

**Waskada Unit No. 19**

**Waterflood Progress Report 2017**

**January 1<sup>st</sup> through December 31<sup>st</sup> 2017**

**Prepared for:**

**Manitoba Industry, Economic Development and Mines**

**Petroleum Branch**

**Prepared by:**

**Tundra Oil and Gas Partnership**

**May 31<sup>st</sup>, 2018**

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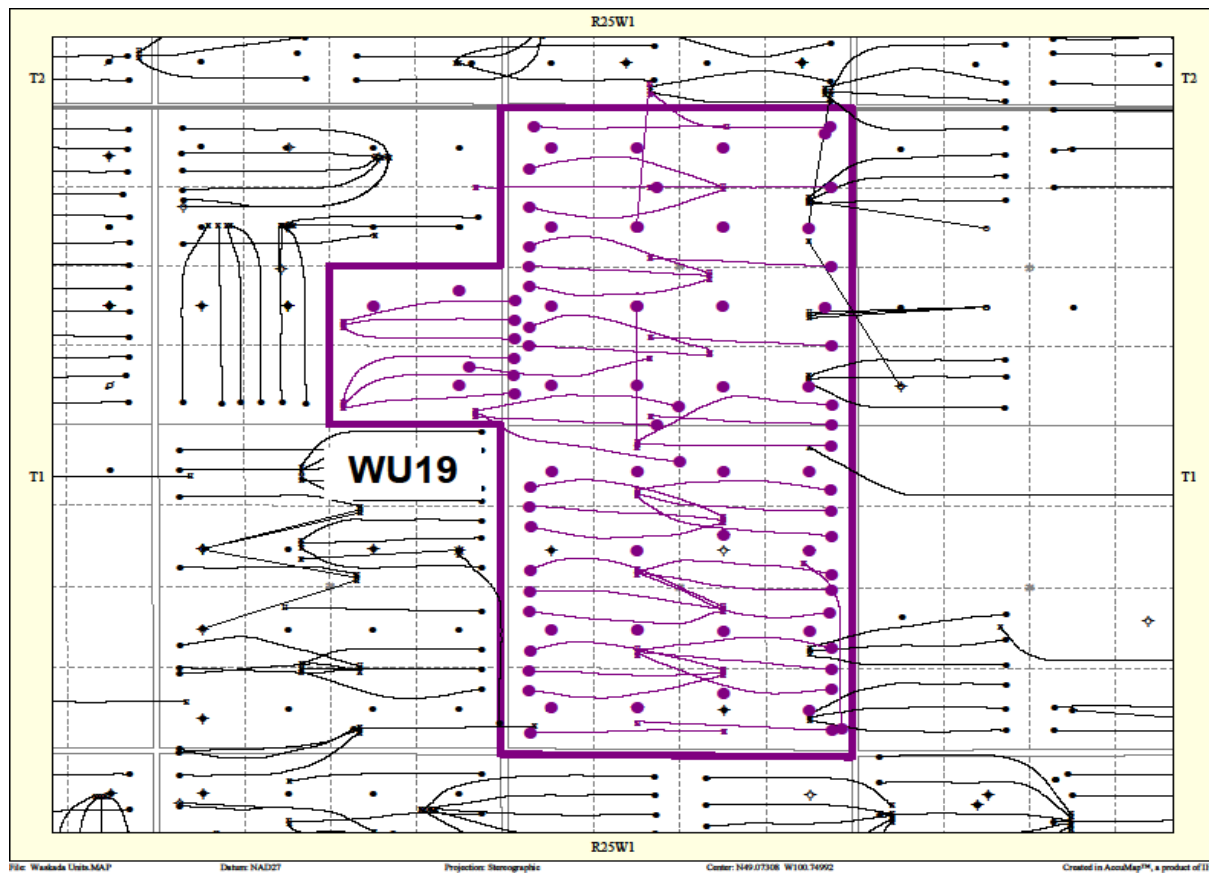
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## INTRODUCTION

The Waskada Unit No. 19 pressure maintenance project commenced water injection into the Lower Amaranth A pool in accordance with Manitoba Energy and Mines Order No. PM 14, dated August 1, 2003. Waskada Unit No. 19 was acquired from EOG Resources Canada Inc. effective October 1, 2014 (closing date December 1, 2014) with Tundra Oil and Gas (Tundra) as the new operator. THE EOR project area, outlined in purple in **Figure 1**, contains 81 wells over 36 LSDs in Township 1, Range 25W1 (**Table 1**).

**Figure 1: Waskada Unit No. 19 Area Outline**



## PRODUCTION HISTORY

For the wells included in Waskada Unit No. 19, production started in December 2001 with the 00/13-34-001-25W1/00 well. Oil production peaked at 505.9 m<sup>3</sup>/d in December 2010. There are currently 30 producing wells in Waskada Unit No. 19. The average production for the unit was 47.9 m<sup>3</sup>/d of oil and 315.8 m<sup>3</sup>/d of water and the average WOR was 6.59 m<sup>3</sup>/m<sup>3</sup> at the end of December 2017 (Table 4). The rates and WOR are presented in Figure 2.

Figure 2: Waskada Unit No. 19 Production/Injection Rates and WOR vs Time

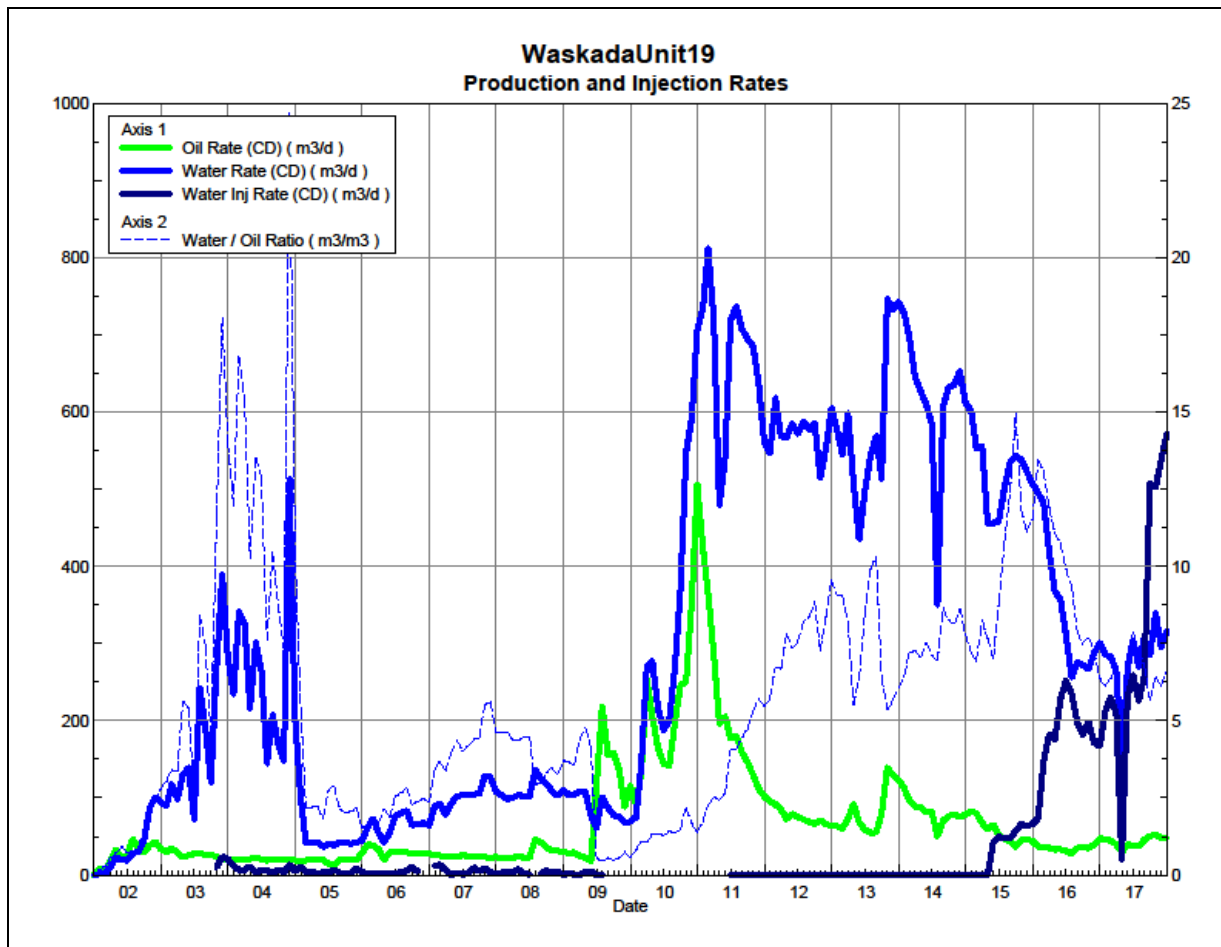
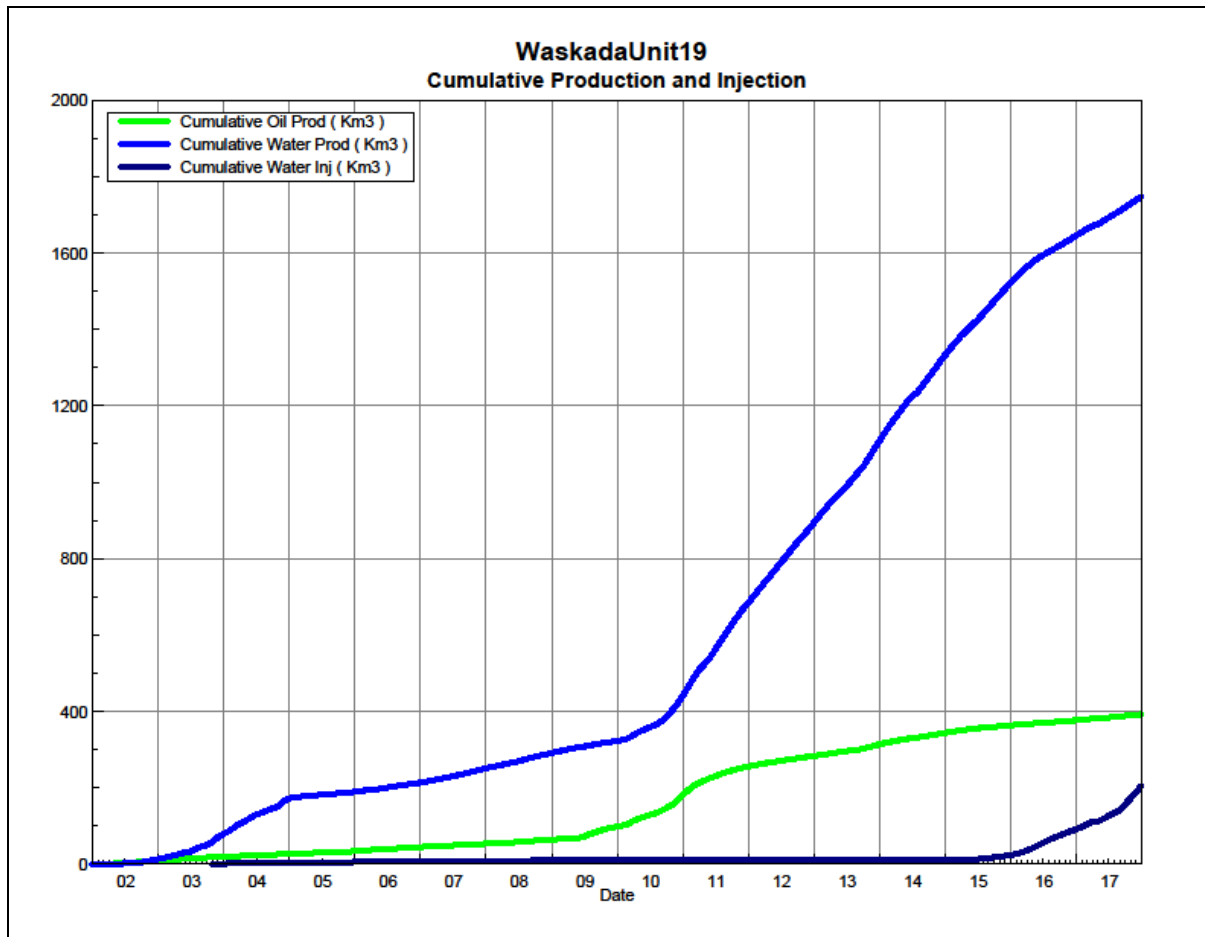


Figure 3 shows the cumulative production for Waskada Unit No. 19 to the end of December 2017 as 392.9 e<sup>3</sup>m<sup>3</sup> of oil, and 1,748.0 e<sup>3</sup>m<sup>3</sup> of water. The cumulative water injected is over 206.3 e<sup>3</sup>m<sup>3</sup>.

**Figure 3. Waskada Unit No. 19 Cumulative Oil, Water and Water Injected vs. Time**



### **WATERFLOOD HISTORY**

Water injection commenced with 4 injector wells on October 2003. Four more injectors were added in November 2003. In 2011, EOG received permission to convert 3 Spearfish injection wells into Mississippian SWD wells. The wells converted were 00/06-27, 00/14-27 and 02/02-27-001-25W1.

Four wells were converted in 2015. In early 2016, six more injectors were added to the Unit. As of the end of December 2017, there are currently 10 active injection wells in Waskada Unit No. 19.

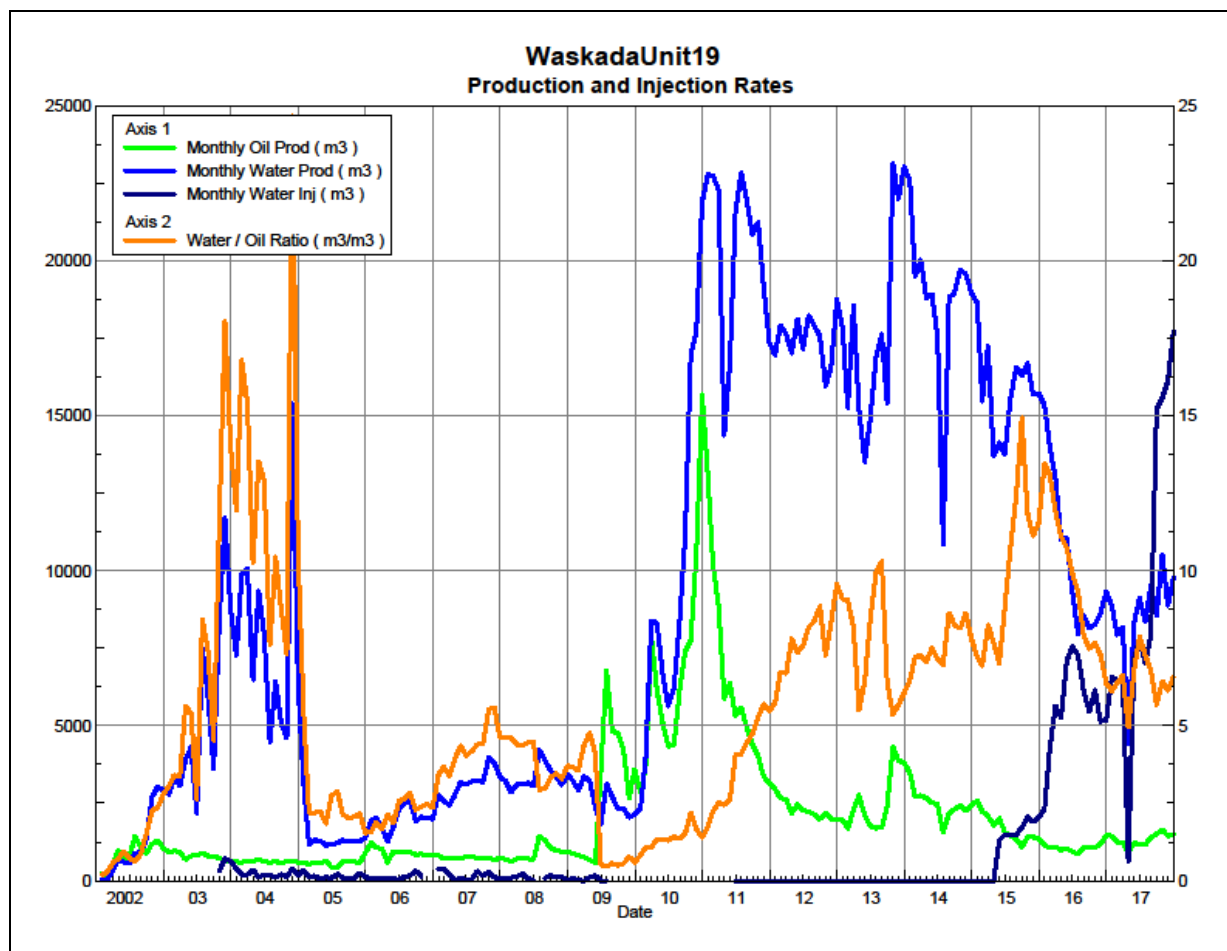
Any future revisions to the waterflood development or surveillance plan would be based on new production or performance response data, technical studies or observed reservoir behavior and reserves recovery interpretations.

## WATERFLOOD PERFORMANCE

From January 1 to December 31 in 2017, Waskada Unit No. 19 produced 118,320 m<sup>3</sup> of total fluids (15,836 m<sup>3</sup> oil, 102,484 m<sup>3</sup> water), and injected 114,703 m<sup>3</sup>. The cumulative VRR since injection commenced in October 2003 is presently at 0.092. Table 2 summarizes the yearly and cumulative VRR for Waskada Unit No. 19.

When water injection commenced in 2003, there was no visible effect on production. This was due to the fact injection rates were insignificant, and the amount of new wells being brought on production at the same time masked any possible benefits from injection. Until 2009, injection pressures remained high which limits injection rates. As a result, EOG discontinued injection into Waskada Unit No. 19 in August 2009. In 2015, water injection was resumed with the conversion of 3 existing wells. In 2016 and 2017, a positive effect was seen on the oil production due to increasing the water injector well count to 10.

**Figure 4. Waskada Unit No. 19 Production and Injection Rates from 2002-2017**



### **INJECTION WELLHEAD PRESSURES**

Individual injection pressure averages for 2017 can be found in **Table 5**.

### **RESERVOIR PRESSURE**

There have been no pressure surveys done on the reservoir.

Gas volumes from the field are measured at the 15-9-2-25W1M battery. There is no individual well gas volume measurement. It is not possible to separate out the gas production from only the wells in Unit 16, so the effectiveness of the pressure maintenance program cannot be evaluated on the GOR.

### **WELL SERVICING**

The following table summarizes the maintenance required on the 81 wells in Waskada Unit No. 19 in 2017.

UWI	Date	Workover
102.09-27-001-25W1.00	9/6/2017	Re-configure Injection Packer Bottomhole Assembly
103.01-27-001-25W1.00	8/13/2017	Cemented Liner Clean Out
103.12-27-001-25W1.00	11/17/2017	Pump Change
103.12-27-001-25W1.00	11/30/2017	Pump Change
103.13-27-001-25W1.00	8/1/2017	Cemented Liner Clean Out
103.16-27-001-25W1.00	7/22/2017	Cemented Liner Clean Out
104.09-27-001-25W1.00	3/15/2017	Water Injection Well Repair - Failed Packer Integrity Test
102.13-34-001-25W1.00	8/22/2017	Cemented Liner Clean Out
102.16-34-001-25W1.00	7/26/2017	Clean-out
103.01-34-001-25W1.00	7/31/2017	Cemented Liner Clean Out
103.04-34-001-25W1.00	7/24/2017	Cemented Liner Clean Out
103.12-34-001-25W1.00	3/22/2017	Hot Oil / Pump Change / Tubing Reconfiguration
103.16-34-001-25W1.00	7/31/2017	Cemented Liner Clean Out
104.05-34-001-25W1.00	1/17/2017	Pump Change
105.04-34-001-25W1.00	7/16/2017	Cemented Liner Clean Out

## **CORROSION AND SCALE PREVENTION**

The facilities in Unit 19 are currently using cathodic protection and chemicals to protect against corrosion and scale. All facilities are monitored every 3 months to assess the corrosion and ensure that proper electrical current is being supplied. There have been no issues with corrosion or scale to date.

Biocide chemical is added to the injection water to prevent any sulfide producing bacteria from forming.

## **CONCLUSION**

The current pressure maintenance program is having little effect on oil production in Waskada Unit No. 19. Tundra will maintain the current pressure maintenance program, and continue to monitor production and pressure performance. Plans for future injection conversions and acid treatments to improve unit performance are being considered for 2018.



TABLE NO. 1: WASKADA UNIT NO. 19 WELL SUMMARY

UWI	Type	Status	On Prod Date	Cum Prd Oil (m3)	Cum Prd Water (m3)	Last Prod Date	On Inj Date	Cum Inj Water (m3)	Last Inj Date
100/01-27-001-25W1/0	Vertical	Abandoned Zone	2/1/2003	1,672	7,285	10/31/2015		0	
102/01-27-001-25W1/0	Horizontal	Producing	2/1/2010	4,609	161,952	12/31/2016		0	
103/01-27-001-25W1/0	Horizontal	Producing	12/1/2010	8,172	20,487	12/31/2016		0	
104/01-27-001-25W1/0	Horizontal	Producing	10/1/2013	2,976	2,687	12/31/2016		0	
102/02-27-001-25W1/0	Vertical	Producing	1/1/2006	1,114	32,319	7/31/2011		0	
100/03-27-001-25W1/0	Vertical	Abandoned	2/1/2003	24	741	3/31/2003		0	
100/04-27-001-25W1/0	Vertical	Injection	N/A	0	0		Nov-2003	1,423	10/31/2008
102/04-27-001-25W1/0	Horizontal	Producing	11/1/2010	10,483	36,041	12/31/2016		0	
103/04-27-001-25W1/0	Horizontal	Injection	12/1/2010	7,192	43,178	1/31/2016	Feb-2016	21,526	12/31/2017
100/05-27-001-25W1/0	Vertical	Abandoned Zone	10/1/2002	5,659	3,956	12/31/2015		0	
102/05-27-001-25W1/0	Horizontal	Producing	12/1/2010	7,642	11,387	12/31/2016		0	
103/05-27-001-25W1/0	Horizontal	Producing	12/1/2010	4,066	49,285	4/30/2016		0	
104/05-27-001-25W1/0	Horizontal	Producing	9/1/2010	9,498	132,169	12/31/2016		0	
100/06-27-001-25W1/0	Vertical	Injection	N/A	0	0		Nov-2003	0	9/30/2015
100/07-27-001-25W1/0	Vertical	Injection	2/1/2003	3,696	1,837	7/31/2013	Feb-2016	7,926	12/31/2017
100/08-27-001-25W1/0	Vertical	Abandoned Zone	1/1/2006	1,925	507	7/31/2014		0	
102/08-27-001-25W1/0	Horizontal	Producing	12/1/2010	5,138	31,124	6/30/2016		0	
103/08-27-001-25W1/0	Horizontal	Producing	12/1/2010	5,759	4,183	12/31/2016		0	
104/08-27-001-25W1/0	Horizontal	Producing	10/1/2010	4,493	45,120	12/31/2016		0	
100/09-27-001-25W1/0	Vertical	Abandoned	10/1/2002	226	6,620	10/31/2003		0	
102/09-27-001-25W1/0	Horizontal	Injection	10/1/2010	4,876	8,770	11/30/2015	Jan-2016	15,130	12/31/2017
103/09-27-001-25W1/0	Horizontal	Producing	10/1/2010	6,573	8,071	12/31/2016		0	
104/09-27-001-25W1/0	Horizontal	Injection	8/1/2010	3,223	38,778	3/31/2014	Jan-2016	23,723	12/31/2017
102/10-27-001-25W1/0	Vertical	Abandoned	N/A	0	0			0	
100/11-27-001-25W1/0	Vertical	Pumping	10/1/2002	3,432	66,979	2/28/2015		0	
102/12-27-001-25W1/0	Horizontal	Producing	9/1/2010	8,534	79,548	4/30/2015		0	
103/12-27-001-25W1/0	Horizontal	Producing	9/1/2010	6,823	59,263	12/31/2016		0	
104/12-27-001-25W1/0	Horizontal	Injection	9/1/2010	5,535	25,660	12/31/2015	Dec-2015	16,948	12/31/2017
100/13-27-001-25W1/0	Vertical	Abandoned Zone	8/1/2002	3,061	111,529	9/30/2013		0	
102/13-27-001-25W1/0	Horizontal	Producing	9/1/2010	8,816	47,918	12/31/2016		0	
103/13-27-001-25W1/0	Horizontal	Producing	9/1/2010	3,100	50,076	12/31/2016		0	
100/14-27-001-25W1/0	Vertical	Injection	N/A	0	0		Nov-2003	0	9/30/2015
102/14-27-001-25W1/0	Horizontal	Producing	11/1/2010	6,834	15,351	12/31/2016		0	
100/15-27-001-25W1/0	Vertical	Abandoned Zone	8/1/2002	4,128	1,976	5/31/2012		0	
100/16-27-001-25W1/0	Vertical	Producing	1/1/2006	1,842	752	7/31/2012		0	
102/16-27-001-25W1/0	Horizontal	Suspended	8/1/2010	5,298	28,210	3/31/2016		0	
103/16-27-001-25W1/0	Horizontal	Producing	8/1/2010	5,660	7,264	7/31/2016		0	
104/16-27-001-25W1/0	Horizontal	Producing	3/1/2013	3,652	2,734	12/31/2016		0	
100/01-33-001-25W1/0	Vertical	Abandoned Zone	3/1/2002	4,823	49,476	6/30/2014		0	
100/07-33-001-25W1/0	Vertical	Pumping	3/1/2002	3,473	5,858	12/31/2013		0	
100/08-33-001-25W1/0	Vertical	Abandoned	N/A	0	0		Nov-2003	1,411	5/31/2015
100/01-34-001-25W1/0	Vertical	Pumping	3/1/2002	3,609	1,073	12/31/2016		0	
102/01-34-001-25W1/0	Horizontal	Abandoned Zone	6/1/2009	9,035	1,504	2/29/2016		0	
103/01-34-001-25W1/0	Horizontal	Producing	3/1/2013	5,589	2,674	12/31/2016		0	
100/02-34-001-25W1/0	Vertical	Injection	N/A	0	0		Oct-2003	2,691	8/31/2015
100/03-34-001-25W1/0	Vertical	Pumping	3/1/2002	4,862	1,595	1/31/2015		0	
102/03-34-001-25W1/0	Horizontal	Injection	6/1/2009	11,281	83,848	11/30/2015	Jan-2016	21,917	12/31/2017
103/03-34-001-25W1/0	Horizontal	Producing	11/1/2010	7,829	3,288	12/31/2016		0	
100/04-34-001-25W1/0	Vertical	Abandoned Zone	12/1/2005	1,311	32,105	5/31/2010		0	
102/04-34-001-25W1/0	Horizontal	Injection	2/1/2010	6,526	1,971	12/31/2015	Feb-2016	14,198	12/31/2017
103/04-34-001-25W1/0	Horizontal	Producing	9/1/2013	5,572	39,116	12/31/2016		0	
104/04-34-001-25W1/0	Horizontal	Producing	9/1/2013	3,853	55,664	12/31/2016		0	
105/04-34-001-25W1/0	Horizontal	Producing	9/1/2013	6,415	5,470	12/31/2016		0	
100/05-34-001-25W1/0	Vertical	Pumping	6/1/2002	4,268	1,619	6/30/2013		0	
102/05-34-001-25W1/0	Horizontal	Producing	6/1/2009	8,486	4,122	12/31/2016		0	
103/05-34-001-25W1/0	Horizontal	Injection	2/1/2010	6,321	1,687	3/31/2015	Mar-2015	23,590	12/31/2017
104/05-34-001-25W1/0	Horizontal	Producing	3/1/2010	11,831	46,121	12/31/2016		0	
105/05-34-001-25W1/0	Horizontal	Producing	9/1/2013	3,696	64,505	12/31/2016		0	
106/05-34-001-25W1/0	Horizontal	Producing	9/1/2013	2,720	51,306	6/30/2016		0	
107/05-34-001-25W1/0	Horizontal	Producing	9/1/2013	9,776	7,486	12/31/2016		0	
100/06-34-001-25W1/0	Vertical	Producing	12/1/2005	2,271	536	6/30/2012		0	
100/07-34-001-25W1/0	Vertical	Pumping	3/1/2002	5,162	1,528	11/30/2014		0	
100/08-34-001-25W1/0	Vertical	Injection	N/A	0	0		Oct-2003	1,675	
102/08-34-001-25W1/0	Horizontal	Producing	6/1/2009	6,317	1,513	12/31/2016		0	5/31/2015
100/09-34-001-25W1/0	Vertical	Producing	6/1/2002	4,558	1,568	11/30/2012		0	
102/09-34-001-25W1/0	Horizontal	Producing	6/1/2009	8,180	1,505	12/31/2016		0	
100/10-34-001-25W1/0	Vertical	Injection	N/A	0	0		Oct-2003	3,206	
100/11-34-001-25W1/0	Vertical	Abandoned Zone	6/1/2002	4,500	1,984	10/31/2014		0	5/31/2015
100/12-34-001-25W1/0	Vertical	Abandoned Zone	12/1/2005	2,822	717	8/31/2013		0	
102/12-34-001-25W1/0	Horizontal	Injection	6/1/2009	7,656	3,742	2/28/2015	Mar-2015	25,995	
103/12-34-001-25W1/0	Horizontal	Producing	3/1/2010	5,323	2,744	12/31/2016		0	
104/12-34-001-25W1/0	Horizontal	Producing	3/1/2010	6,198	12,592	12/31/2016		0	12/31/2017
100/13-34-001-25W1/0	Vertical	Pumping	12/1/2001	5,272	1,836	5/31/2015		0	
102/13-34-001-25W1/0	Horizontal	Producing	3/1/2010	10,881	88,542	12/31/2016		0	
103/13-34-001-25W1/0	Horizontal	Producing	3/1/2010	8,289	3,486	12/31/2016		0	
100/14-34-001-25W1/0	Vertical	Abandoned Zone	12/1/2005	1,659	721	4/30/2012		0	
102/14-34-001-25W1/0	Horizontal	Injection	7/1/2008	8,110	10,093	6/30/2015	Sep-2015	24,449	
100/15-34-001-25W1/0	Vertical	Pumping	6/1/2002	4,204	1,446	7/31/2012		0	
100/16-34-001-25W1/0	Vertical	Abandoned	N/A	0	0		Oct-2003	479	12/31/2017
102/16-34-001-25W1/0	Horizontal	Producing	6/1/2009	8,242	2,550	12/31/2016		0	
103/16-34-001-25W1/0	Horizontal	Producing	8/1/2010	6,294	6,688	12/31/2016		0	8/31/2004
				392,941	1,748,030				
								206,285	

**TABLE NO. 2 - Waskada Unit No. 19 VRR Calculations**

Date	Monthly Oil Prod m3	Cum Oil Prod Km3	Monthly Water Prod m3	Cum Water Prod Km3	Water Oil Ratio m3/m3	Monthly Water Inj m3	Cum Water Inj Km3	VRR	Cum VRR
2001	4	0.004	0	0.000	0.00	0	0.000	0.000	0.000
2002	10,244	10.248	14,062	14.062	1.37	0	0.000	0.000	0.000
2003	9,591	19.839	65,411	79.473	6.82	1,818	1.818	0.024	0.018
2004	7,425	27.264	93,300	172.773	12.57	2,937	4.755	0.029	0.023
2005	7,093	34.357	16,885	189.658	2.38	2,138	6.893	0.085	0.030
2006	10,975	45.332	24,031	213.689	2.19	1,631	8.524	0.044	0.032
2007	8,780	54.112	37,568	251.257	4.28	2,421	10.945	0.051	0.035
2008	10,771	64.883	40,022	291.279	3.72	1,487	12.432	0.028	0.034
2009	34,114	98.998	31,617	322.895	0.93	579	13.011	0.008	0.030
2010	81,848	180.845	117,546	440.441	1.44	0	13.011	0.000	0.020
2011	75,155	256.000	243,772	684.213	3.24	0	13.011	0.000	0.013
2012	27,659	283.659	209,773	893.986	7.58	0	13.011	0.000	0.010
2013	30,379	314.038	213,317	1,107.303	7.02	0	13.011	0.000	0.009
2014	29,739	343.777	224,198	1,331.500	7.54	0	13.011	0.000	0.007
2015	20,310	364.090	189,446	1,520.946	9.33	13,492	26.503	0.063	0.012
2016	13,018	377.105	124,600	1,645.547	9.57	67,424	93.927	0.483	0.044
2017	15,836	392.941	102,484	1,748.030	6.47	114,703	206.285	0.950	0.092

TABLE NO. 3

**Tundra Oil and Gas  
Waskada Unit No. 19  
2017 Injection Volumes**

Well Location	Date	Hours On	H <sub>2</sub> O Inj Cal-d avg (m <sup>3</sup> /d)	Monthly Injected H <sub>2</sub> O (m <sup>3</sup> )
<b>Unit No. 19 Total:</b>				
	Jan-17	0	213	6,595
	Feb-17	0	230	6,441
	Mar-17	0	210	6,503
	Apr-17	0	21	622
	May-17	0	231.3	7,171
	Jun-17	0	259.1	7,773
	Jul-17	0	225.9	7,001
	Aug-17	0	257.2	7,972
	Sep-17	0	507.0	15,209
	Oct-17	0	502.4	15,573
	Nov-17	0	537.2	16,116
	Dec-17	0	571.9	17,728
<b>2017 Group Totals:</b>				<b>114,703</b>

<b>Unit No. 19 Total:</b>				
	2001	0		
	2002	0		
	2003	0	19.8	1,668
	2004	0	8.0	2,592
	2005	0	5.9	1,718
	2006	0	5.4	1,094
	2007	0	6.6	2,051
	2008	0	4.4	1,162
	2009	0	2.7	381
	2010	0	0.0	
	2011	0	0.0	0
	2012	0	0.0	0
	2013	0	0.0	0
	2014	0	0.0	0
	2015	0	55.1	13,492
	2016	0	184.1	67,424
	2017	0	313.8	114,703
<b>Group Totals:</b>				<b>206,285</b>

TABLE NO. 4

**Tundra Oil and Gas  
Waskada Unit No. 19  
2017 Production Volumes**

Date	Hours On	Oil Rate (CD) m3/d	Monthly Oil Prod m3	Water Rate (CD) m3/d	Monthly Water Prod m3	Water Oil Ratio m3/m3	Well Count
Jan-17	21,384	46.64	1,446	285.27	8,844	6.12	29
Feb-17	20,256	44.48	1,246	283.43	7,936	6.37	30
Mar-17	20,928	39.93	1,238	264.08	8,187	6.61	28
Apr-17	12,696	29.85	896	147.81	4,434	4.95	18
May-17	21,576	39.37	1,221	268.36	8,319	6.82	29
Jun-17	22,848	38.59	1,158	304.00	9,120	7.88	32
Jul-17	22,392	37.15	1,152	269.87	8,366	7.27	30
Aug-17	21,336	45.50	1,411	307.93	9,546	6.77	29
Sep-17	19,776	50.18	1,505	284.76	8,543	5.68	27
Oct-17	23,376	52.72	1,634	339.59	10,527	6.44	31
Nov-17	21,504	48.18	1,445	295.75	8,872	6.14	30
Dec-17	22,464	47.95	1,486	315.79	9,790	6.59	30
	250,536		15,836		102,484		

Date	Hours On	Oil Rate (CD) m3/d	Monthly Oil Prod m3	Water Rate (CD) m3/d	Monthly Water Prod m3	Water Oil Ratio m3/m3	Well Count
2001	24	0.11	4	0.00	0	0.00	1
2002	68,280	28.07	10,244	38.53	14,062	1.37	9
2003	129,672	26.28	9,591	179.21	65,411	6.82	17
2004	132,144	20.29	7,425	254.92	93,300	12.57	16
2005	131,304	19.43	7,093	46.26	16,885	2.38	16
2006	187,747	30.07	10,975	65.84	24,031	2.19	23
2007	195,888	24.05	8,780	102.93	37,568	4.28	23
2008	201,480	29.43	10,771	109.35	40,022	3.72	24
2009	197,640	93.46	34,114	86.62	31,617	0.93	28
2010	308,304	224.24	81,848	322.04	117,546	1.44	41
2011	463,440	205.90	75,155	667.87	243,772	3.24	68
2012	447,576	75.57	27,659	573.15	209,773	7.58	62
2013	413,376	83.23	30,379	584.43	213,317	7.02	55
2014	410,280	81.48	29,739	614.24	224,198	7.54	49
2015	347,736	55.76	20,310	519.04	189,446	9.88	40
2016	242,352	35.57	13,018	340.87	124,600	9.68	28
2017	250,536	43.38	15,836	280.55	102,484	6.47	29
	4,127,779		392,941		1,748,030		

**TABLE NO. 5 - Average Injection Pressures**

	<b>00/02-34 Inj</b>	<b>00/04-27 Inj</b>	<b>00/06-27 Inj</b>	<b>00/07-27 Inj</b>	<b>00/08-33 Inj</b>	<b>00/08-34 Inj</b>	<b>00/10-34 Inj</b>	<b>00/14-27 Inj</b>	<b>02/03-34 Inj</b>
<b>Year</b>	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)
2014	0.0	0.0	4575.8	0.0	0.0	0.0	0.0	3695.5	0.0
2015	3196.4	0.0	4099.7	0.0	2986.0	3156.2	3169.3	3282.6	0.0
2016	3163.4	0.0	4000.3	1722.9	2388.7	1059.3	4827.7	220.2	1333.2
2017	4850.0	0.0	4000.0	1528.7	5000.0	4800.0	4800.0	0.0	1992.9

	<b>02/04-34 Inj</b>	<b>02/09-27 Inj</b>	<b>02/12-34 Inj</b>	<b>02/14-34 Inj</b>	<b>03/04-27 Inj</b>	<b>03/05-34 Inj</b>	<b>04/09-27 Inj</b>	<b>04/12-27 Inj</b>
<b>Year</b>	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	50.2	0.0	0.0	51.3	0.0	0.0
2016	4384.3	933.1	1490.2	1115.1	2399.9	1889.4	882.5	1658.0
2017	2167.2	82.2	1865.5	2124.1	2592.9	1883.6	1784.4	2172.6