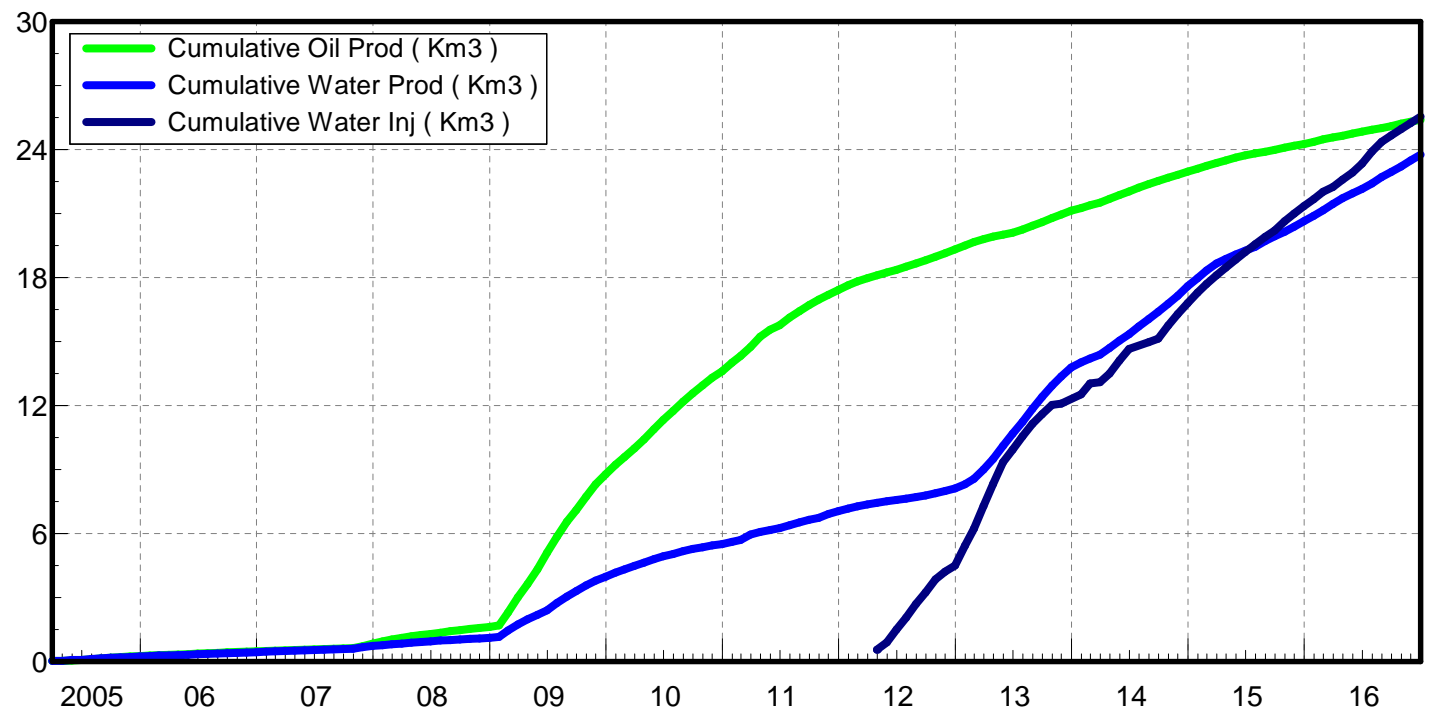
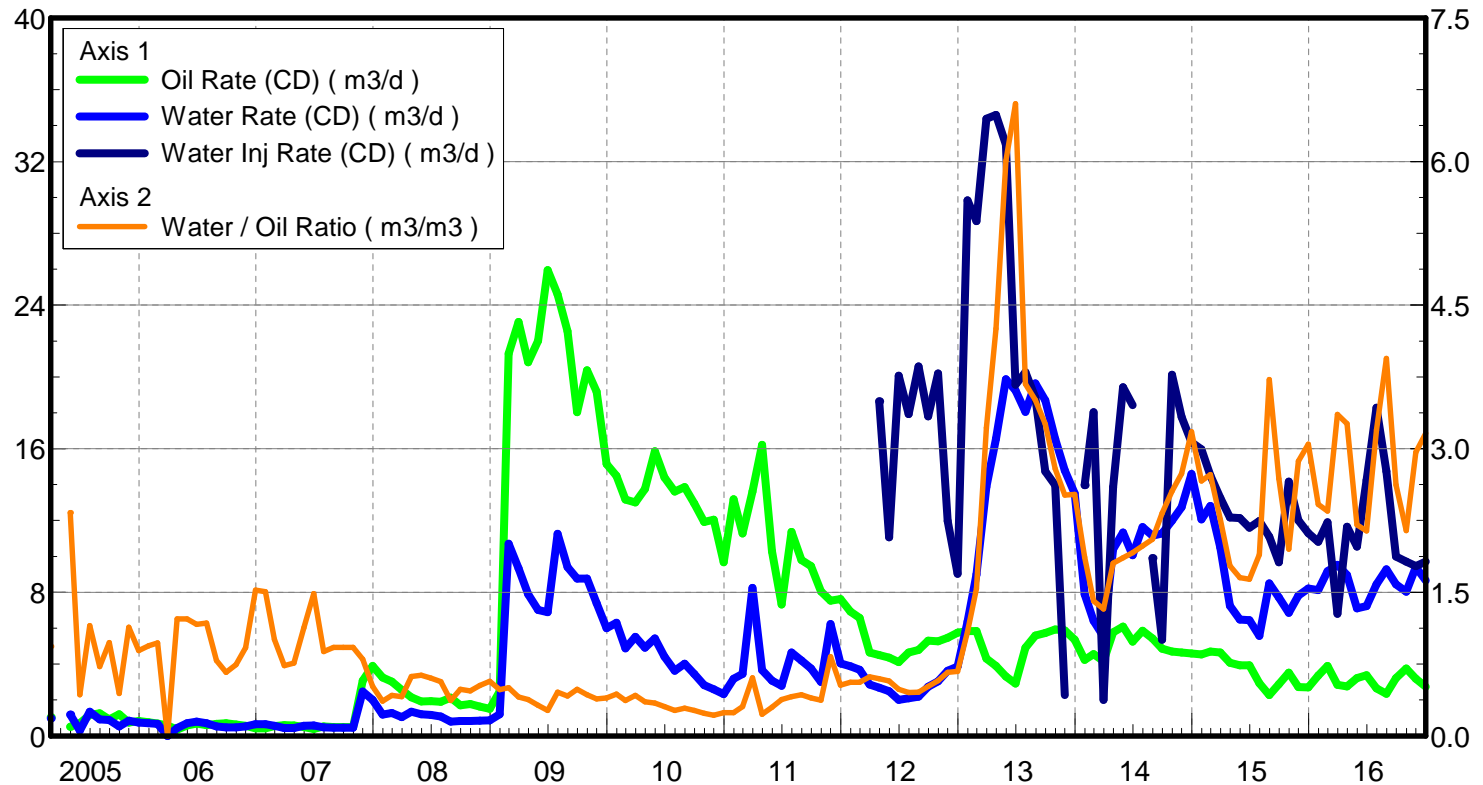
May 30, 2017

Water Rate (CD) : 10.08 m3/d

Water / Oil Ratio : 3.46 m3/m3

Operator: TUNDRA\_OIL\_&\_GAS\_LIMITED

Water Inj Rate (CD) : 9.79 m3/d



Oil Formation Vol Factor : 1.07100 m3/m3

Pattern: 02/16-06-008-28Inj Set: SinclairUnit#5

Oil Rate (CD) : 4.06 m3/d

Water Formation Vol Factor : 1.00150 m3/m3

May 30, 2017

Water Rate (CD) : 11.89 m3/d

Water / Oil Ratio : 3.66 m3/m3

Operator: TUNDRA\_OIL\_&\_GAS\_LIMITED

Water Inj Rate (CD) : 19.61 m3/d

