

**Waskada Unit No. 17**  
**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**

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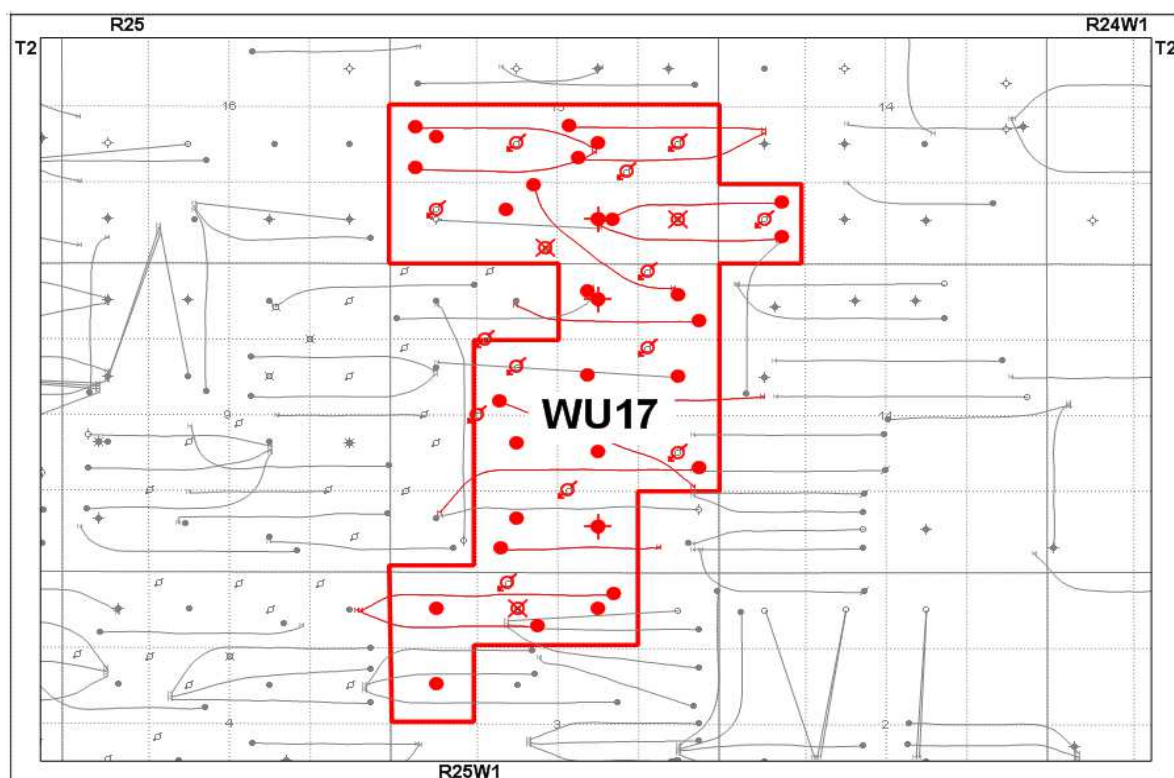
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## **INTRODUCTION**

The Waskada Unit No.17 pressure maintenance project commenced water injection into the Lower Amaranth A pool in accordance with Manitoba Energy and Mines Order No. PM 66, dated October 1, 1991. Waskada Unit No. 17 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 red in [Figure 1](#), contains 48 wells over 23 LSDs in Township 2, Range 25W1 ([Table 1](#)).

**Figure 1: Waskada Unit No. 17 Area Outline**



## **PRODUCTION HISTORY**

For the wells included in Waskada Unit No. 17, production started in December 1982 with the 00/15-10-002-25W1/00 well. From 1982 – 1990, 25 wells were drilled. Oil production peaked at 72.3 m<sup>3</sup>/d in September 1990. From 2012-2014, 11 new producers were added to the unit, resulting in a peak in oil production of 212.4 m<sup>3</sup>/d in November 2014. There are currently 28 producing wells in Waskada Unit No. 17. The average production for the unit was 40.4 m<sup>3</sup>/d of oil and 37.3 m<sup>3</sup>/d of water and the average WOR was 0.92 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. 17 Production/Injection Rates and WOR vs Time

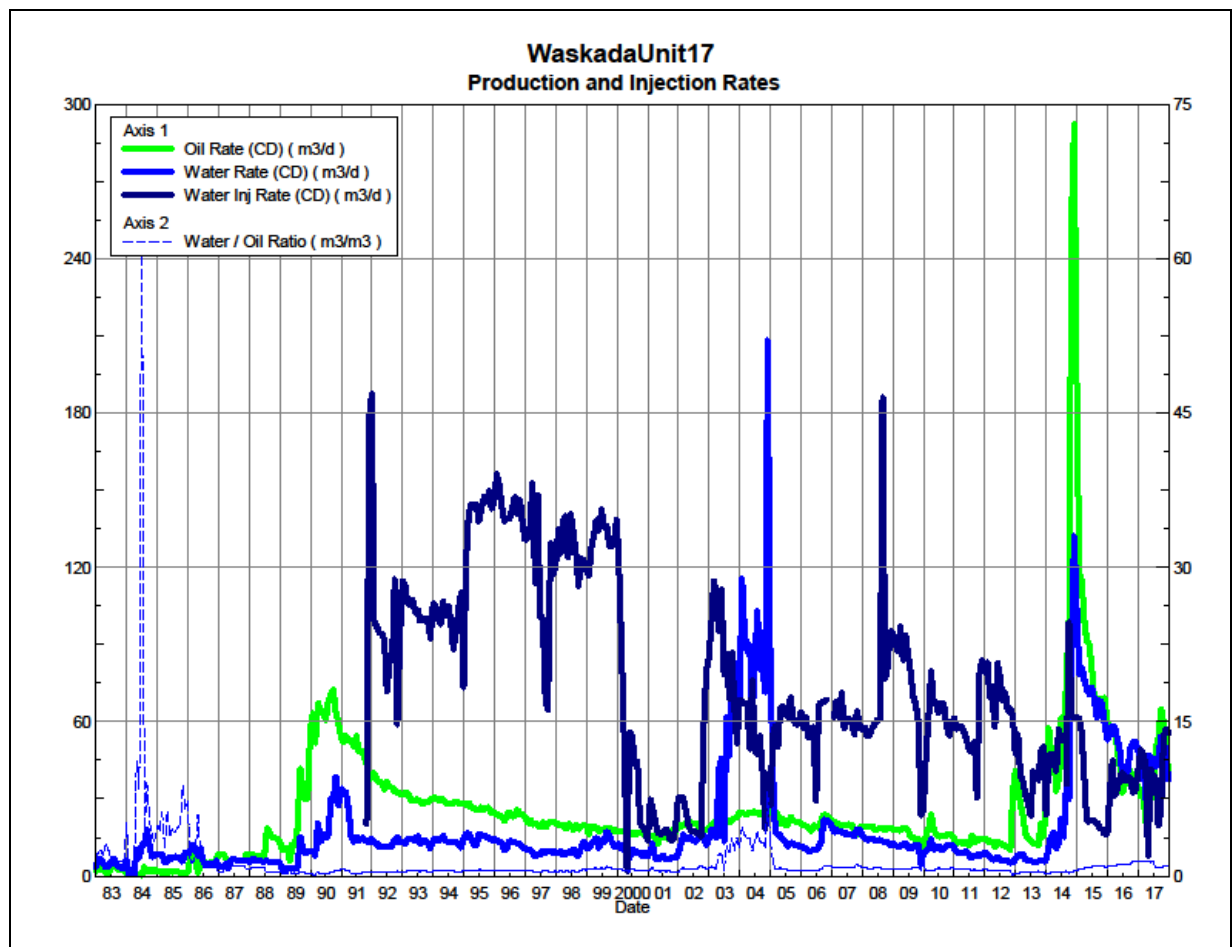
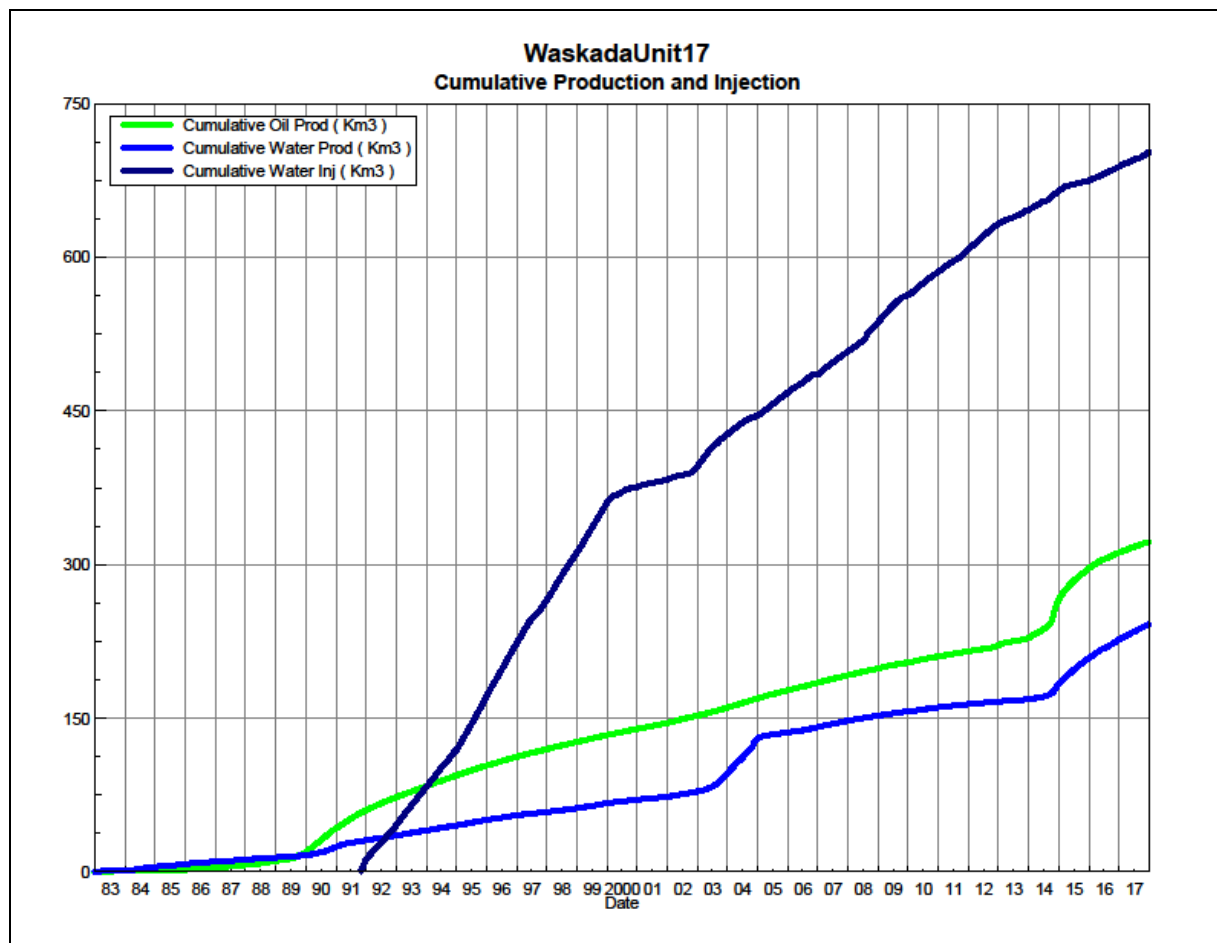


Figure 3 shows the cumulative production for Waskada Unit No. 17 to the end of December 2017 as 321.4 e³m³ of oil, and 241.8 e³m³ of water. The cumulative water injected is over 702.8 e³m³.

**Figure 3. Waskada Unit No. 17 Cumulative Oil, Water and Water Injected vs. Time**



### **WATERFLOOD HISTORY**

Water injection commenced with 6 injector wells on October 1991. Two more injectors wells were added in November 2001 and 7 more in October 2002. Of the 14 injector wells operating in 2017, 8 were active at the end of 2017.

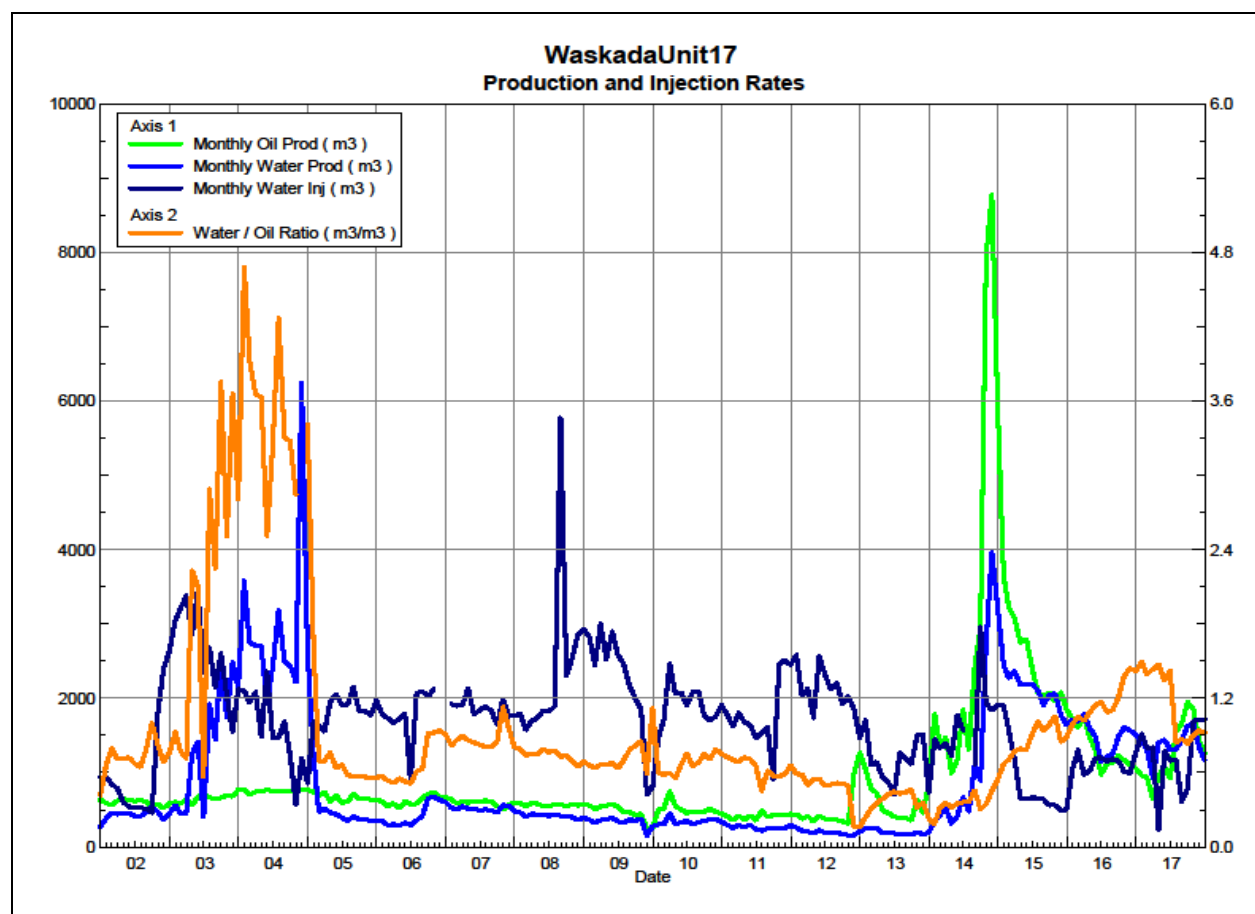
Any future revisions to the waterflood development or surveillance plan would be based on new production or performance response data, technical studies or observed reservoir behavior and reserves recovery interpretations.

## WATERFLOOD PERFORMANCE

From January 1 to December 31 in 2017, Waskada Unit No. 17 produced 31,522 m<sup>3</sup> of total fluids (15,170 m<sup>3</sup> oil, 16,352 m<sup>3</sup> water), and injected 14,552 m<sup>3</sup> of source water, giving an annual oil and water voidage replacement ratio (VRR) of 0.431 for this reporting period. The cumulative VRR since injection commenced in October 1991 is presently at 1.135. The cumulative VRR reached 1.0 in 1995 and has maintained values of 1.17 – 1.64 since 1997. Table 2 summarizes the yearly and cumulative VRR for Waskada Unit No. 17.

In 2011, the injection rate was increased from approximately 1500 m<sup>3</sup>/month in January to 2300 m<sup>3</sup>/month in March. This increase resulted in a small increase in produced volumes (Figure 4). The injection rate was also increased in 2002, which also had a positive effect on the oil production. The increase in production in 2012-14 can be attributed to the addition of 11 new producers (1 in 2012, 2 in 2013 and 8 in 2014).

**Figure 4. Waskada Unit No. 17 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 Waskada Unit No. 17, so the effectiveness of the pressure maintenance program cannot be evaluated on the GOR.

### **WELL SERVICING**

The following table summarizes the maintenance done on the Waskada Unit No. 17 wells in 2017:

<b>UWI</b>	<b>Date</b>	<b>Job</b>
100.12-03-002-25W1.00	12/6/2017	Rigless Acid Stimulation
103.08-10-002-25W1.00	7/18/2017	Pump Change
103.03-15-002-25W1.00	9/14/2017	Pump Change/ Tubing Reconfiguration
103.05-15-002-25W1.00	7/10/2017	Pump Change

### **CORROSION AND SCALE PREVENTION**

The facilities in Waskada Unit No. 17 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 a positive effect on oil production in Waskada Unit No. 17. Tundra will maintain the current pressure maintenance program, and continue to monitor production and pressure performance. Plans for future injection conversions and well interventions to optimize the waterflood are currently being reviewed.

TABLE NO. 1: WASKADA UNIT NO. 17 WELL SUMMARY

UWI	Type	Status	On Prod Date	Cum Prd Oil (m3)	Cum Prd Water (m3)	Last Prod Date	On Injection Date	Cum Inj Water (m3)	Last Inj Date
100/12-03-002-25W1/0	Vertical	Producing	1/29/1990	5,609.4	9,895.6	12/31/2017		-	
100/13-03-002-25W1/0	Vertical	Pumping	7/20/1989	17,655.0	1,895.8	5/31/2016		-	
100/14-03-002-25W1/0	Vertical	Abandoned	11/22/1989	1,141.3	204.9	8/31/1991	Oct-1991	68,073.7	2/28/2005
102/14-03-002-25W1/0	Vertical	Injection	N/A	-	-		Oct-2002	5,877.0	6/30/2015
103/14-03-002-25W1/0	Horizontal	Producing	9/18/2014	7,510.6	2,021.4	12/31/2017		-	
100/15-03-002-25W1/0	Vertical	Pumping	8/2/1990	4,459.1	24,893.5	12/31/2015		-	
102/15-03-002-25W1/0	Horizontal	Producing	6/27/2017	4,902.5	1,477.0	12/31/2017		-	
100/02-10-002-25W1/0	Vertical	Abandoned	7/9/1990	3,438.1	6,493.1	3/31/2003		-	
1C0/02-10-002-25W1/0	Vertical	Injection	N/A	-	-		Oct-2002	5,576.5	11/30/2014
100/03-10-002-25W1/0	Vertical	Producing	7/27/1989	13,142.1	5,279.7	12/31/2017		-	
102/03-10-002-25W1/0	Horizontal	Producing	11/14/2012	8,125.1	1,285.2	12/31/2017		-	
100/06-10-002-25W1/0	Vertical	Producing	8/6/1989	9,192.5	8,773.6	7/31/2017		-	
1C0/06-10-002-25W1/0	Vertical	Injection	N/A	-	-		Nov-2001	2,519.7	6/30/2016
100/07-10-002-25W1/0	Vertical	Pumping	3/19/1990	17,714.3	23,931.4	12/31/2017		-	
100/08-10-002-25W1/0	Vertical	Injection	7/12/1990	570.1	175.7	9/30/1991	Oct-1991	65,300.8	12/13/2017
103/08-10-002-25W1/0	Horizontal	Producing	10/22/2014	9,760.4	3,481.3	12/31/2017		-	
1C0/08-10-002-25W1/0	Vertical	Injection	N/A	-	-		Oct-2002	16,110.3	12/13/2017
100/09-10-002-25W1/0	Vertical	Pumping	3/20/1990	21,550.1	2,757.0	8/31/2016		-	
1C0/09-10-002-25W1/0	Vertical	Injection	N/A	-	-		Oct-2002	31,851.4	12/13/2017
100/10-10-002-25W1/0	Vertical	Pumping	12/13/1989	13,845.8	1,659.8	5/31/2015		-	
100/11-10-002-25W1/0	Vertical	Injection	7/8/1988	3,313.7	96.5	10/31/1991	Oct-1991	85,354.2	12/13/2017
103/11-10-002-25W1/0	Horizontal	Producing	3/24/2014	6,137.0	3,051.7	12/31/2017		-	
104/11-10-002-25W1/0	Horizontal	Producing	9/17/2014	9,310.2	1,972.0	12/31/2017		-	
1C0/11-10-002-25W1/0	Vertical	Injection	N/A	-	-		Nov-2001	22,209.7	11/30/2015
100/15-10-002-25W1/0	Vertical	Abandoned	12/11/1982	1,737.6	7,558.2	11/30/1989		-	
102/15-10-002-25W1/0	Vertical	Pumping	11/27/1989	10,992.9	8,017.0	7/31/2017		-	
100/16-10-002-25W1/0	Vertical	Pumping	12/15/1989	29,027.0	7,630.9	12/31/2017		-	
103/16-10-002-25W1/0	Horizontal	Producing	10/4/2014	5,400.3	9,368.0	12/31/2017		-	
1C0/16-10-002-25W1/0	Vertical	Injection	N/A	-	-		Oct-2002	19,700.3	12/13/2017
100/04-14-002-25W1/0	Vertical	Injection	8/15/1989	3,943.6	927.8	4/30/2014	Jan-2016	1,391.4	12/13/2017
102/04-14-002-25W1/0	Horizontal	Producing	9/28/2014	7,079.4	2,868.4	12/31/2017		-	
103/04-14-002-25W1/0	Horizontal	Producing	9/27/2014	7,181.5	1,462.3	12/31/2017		-	
100/01-15-002-25W1/0	Vertical	Abandoned Zone	2/24/1990	1,138.2	164.5	10/31/1991	Oct-1991	77,361.4	11/30/2003
100/02-15-002-25W1/0	Vertical	Abandoned	6/18/1983	521.9	1,082.0	9/30/1984		-	
102/02-15-002-25W1/0	Vertical	Pumping	7/21/1990	6,396.2	34,777.1	5/31/2012		-	
100/03-15-002-25W1/0	Vertical	Producing	7/9/1988	18,324.5	3,912.2	4/30/2014		-	
103/03-15-002-25W1/0	Horizontal	Producing	7/9/2014	8,108.0	8,129.0	12/31/2017		-	
1A0/03-15-002-25W1/0	Vertical	Abandoned	N/A	-	-		Oct-2002	10,933.0	12/31/2004
102/04-15-002-25W1/0	Vertical	Injection	11/11/1987	1,727.0	90.8	8/31/1991	Oct-1991	205,775.3	3/31/2015
100/05-15-002-25W1/0	Vertical	Producing	1/10/1986	20,260.9	13,693.9	12/31/2017		-	
102/05-15-002-25W1/0	Horizontal	Producing	12/21/2013	5,072.6	2,078.9	12/31/2017		-	
103/05-15-002-25W1/0	Horizontal	Producing	9/29/2014	7,083.5	28,164.2	12/31/2017		-	
100/06-15-002-25W1/0	Vertical	Injection	8/9/1989	1,818.2	71.0	10/31/1991	Oct-1991	73,442.3	12/13/2017
100/07-15-002-25W1/0	Vertical	Pumping	12/19/1989	12,755.1	1,096.3	12/31/2017		-	
103/07-15-002-25W1/0	Horizontal	Producing	12/26/2013	5,398.7	1,215.3	12/31/2017		-	
104/07-15-002-25W1/0	Horizontal	Producing	10/24/2014	5,303.6	3,226.9	12/31/2017		-	
1A0/07-15-002-25W1/0	Vertical	Injection	N/A	-	-		Oct-2002	7,146.0	4/30/2016
100/08-15-002-25W1/0	Vertical	Injection	2/26/1990	10,327.9	8,226.2	12/31/2015	Jan-2016	4,161.2	12/13/2017
				326,975.9	243,106.1				



**TABLE NO. 2 - 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
1982	62	0.061	112	0.112	1.83		0.000	0.000	0.000
1983	886	0.948	1,740	1.852	1.96		0.000	0.000	0.000
1984	556	1.504	2,966	4.818	5.33		0.000	0.000	0.000
1985	527	2.031	2,639	7.457	5.01		0.000	0.000	0.000
1986	2,102	4.133	2,552	10.009	1.21		0.000	0.000	0.000
1987	2,458	6.591	1,953	11.962	0.79		0.000	0.000	0.000
1988	4,259	10.850	2,105	14.067	0.49		0.000	0.000	0.000
1989	8,384	19.234	2,264	16.331	0.27		0.000	0.000	0.000
1990	23,097	42.331	7,907	24.238	0.34		0.000	0.000	0.000
1991	17,649	59.980	6,610	30.848	0.37	11,761	11.761	0.437	0.118
1992	12,763	72.743	4,577	35.425	0.36	33,425	45.186	1.736	0.379
1993	10,847	83.590	4,935	40.360	0.45	37,546	82.732	2.157	0.606
1994	10,528	94.118	4,945	45.305	0.47	36,033	118.764	2.113	0.774
1995	9,584	103.702	5,395	50.700	0.56	51,942	170.707	3.164	1.004
1996	8,654	112.355	4,506	55.207	0.52	52,252	222.959	3.614	1.209
1997	7,445	119.800	3,355	58.562	0.45	42,058	265.017	3.529	1.350
1998	7,070	126.870	3,521	62.083	0.50	46,808	311.825	4.017	1.499
1999	6,604	133.474	4,835	66.918	0.73	48,343	360.168	3.889	1.634
2000	6,121	139.595	3,447	70.365	0.56	15,666	375.834	1.494	1.628
2001	5,773	145.368	2,812	73.177	0.49	7,294	383.127	0.772	1.594
2002	7,114	152.483	5,299	78.476	0.74	12,558	395.685	0.932	1.559
2003	7,876	160.359	16,751	95.227	2.13	31,446	427.130	1.218	1.527
2004	9,026	169.384	35,279	130.506	3.91	18,431	445.561	0.404	1.370
2005	7,951	177.335	5,725	136.231	0.72	22,256	467.817	1.497	1.375
2006	7,468	184.803	5,180	141.410	0.69	17,884	485.701	1.299	1.372
2007	7,078	191.881	6,141	147.551	0.87	22,355	508.056	1.565	1.380
2008	6,787	198.668	5,002	152.553	0.74	28,727	536.783	2.243	1.409
2009	5,576	204.244	3,991	156.544	0.72	26,267	563.050	2.525	1.438
2010	6,141	210.385	4,094	160.638	0.67	22,960	586.010	2.058	1.456
2011	4,951	215.336	3,127	163.765	0.63	21,464	607.474	2.433	1.477
2012	6,001	221.337	2,352	166.118	0.39	24,965	632.439	2.698	1.503
2013	6,978	228.315	2,372	168.490	0.34	13,790	646.228	1.326	1.499
2014	37,908	266.220	15,052	183.542	0.40	18,499	664.727	0.315	1.357
2015	29,958	296.180	25,171	208.713	0.84	10,006	674.733	0.168	1.228
2016	15,625	311.806	18,042	226.755	1.15	13,499	688.232	0.375	1.176
2017	15,170	326.976	16,352	243.106	1.08	14,552	702.784	0.431	1.135

TABLE NO. 3

**Tundra Oil and Gas  
Waskada Unit No. 17  
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. 17 Total:</b>				
	Jan-17	0	49.0	1,520
	Feb-17	0	47.6	1,333
	Mar-17	0	43.2	1,339
	Apr-17	0	7.7	231
	May-17	0	41.6	1,289
	Jun-17	0	38.5	1,155
	Jul-17	0	38.0	1,178
	Aug-17	0	19.6	608
	Sep-17	0	26.0	779
	Oct-17	0	54.5	1,688
	Nov-17	0	57.2	1,717
	Dec-17	0	55.4	1,716
<b>2017 Group Totals:</b>				<b>14,552</b>

## Unit No. 17 Total:

1982	0	0.0	0
1983	0	0.0	0
1984	0	0.0	0
1985	0	0.0	0
1986	0	0.0	0
1987	0	0.0	0
1988	0	0.0	0
1989	0	0.0	0
1990	0	0.0	0
1991	0	32.2	11,761
1992	0	91.6	33,425
1993	0	102.9	37,546
1994	0	98.7	36,033
1995	0	142.3	51,942
1996	0	143.2	52,252
1997	0	115.2	42,058
1998	0	128.2	46,808
1999	0	132.4	48,343
2000	0	42.9	15,666
2001	0	20.0	7,294
2002	0	34.4	12,558
2003	0	86.2	31,446
2004	0	50.5	18,431
2005	0	61.0	22,256
2006	0	49.0	17,884
2007	0	61.2	22,355
2008	0	78.7	28,727
2009	0	72.0	26,267
2010	0	62.9	22,960
2011	0	58.8	21,464
2012	0	68.2	24,964
2013	0	37.8	13,790
2014	0	55.4	18,499
2015	0	27.6	10,006
2016	0	36.9	13,499
2017	0	39.9	14,552
<b>Group Totals:</b>			<b>702,783</b>

TABLE NO. 4

**Tundra Oil and Gas**  
**Waskada Unit No. 17**  
**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	14,208	30.95	960	46.15	1,431	1.49	19
Feb-17	13,872	33.54	939	46.75	1,309	1.39	21
Mar-17	9,336	20.70	642	29.71	921	1.44	13
Apr-17	12,048	31.72	952	46.67	1,400	1.47	17
May-17	15,000	34.62	1,073	46.48	1,441	1.34	20
Jun-17	12,960	30.69	921	43.66	1,310	1.42	18
Jul-17	14,448	50.05	1,552	42.31	1,312	0.85	19
Aug-17	12,024	53.48	1,658	46.53	1,442	0.87	16
Sep-17	13,728	64.95	1,949	54.19	1,626	0.83	19
Oct-17	14,664	59.71	1,851	53.75	1,666	0.90	20
Nov-17	12,168	47.43	1,423	44.54	1,336	0.94	17
Dec-17	12,288	40.39	1,252	37.35	1,158	0.92	17
	156,744		15,170		16,352		

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
1982	504	1.98	62	3.62	112	1.83	1
1983	12,816	2.43	886	4.77	1,740	1.96	2
1984	11,064	1.52	556	8.10	2,966	5.33	2
1985	8,112	1.44	527	7.23	2,639	5.01	1
1986	10,608	5.76	2,102	6.99	2,552	1.21	2
1987	9,480	6.73	2,458	5.35	1,953	0.79	3
1988	25,608	11.64	4,259	5.75	2,105	0.49	5
1989	54,192	22.97	8,384	6.20	2,264	0.27	15
1990	162,648	63.28	23,097	21.66	7,907	0.34	23
1991	177,888	48.35	17,649	18.11	6,610	0.37	23
1992	144,240	34.87	12,763	12.50	4,577	0.36	17
1993	146,736	29.72	10,847	13.52	4,935	0.45	17
1994	145,488	28.84	10,528	13.55	4,945	0.47	17
1995	143,928	26.26	9,584	14.78	5,395	0.56	17
1996	142,320	23.64	8,654	12.31	4,506	0.52	17
1997	139,008	20.40	7,445	9.19	3,355	0.45	17
1998	141,264	19.37	7,070	9.65	3,521	0.50	17
1999	138,792	18.09	6,604	13.25	4,835	0.73	17
2000	146,208	16.72	6,121	9.42	3,447	0.56	17
2001	137,592	15.82	5,773	7.70	2,812	0.49	17
2002	137,736	19.49	7,114	14.52	5,299	0.74	17
2003	134,928	21.58	7,876	45.89	16,751	2.13	17
2004	136,872	24.66	9,026	96.39	35,279	3.91	17
2005	135,000	21.78	7,951	15.68	5,725	0.72	17
2006	137,724	20.46	7,468	14.19	5,180	0.69	17
2007	135,744	19.39	7,078	16.82	6,141	0.87	17
2008	139,032	18.54	6,787	13.67	5,002	0.74	17
2009	120,408	15.28	5,576	10.93	3,991	0.72	17
2010	137,328	16.83	6,141	11.22	4,095	0.67	17
2011	127,440	13.56	4,951	8.57	3,127	0.63	17
2012	128,400	16.40	6,001	6.43	2,352	0.39	16
2013	122,520	19.12	6,978	6.50	2,372	0.34	18
2014	143,424	88.72	32,384	37.60	13,722	0.42	26
2015	203,784	82.29	29,958	69.05	25,171	0.86	23
2016	176,568	42.73	15,625	49.33	18,042	1.18	20
2017	156,744	41.52	15,170	44.84	16,352	1.16	18
	4,172,148		321,452		241,777		

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

	00/04-14 Inj	00/06-15 Inj	00/08-10 Inj	00/08-15 Inj	00/11-10 Inj	02/04-15 Inj	02/14-03 Inj	A0/07-15 Inj	C0/02-10 Inj	C0/06-10 Inj	C0/08-10 Inj	C0/09-10 Inj	C0/11-10 Inj	C0/16-10 Inj
Year	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)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)
2014	0.0	5000.0	4500.0	0.0	0.0	2600.0	0.0	0.0	0.0	5000.0	5000.0	3000.0	4546.9	5000.0
2015	0.0	4654.4	4735.8	0.0	3184.1	2241.4	3703.8	3802.7	0.0	4890.1	4998.6	4213.0	4765.7	4885.7
2016	2227.7	4636.6	4933.5	754.4	1738.9	2000.0	5000.0	4856.8	0.0	4874.7	4992.2	4898.1	4900.0	4885.8
2017	4335.4	4752.9	4837.7	624.2	2224.1	2000.0	5000.0	4800.0	0.0	4850.0	4862.5	4781.2	4900.0	4747.0