

**KOLA UNIT NO. 1**  
**WATERFLOOD EOR PROJECT**  
**ANNUAL REPORT FOR 2015**

**March 29, 2016**

**Tundra Oil and Gas Partnership**

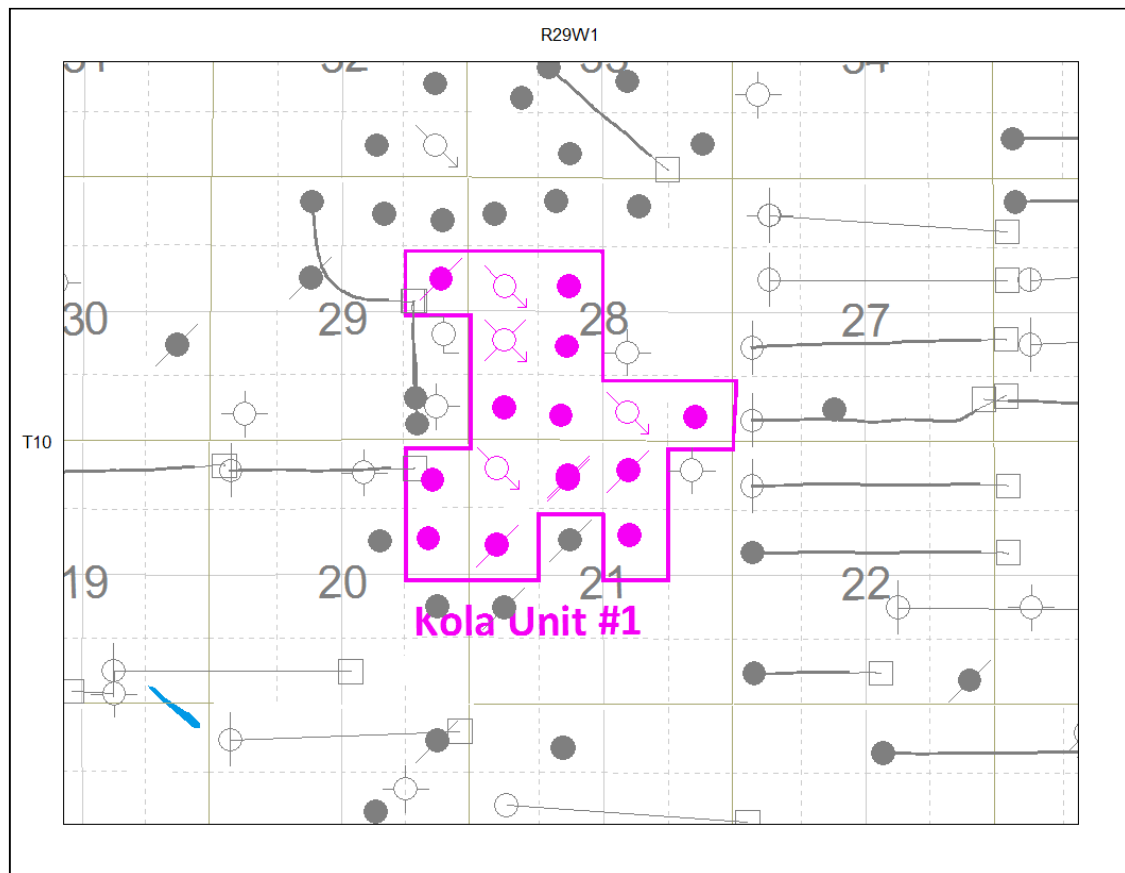
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## **INTRODUCTION**

Kola Unit No. 1 Enhanced Oil Recovery (EOR) Waterflood Project was approved under Board Order No. PM 71 effective October 1, 1993 with Tundra Oil and Gas Ltd. as Operator. In May 1995, Board Order No. PM 71 was replaced by Waterflood Order No. 2. The EOR project area contains 16 wells in 16 LSDs in Township 10, Range 29 W1 as shown in the figure below. Well list and well status is available in Appendix A.

**Figure 1: Kola Unit No. 1 Area Outline**



In accordance with Section 73 of the Manitoba Drilling and Production Regulation, Tundra hereby submits the 2015 Annual Progress Report for Kola Unit No. 1 as required by Waterflood Order No. 2.

## **DISCUSSION**

### **Production History**

For the wells included in Kola Unit No. 1, production started in October 1985 with 00/13-21-010-29W1/0 well (00/13-21). Oil production peaked at 41.5 m<sup>3</sup>/d in February 1988. The unit was producing 2.81 m<sup>3</sup>/d of oil and 24.20 m<sup>3</sup>/d of water in December

2015. The average WOR in 2015 was 8.9 m<sup>3</sup>/m<sup>3</sup>. Oil production rate, injection rate, and WOR during each month for each injection pattern is presented in Appendix D. The rates and WOR are plotted in Figure 2.

**Figure 2: Kola Unit No. 1 Production/Injection Rates and WOR vs Time**

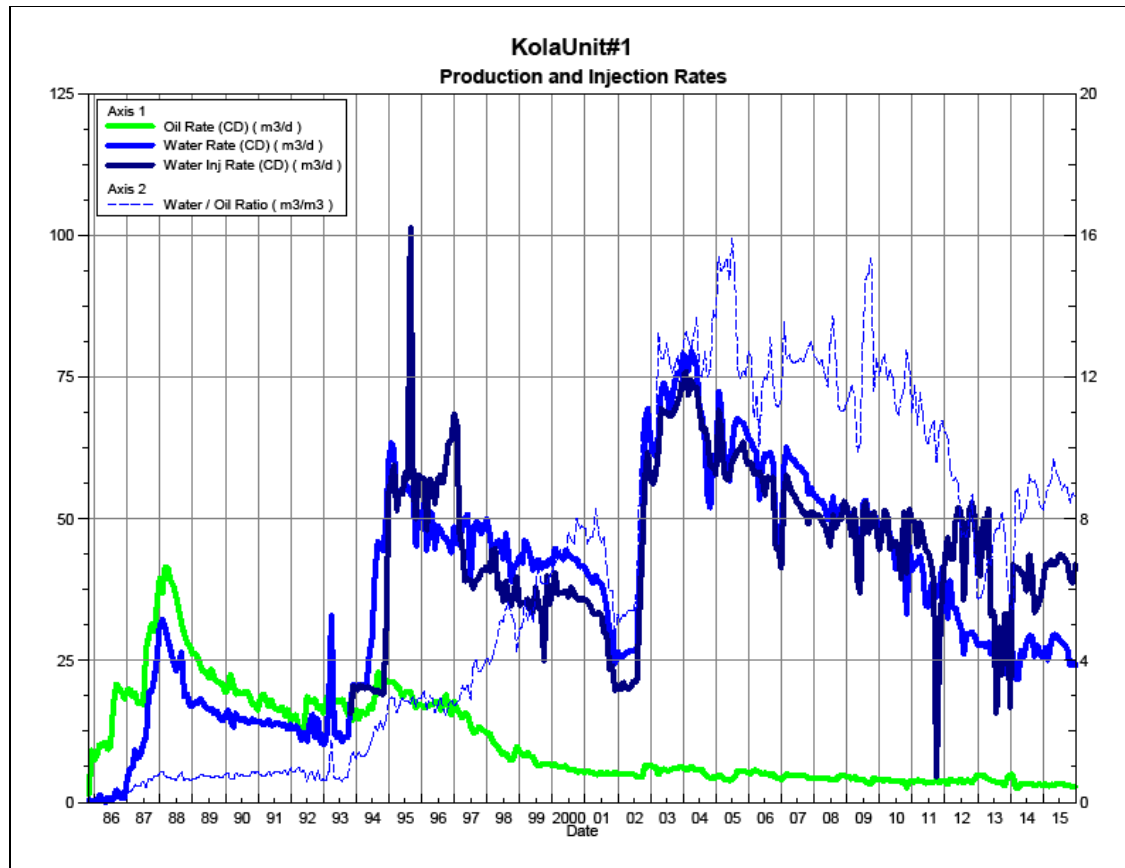
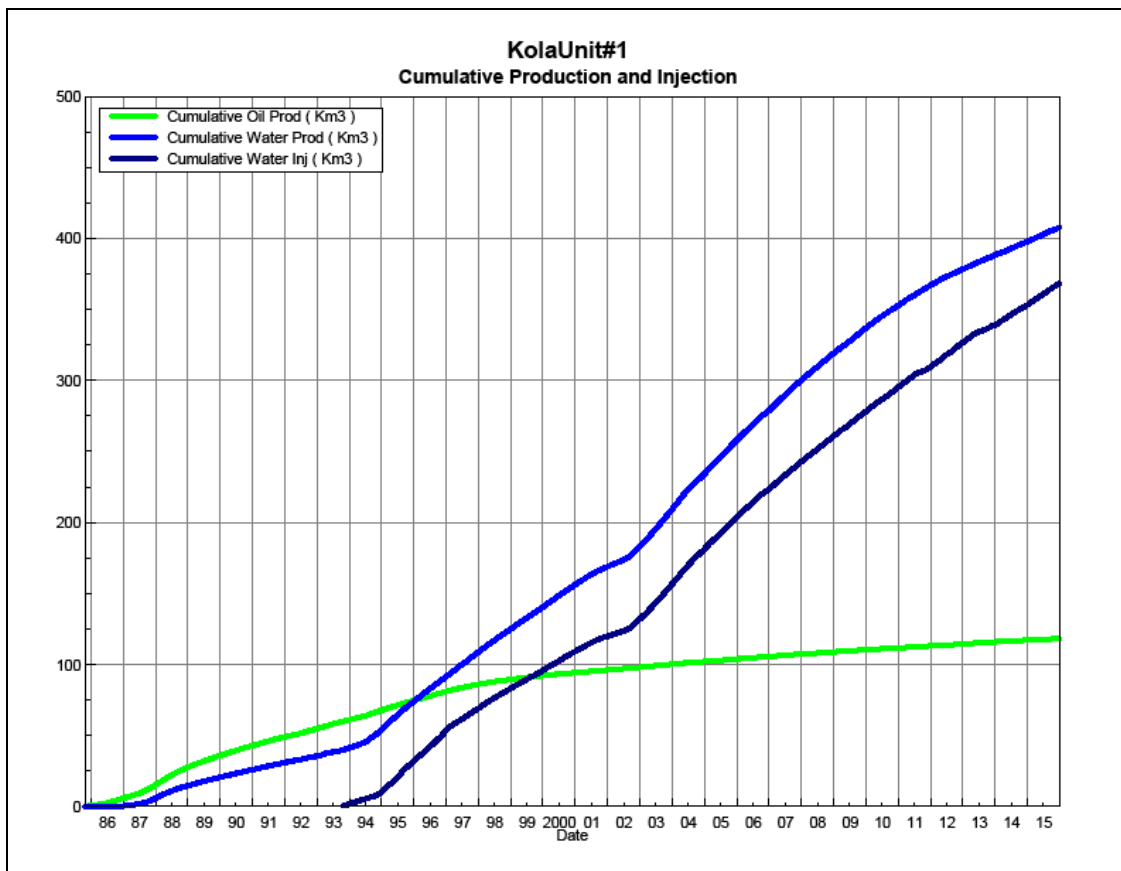


Figure 3 shows the cumulative production for Kola Unit No. 1 to the end of December 2015 as 118 e<sup>3</sup>m<sup>3</sup> of oil, and 408 e<sup>3</sup>m<sup>3</sup> of water. Cumulative water injected is just over 369 e<sup>3</sup>m<sup>3</sup>. The cumulative volume of oil, and water produced and fluid injected for each injection pattern is presented in Appendix D.

**Figure 3: Kola Unit No. 1 Cumulative Oil, Water and Water Injected vs. Time**



### **Waterflood History**

As of December 2015 the Unit has 3 active vertical injectors and 3 injection patterns in place. In November 2010, the vertical injector at 100/05-28-010-29W1 was abandoned. Water injection started in October 1993. An overall summary for each injector pattern is presented in Appendix B.

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**

Injected fluid consisted of produced water from the Lodgepole formation, from the unit and surrounding area until November 2013. Injection water for Kola Unit No. 1 is now being provided from the Jurassic source water well at 100/02-25-010-29W1 (2-25). Tundra received approval from the Petroleum Branch in March 2013 to use the 2-25 well

as a source water well for waterflood operations. Jurassic-sourced water is pumped from the 2-25 source well to the Daly 12-24-10-29 battery, where it is filtered to 50 microns and then pumped up to injection system pressure.

### **Injection Wellhead Pressures**

The average monthly wellhead injection pressures for each injection well are summarized in Appendix C, and shows all injection pressures since 2003. The injection pressure in December 2015 was 6154, 6594 and 5204 kPag for 00/13-21, 00/02-28 and 00/12-28-010-29W1, respectively.

### **Reservoir Pressure**

No reservoir pressure measurements were taken at Kola Unit No. 1 in 2015.

### **Well Servicing**

No maintenance was required on the 16 wells in Kola Unit No. 1 in 2015.

### **Voidage Replacement**

Cumulative voidage for the Kola Unit No. 1 was 0.693 in December 2015. Since 2010, the monthly voidage has been greater than 1, which puts the Kola Unit No. 1 on track to achieve a cumulative VRR of 1. Plots of the Voidage Replacement Ratio on a monthly and cumulative basis for each injector pattern is presented in Appendix D.

### **Waterflood Performance Discussion**

The OOIP for Kola Unit No. 1 is estimated at 1547  $\text{e}^3\text{m}^3$ . The recovery factor for Kola Unit No. 1 was 7.6% based on 118  $\text{e}^3\text{m}^3$  of cumulative oil recovered to the end of 2015. The ultimate expected recoverable reserve based on decline analysis is 127  $\text{e}^3\text{m}^3$  or an ultimate recovery factor of 8.2%.

The overall performance of this waterflood has been poor as indicated by low recovery factors, and poor waterflood response. Any increased or supported oil rates, that may be as a result of injected water sweeping the reservoir, are not sustained for a very long time.

Trends in production are very stable and at a mature state. No changes are anticipated in the future trends. While overall cumulative voidage is above unity, an examination of the individual patterns reveals that injected water should be diverted from the 12-28 pattern to the 13-21 and 2-28 patterns, which are under-injected. There is the possibility of an additional injector well to improve sweep efficiency in an area of the reservoir with no waterflood response, and even additional development is possible.

Optimization of the waterflood will be evaluated to inject water in under-supported areas of the pool, with consideration for additional injection. Also, facility enhancements in the area may increase water handling capacity so that sufficient water volumes can be provided to the pool.



## **List of Appendices**

Appendix A: Well Name and Well Status

Appendix B: Injection Pattern Summary

Appendix C: Average Monthly Injection Wellhead Pressures

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

00/13-21-010-29W1

00/02-28-010-29W1

00/12-28-010-29W1



## Appendix A

| UWI                   | Well Status         |
|-----------------------|---------------------|
| 100/09-20-010-29W1/00 | Capable of OIL Prod |
| 100/16-20-010-29W1/00 | Capable of OIL Prod |
| 100/10-21-010-29W1/00 | Capable of OIL Prod |
| 100/12-21-010-29W1/00 | ABD Producer        |
| 100/13-21-010-29W1/00 | WTR Injection       |
| 100/14-21-010-29W1/00 | ABD Producer        |
| 100/14-21-010-29W1/02 | ABD Producer        |
| 100/15-21-010-29W1/00 | ABD Producer        |
| 100/01-28-010-29W1/00 | Capable of OIL Prod |
| 100/02-28-010-29W1/00 | WTR Injection       |
| 100/03-28-010-29W1/00 | Capable of OIL Prod |
| 100/04-28-010-29W1/00 | Capable of OIL Prod |
| 100/05-28-010-29W1/00 | ABD WTR Injection   |
| 100/06-28-010-29W1/00 | Capable of OIL Prod |
| 100/11-28-010-29W1/00 | Capable of OIL Prod |
| 100/12-28-010-29W1/00 | WTR Injection       |
| 100/09-29-010-29W1/00 | ABD Producer        |

## Appendix B

**Kola Unit No. 1 Pattern Summary as of December 2015**

[illegible]

Appendix C

| Average Monthly Injection Pressure (kPag) |                    |           |           |           |
|-------------------------------------------|--------------------|-----------|-----------|-----------|
| Month                                     | Injection Pressure |           |           |           |
|                                           | 100/13-21          | 100/02-28 | 100/05-28 | 100/12-28 |
| Jul-02                                    | 0                  | 0         | 0         | 0         |
| Aug-02                                    | 5996               | 4283      | 234       | 2178      |
| Sep-02                                    | 10934              | 7810      | 426       | 5108      |
| Oct-02                                    | 10934              | 7810      | 3013      | 5600      |
| Nov-02                                    | 10934              | 7810      | 4071      | 5600      |
| Dec-02                                    | 10934              | 7810      | 4071      | 5600      |
| Jan-03                                    | 10366              | 8490      | 2919      | 6206      |
| Feb-03                                    | 9905               | 9697      | 2840      | 6147      |
| Mar-03                                    | 9745               | 9752      | 2840      | 6096      |
| Apr-03                                    | 9735               | 9062      | 3053      | 6107      |
| May-03                                    | 10355              | 8706      | 3550      | 6036      |
| Jun-03                                    | 10366              | 8520      | 3550      | 6035      |
| Jul-03                                    | 10366              | 8520      | 3550      | 6035      |
| Aug-03                                    | 10366              | 8520      | 3550      | 6035      |
| Sep-03                                    | 10345              | 8921      | 3268      | 6019      |
| Oct-03                                    | 10274              | 10240     | 2138      | 5965      |
| Nov-03                                    | 10274              | 10240     | 2138      | 5965      |
| Dec-03                                    | 10274              | 10240     | 2138      | 5965      |
| Jan-04                                    | 10274              | 10240     | 2138      | 5965      |
| Feb-04                                    | 10274              | 10240     | 2138      | 5965      |
| Mar-04                                    | 10274              | 10240     | 2138      | 5965      |
| Apr-04                                    | 10274              | 10240     | 2138      | 5965      |
| May-04                                    | 10274              | 10240     | 2138      | 5965      |
| Jun-04                                    | 10274              | 10240     | 2138      | 5965      |
| Jul-04                                    | 10274              | 10240     | 2138      | 5965      |
| Aug-04                                    | 10274              | 10240     | 2138      | 5965      |
| Sep-04                                    | 10274              | 10957     | 3430      | 6304      |
| Oct-04                                    | 10040              | 11100     | 3377      | 6340      |
| Nov-04                                    | 10200              | 11100     | 3600      | 6600      |
| Dec-04                                    | 10200              | 11100     | 3600      | 6600      |
| Jan-05                                    | 10200              | 11100     | 3600      | 6600      |
| Feb-05                                    | 10386              | 11100     | 3229      | 6600      |
| Mar-05                                    | 10600              | 11100     | 2800      | 6600      |
| Apr-05                                    | 10600              | 11100     | 2800      | 6600      |
| May-05                                    | 10600              | 11100     | 2800      | 6600      |
| Jun-05                                    | 10013              | 11103     | 3040      | 6573      |
| Jul-05                                    | 9052               | 10986     | 3300      | 7262      |
| Aug-05                                    | 9781               | 10835     | 2700      | 6232      |
| Sep-05                                    | 9920               | 11033     | 2813      | 6067      |
| Oct-05                                    | 9800               | 11200     | 3700      | 6400      |
| Nov-05                                    | 9920               | 11100     | 3620      | 6410      |
| Dec-05                                    | 11000              | 10200     | 2900      | 6500      |

| Month  | Injection Pressure |           |           |           |
|--------|--------------------|-----------|-----------|-----------|
|        | 100/13-21          | 100/02-28 | 100/05-28 | 100/12-28 |
| Jan-06 | 11035              | 10200     | 2829      | 6500      |
| Feb-06 | 10896              | 10534     | 2682      | 6538      |
| Mar-06 | 10600              | 11148     | 2650      | 6416      |
| Apr-06 | 10777              | 9910      | 2682      | 6322      |
| May-06 | 10884              | 10540     | 3152      | 6342      |
| Jun-06 | 10840              | 10733     | 1133      | 6382      |
| Jul-06 | 10794              | 10890     | 1         | 6581      |
| Aug-06 | 10778              | 10834     | 404       | 6479      |
| Sep-06 | 10801              | 10750     | 2850      | 6520      |
| Oct-06 | 10801              | 2416      | 3000      | 6578      |
| Nov-06 | 10867              | 2280      | 100       | 6601      |
| Dec-06 | 10900              | 1626      | 0         | 6745      |
| Jan-07 | 9689               | 5105      | 1078      | 6821      |
| Feb-07 | 10370              | 9443      | -         | 6731      |
| Mar-07 | 10452              | 9923      | -         | 6323      |
| Apr-07 | 10410              | 10350     | -         | 6247      |
| May-07 | 10500              | 10300     | -         | 6201      |
| Jun-07 | 10500              | 10300     | -         | 6201      |
| Jul-07 | 9871               | 10523     | -         | 6307      |
| Aug-07 | 9000               | 10601     | -         | 6300      |
| Sep-07 | 9580               | 10600     | -         | 6397      |
| Oct-07 | 9600               | 10600     | -         | 6400      |
| Nov-07 | 8940               | 10820     | -         | 6401      |
| Dec-07 | 8832               | 11103     | -         | 6503      |
| Jan-08 | 8300               | 11200     | -         | 6600      |
| Feb-08 | 8345               | 11111     | -         | 6455      |
| Mar-08 | 8400               | 11000     | -         | 5803      |
| Apr-08 | 7960               | 11107     | -         | 6527      |
| May-08 | 7990               | 11190     | -         | 6790      |
| Jun-08 | 8000               | 11200     | -         | 6800      |
| Jul-08 | 8645               | 11265     | -         | 6800      |
| Aug-08 | 8710               | 11087     | -         | 6539      |
| Sep-08 | 7560               | 10967     | -         | 4247      |
| Oct-08 | 7700               | 11200     | -         | 4000      |
| Nov-08 | 7967               | 11300     | -         | 4680      |
| Dec-08 | 8200               | 11400     | -         | 5200      |
| Jan-09 | 8200               | 11400     | -         | 5200      |
| Feb-09 | 8200               | 11400     | -         | 5200      |
| Mar-09 | 8200               | 11516     | -         | 5200      |
| Apr-09 | 8200               | 11800     | -         | 5200      |
| May-09 | 8200               | 11800     | -         | 5362      |
| Jun-09 | 8187               | 10254     | -         | 5410      |
| Jul-09 | 7801               | 10401     | -         | 5701      |
| Aug-09 | 7800               | 4535      | -         | 5700      |
| Sep-09 | 7800               | 6200      | -         | 5700      |
| Oct-09 | 8003               | 9171      | -         | 5826      |
| Nov-09 | 5607               | 11633     | -         | 6274      |
| Dec-09 | 23                 | 11717     | -         | 6301      |

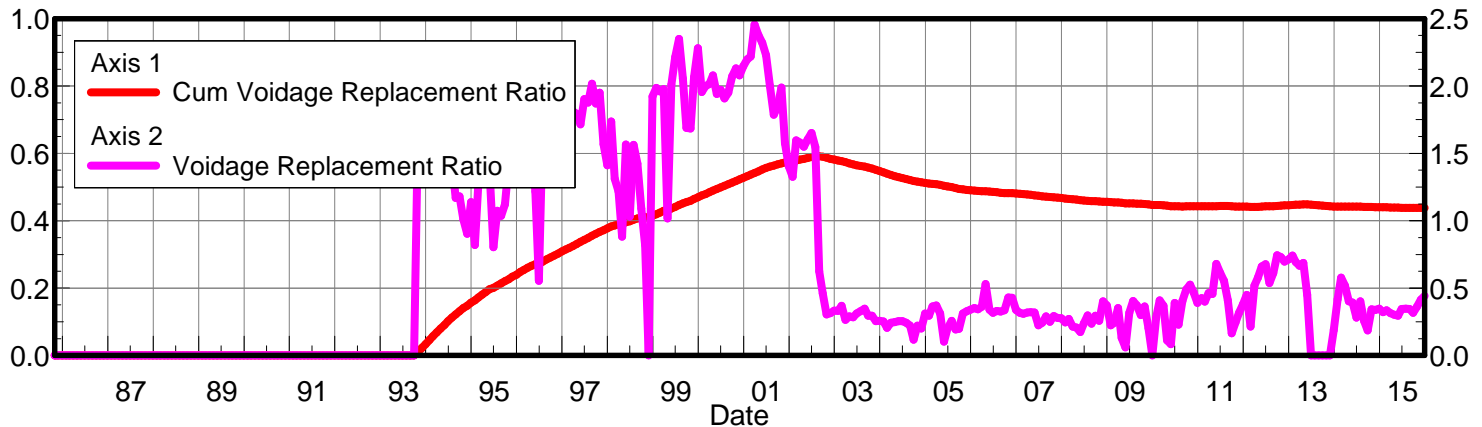
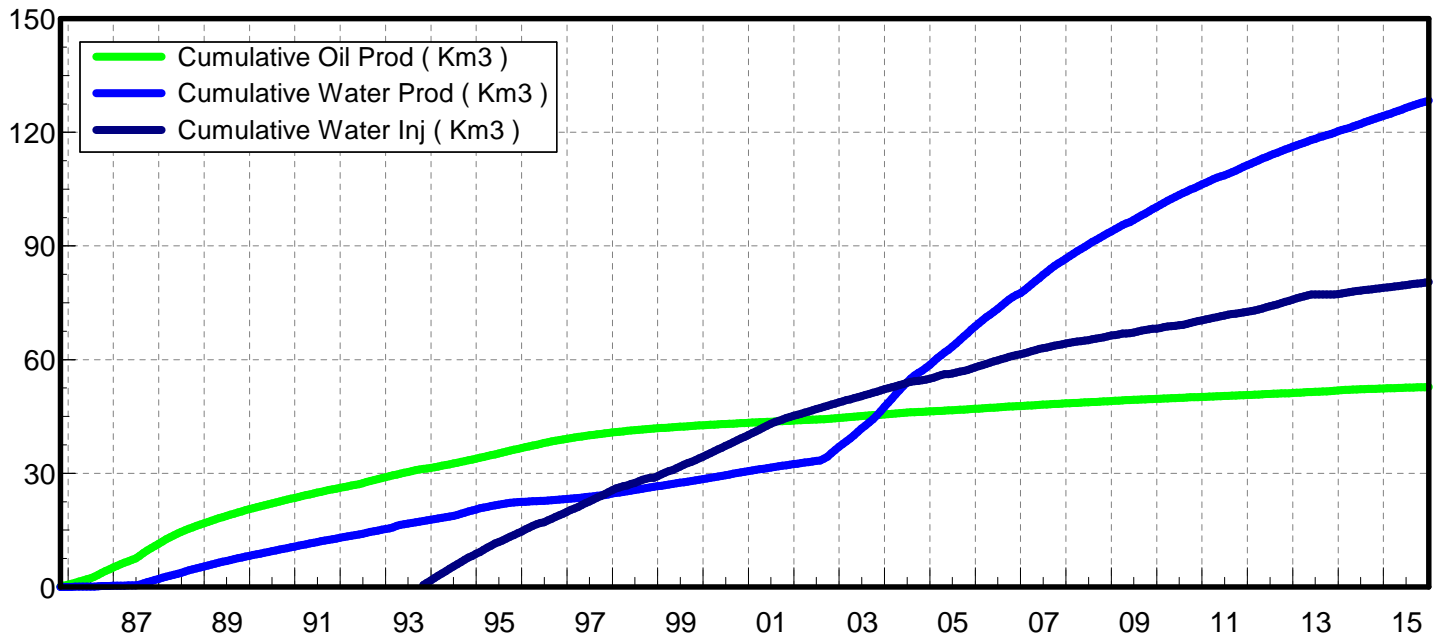
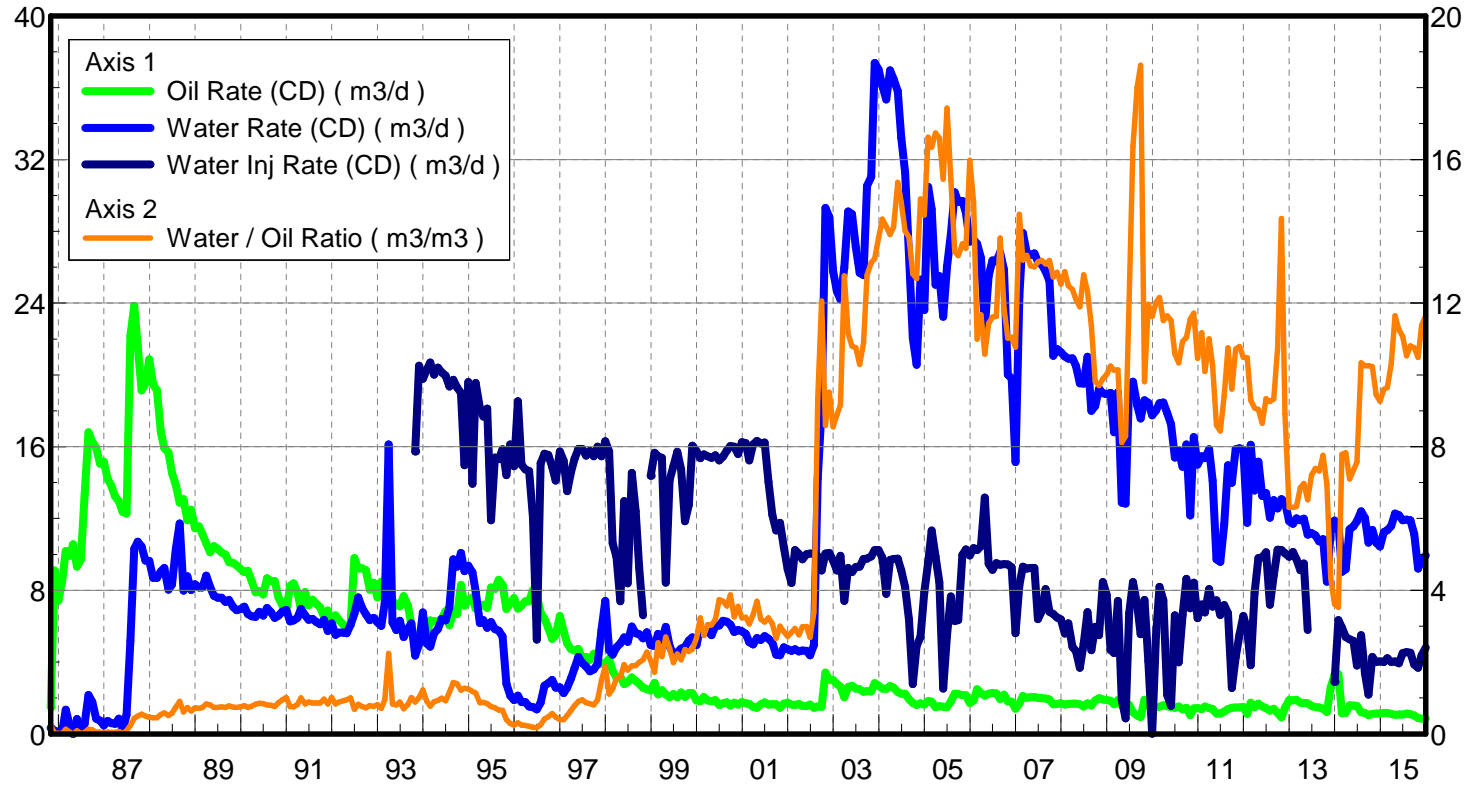
| Month  | Injection Pressure |           |           |           |
|--------|--------------------|-----------|-----------|-----------|
|        | 100/13-21          | 100/02-28 | 100/05-28 | 100/12-28 |
| Jan-10 | 5281               | 11490     | -         | 6239      |
| Feb-10 | 9941               | 11079     | -         | 6161      |
| Mar-10 | 8703               | 11397     | -         | 6315      |
| Apr-10 | 1687               | 10714     | -         | 6357      |
| May-10 | 721                | 11232     | -         | 6397      |
| Jun-10 | 6230               | 10437     | -         | 6040      |
| Jul-10 | 4387               | 10052     | -         | 5787      |
| Aug-10 | 6190               | 2790      | -         | 5300      |
| Sep-10 | 8860               | 8510      | -         | 5754      |
| Oct-10 | 8242               | 8978      | -         | 5727      |
| Nov-10 | 8897               | 8954      | -         | 5704      |
| Dec-10 | 8977               | 9239      | -         | 5800      |
| Jan-11 | 7010               | 8234      | -         | 5789      |
| Feb-11 | 8257               | 7477      | -         | 5784      |
| Mar-11 | 8963               | 6076      | -         | 5869      |
| Apr-11 | 9000               | 6000      | -         | 5900      |
| May-11 | 7381               | 3290      | -         | 5816      |
| Jun-11 | 7413               | 4107      | -         | 5767      |
| Jul-11 | 8387               | 4806      | -         | 5806      |
| Aug-11 | 8200               | 4900      | -         | -         |
| Sep-11 | 6232               | 3284      | -         | 0         |
| Oct-11 | 7619               | 3465      | -         | 5213      |
| Nov-11 | 8000               | 3600      | -         | 5800      |
| Dec-11 | 8000               | 3600      | -         | 5800      |
| Jan-12 | 7871               | 3729      | -         | 5929      |
| Feb-12 | 7800               | 3800      | -         | 6000      |
| Mar-12 | 7800               | 3800      | -         | 6000      |
| Apr-12 | 7800               | 3800      | -         | 6000      |
| May-12 | 7800               | 3800      | -         | 6000      |
| Jun-12 | 7800               | 3800      | -         | 6000      |
| Jul-12 | 7800               | 3800      | -         | 6000      |
| Aug-12 | 7577               | 3694      | -         | 5835      |
| Sep-12 | 900                | 500       | -         | 900       |
| Oct-12 | 900                | 500       | -         | 900       |
| Nov-12 | 900                | 500       | -         | 900       |
| Dec-12 | 900                | 500       | -         | 900       |
| Jan-13 | 900                | 500       | -         | 900       |
| Feb-13 | 900                | 500       | -         | 900       |
| Mar-13 | 900                | 500       | -         | 900       |
| Apr-13 | 900                | 500       | -         | 900       |
| May-13 | 900                | 500       | -         | 900       |
| Jun-13 | 390                | 2257      | -         | 4130      |
| Jul-13 | 0                  | 3600      | -         | 6600      |
| Aug-13 | 0                  | 3600      | -         | 6600      |
| Sep-13 | 0                  | 3600      | -         | 6600      |
| Oct-13 | 0                  | 3600      | -         | 6600      |
| Nov-13 | 0                  | 3600      | -         | 6600      |
| Dec-13 | 2669               | 4734      | -         | 6040      |

| Month  | Injection Pressure |           |           |           |
|--------|--------------------|-----------|-----------|-----------|
|        | 100/13-21          | 100/02-28 | 100/05-28 | 100/12-28 |
| Jan-14 | 6598               | 6689      | -         | 6106      |
| Feb-14 | 6715               | 6725      | -         | 5823      |
| Mar-14 | 6869               | 6800      | -         | 6376      |
| Apr-14 | 6900               | 6800      | -         | 6400      |
| May-14 | 6900               | 6800      | -         | 6402      |
| Jun-14 | 5975               | 6808      | -         | 6287      |
| Jul-14 | 5570               | 6808      | -         | 6272      |
| Aug-14 | 5302               | 6800      | -         | 6155      |
| Sep-14 | 6592               | 4192      | -         | 5543      |
| Oct-14 | 6273               | 5785      | -         | 6540      |
| Nov-14 | 6014               | 5767      | -         | 6486      |
| Dec-14 | 6076               | 5582      | -         | 6446      |
| Jan-15 | 6116               | 6064      | -         | 6497      |
| Feb-15 | 6299               | 6041      | -         | 6392      |
| Mar-15 | 6582               | 6296      | -         | 6342      |
| Apr-15 | 6427               | 6200      | -         | 6235      |
| May-15 | 5775               | 6178      | -         | 6156      |
| Jun-15 | 6422               | 6658      | -         | 6058      |
| Jul-15 | 6209               | 6667      | -         | 6064      |
| Aug-15 | 5979               | 6434      | -         | 5870      |
| Sep-15 | 5662               | 6590      | -         | 6069      |
| Oct-15 | 5227               | 5844      | -         | 5511      |
| Nov-15 | 6062               | 6466      | -         | 5324      |
| Dec-15 | 6154               | 6594      | -         | 5204      |

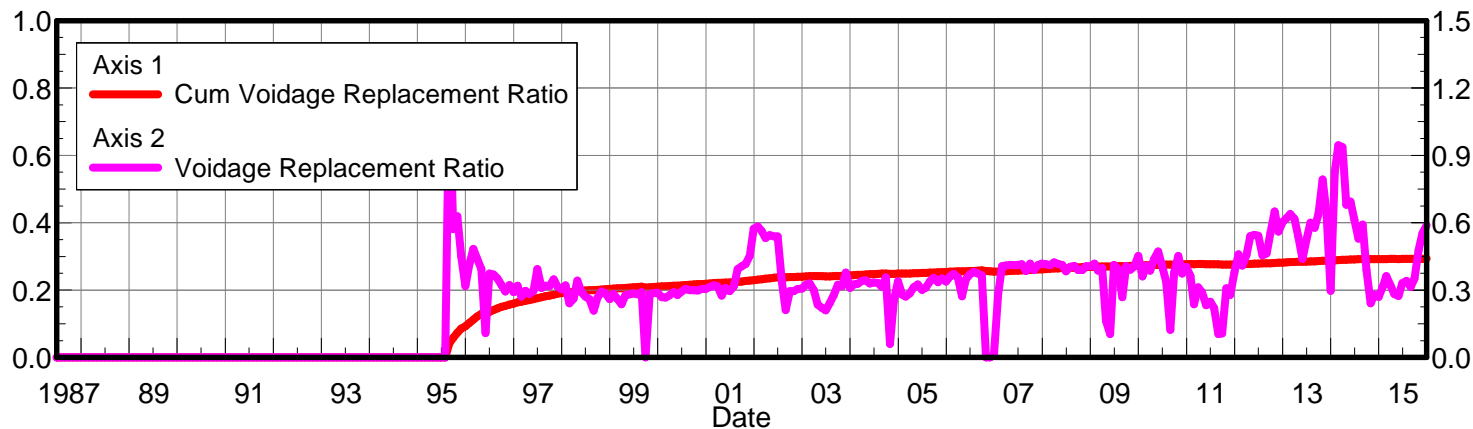
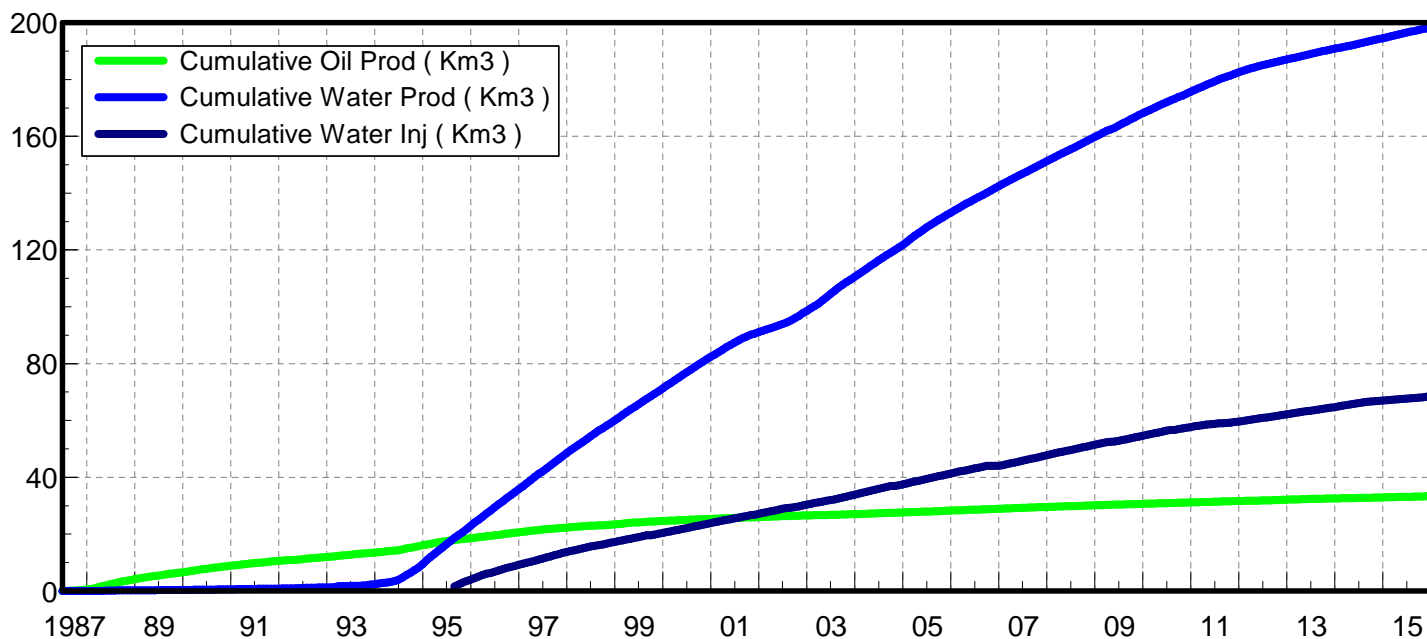
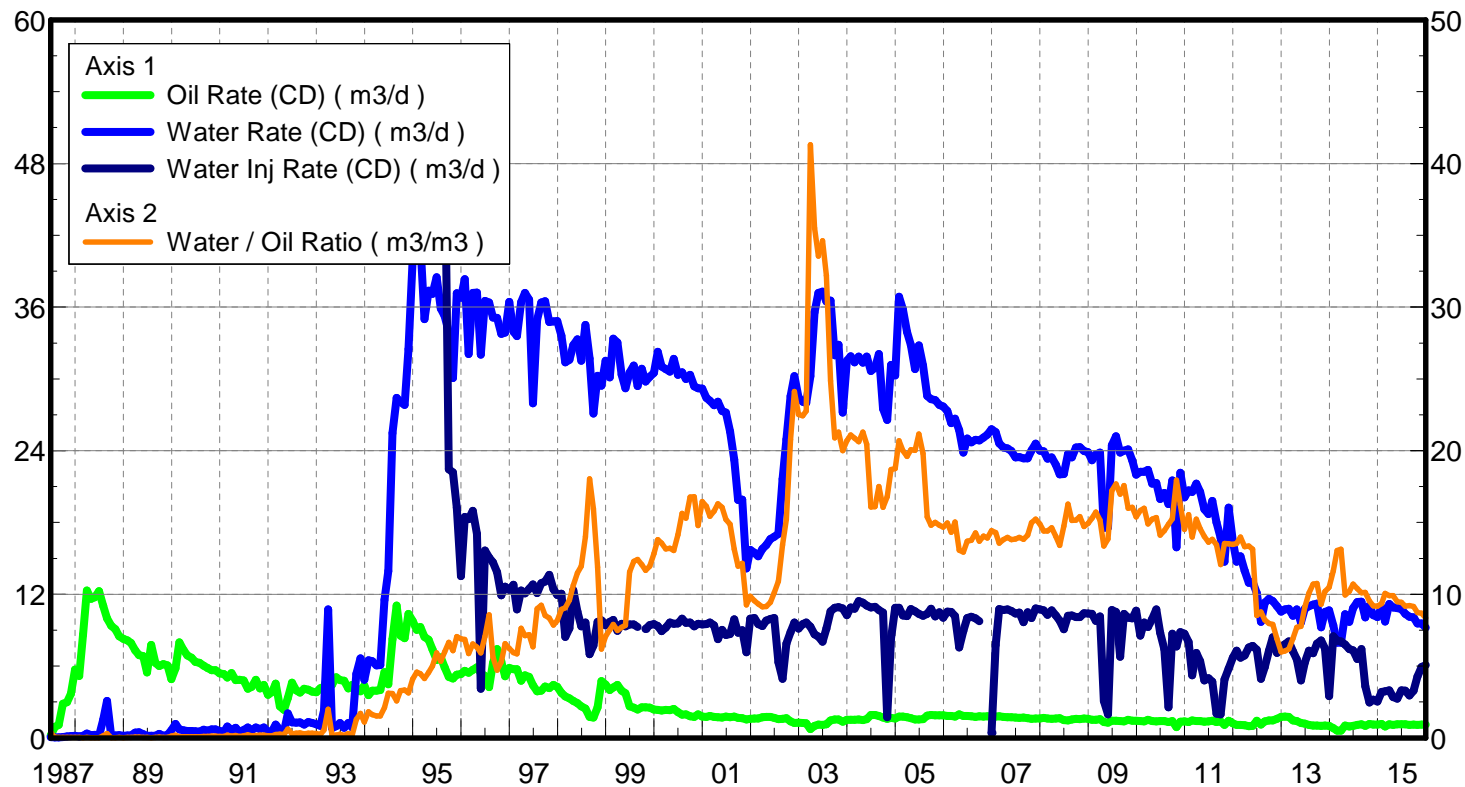
## **Appendix D**

### **Rates and VRR Plots**

Oil Formation Vol Factor : 1.000000 m3/m3  
 Water Formation Vol Factor : 1.000000 m3/m3  
 Water / Oil Ratio : 11.66 m3/m3  
 Pattern : 00/13-21-010-29  
 Inj Set: KolaUnit#1  
 March 15, 2016  
 Operator: Tundra\_O&G\_Prtshp  
 Oil Rate (CD) : 0.85 m3/d  
 Water Rate (CD) : 9.95 m3/d  
 Water Inj Rate (CD) : 4.81 m3/d



Oil Formation Vol Factor : 1.00000 m3/m3  
 Water Formation Vol Factor : 1.00000 m3/m3  
 Water / Oil Ratio : 8.34 m3/m3  
 Pattern : 00/02-28-010-29  
 Inj Set: KolaUnit#1  
 March 15, 2016  
 Operator: Tundra\_O&G\_Prtshp  
 Oil Rate (CD) : 1.10 m3/d  
 Water Rate (CD) : 9.20 m3/d  
 Water Inj Rate (CD) : 6.10 m3/d



Oil Formation Vol Factor : 1.000000 m3/m3  
 Water Formation Vol Factor : 1.000000 m3/m3  
 Water / Oil Ratio : 5.94 m3/m3  
 Pattern : 00/12-28-010-29  
 Inj Set: KolaUnit#1  
 March 15, 2016  
 Operator: Tundra\_O&G\_Prtshp  
 Oil Rate (CD) : 0.85 m3/d  
 Water Rate (CD) : 5.05 m3/d  
 Water Inj Rate (CD) : 31.03 m3/d

