

Waskada Unit No. 18
Waterflood Progress Report 2017
January 1st through December 31st 2017

Prepared for:
Manitoba Industry, Economic Development and Mines
Petroleum Branch

Prepared by:
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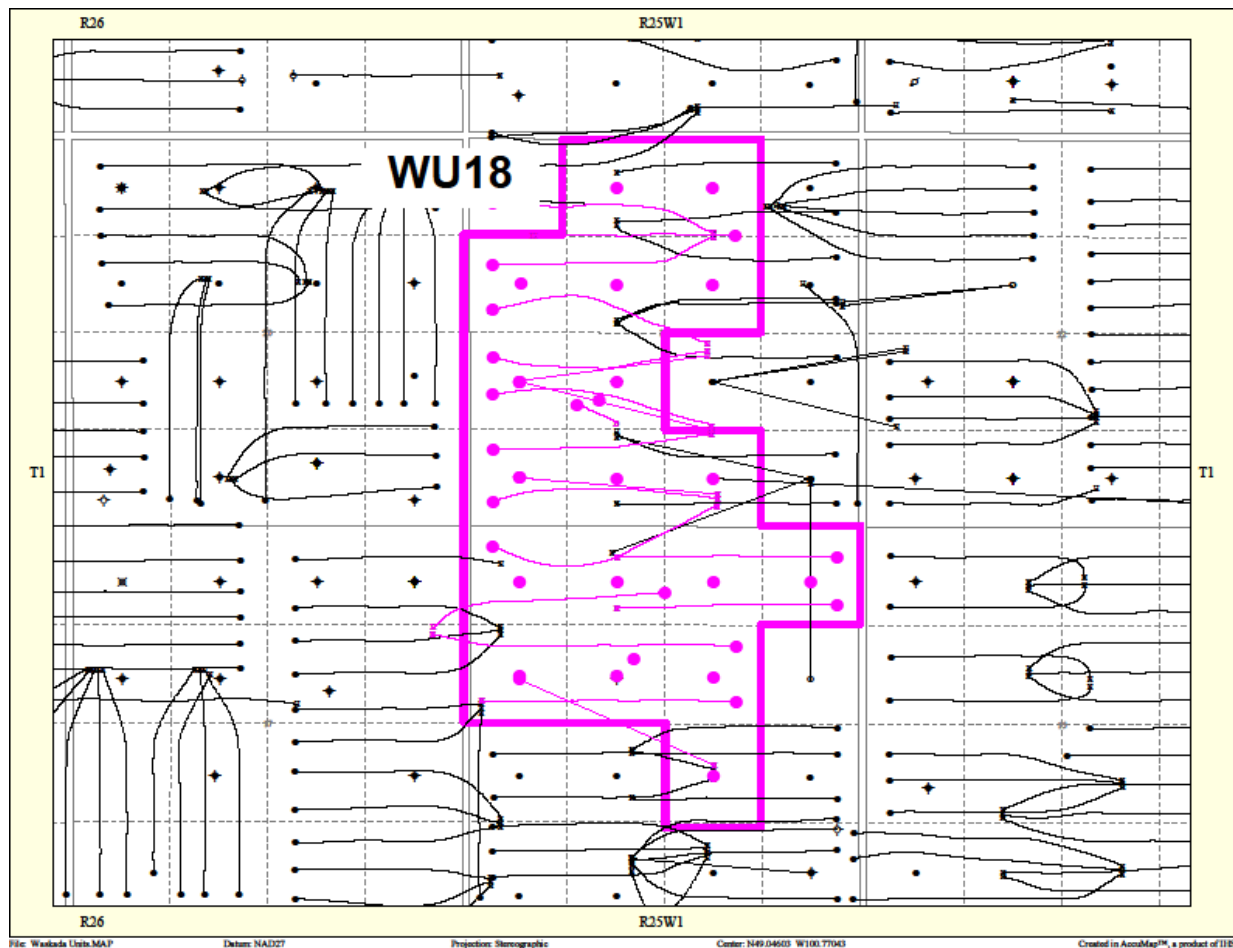
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INTRODUCTION

The Waskada Unit No. 18 pressure maintenance project commenced water injection into the Lower Amaranth A pool in accordance with Manitoba Energy and Mines Order No. PM 68, dated October 1, 1991. Waskada Unit No. 18 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 pink in [Figure 1](#), contains 35 wells over 18 LSDs in Township 1, Range 25W1 ([Table 1](#)).

Figure 1: Waskada Unit No. 18 Area Outline



PRODUCTION HISTORY

For the wells included in Waskada Unit No. 18, production started in November 1989 with the 02/11-16-001-25W1/00 well. From 1989 – 1991, 18 wells were drilled. Oil production peaked at 47.56 m³/d in March 1991. From 2007-2011, 14 new producers were added to the unit, resulting in a peak in oil production of 190.73 m³/d in January 2011. There are currently 20 producing wells in Waskada Unit No. 18. The average production for the unit was 21.9 m³/d of oil and 24.2 m³/d of water and the average WOR 1.11 m³/m³ at the end of December 2017 (Table 4). The rates and WOR are presented in Figure 2.

Figure 2: Waskada Unit No. 18 Production/Injection Rates and WOR vs Time

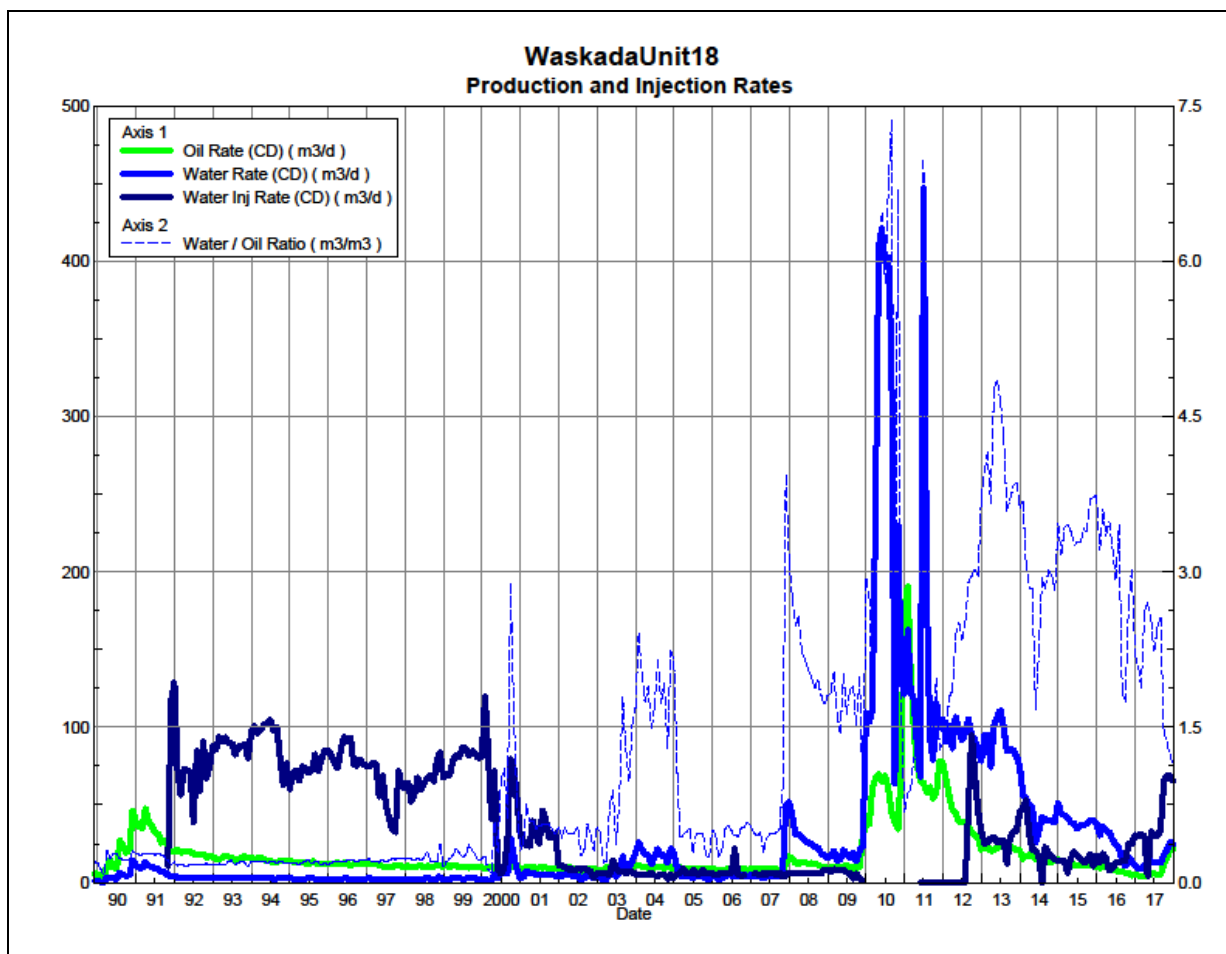
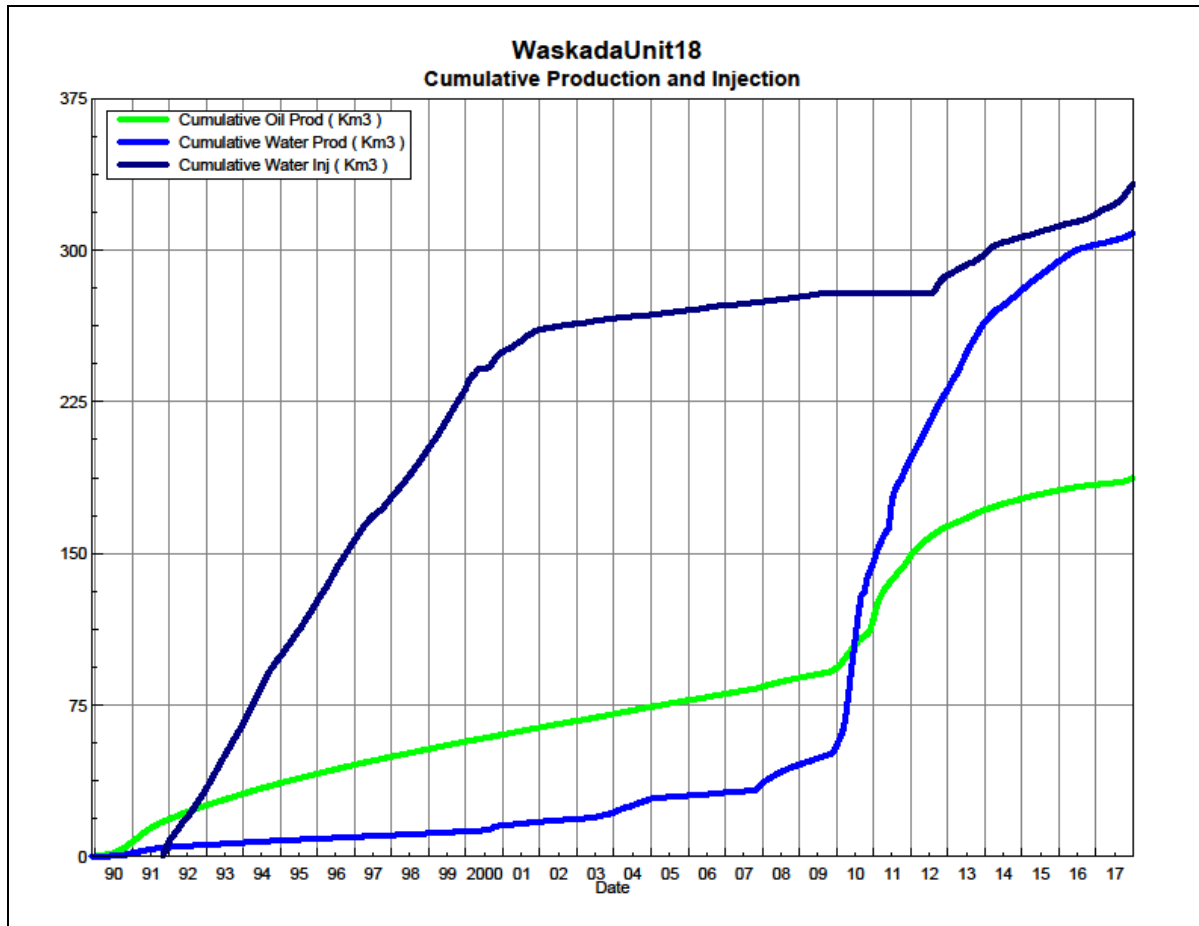


Figure 3 shows the cumulative production for Waskada Unit No. 18 to the end of December 2017 as 187.4 e³m³ of oil, and 308.4 e³m³ of water. The cumulative water injected is over 332.8 e³m³.

Figure 3. Waskada Unit No. 18 Cumulative Oil, Water and Water Injected vs. Time



WATERFLOOD HISTORY

Water injection commenced with 4 injector wells on October 1991. Two more injectors were added in March 2001. In 2011, EOG received permission to convert 3 Spearfish injection wells into Mississippian SWD wells. As of the end of December 2017, there are 3 active Spearfish injection wells.

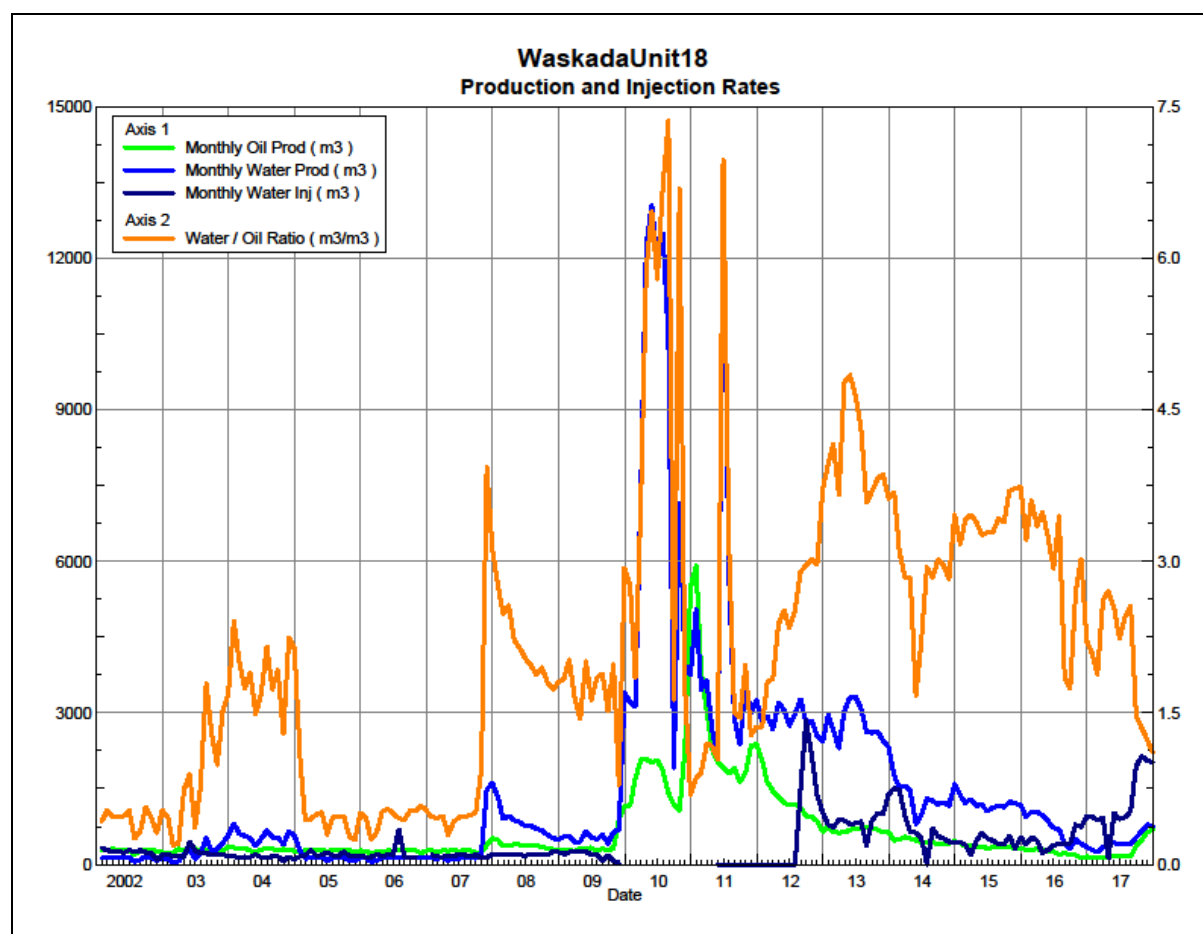
Any future revisions to the waterflood development or surveillance plan would be based on new production or performance response data, technical studies or observed reservoir behavior and reserves recovery interpretations.

WATERFLOOD PERFORMANCE

From January 1 to December 31 in 2017, Waskada Unit No. 18 produced 8,985 m³ of total fluids (3,370 m³ oil, 5,615 m³ water), and injected 14,934 m³ of source water, giving an annual oil and water voidage replacement ratio (VRR) of 1.574 for this reporting period. The cumulative VRR since injection commenced in May 1987 is presently at 0.616. **Table 2** summarizes the yearly and cumulative VRR for Waskada Unit No. 18.

When water injection commenced in 1991, there was no effect on production. In 2002, water injection rates fell off sharply as wellhead injection pressures increased. In 2009, the amount of water that could be injected vertically was insignificant. Injection was halted in 2010. In 2011, EOG received permission to convert 3 of the Spearfish injection wells to Mississippian disposal wells. The wells converted were 00/10-21, 00/15-16 and 03/11-16-001-25W1. In August 2012, EOG converted the 02/12-21-001-25W1 horizontal producer to an injection well to observe if horizontal injection is more effective than vertical injection at increasing production.

Figure 4. Waskada Unit No. 18 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 done on the Waskada Unit No. 18 wells in 2017:

UWI	Date	Workover
100.15-16-001-25W1.00	10/24/2017	Packer Change / SWD Cleanout
102.10-16-001-25W1.00	10/30/2017	Cemented Liner Clean Out
102.14-16-001-25W1.00	10/18/2017	Cemented Liner Clean Out
102.04-21-001-25W1.00	8/30/2017	Cemented Liner Clean Out
102.05-21-001-25W1.00	9/24/2017	Cemented Liner Clean Out
103.04-21-001-25W1.00	3/17/2017	Pump Change / Lower PSN

CORROSION AND SCALE PREVENTION

The facilities in Unit 18 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. 18. 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. 18 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
100/07-16-001-25W1/0	Vertical	Abandoned Zone	7/1/1990	6,851	404	5/31/2012		0	
100/10-16-001-25W1/0	Vertical	Abandoned Zone	11/1/1990	8,853	918	7/31/2016		0	
102/10-16-001-25W1/0	Horizontal	Producing	11/1/2009	10,728	13,525	12/31/2017		0	
103/10-16-001-25W1/0	Horizontal	Producing	2/1/2010	9,441	28,560	12/31/2017		0	
102/11-16-001-25W1/0	Vertical	Abandoned	11/1/1989	1,894	236	9/30/1991	10/1/1991	75,629	6/30/2006
103/11-16-001-25W1/0	Vertical	SWD	N/A	0	0		3/1/2001	3,768	6/30/2009
100/12-16-001-25W1/0	Vertical	Producing	11/1/1990	4,999	876	8/31/2012		0	
100/13-16-001-25W1/0	Vertical	Producing	2/1/1991	4,326	3,634	7/31/2017		0	
102/13-16-001-25W1/0	Horizontal	Potential	11/1/2010	6,274	14,551	12/31/2017		0	
100/14-16-001-25W1/0	Vertical	Pumping	7/1/1990	6,725	1,051	1/31/2015		0	
102/14-16-001-25W1/0	Horizontal	Producing	11/1/2011	5,428	3,103	12/31/2017		0	
100/15-16-001-25W1/0	Vertical	SWD	3/1/1990	1,462	591	10/31/1991	10/1/1991	61,938	9/30/2009
100/16-16-001-25W1/0	Vertical	Pumping	2/1/1991	5,854	16,204	12/31/2017		0	
102/16-16-001-25W1/0	Horizontal	Suspended	12/1/2009	1,102	77,371	7/31/2011		0	
103/16-16-001-25W1/0	Horizontal	Producing	10/1/2009	8,728	49,929	11/30/2016		0	
100/02-21-001-25W1/0	Vertical	Pumping	7/1/1990	6,701	608	9/30/2016		0	
100/03-21-001-25W1/0	Vertical	Producing	3/1/1990	9,496	8,070	12/31/2017		0	
100/04-21-001-25W1/0	Vertical	Abandoned	10/1/1990	3,219	2,477	11/30/2000		0	
102/04-21-001-25W1/0	Horizontal	Producing	11/1/2010	7,212	3,536	12/31/2017		0	
103/04-21-001-25W1/0	Horizontal	Producing	12/1/2010	5,828	17,979	12/31/2017		0	
100/05-21-001-25W1/0	Vertical	Producing	2/1/1991	7,634	2,657	5/31/2017		0	
102/05-21-001-25W1/0	Horizontal	Producing	12/1/2010	7,768	11,709	12/31/2017		0	
103/05-21-001-25W1/0	Horizontal	Producing	12/1/2010	6,491	2,243	12/31/2017		0	
100/06-21-001-25W1/0	Vertical	Abandoned	11/1/1990	501	216	10/31/1991	10/1/1991	74,313	3/31/2001
102/06-21-001-25W1/0	Vertical	Abandoned	N/A	0	0		3/1/2001	3,055	11/30/2001
103/06-21-001-25W1/0	Dir/Dev	SWD	N/A	0	0			0	
100/10-21-001-25W1/0	Vertical	SWD	10/1/1990	841	210	10/31/1991	10/1/1991	60,103	11/30/2009
100/11-21-001-25W1/0	Vertical	Pumping	7/1/1990	6,734	1,334	1/31/2016		0	
100/12-21-001-25W1/0	Vertical	Pumping	10/1/1990	7,865	3,803	12/31/2017		0	
102/12-21-001-25W1/0	Horizontal	Injection	12/1/2010	3,785	1,275	3/31/2012	8/1/2012	40,082	12/31/2017
103/12-21-001-25W1/0	Horizontal	Producing	12/1/2010	6,251	1,748	12/31/2017		0	
102/13-21-001-25W1/2	Horizontal	Producing	12/1/2010	3,854	1,827	12/31/2017		0	
100/14-21-001-25W1/0	Vertical	Injection	3/1/1991	8,916	1,115	3/31/2015		4,464	12/31/2017
100/15-21-001-25W1/0	Vertical	Injection	11/1/1990	6,363	751	2/28/2013		9,463	12/31/2017
102/15-21-001-25W1/0	Horizontal	Suspended	10/1/2007	5,318	35,910	7/31/2013		0	
				187,442	308,419				

TABLE NO. 2 - Waskada Unit No. 18 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
1989	339	0.339	66	0.066	0.19	0	0.000	0.000	0.000
1990	6,979	7.318	1,784	1.850	0.26	0	0.000	0.000	0.000
1991	11,355	18.673	2,943	4.793	0.26	7,816	7.816	0.488	0.298
1992	6,805	25.477	1,169	5.962	0.17	25,867	33.683	2.876	0.955
1993	5,779	31.256	1,087	7.049	0.19	32,427	66.109	4.194	1.538
1994	5,221	36.478	1,032	8.081	0.20	32,903	99.013	4.676	1.979
1995	4,618	41.096	875	8.956	0.19	27,508	126.520	4.447	2.251
1996	4,438	45.534	920	9.877	0.21	29,853	156.373	4.955	2.512
1997	3,981	49.515	868	10.745	0.22	21,457	177.831	3.940	2.627
1998	3,820	53.335	886	11.630	0.23	24,241	202.071	4.592	2.769
1999	3,685	57.020	989	12.620	0.27	29,328	231.399	5.610	2.959
2000	3,465	60.485	2,836	15.456	0.82	18,424	249.823	2.701	2.939
2001	3,491	63.976	1,927	17.383	0.55	10,860	260.683	1.828	2.866
2002	3,290	67.266	1,486	18.868	0.45	2,940	263.623	0.558	2.740
2003	3,371	70.638	3,130	21.998	0.93	2,633	266.256	0.376	2.579
2004	3,543	74.180	6,738	28.737	1.90	1,707	267.962	0.158	2.350
2005	3,297	77.477	1,561	30.297	0.47	2,344	270.306	0.438	2.264
2006	3,135	80.612	1,492	31.789	0.48	2,155	272.461	0.423	2.189
2007	3,555	84.167	4,409	36.198	1.24	2,023	274.484	0.238	2.064
2008	4,386	88.552	9,403	45.601	2.14	2,398	276.882	0.166	1.878
2009	5,031	93.584	9,428	55.029	1.87	1,924	278.805	0.126	1.714
2010	24,369	117.952	90,614	145.643	3.72	0	278.805	0.000	0.991
2011	30,880	148.833	51,152	196.796	1.66	0	278.805	0.000	0.749
2012	14,610	163.443	34,324	231.120	2.35	8,927	287.733	0.154	0.669
2013	8,167	171.609	33,303	264.422	4.08	10,382	298.115	0.220	0.624
2014	5,520	177.129	15,814	280.236	2.86	8,407	306.522	0.367	0.613
2015	4,178	181.310	14,320	294.556	3.43	5,321	311.843	0.278	0.600
2016	2,765	184.072	8,249	302.805	2.98	6,038	317.881	0.528	0.599
2017	3,370	187.442	5,615	308.419	1.67	14,934	332.815	1.574	0.616

TABLE NO. 3

**Tundra Oil and Gas
Waskada Unit No. 18
2017 Injection Volumes**

Well Location	Date	Hours On	H ₂ O Inj Cal-d avg (m ³ /d)	Monthly Injected H ₂ O (m ³)
Unit No. 18 Total:				
	Jan-17	0	30.4	943
	Feb-17	0	31.2	873
	Mar-17	0	29.8	923
	Apr-17	0	4.2	127
	May-17	0	32.9	1,021
	Jun-17	0	29.9	897
	Jul-17	0	30.2	936
	Aug-17	0	34.0	1,054
	Sep-17	0	64.9	1,946
	Oct-17	0	69.1	2,143
	Nov-17	0	68.4	2,051
	Dec-17	0	65.3	2,023
2017 Group Totals:				14,934
Unit No. 18 Total:				
	1989	0	0.0	0
	1990	0	0.0	0
	1991	0	21.4	7,816
	1992	0	70.9	25,867
	1993	0	88.8	32,427
	1994	0	90.1	32,903
	1995	0	75.4	27,508
	1996	0	81.8	29,853
	1997	0	58.8	21,457
	1998	0	66.4	24,241
	1999	0	80.3	29,328
	2000	0	50.5	18,424
	2001	0	29.8	10,860
	2002	0	8.1	2,940
	2003	0	7.2	2,633
	2004	0	4.7	1,707
	2005	0	6.4	2,344
	2006	0	5.9	2,155
	2007	0	5.5	2,023
	2008	0	6.6	2,398
	2009	0	5.3	1,924
	2010	0	0.0	0
	2011	0	0.0	0
	2012	0	24.4	8,927
	2013	0	28.4	10,382
	2014	0	23.2	8,407
	2015	0	14.6	5,321
	2016	0	16.5	6,038
	2017	0	40.9	14,934
Group Totals:				332,815

TABLE NO. 4

**Tundra Oil and Gas
Waskada Unit No. 18
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	8,376	4.46	138	9.29	288	2.08	11
Feb-17	7,080	4.51	126	8.50	238	1.89	11
Mar-17	7,368	4.27	133	11.18	347	2.62	10
Apr-17	6,648	4.92	148	13.32	400	2.71	9
May-17	7,632	5.46	169	13.88	430	2.54	10
Jun-17	7,728	5.88	176	13.14	394	2.24	11
Jul-17	7,896	5.17	160	12.68	393	2.45	11
Aug-17	7,488	5.02	156	12.84	398	2.56	10
Sep-17	6,936	12.07	362	17.78	533	1.47	10
Oct-17	7,944	15.62	484	21.09	654	1.35	11
Nov-17	8,712	21.26	638	26.31	789	1.24	12
Dec-17	9,048	21.91	679	24.22	751	1.11	12
	92,856		3,370		5,615		

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
1989	1,296	0.93	339	0.18	66	0.19	1
1990	46,848	19.12	6,979	4.89	1,784	0.26	6
1991	141,504	31.11	11,355	8.06	2,943	0.26	17
1992	121,032	18.64	6,805	3.20	1,169	0.17	14
1993	118,320	15.83	5,779	2.98	1,087	0.19	14
1994	118,704	14.30	5,221	2.83	1,032	0.20	14
1995	117,072	12.65	4,618	2.40	875	0.19	14
1996	120,240	12.16	4,438	2.52	920	0.21	14
1997	119,712	10.91	3,981	2.38	868	0.22	14
1998	120,360	10.47	3,820	2.43	886	0.23	14
1999	116,472	10.10	3,685	2.71	989	0.27	14
2000	114,096	9.49	3,465	7.77	2,836	0.82	14
2001	110,280	9.56	3,491	5.28	1,927	0.55	13
2002	107,448	9.01	3,290	4.07	1,486	0.45	13
2003	94,152	9.24	3,371	8.58	3,130	0.93	13
2004	109,944	9.71	3,543	18.46	6,738	1.90	13
2005	109,368	9.03	3,297	4.28	1,561	0.47	13
2006	107,508	8.59	3,135	4.09	1,492	0.48	13
2007	113,875	9.74	3,555	12.08	4,409	1.24	13
2008	118,440	12.02	4,386	25.76	9,403	2.14	14
2009	118,368	13.78	5,031	25.83	9,428	1.87	15
2010	146,808	66.76	24,369	248.26	90,614	3.72	19
2011	197,928	84.60	30,880	140.14	51,152	1.66	26
2012	179,232	39.92	14,610	93.78	34,324	2.35	23
2013	164,232	22.37	8,167	91.24	33,303	4.08	21
2014	161,328	15.12	5,520	43.32	15,814	2.86	21
2015	151,872	11.45	4,178	39.25	14,320	3.44	17
2016	128,568	7.56	2,765	22.58	8,249	2.90	15
2017	92,856	9.21	3,370	15.35	5,615	2.02	11
	3,467,863		187,442		308,419		

TABLE NO. 5 - Average Injection Pressures

	00/14-21 Inj	00/15-21 Inj	02/12-21 Inj
Year	Inj Pressure (kPa)	Inj Pressure (kPa)	Inj Pressure (kPa)
2014	0.0	0.0	5000.0
2015	2795.1	1012.0	4926.4
2016	4660.7	2741.7	4210.3
2017	4530.9	1909.4	4447.4