



Canadian Natural

**Directive 054 Presentation Day 2: Surface
Operations, Compliance, and Issues Not
Related to Resource Evaluation and Recovery**

January 24, 2017

PREMIUM. VALUE. DEFINED GROWTH. INDEPENDENT.

Primrose, Wolf Lake, and Burnt Lake 2016 Annual Presentation to the AER



Directive 54: Performance Presentations, Auditing, and Surveillance of In Situ Oil Sands Schemes

- January 23, 2017
 - 3.1.1 Subsurface Issues Related to Resource Evaluation and Recovery
- January 24, 2017
 - 3.1.2 Surface Operations, Compliance, and Issues Not Related to Resource Evaluation and Recovery

Outline - Surface Operations, Compliance, and Issues Not Related to Resource Evaluation and Recovery



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Outline - Surface Operations, Compliance, and Issues Not Related to Resource Evaluation and Recovery



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Primrose, Wolf Lake, and Burnt Lake Annual Directive 54 Presentation



AER	Alberta Energy Regulator	m ³	cubic metre
ALMS	Alberta Lake Management Society	m ³ /d	cubic metres per day
AGP	above-ground pipeline	MARP	Measurement, Accounting & Reporting Plan
AQHI	Alberta Quality Health Index	mg/l	milligrams per litre
BFW	boiler feedwater	ML	Muriel Lake
BRWA	Beaver River Watershed Alliance	MPa	Mega Pascal
BV	Bonneyville	Mwh	Megawatt hour
BS&W	basic sediment and water	MWHIP	Maximum wellhead injection pressure
CEMS	continuous emissions monitoring system	NOx	oxides of nitrogen
Cl	chlorine	Obs	observation
CL	Cold Lake	ORF	oil removal filter
CPF	central processing facility	PEP	Primrose East Plant
CSS	cyclic steam stimulation	PNP	Primrose North Plant
CWE	cold water equivalent	PSP	Primrose South Plant
DI	Depletion Index	PAW	Primrose and Wolf Lake
DCS	Digital Control System	profac	proration factor
DDS	digital data submission	QAP	Quality Assurance Program
E3	Empress 3	SO ₂	sulphur dioxide
e3m3	thousand cubic metres	SR	Sand River
EL	Ethal Lake	t/d	tonnes per day
EPEA	Alberta Environmental Protection and Enhancement Act	tCO ₂ e	tonnes of carbon dioxide equivalents
Fm	Formation	TDS	total dissolved solids
FTS	flow to surface	UWI	unique well identifier
GOR	gas oil ratio	VRU	vapour recovery unit
ha	hectare	WDW	water disposal well
ISF	induced static flow	WLP	Wolf Lake Plant
kPa	kiloPascal	WSW	water source well
LICA	Lakeland Industrial and Community Association		

Facilities

- Detailed site survey plans - refer to included drawings:
 - Wolf Lake Plant plot plan
 - Primrose Plant plot plans (South, North, East)
 - Typical pad plot plan (Primrose East)
- Simplified plant schematic - refer to included drawings:
 - Wolf Lake / Primrose simplified plant facilities schematic
- Summary of modifications:
 - Wolf Lake U9 acid scrubber
 - Wolf Lake U10 MDA nuclear interface probe
 - Wolf Lake U1 DCS upgrade complete
 - Wolf Lake pad MC1 steam letdown valve upgrade
 - Wolf Lake pad Z8 steamflood conversion

- Pipeline challenges
 - Wolf Lake field pipelines
 - Z8 emulsion line repairs and inspections
 - Primrose BFW pipelines
 - Pigging, inspections, repairs, replacements
 - Primrose East Emulsion pipeline
 - Pigging, inspections, repairs

Specific Project Update

- Wolf Lake Produced Water Debottleneck
 - Phase 2 completed
 - Additional ORFs in U2
 - ISF modifications in U2
 - Additional heat exchangers added in U8
 - Various upgrades in U1, de-sanding, interface measurement
 - Phase 3 in detailed engineering – to be completed in 2017
 - Phase 4 in scoping

Wolf Lake CPF Performance



- Bitumen and water treatment
 - Overall water quality and oil treating targets were met:
 - Set produced water treating records
 - Treating challenges existed due to large number of wellbore acid stimulations

Facility Performance

- Power generation/consumption on a monthly basis

Primrose and Wolf Lake - 2016 Power Generation and Consumption

Month	Power Generation MWh	Power Consumption MWh	Net MWh
January	63,183	67,102	-3,920
February	47,165	58,301	-11,136
March	62,086	61,543	543
April	57,748	55,157	2,591
May	57,785	57,377	408
June	54,151	54,108	43
July	54,409	53,620	788
August	46,829	58,984	-12,155
September	56,508	58,572	-2,064
October	47,667	62,651	-14,983
November	59,829	68,058	-8,229
December	65,718	72,219	-6,500

Sources:

Energy Components - Cogen Accounting Report 6, PSEP - Primrose Power Plant Monthly

Power consumption was taken from BPIMS CV4338 (Total CNRL Electrical Load) / EC CV4330

- Power is bought and or sold to the grid as the field electrical demand changes, generation level is constant
- Canadian Natural reports all power produced or consumed, and conducts an annual net settlement of power generated or consumed with the Alberta Utilities Commission (AUC)

Facility Performance



- Gas Usage on a monthly basis

	Total Purchased Gas	Total Solution Gas Conserved	Total Vented Gas	Total Solution Gas Flared	Solution Gas Conserved
Month	e3m3	e3m3	e3m3	e3m3	%
January	122,049	20,058	0.6	526	97.4%
February	93,055	17,873	0.2	300	98.3%
March	97,373	18,920	0.6	82	99.6%
April	92,421	16,357	1.9	97	99.4%
May	112,513	15,885	1.9	68	99.6%
June	114,040	13,653	7.1	1562	89.7%
July	127,210	10,939	0.9	1518	87.8%
August	123,277	17,044	2.5	213	98.8%
September	123,779	16,766	3.7	110	99.3%
October	120,365	18,476	0.9	805	95.8%
November	131,686	18,495	5.5	69	99.6%
December	0	8,354	0.0	168	98.0%

*Total purchased gas does not include gas from site gas wells

*Solution gas flared volumes are corrected to remove purchased gas to flare

*Total gas vented includes brackish water associated vent gas

*Total Purchased Gas and Total Vented Gas for the month of December to be confirmed following Petrinex submission.

*2016 December volumes will be available after Jan 20, 2017.

Facility Performance



- Flaring & Solution Gas Conservation Compliance
 - All Primrose and Wolf Lake facilities are equipped for gas conservation except one pilot well, 15BM – granted exemption in 2004
 - New pads (since 2004) are built with VRUs or are linked to a neighboring pad's VRU
- Solution Gas Flare Volumes
 - During the June / July 2016 Unit 2 outage, the mixed gas fuel drum (located in Unit 2) was not operation. Gas from Unit 8 and Unit 10 end up in the U2 mixed fuel gas drum. Therefore, increased flaring was observed in June/July.
- Facility Venting Compliance
 - No routine venting in the field
 - No routine venting at Primrose North, South or East plants
 - Vapour recovery on all major sources of solution gas at Wolf Lake

Facilities – Greenhouse Gas Emissions



- PAW Greenhouse Gas Emissions

Month	2016 (tCO ₂ e)
January	282,800
February	230,100
March	244,700
April	233,200
May	276,800
June	272,100
July	297,200
August	311,100
September	307,700
October	301,900
November	324,100
December*	322,300
Year Total	3,404,000

* Forecast

Measurement and Reporting



- Measurement, Accounting & Reporting Plan (MARP) for Wolf Lake / Primrose Thermal Bitumen Scheme Approved May 1st, 2007. Annual updates in March.
- AER MARP audit was conducted on Oct 26th 2016. First round response was submitted on December 7th 2016.
- Methods for estimating well production and injection volumes reported to Petrinex
 - Produced emulsion from the scheme is commingled at the battery. Bitumen and water production from the battery is prorated to each well using monthly proration test data and proration factors.
 - $\text{Total Battery Oil (Water) / Total Test Oil (Water) at Wells} = \text{Oil (Water) Proration Factor}$
 - $\text{Oil (Water) Proration Factor} * \text{Each Well Test Oil (Water) Volume} = \text{Oil (Water) Allocated to Each Well}$

Measurement and Reporting (con't)



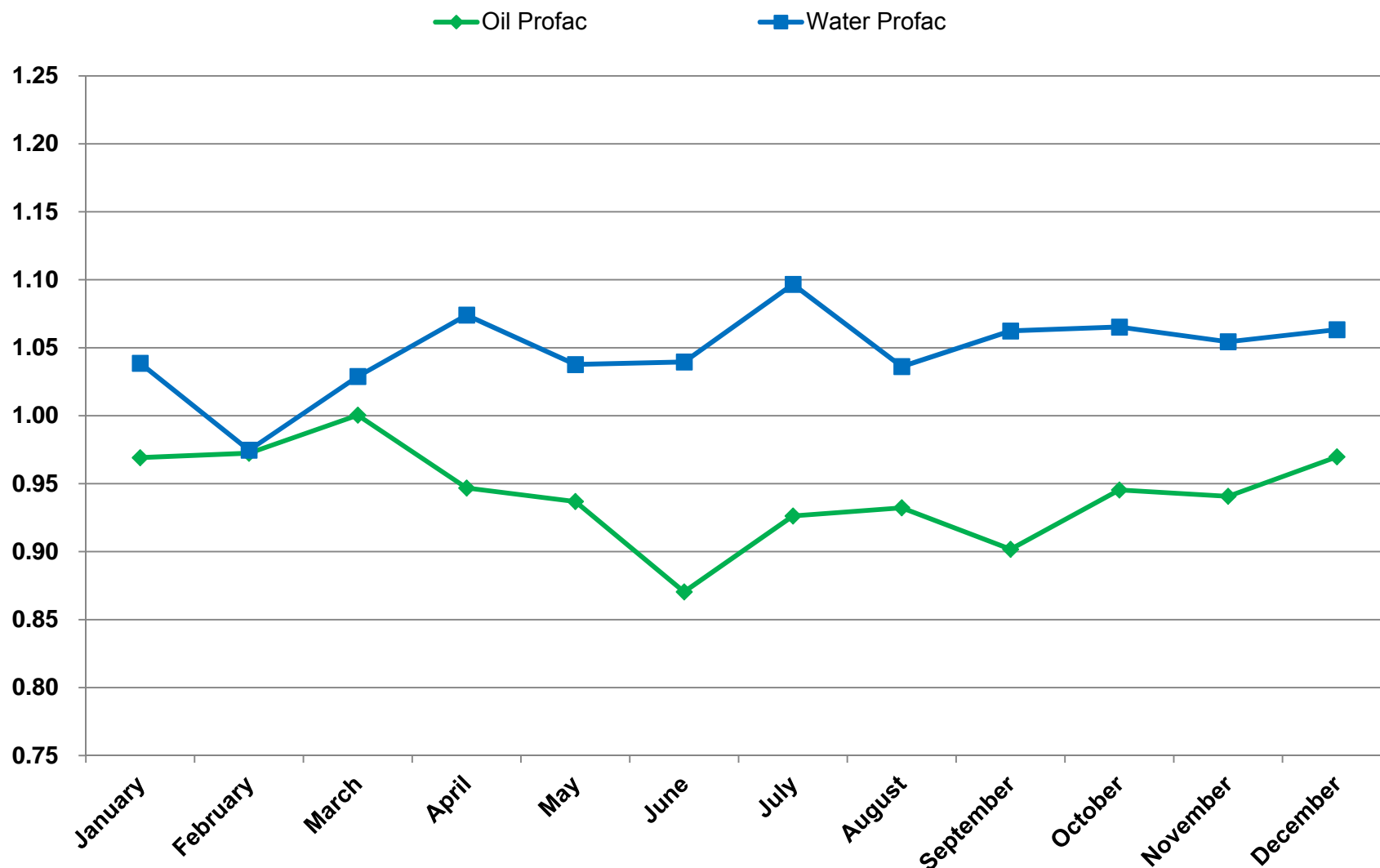
- Gas allocated to each well is determined by GOR (gas oil ratio) for the battery
 - $\text{Total Solution Gas Produced} / \text{Total Battery Oil} = \text{Gas Oil Ratio}$
 - $\text{Gas Oil Ratio} * \text{Oil Allocated to Each Well} = \text{Gas Allocated to Each Well}$
- Injected volumes of steam and water are not estimated, they are continuously measured at wellhead
- Some pads have capability to take steam from Primrose South or Primrose North. Combined proration factor for both plants used for steam transfer volume estimation.

Measurement and Reporting (con't)



- Test Durations
 - Canadian Natural field operations has identified the test durations, gross fluid rates and BS&W results required to obtain valid proration test data for each well
 - Most wells have 4 hour proration test durations; however some wells may be tested from 1 to 6 hours depending on their unique operating conditions and cycle maturity
 - Each well is tested each month and may be tested several times throughout the month

Measurement and Reporting – Proration Factors



Water Production, Injection, and Uses



- Primrose & Wolf Lake Project Water Source Well Listing

Non-saline Water Source Wells		Saline Water Source Wells	
Wolf Lake	Primrose ¹	Grand Rapids ²	McMurray
1F1/12-10-066-05W4M (E3)	1F1/10-05-067-04W4M (EL)	102/10-08-066-05W4M	1F1/11-06-067-03W4M
1F2/12-10-066-05W4M (ML)	1F1/14-05-067-04W4M (EL)	102/05-16-066-05W4M	1F1/16-12-067-04W4M
1F1/ 06-10-066-05W4M (ML)	1F2/15-05-067-04W4M (EL)	104/05-16-066-05W4M	1F1/11-05-067-03W4M
1F2/06-10-066-05W4M (ML)	04-14-067-03W4M (BV)	109/01-17-066-05W4M	1F2/13-18-067-03W4M
1F1/13-10-066-05W4M (ML)	NW 08-068-04W4M (EL)	107/02-17-066-05W4M	1F1/14-08-067-03W4M
1F2/13-10-066-05W4M (E3)	NW 08-068-04W4M (EL)	106/08-17-066-05W4M	1F1/12-09-067-03W4M
02-07-066-05W4M (SR) ³	14-04-067-04W4M (EL)	107/08-17-066-05W4M	1F2/12-09-067-03W4M
06-08-066-05W4M (SR) ³	11-05-067-04W4M (EL)		1F1/10-08-067-03W4M
	10-05-067-04W4M (EL)		1F1/02-12-067-03W4M
	10-05-067-04W4M (EL)		1F1/07-06-067-03W4M
			1F1/16-06-067-03W4M

Notes:

1. Primrose non-saline water source wells are utility or domestic/sanitary use only

2. Grand Rapids Fm. source wells not currently in use

3. Wolf Lake field office domestic/sanitary water source wells

Water Production, Injection, and Uses



- Water Uses: Saline and non-saline
 - Saline water uses
 - Primary source of boiler feed water make-up
 - De-sand quench, filter backwash – ends up as boiler feed water
 - Non-saline water uses
 - Utility water, utility steam, seal flush and gland water, slurry make-up, dilution water, filter backwash, quench water
 - Fish Hatchery effluent used as boiler feed water make-up at Burnt Lake and occasionally used as cooling water in emulsion line flowback
 - Occasional boiler feed water make-up as required
 - Sanitary/domestic purposes at each plant, the Wolf Lake office, PRS camp
 - Drilling, well servicing, ice road construction, and dust control
- Water Act Licences
 - Non-saline (Quaternary) groundwater monitored and reported per Water Act license requirements

Water Production, Injection, and Uses



- Water Quality Assessment
 - Plant Runoff Surface Water – Burnt Lake Plant, PRN Plant, PRS Plant
 - Average TDS = 147 mg/L
 - Cold Lake Fish Hatchery Effluent – Low Lift Pump Station
 - Average TDS = 134 mg/L
 - Quaternary Water Source Wells – Empress Unit 3 & Muriel Lake Formation Aquifers
 - Average TDS = 583 mg/L
 - Grand Rapids Fm. Water Source Wells
 - Average TDS = 9,721 mg/L
 - McMurray Fm. Water Source Wells
 - Average TDS = 7,276 mg/L
 - Produced Water Quality
 - Typical parameters: TDS = 6,670 mg/L, Cl = 3,390 mg/L, pH 7.45, hardness = 163 mg/L

Water Production, Injection, and Uses



- Non-saline, saline, produced and steam injection volumes

Primrose and Wolf Lake - 2016 Monthly Water and Steam Volumes

	Surface Water ¹	Non-Saline Groundwater ²	Saline Water ³	Produced Water	Steam Injection	PW Recycled	Actual Water Disposal	Water Disposal Limit ⁴
Month	m ³ /day	m ³ /d	m ³ /d	m ³ /d	m ³ /d	%	%	%
January	755	3,519	27,646	36,701	65,307	100.1	4.4	23.1
February	585	2,918	22,199	33,593	55,607	98.7	4.4	22.5
March	593	3,066	16,862	38,428	54,881	99.3	4.5	20.8
April	610	2,867	12,140	43,264	54,190	97.6	5.5	19.3
May	880	2,695	13,820	49,229	63,759	99.1	3.2	19.4
June	1,079	3,056	22,687	47,730	64,567	96.1	9.3	21.4
July	805	3,340	20,938	50,726	68,547	97.9	6.5	20.7
August	571	2,693	9,033	67,680	71,936	95.1	7.4	17.7
September	815	2,580	9,565	70,015	73,681	93.4	8.4	17.8
October	741	2,265	7,718	68,315	69,887	92.1	9.2	17.5
November	583	2,962	12,807	73,160	77,326	90.6	11.5	18.3
December	643	2,684	8,750	70,738	73,606	94.2	8.8	17.6
Average	722	2,887	15,320	54,271	67,657	96.2	6.9	19.6

Notes:

1. Surface water is effluent diversion from Cold Lake fish hatchery and surface water runoff
2. Non-saline ground water from Wolf Lake water source wells
3. Saline water is from McMurray aquifers
4. Dir. 81 Water Disposal Limit as per Approval No. 9140W, Dp 0.16.
5. 2016 December produced water and steam injection volumes are average of 2016-11 & 2016-10.

$$\text{PW Recycled} = \frac{(\text{Total PW} - \text{PW to Disposal})}{\text{Total PW}}$$

Water Production, Injection, and Uses



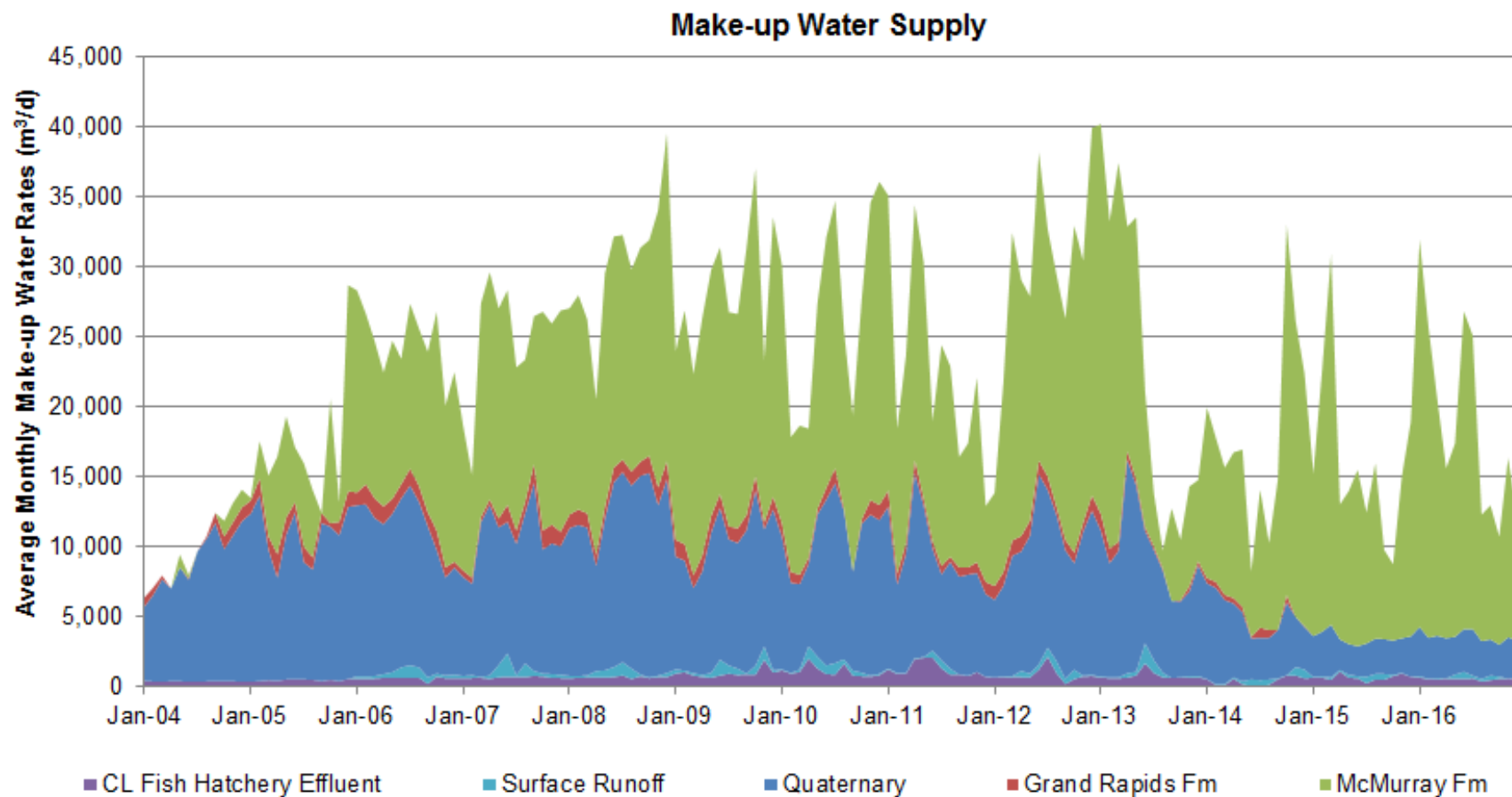
McMurray Saline Water – Avg. 15,320 m³/d

Cold Lake Fish Hatchery Effluent – Avg. 556 m³/d

Grand Rapids Saline Water – Avg. 0 m³/d

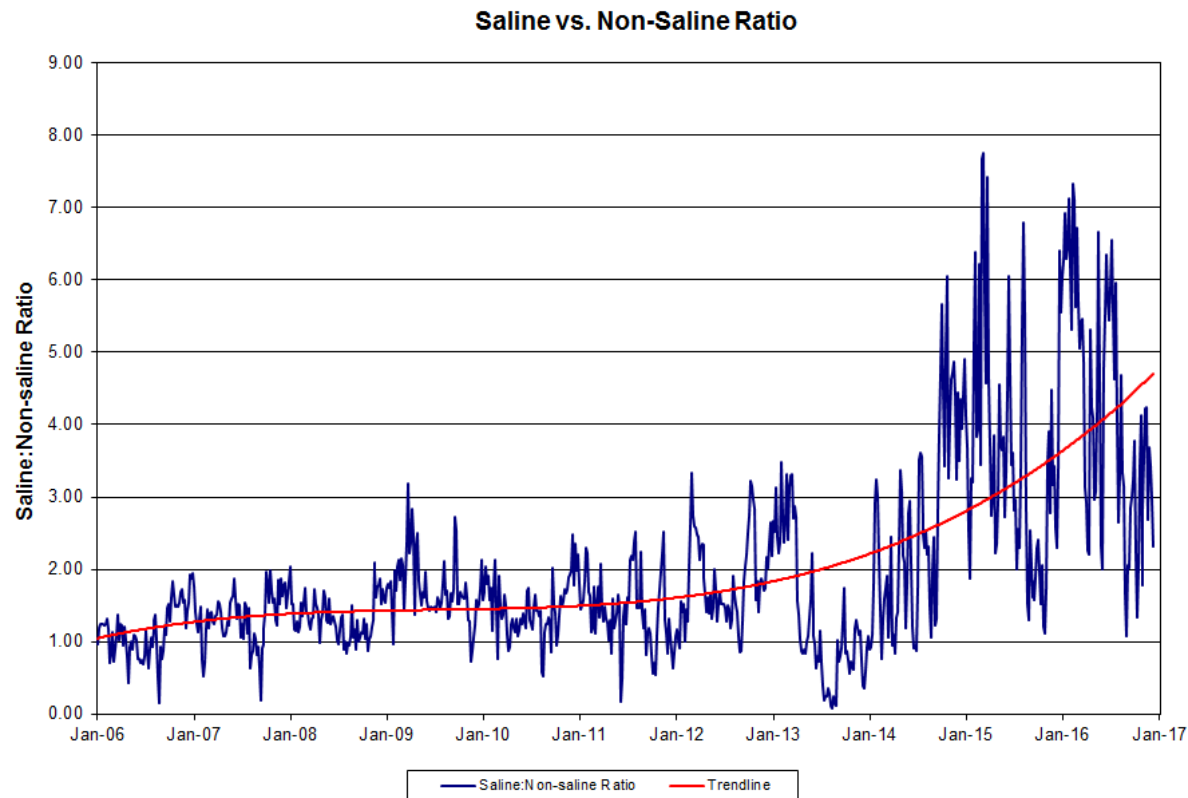
Plant Runoff Water – Avg. 166 m³/d

Quaternary Non-saline Water – Avg. 2,887 m³/d



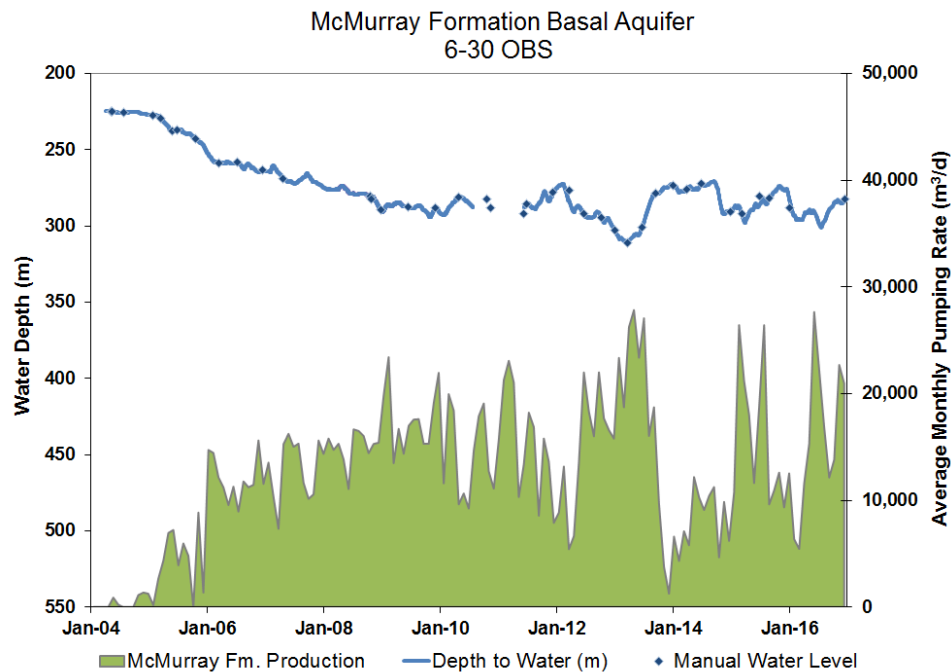
Water Production, Injection, and Uses

- Improved Saline to Non-Saline Groundwater Use Ratio
 - Saline to non-saline groundwater ratio shows increasing trend over time
 - Non-saline usage similar to 2015 (3,609 vs. 3,474 m³/d in 2015)
 - Saline usage increased by almost 3,000 m³/d in 2016 (15,320 vs. 12,520 m³/d in 2015)

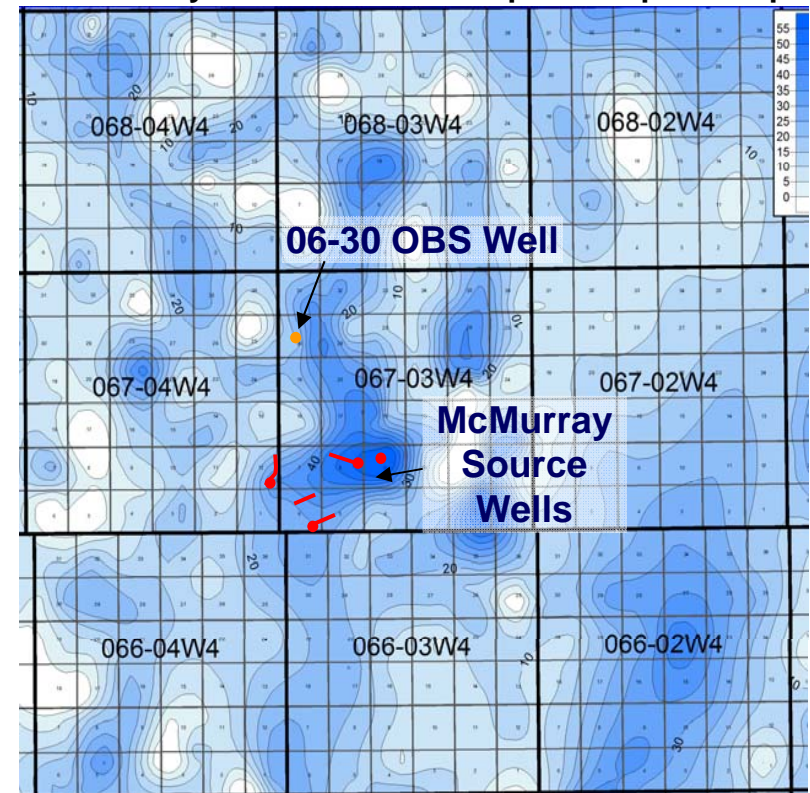


McMurray Saline Water Supply

- Producing wells
 - 4 horizontal and 6 vertical wells
- 2016 production
 - Average: 15,320 m³/d
 - Maximum: 33,197 m³/d
- Drawdown of 58 m in 6-30 OBS well



McMurray Formation Basal Aquifer Isopach Map



Water & Waste Disposal Wells, Landfill Waste UWI List & Disposal Compliance



- Primrose & Wolf Lake Project Disposal Water Well UWI Listing

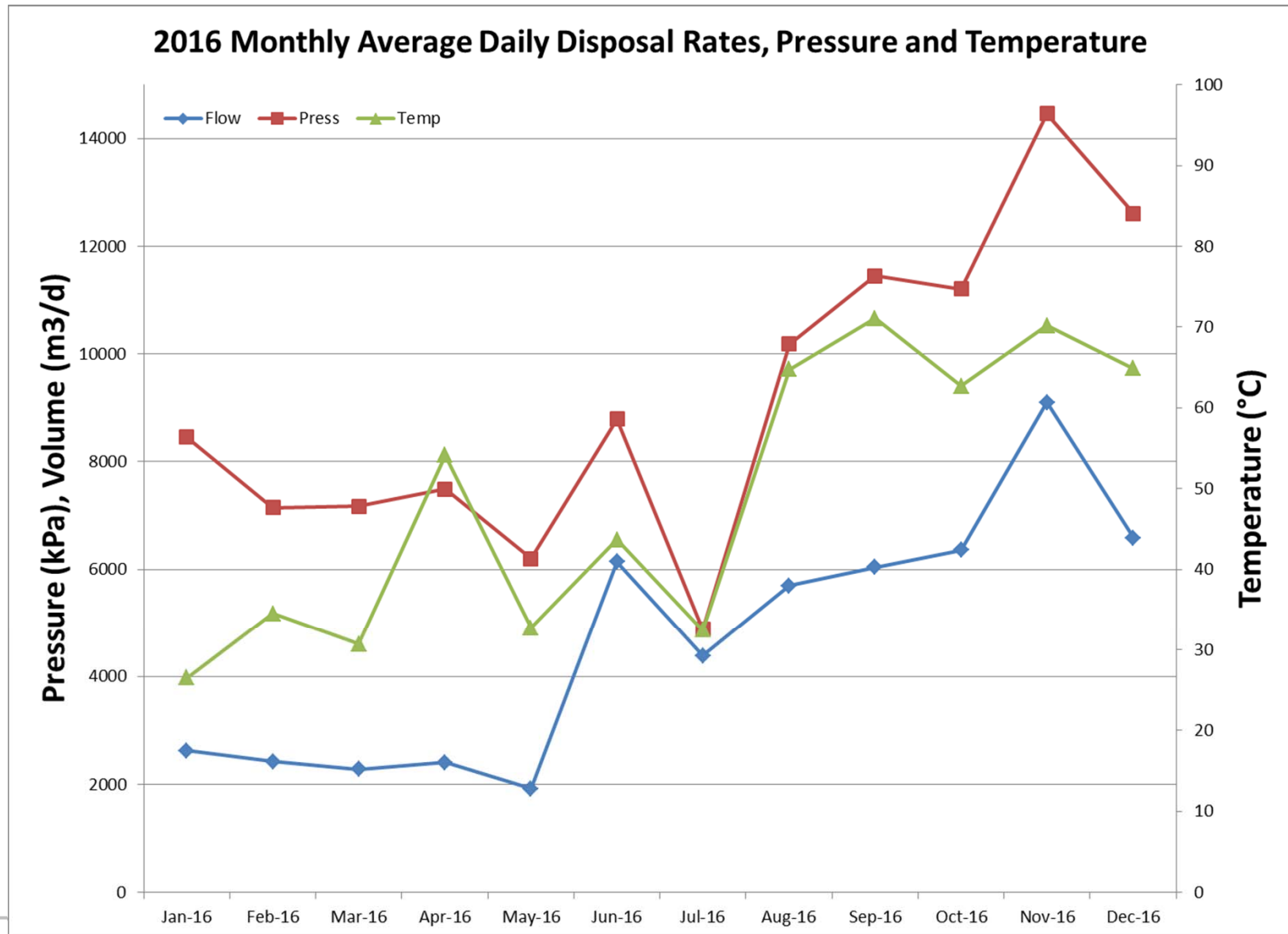
Wolf Lake		Primrose South	
Well	Formation	Well	Formation
WDW #2 - 100/10-08-066-05W4	Mid Cambrian	103 /10-05-067-04W4/00	McMurray
WDW #4 - 100/05-08-066-05W4	Mid Cambrian		
WDW #5 - 100/15-07-066-05W4	Mid Cambrian		
WDW #9 - 100/14-05-066-05W4	Mid Cambrian		
WDW #11 - 100/07-08-066-05W4	Mid Cambrian		
WDW #14 - 102/06-09-066-05W4	Mid Cambrian		

- Wolf Lake (WDW #2, 4, 5 ,9, 11 & 14)
 - WDW #9 was re-activated in late 2015
 - Wells WDW #11 & 14 were drilled and completed in 2016

Primrose South

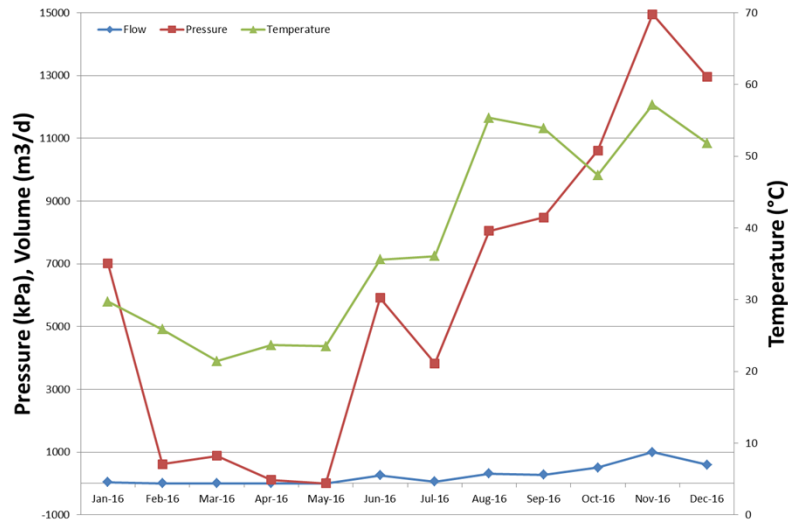
- 103/10-05-067-04/W4 - Well is suspended (bridge plug)

Water & Waste Disposal Wells, Landfill Waste Wolf Lake Disposal Volumes

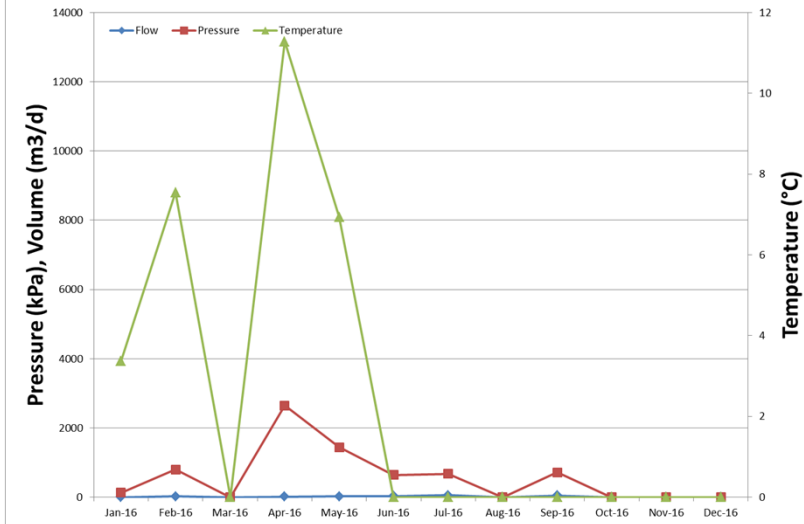


Water & Waste Disposal Wells, Landfill Waste Wolf Lake Disposal Volumes

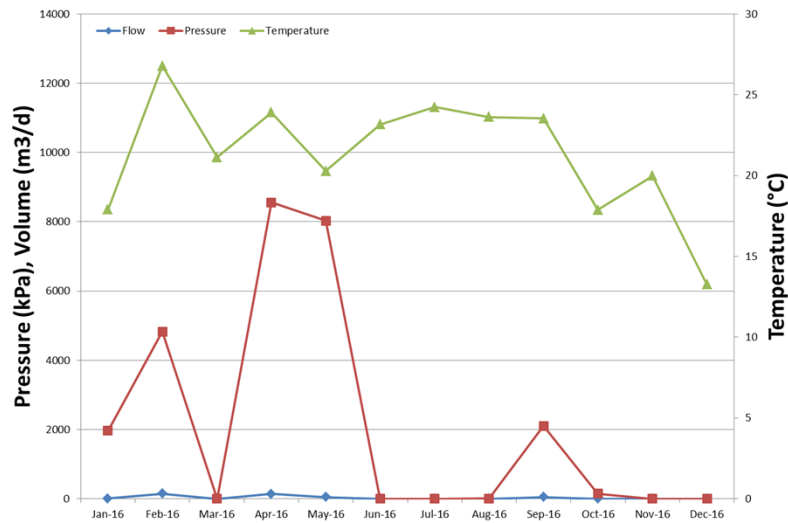
WDW #2: 2016 Average Monthly Disposal Rates, Pressure and Temperature



WDW #5: 2016 Average Monthly Disposal Rates, Pressure and Temperature

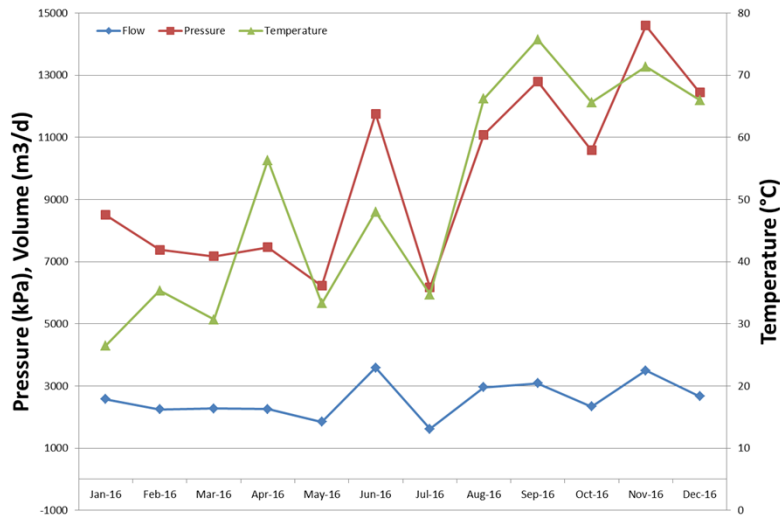


WDW #4: 2016 Average Monthly Disposal Rates, Pressure and Temperature

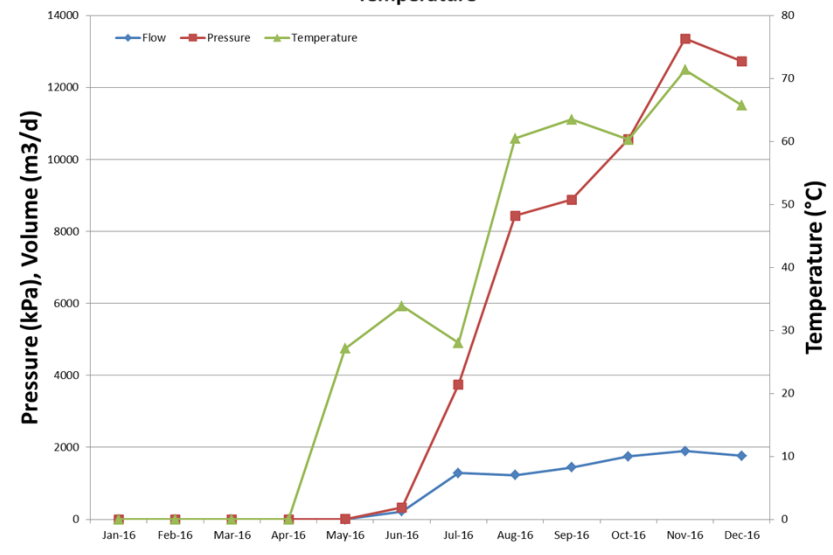


Water & Waste Disposal Wells, Landfill Waste Wolf Lake Disposal Volumes

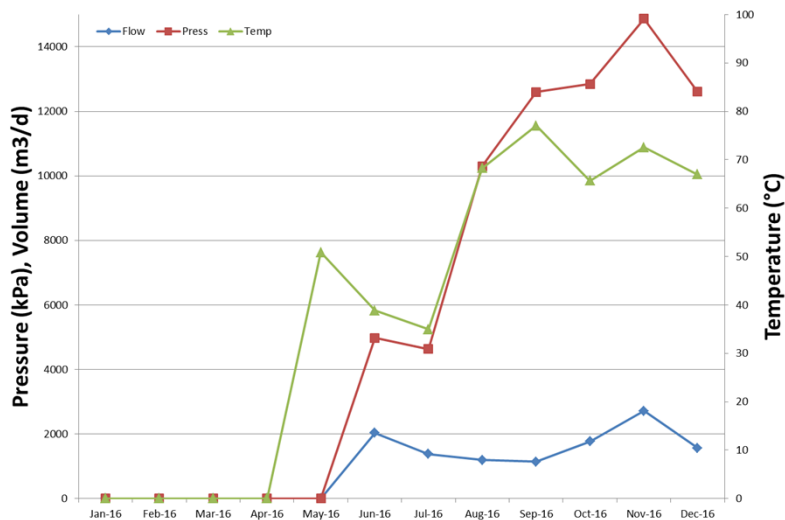
WDW #9: 2016 Average Monthly Disposal Rates, Pressure and Temperature



WDW #11: 2016 Average Monthly Disposal Rates, Pressure and Temperature

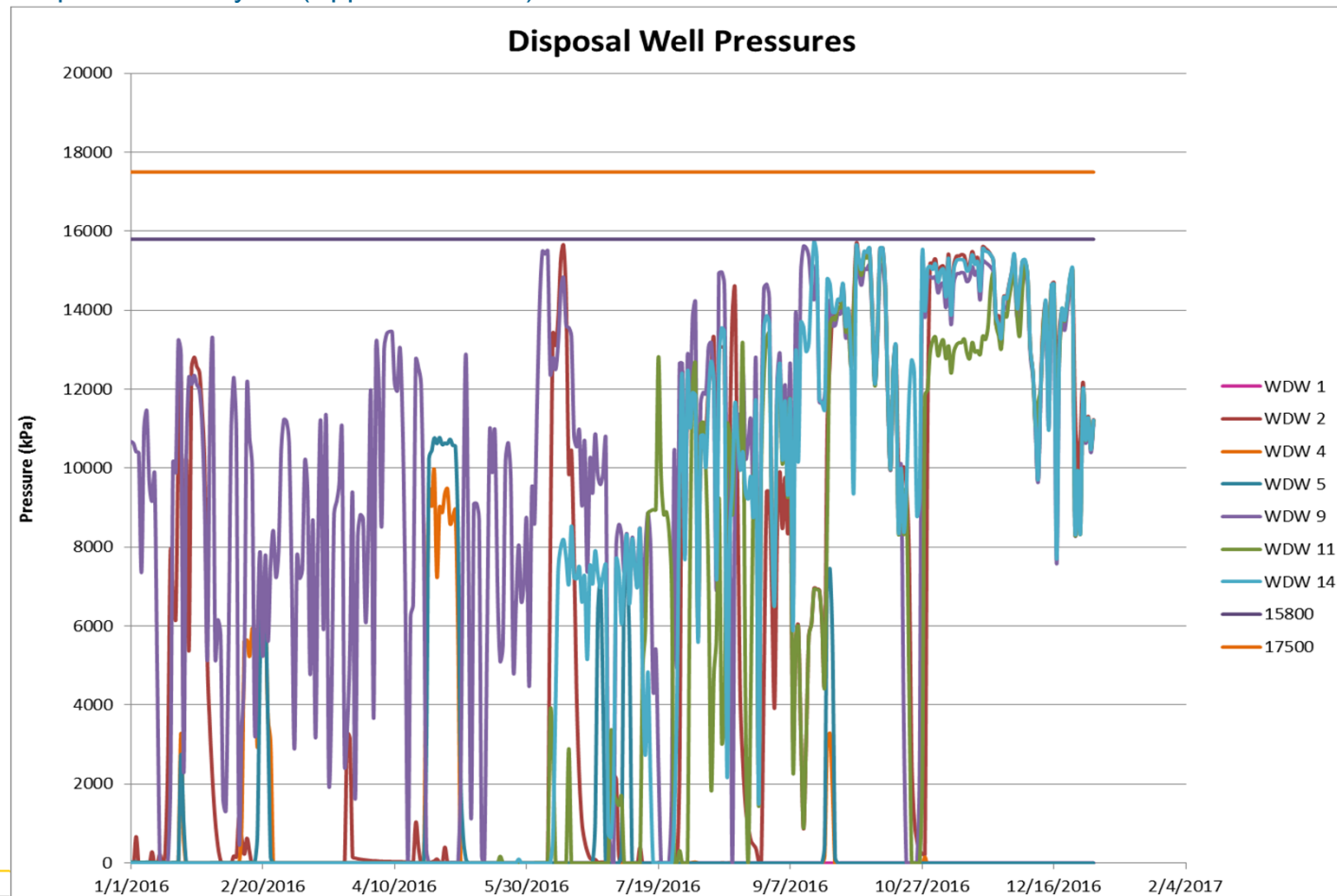


WDW #14: 2016 Average Monthly Disposal Rates, Pressure and Temperature



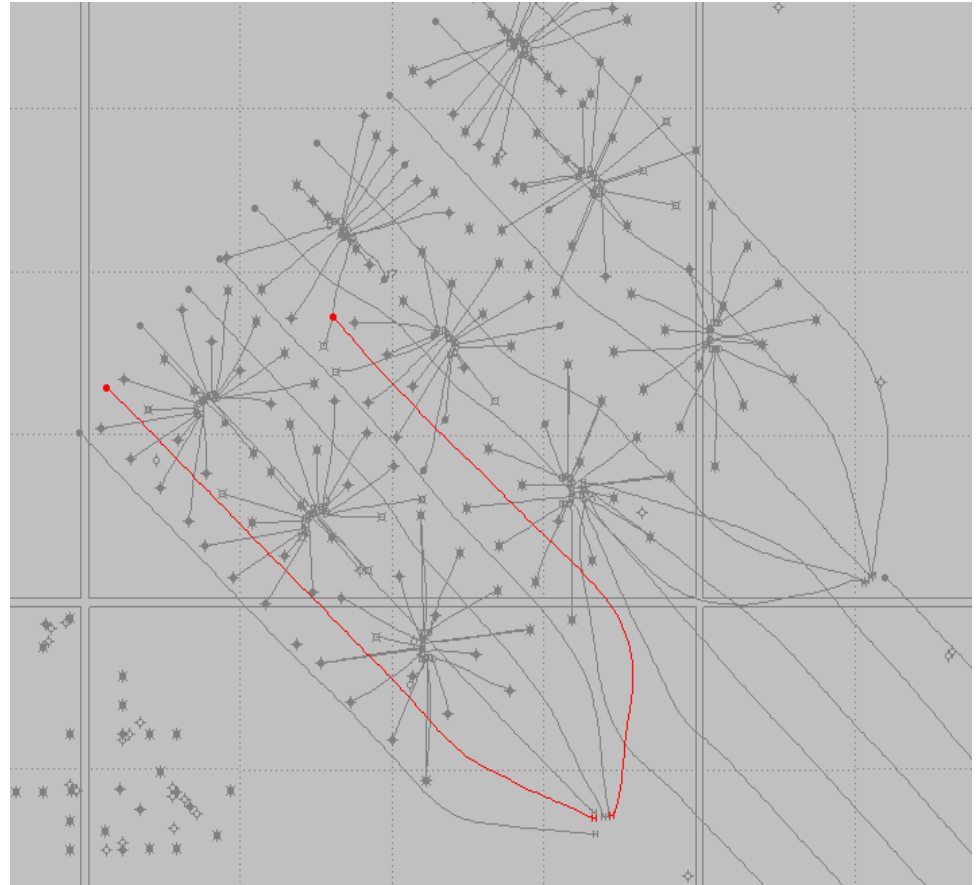
Wolf Lake Disposal Well Pressures

- Wolf Lake disposal well pressures (WDW # 1, 2, 4, 5, 9, 11 & 14)
 - Injection Pressures did not exceed 17,500 kPa in 2016
 - Pressures can exceed 15,800 kPa, up to 17,500 kPa for a maximum 24 hr. period for up to 2% of the operating time per calendar year (Approval 8672E)



Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage

- Water is stored in the C3 Formation
 - Converted two wells to injectors in June 2003
- Injected 894,441 m³ total
 - 496,645 m³ to M2-S
 - 110,448 m³ in 2016
 - 397,796 m³ to M2-E
 - 99,225 m³ in 2016



Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage Volumes



- Wolf Lake Water Storage – Disposal Volumes

Year	Month	M2_E				M2_S			
		Gross (m3/d)	Oil (m3/d)	Water (m3/d)	Water Inj (m3/d)	Gross (m3/d)	Oil (m3/d)	Water (m3/d)	Water Inj (m3/d)
2003		21	2	20	243	40	1	39	292
2004		0		0	21	28	0.2	28	49
2005					0.3				4
2006									
2007					146				174
2008									
2009									
2010					16				0.03
2011					5.39				0.14
2012					5.19				0.09
2013					3005.91				3741.37
2014					16270				17616.9
2015					4106.37				4594.31
2016	Jan				140.79				169.90
	Feb				123.33				123.08
	Mar				135.46				189.65
	Apr				1005.85				1155.16
	May				463.81				565.56
	Jun				800.79				946.29
	Jul				223.12				312.99
	Aug				504.28				669.78
	Sep				585.55				643.54
	Oct				382.82				404.80
	Nov				523.54				556.48
	Dec				571.15				535.82

Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage Volumes



- Wolf Lake Water Storage – Produced 2016 Volumes

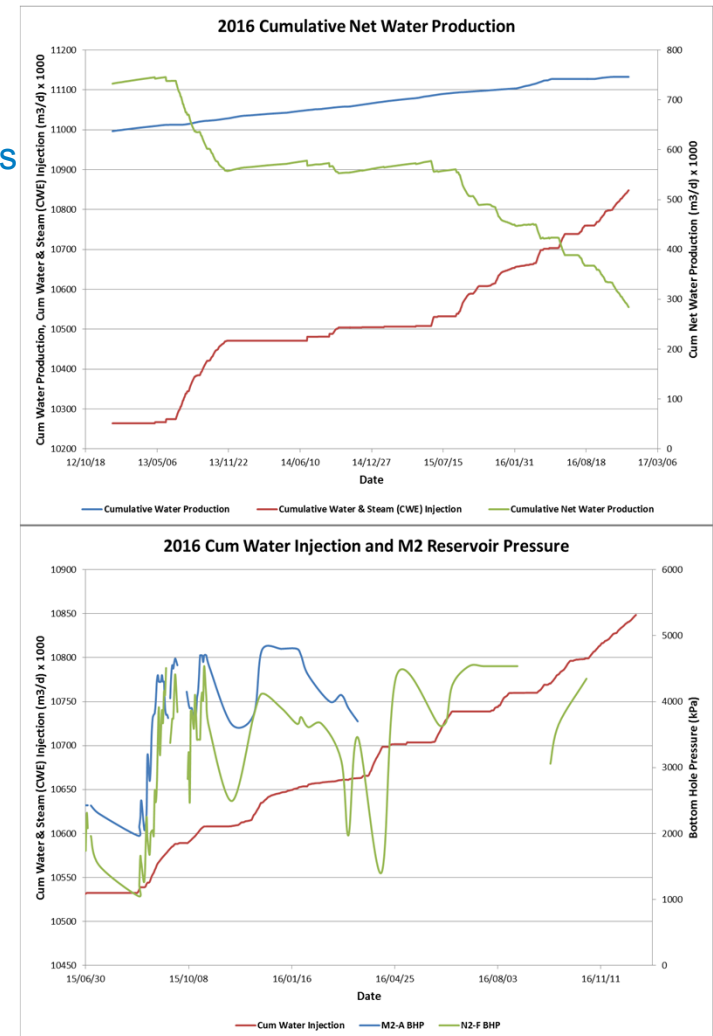
Year	Month	M2_B				M2_C				M2_D			
		Gross (m3/d)	Oil (m3/d)	Water (m3/d)	Water Inj (m3/d)	Gross (m3/d)	Oil (m3/d)	Water (m3/d)	Water Inj (m3/d)	Gross (m3/d)	Oil (m3/d)	Water (m3/d)	Water Inj (m3/d)
2016	Jan	159.9	0.5	159.4		346.7	12	334.7		1350	35	1315	
	Feb	750	14.9	735.1		2717.6	108.6	2609		2656.3	80.4	2575.9	
	Mar	2880.8	54.2	2826.6		2282.8	88.4	2194.4		1648.3	48.2	1600.1	
	Apr	2700.8	39.1	2661.7		2520.4	74.1	2446.3		2905.2	61.6	2843.6	
	May	1323.9	0	1323.9		759.9	0	759.9		1235	0	1235	
	Jun	0	0	0		0	0	0		0	0	0	
	Jul	0	0	0		0	0	0		0	0	0	
	Aug	0	0	0		0	0	0		0	0	0	
	Sep	1128	0	1128		679.6	0	679.6		997.4	0	997.4	
	Oct	929.8	0	929.8		399.7	0	399.7		1244	0	1244	
	Nov	61.1	0	61.1		24.3	0	24.3		15.4	0	15.4	
	Dec	0	0	0		0	0	0		0	0	0	

Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage Compliance



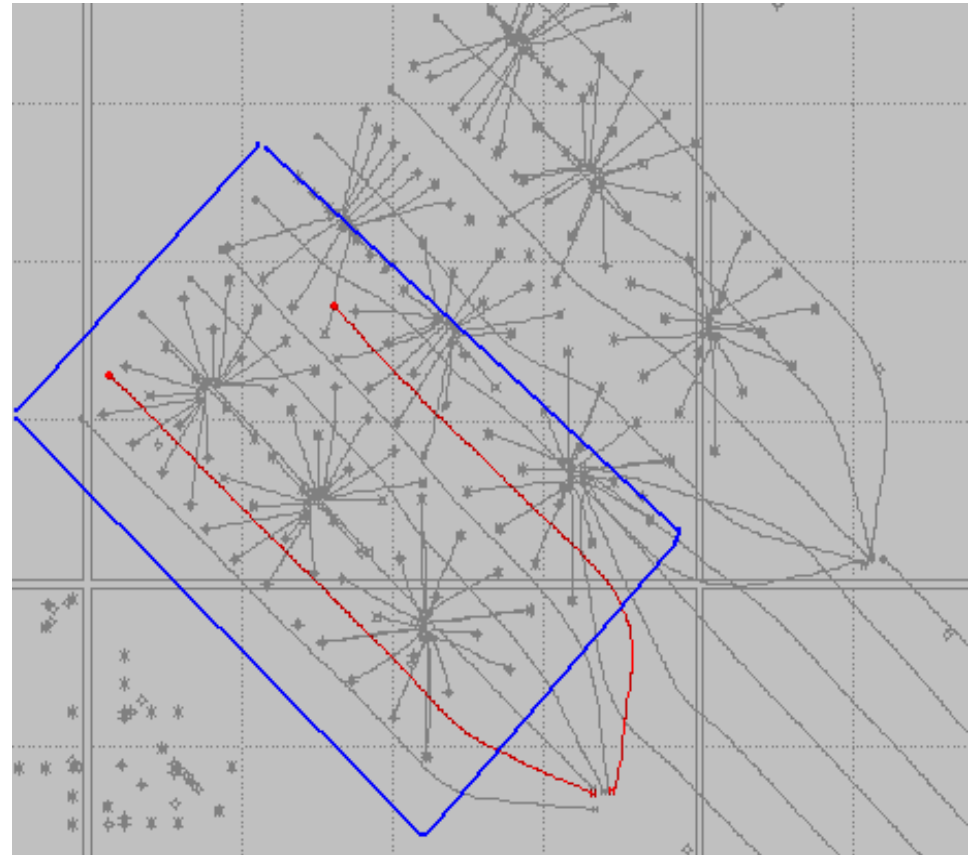
- Formation Integrity and Pressure Monitoring
 - AER Approval No. 9108A was amended to use a Lower Grand Rapids Formation observation well to monitor for migration of fluids out of the zone in lieu of logging the wells used as water injectors
 - Pressures did not exceed the allowable 9 MPa on the Grand Rapids Formation observation well during water injection
 - M2-E passed packer isolation test on Aug 17, 2016
 - M2-S passed packer isolation test on Sept 6, 2016
 - No wellbore integrity issues encountered
- Wolf Lake Water Storage – Reservoir
 - M2 & N2 Cumulative DI = 1.09
 - Cumulative Gross Production = 11,897,602 m³
 - Cumulative Oil Production = 1,490,048 m³
 - Cumulative Steam Injected = 9,971,916 m³ CWE
 - Cumulative Water Injected = 904,571 m³
 - M2 & N2 Remaining Voidage = 1,021,115 m³

$$DI = \frac{\text{Total Fluid Produced (Bitumen + Water)}}{\text{Total Fluid Injected (CWE)}}$$



Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage Balance

- From the outlined area (M2 wells and N2-F)
 - Total Injected Water = 894,441 m³ since Jan '03
 - Total Produced Water = 728,465 m³ since Jan '03
 - Difference = 165,976 m³
- Expect to utilize M2 storage in 2017
- Stored water is produced through horizontal wells surrounding the M2-E and M2-S injector wells and sent to Wolf Lake water treatment plant for recycle



Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage Summary



- Injectors appear to communicate readily with offset wells
- No problems anticipated when pumping out injected water
- Intend to maintain two wells for injection
- Expect to utilize water storage as required in 2017
- M2-E and M2-S are classified as disposal wells on S-4 forms

Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage Summary



- Waste to Tervita Landfill
 - 2,260 tonnes – Contaminated Soil (crude oil, condensate, produced & salt water)
 - 67,533 tonnes – Lime Waste

- Waste to Terivata Cavern
 - 2,304 m³ – Sludge Hydrocarbons and Sand
 - 480 m³ – Crude Oil/Condensate Emulsions
 - 202 m³ – Filter Media Water Treatment
 - 37 m³ – Wax Pigging Waste
 - 26 m³ – Waste Water
 - 22 m³ – Wash Fluid
 - 21 m³ – Hydrovac Material
 - 12 m³ – Contaminated Soil

Water & Waste Disposal Wells, Landfill Waste Wolf Lake Water Storage Summary



- Waste to RBW
 - 350 m³ – Solid waste – contaminated soils, contaminated waters, plastics, filters, asbestos, lube oil, scrap oil, glycol, fluorescent tubes, misc. electronics
- Waste to NewAlta
 - 43 m³ – Sludge Hydrocarbons

Wastewater and Surface Water

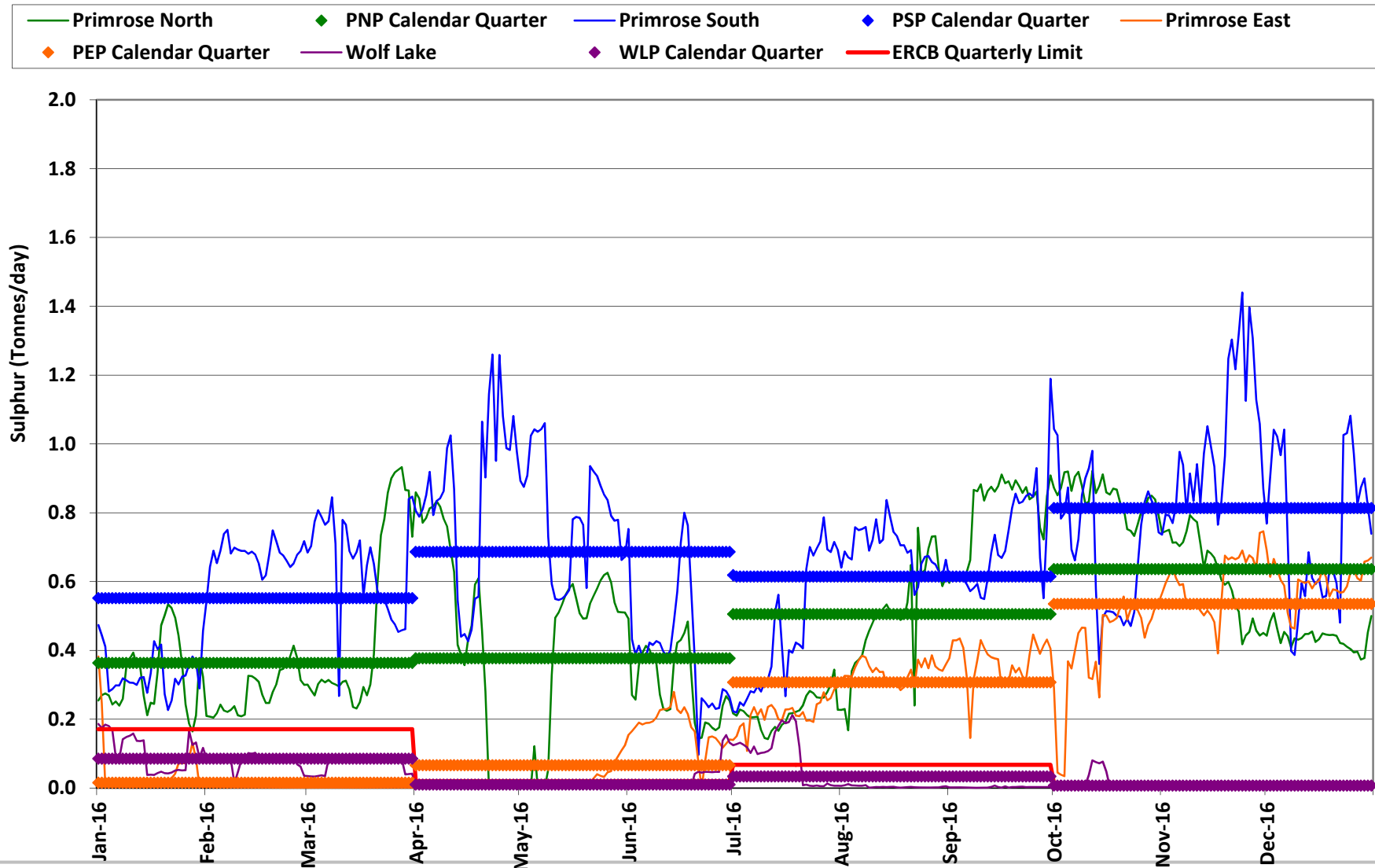
- Wastewater
 - All facilities including: Wolf Lake Plant, Primrose South Plant, Primrose North Plant, Primrose East Plant, Burnt Lake Facility and Wolf Lake Administration (new building), have the wastewater stored in tanks
 - Tanks are emptied and hauled to local municipal facilities for disposal.
 - Wolf Lake Administration (old building) has a separate waste/septic field
- Surface runoff handling
 - The Primrose and Wolf Lake facilities have a total of 7 surface water run off handling ponds.
 - The surface water is either released to adjacent crown lands or used as per existing Water Act licenses for purposes such as: steam injection, dust control, and drilling uses.
- Volumes from the handling of wastewater and surface water runoff are both reported annually as part of the Industrial Waste Water submission due March 31, 2017.

Sulphur Production

- EPEA approval limits for SO₂:
 - PSP + WLP = 6.7 t/d
 - PNP = 2.0 t/d
 - PEP = 2.0 t/d
- CEMS values are used for reporting at all steam plants
 - PNP from September 1, 2010 onward
 - PEP, PSP, and WLP from April 1, 2011 onward
- Quarterly averages for all steam plants < 1.0 t/d sulphur
- Contingency for compliance with ID 2001-3 is currently to restrict/delay production to maintain sulphur level below 1 t/d quarterly average
 - Production was not restricted or delayed in 2016 to maintain sulphur levels below the 1 t/d quarterly average
 - Canadian Natural does not plan to install sulphur recovery at this time

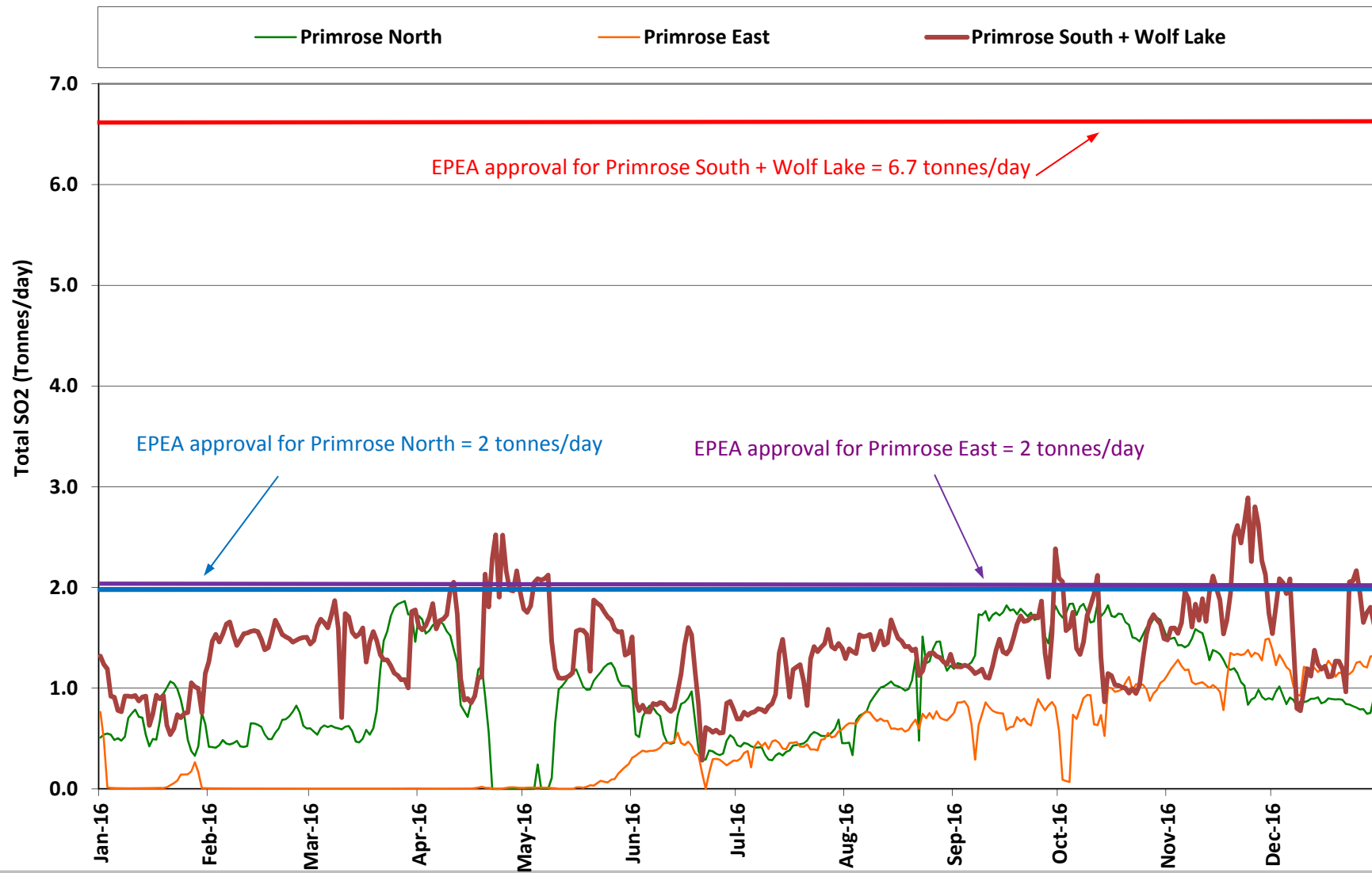
Sulphur Production

2016 Primrose & Wolf Lake Sulphur Emissions



SO₂ Emissions

2016 Primrose & Wolf Lake SO₂ Emissions



Environmental Summary

EPEA Approval and Amendments



- The Primrose and Wolf Lake Project currently operates under EPEA Approval 11115-04-00
 - Approval 11115-04-00 expires September 30, 2025
 - There were no amendments in 2016

Environmental Summary Compliance



- Compliance Issues

- EPEA Approval: Air Related

- There were no SO₂ exceedances in 2016
 - There was one NO_x exceedance in 2016
 - CIC# 311435 - During the hour from 17:00 - 18:00 on May 15, 2016, the Approval limit of 77.1 kg/h was exceeded. The average emissions during this hour was 85.68 kg/h
 - There were zero noncompliance incidents related to the CEMS in 2016. An third party audit will be completed on the CEMS QAP on January 12, 2016.
 - Variance was granted for Smoke Emissions from the Wolf Lake Facility Flare (RQST LTR APRVL, 2016 07 11, F23101, FIS 2016) from June 21 – July 21, 2016

Environmental Summary Compliance



- Compliance Issues

- Water Related:

- AER Reference # 311664, Diversion License 00238513
 - Location: Wolf Lake Source Well WSW 02 (12-10-066-05 W4M)
 - Three weekly groundwater levels inaccurate in April 2016, due to an incorrect depth range on pressure transducer
 - AER Reference # 313514, Diversion License 00365684
 - Location: Wolf Lake Office Supply Well (06-08-66-5W4)
 - Water level readings were not taken during January to July, due to an oversight.
 - AER Reference # 316477, Diversion License 00238513
 - Location: Wolf Lake Monitoring Well WOBW 12 (9-07-66-5 W4M)
 - Weekly water level data was inaccurate during July - Aug 2016, and occasionally prior to this, when water levels rose slightly above the depth range of the transducer. Also, the WOBW 9b data logger was inoperative during August due to a malfunction.
 - AER Reference # 320580, Diversion License 00238513
 - Location: Wolf Lake Water Source Wells WSW 02, WSW 04 and WSW 06
 - The maximum daily pumping rate was exceeded for one day at WSW 02, and two days each at WSW 04 and WSW 06.

Environmental Summary Monitoring Programs



- Environmental Monitoring Programs currently underway include:
 - Wildlife Monitoring Program
 - Wildlife Mitigation Plan
 - Wildlife Habitat Enhancement Program
 - Wetlands and Hydrology Monitoring Program

Environmental Summary Monitoring Programs



- Wildlife Monitoring Program
 - Amphibian surveys
 - 3 rounds of amphibian surveys were completed in May and June 2016, with a specific focus on documenting the presence of western toad, a provincially and federally listed species.
 - 84 plots were sampled across the Primrose and Wolf Lake Project area.
- Wildlife Use of Crossing Structures and Response to Above-ground pipelines
 - Wildlife use of structures built over the above-ground pipeline was monitored.
 - 30 cameras were deployed year-round.
 - Camera maintenance was performed three times in 2016 to check/replace batteries and download photos.
- Wildlife Response of Restored Linear Features
 - Wildlife response to restored seismic lines was documented by monitoring locations that received habitat enhancement treatment (e.g., mounding, tree felling, and seedling planting) and nearby reference sites that had not received any habitat enhancement treatments.
 - Cameras were deployed year-round and included 15 cameras on treated lines and 15 cameras on non-treated reference lines.
 - Treatments are designed to reduce predator (i.e., grey wolf and black bear) and human use of linear features, which improves habitat quality for woodland caribou. Camera maintenance was performed three times in 2016 to check/replace batteries and download photos.

Environmental Summary

Monitoring Programs



- Seedling Planting
 - Supplemental seedling planting was conducted along linear features affected by forest fires that occurred in summer 2015.
 - Objective is to return natural vegetation along the seismic lines to return functional wildlife habitat.
 - 8,370 seedlings were planted along 16 seismic lines.
- Preconstruction Surveys (Above-ground pipelines)
 - Pre-construction wildlife surveys were conducted along new above-ground pipeline corridors associated with Primrose North Pads 70 to 73.
 - Objective is to inform pipeline design, specifically the placement of wildlife crossings, by documenting areas of wildlife movement (e.g., game trails) and recording wildlife habitat along the corridors.
- Maintenance of Nest Boxes and Bat Boxes
 - 13 bird nest boxes and 2 bat roosting boxes were maintained across the Project area. These boxes provide supplemental habitat for wildlife.
 - Evidence of use was recorded at 7 boxes.
- Updates to Wildlife Monitoring Programs
 - An updated Wildlife Mitigation and Monitoring Program and an updated Caribou Mitigation and Monitoring Program was developed as required under the renewed EPEA Approval conditions.
 - These plans were submitted to the AER for review in August 2016.
- The next Comprehensive Wildlife Report will be submit to the AER on or before May 15, 2017

Environmental Summary Monitoring Programs



- Hydrology, Wetlands and Water Quality Monitoring Program
 - Wetland Monitoring Component
 - Preliminary observations of the PAW wetland monitoring program's 2016 re-measurement data indicates that there were only minor differences in overall species richness among monitoring and reference sites compared to previous years.
 - Hydrology Monitoring Component
 - During the 2016 monitoring program all lakes appeared to exhibit hydrological regimes similar to those of past years.
 - Water Quality Component
 - Based on the to-date results for the surface water quality samples from Burnt Lake and Sinclair Lake there were no large deviations observed in the analytical results when compared with those from previous years with the exception of toluene exceedances and benzene, ethylbenzene and xylene detections, in the July samples from Burnt Lake.
 - These impacts are inferred to be a results of the new boat motor used to access the sampling locations. Though the same sample protocols were used during the July event as during all historical events, additional precautions were taken during the October event to prevent any anthropogenic contamination in the samples.
 - During the October sampling events all hydrocarbon parameters were below the laboratory detection limit.

Environmental Summary Monitoring Programs



- Reclamation activities in 2016:
 - Re-vegetation Program consisted of reforesting 73.56 ha
 - Approximately 113,253 tree and shrub seedlings were planted.
 - Planting on borrows areas accounted for 35.31 ha
 - total of 67,140 tree and shrub seedlings
 - In-fill planting and remedial on borrows areas affected by the 2015 wild fires accounted for 32.57 ha
 - 20,580 tree and shrub seedlings.
 - Linear Disturbance Planting for remedial due to 2015 wild fires;
 - Total of 8370 Black Spruce
 - Flow to surface sites planting accounted for 5.68 ha
 - Total of 17,163 trees and shrub seedlings
- Proposed activities in 2017:
 - Reforestation of 6.4 ha sump in Primrose South.
 - Reforestation 13.1 ha of reclaimed FTS borrow areas
 - Reforestation of 4.13 ha of Reclaimed FTS Dome Wells sites

2016 FTS Update

- 2016 FTS Monitoring Activities Summary:
 - Continue monitoring of all sites.
 - On-going monitoring of shallow & deep groundwater.
 - On-going monitoring of sentinel wells around fluid levels in Fissure Containment Structures (FCS).
 - On-going monitoring of physical condition of all sites (i.e. erosion, surface water monitoring, monthly boat surveillance surveys 09-21).
- Compliance
 - No noncompliance incidents related to FTS events.
 - No noncompliance in regards to surface water releases at the FTS sites

2016 FTS Update

- 2016 FTS Milestone Summary:
 - Completion of 09-21 FTS Wall Removal was completed Feb. 12, 2016.
 - Stored water was re-entered into 09-21 Waterbody April 7, 2016.
 - Submitted requests for closure on the Environmental Protection and Enforcement Orders to AER.
 - Removed sentinel wells and installed new shallow groundwater monitoring wells at terrestrial sites.
 - Secured dispositions for FTS sites and an extension for Pad 74.
 - Submission of Groundwater Risk Management Plans (RMP's).
 - Final Reclamation completed at all borrow areas, interim completed at all the pads and road ways.

Environmental Summary

Regional Initiatives



- LICA Airshed Zone
 - The LICA Airshed Zone is responsible for operating a regional air monitoring network for part of the Lakeland and adjacent area inclusive of passive and continuous monitoring networks.
 - In addition to posting the air monitoring network results to the LICA website, the LICA Airshed Zone also posts real time air monitoring results for the regional Alberta Quality health Index (AQHI)
 - Promotes understanding of air quality in the region.

Environmental Summary

Regional Initiatives



- Beaver River Watershed Alliance (BRWA):
 - The Beaver River Watershed Alliance (BRWA) serves as the Watershed Planning and Advisory Council for the Beaver River watershed.
 - Canadian Natural has an industry seat on the Steering Committee and participates as the Co-chair.
 - The BRWA continues to work on the Integrated Watershed Management Plan as part of Alberta's Water for Life Strategy. Canadian Natural is part of the Technical Advisory Team. The current focus is on stakeholder engagement.
 - The BRWA has developed eight thematic posters to provide decision makers and the general public with easy to understand visual information about the extent of key stressors, vulnerable areas and important ecological features in the watershed. Hard copies of the posters have been distributed electronic copies are being made available.
 - The BRWA is working on a riparian enhancement project along the Beaver River. They are currently working with one landowner and a second person has expressed interest in participating. They are scoping the project to apply for funding in 2017.
 - LICA/BRWA continued to support Lakewatch program conducted by Alberta Lakewatch Society (ALMS). 10 lakes were monitored in the LICA region. Results can be found on the ALMS website.
 - The Education and Outreach coordinator was very busy with school and youth programs. She partnered with other WPACs to develop the X-Stream Science program. It is a program developed for high school students. The students used scientific protocols to collect aquatic benthic macroinvertebrates and conduct water quality tests to answer the question "What is the health of my local river?" The BRWA received an Award of Excellence from Synergy Albert for this program.

Environmental Summary

Arsenic Mobility Investigation



- Arsenic Mobility Research Program Description
 - Long-term research program at Z8 Pad ongoing since 2001.
 - Evaluating the liberation of arsenic associated with elevated groundwater temperatures from steaming a thermal pad.
 - Thirty-five groundwater monitoring wells installed primarily in shallow and deep Quaternary aquifers (Empress, Bonnyville and Sand River formations).
 - Monitoring temperature, chemistry and water level data in all wells to complete temporal assessments associated with steaming with a focus on the Empress and Sand River.
- Research Program Highlights from 2016
 - Empress aquifer results consistent with historical findings
 - thermal and arsenic plumes are migrating downgradient of the pad.
 - arsenic concentrations continue to decrease near thermal pad.
 - On-going groundwater data collection to understand flow system and geochemistry of the Sand River aquifer.
 - Steamflood operations started in 2016. Groundwater data collected will be compared to findings from previous CSS operations

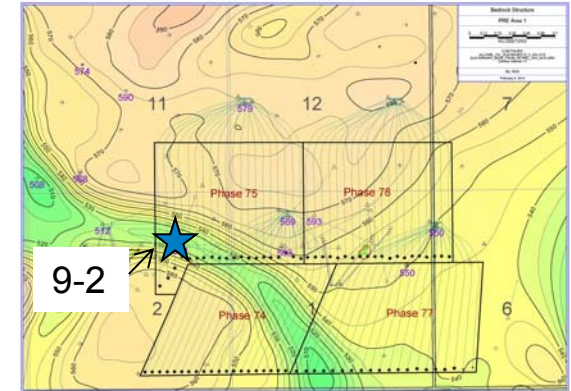
Environmental Summary

Groundwater Monitoring and Management



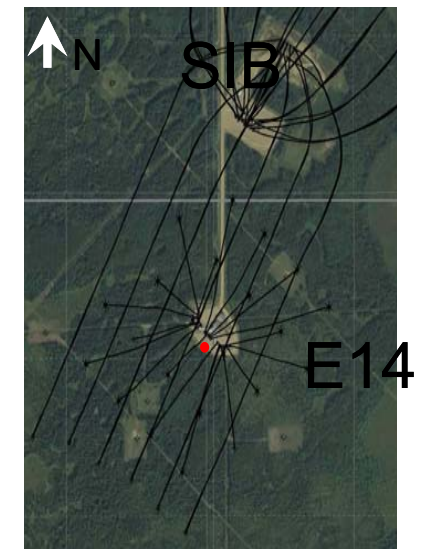
- Groundwater monitoring well installed at 09-02-067-03W4M as per the Primrose East Area 1 steamflood application

- Installed in 2014 to monitor changes in the Muriel Lake Aquifer associated with steamflood operation
- No anomalous groundwater chemistry or pressure data
- In-situ temperature reflects ambient conditions



- Groundwater monitoring well installed at E14 Pad (16-32-065-05W4M) as per the amendment to the Commercial Scheme Approval 9140I for SIB Pad

- Installed in 2010 to monitor changes in the basal Quaternary aquifer associated with SIB operation
- Completed in the Muriel Lake Formation Aquifer
- No anomalous groundwater levels or chemistry results
- In-situ groundwater temperature reflective of ambient conditions



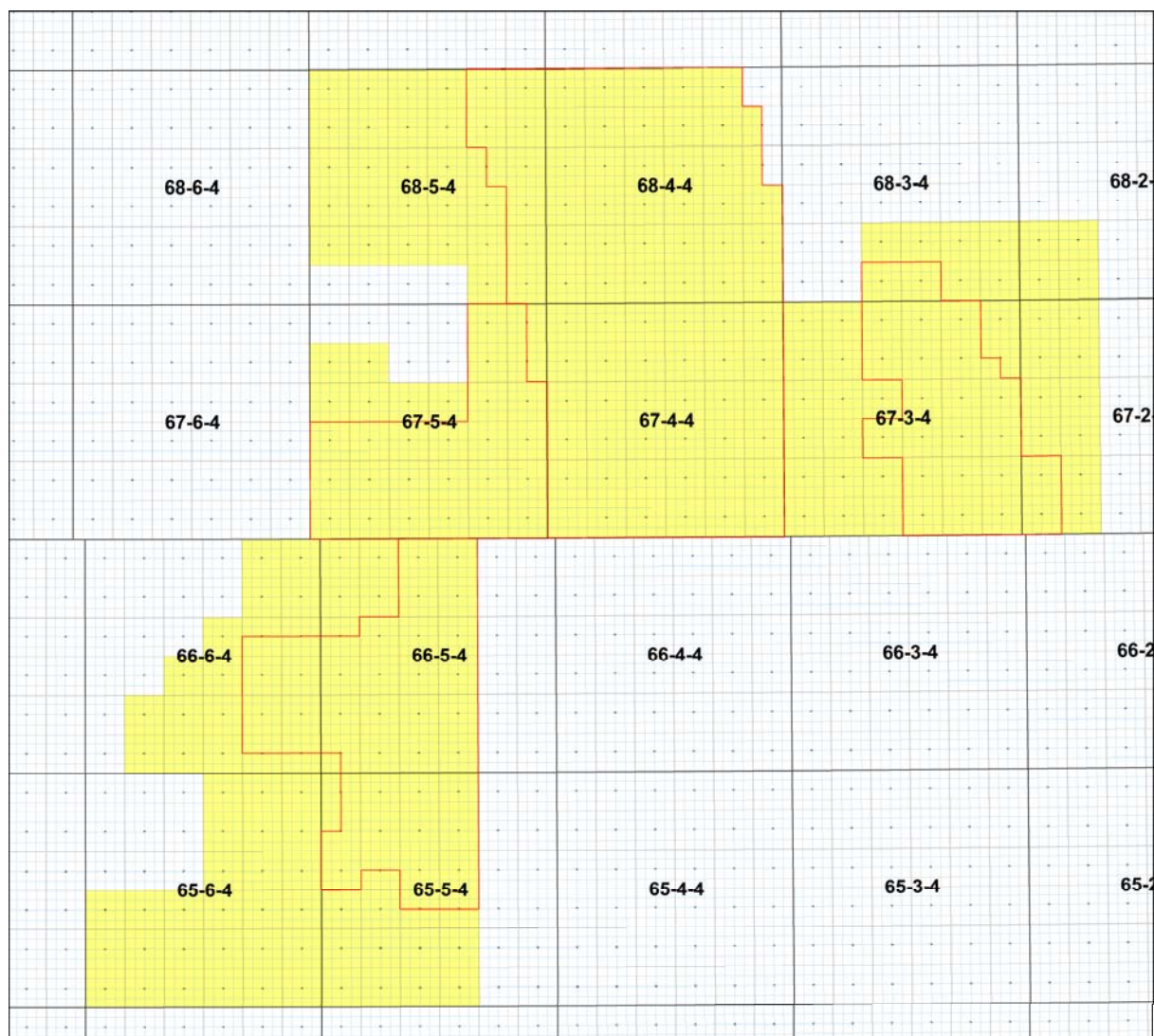
Environmental Summary

Groundwater Monitoring and Management



- 2009 Flow to Surface (FTS):
 - On-going application of the Pad 74 Risk Management Plan including monitoring, sampling and reporting.
 - Monitoring and sampling results are reported annually to AER/ESRD via EPEA Approval since March 2012.
- 2013 Flow to Surface (FTS):
 - On-going deep groundwater monitoring program including quarterly monitoring and sampling, and annual reporting.
 - On-going shallow groundwater monitoring. Shallow groundwater monitoring well network revised and new shallow monitoring wells installed for the purpose of long-term groundwater monitoring.
 - Risk Management Plans providing a long-term framework to identify and address potential risks. Submitted to AER in September 2016.
- Groundwater monitoring results indicate very limited subsurface impacts associated with FTS.

Approval 9140FF – Oil Sands Primrose Wolf Lake



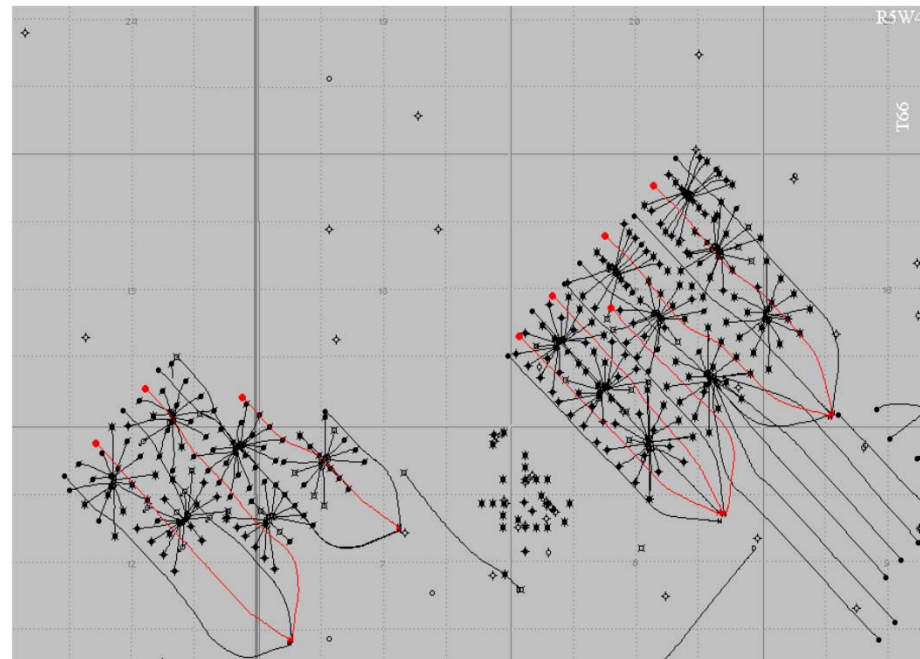
Approval 9140 – 2016 Amendments



- Amendment X
 - Z8 Steamflood Approval
- Amendment Y
 - Phases 92 and 93 Modified Steam, Risk Assessment and Mitigation
- Amendment Z
 - Phases 22S, 94 and 95 Modified Steam, Risk Assessment and Mitigation
- Amendment AA
 - Amendment to previously submitted steaming applications for Pad 92 & Pad 93
- Amendment BB
 - Wolf Lake Sparky C SAGD (2 pads) Approval
- Amendment CC
 - Phases 92, 93, 94 and 95 Modified Steam, Risk Assessment and Mitigation
- Amendment DD
 - Wolf Lake MC1 SAGD Pad NCG Co-Injection Approval
- Amendment EE
 - Phases 90 and 91 Modified Steam, Risk Assessment and Mitigation
- Amendment FF
 - Amendment to previously submitted steaming applications for Pad 93 (13-16A93), Pad 94 & Pad 95

Approval 9108A – Wolf Lake Water Storage Amended October 2015

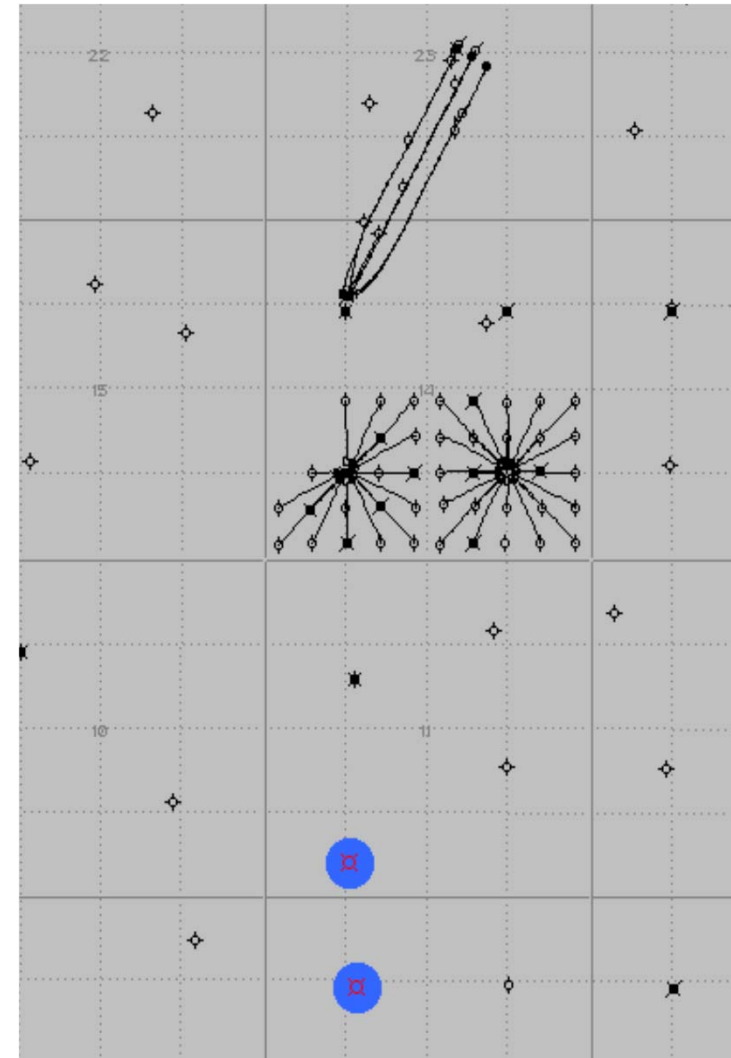
- Approval 9108A was amended in October 2015 at the request of the AER
 - The Operator must install daily pressure monitoring in the Lower Grand Rapids Formation at the 07/02-17-066-05W4M/2 well by December 31, 2015,
 - In the event that fluid migration is detected at this well, the Operator must immediately notify the AER In Situ Authorizations Group and submit a plan to assess and mitigate the potential impact of disposal operations within 60 days of detection.
- Directive 054
 - (a) Summary of monthly injected and produced volumes/well
 - (b) Well/Formation Integrity and pressure monitoring
 - (c) Remaining Reservoir Water Storage
 - (d) Water Balance, Bitumen Volumes and Incremental Recovery
 - (e) Overall performance and 2016 plans
 - (f) Discussion of produced water utilization & fresh water reductions



Approval 8186A – Burnt Lake Water Disposal Approved February 1999



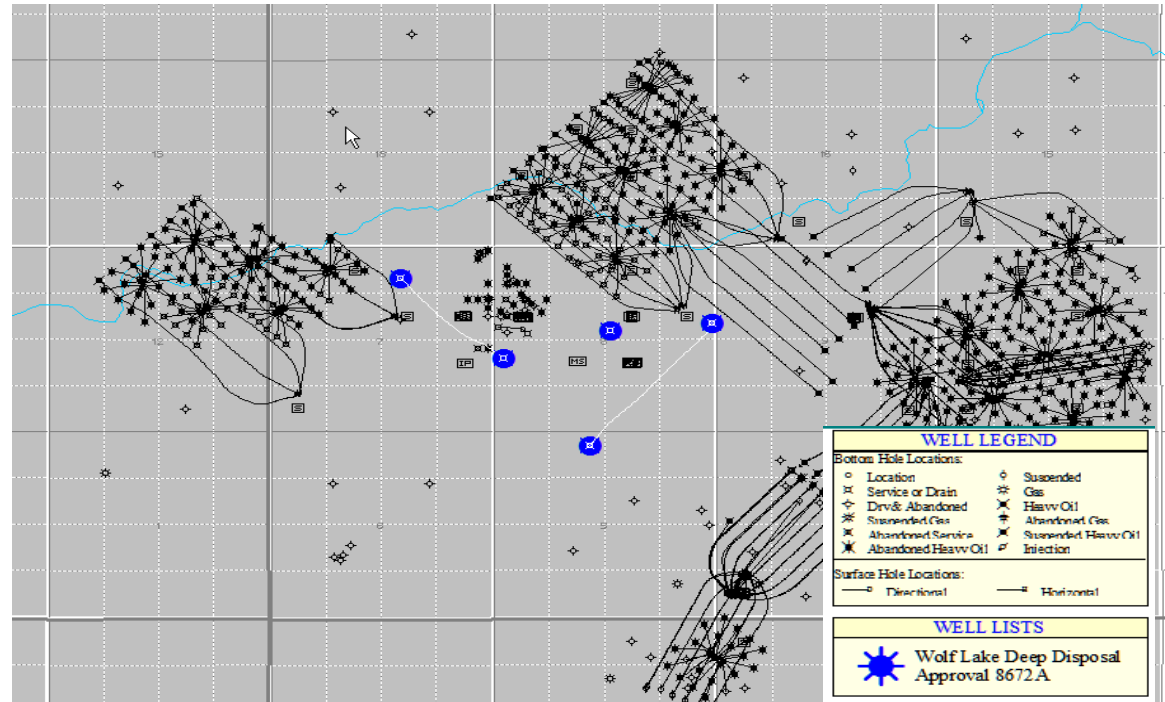
- Approval Compliance Requirements
 - Directive 51 Compliance
 - Maximum Injection Pressures (kPa)
 - F1/11-02-067-03W4/0 abandoned
 - 00/03-11-067-03W4/0 = 5,500
- F1/11-02-067-03W4 was abandoned in November 2016
- No disposal as water is now recovered and re-used



Approval 8672E – Wolf Lake Deep Disposal Approved June 2010



- Operational injection pressure limit 15,800 kPa
- Maximum injection pressure 17,500 kPa for a 24 hour period (up to 2% of operating time per calendar year)
- 2016 Amendments:
 - 8672B – Increase in MWHIP for WDW#1, 2, 4, 5 and 9 from 13.7 to 15.8 MPa
 - 8672C – Addition of WDW#11 and WDW#14
 - 8672D – Increase upper pH limit to 12.5 for all wells
 - 8672E – Increase in MWHIP for WDW#11 and #14 to 15.8 MPa



- Disposal wells under Approval 8672E:
 - WDW#1 - 100/09-08-066-05W4/0
 - WDW#2 - 100/10-08-066-05W4/0
 - WDW#4 - 100/05-08-066-05W4/0
 - WDW#5 - 100/15-07-066-05W4/0
 - WDW#9 - 100/14-05-066-05W4/0
 - WDW#11 - 100/07-08-066-05W4/0
 - WDW#14 - 102/06-09-066-05W4/0

Approval 8673A – Cavern Disposal

Approved October 2000



- Approval Compliance Requirements
 - Monitoring Maximum Injection Pressures
 - Did not exceed maximum allowable injection pressure
 - Annual Report
 - 2017 Report will be prepared following annual cavern sounding
- Salt Cavern 1 – 118/12-8-66-5W4
 - Cavern volume (as of March 2016 sounding) 182,217 m³
 - Wash water 19,506 m³
 - Cavern wash water is sent to disposal wells
 - Oily waste (bitumen) 3,945 m³
 - Solid waste 8,508 m³
 - Next Cavern sounding expected in April 2017

Approval 8673A – Cavern Disposal

Approved October 2000

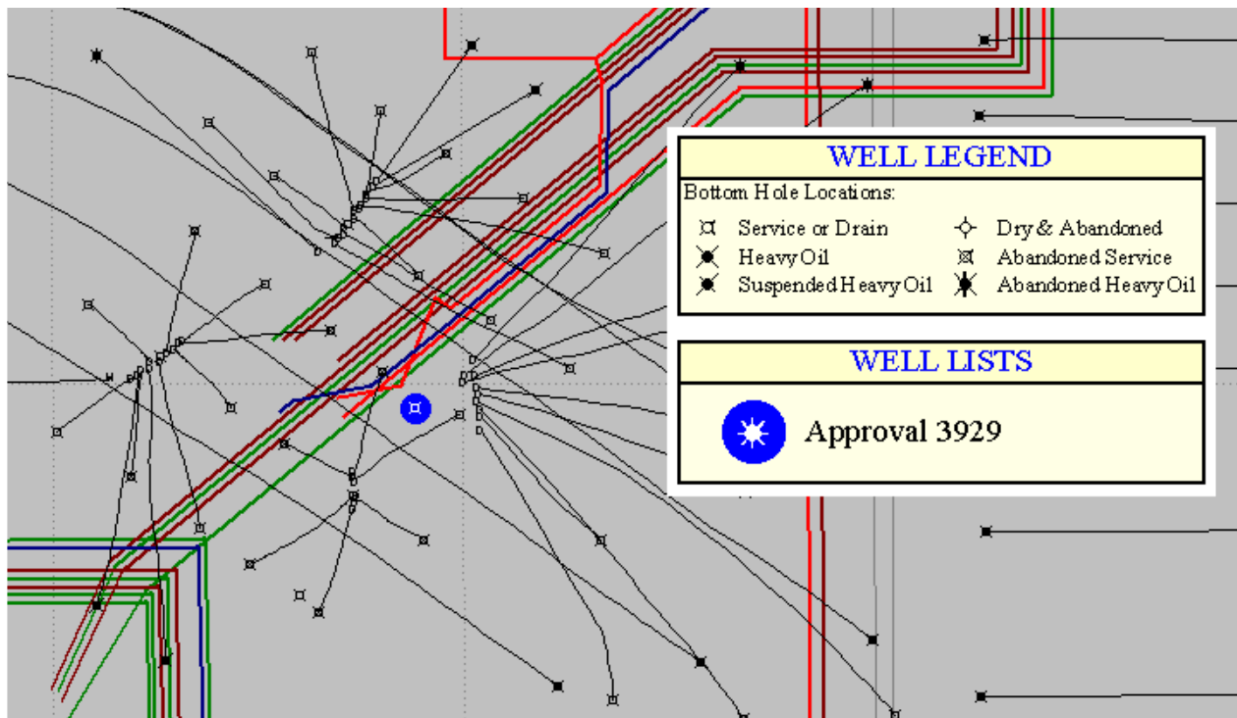


- Approval Compliance Requirements
 - Cavern #2 was approved for disposal in June 2016
 - Monitoring Maximum Injection Pressures
 - Did not exceed maximum allowable injection pressure
 - Annual Report
 - 2017 Report will be prepared following annual cavern sounding
- Salt Cavern 2 - 119/12-8-66-5W4
 - Cavern volume (as of March 2016 sounding) 54,254 m³
 - Wash water 13,476 m³
 - Cavern wash water is sent to disposal wells
 - Next Cavern sounding expected in April 2017

Approval 3929A – Primrose Class 1b Disposal Amended September 2011



- Approval Compliance Requirements
 - Originally approved 1983
 - Transferred to Canadian Natural from Dome Petroleum – September 2011
 - Directive 51 Compliance
 - Maximum Wellhead Injection Pressures (kPa)
 - 03/10-05-067-04W4/0 = 6,000



Additional Disposal Approvals



- Approval No. 4128D – Class II Disposal
 - Transferred to Canadian Natural from Dome Petroleum – September 2011
 - Directive 51 Compliance
 - 02/10-05-067-04W4/0 = 16,000 kPA

Compliance Disclosures

- Reportable spills
 - 14 reportable spills were reported during 2016 including;
 - 4 emulsion
 - 4 produced water
 - 2 boiler feed water
 - 1 blow down water
 - 1 hydraulic oil
 - 1 steam condensate
 - 1 glycol
- Digital Data Submissions (DDS)
 - Notifications/Submissions were entered into the DDS as per Directives in 2016.

Compliance Disclosures

- Field Self Disclosure
 - Erosion (sedimentation) that went off lease at Pad 65.
- Voluntary Self Disclosures
 - April 2016:
 - Disposal Approval 8672: Hydraulic isolation log and interpretations for well 05-08 (Clause 6) were not submitted by the specified time.
 - Logs and interpretation were submitted on May 17, 2016.
 - June 2016:
 - Disposal Approval 8672 - Class 1b disposal well pH was exceeded (9.0)
 - Approval was amended for a maximum pH of 12.5
 - pH probe was relocated to the flow path downstream of the low pressure booster pumps
 - May/November 2016:
 - Approval 9140 Clause 15 - Canadian Natural is working with the AER to properly define bottom hole injection pressure (BHIP)

Future Plans

- Wolf Lake Produced Water Debottlenecking
 - Phase 3 Upgrades planned for 2017
 - Phase 4 in the scoping stages for 2018 execution
- Wolf Lake Acid Job Handling Improvements
 - Improvements to slop oil and rag layer treatment
 - Improvements to water treatment hardness handling
- Primrose East Heat Integration
 - Install new exchanger for additional cooling associated with steamflood
- PSP DCS Upgrades
- PSP HRSG Steam Quality and Capacity Increase
- S1A re-drills
- Pad Adds to re-start in 2018

Future Plans

- Various small sustaining capital projects
 - To replace aging infrastructure and equipment
 - To reduce operating costs
 - To improve environmental performance



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