Canadian Natural

SURFACE OPERATIONS, COMPLIANCE, AND ISSUES NOT RELATED TO RESOURCE EVALUATION AND RECOVERY

February 5, 2020

PREMIUM VALUE. DEFINED GROWTH. INDEPENDENT.

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 - Acronyms

AER	Alberta Energy Regulator
ALMS	Alberta Lake Management Society
AGP	above-ground pipeline
AQHI	Alberta Quality Health Index
BFW	Boiler Feedwater
BRWA	Beaver River Watershed Alliance
BV	Bonnyville
BS&W	basic sediment and water
CEMS	continuous emissions monitoring system
Cl	chlorine
CL	Cold Lake
CPF	central processing facility
CSS	cyclic steam stimulation
CWE	cold water equivalent
DI	Depletion Index
DCS	Digital Control System
DDS	digital data submission
E3	Empress 3
e3m3	thousand cubic metres
EL	Ethel Lake
EPEA	Alberta Environmental Protection and Enhancement Act
Fm	Formation
FTS	flow to surface
GOR	gas oil ratio
ha	hectare
ISF	induced static flow
kPa	kiloPascal
LICA	Lakeland Industrial and Community Association
m^3	cubic metre
m^3 /d	cubic metres per day
MARP	Measurement, Accounting & Reporting Plan
mg/l	milligrams per litre
ML	Muriel Lake
MPa	Mega Pascal
Mwh	Megawatt hour
MWHIP	Maximum wellhead injection pressure
NOx	oxides of nitrogen
Obs	observation

Primrose, Wolf Lake, and Burnt Lake
Annual Directive 54 Presentation – Acronyms *(cont'd)*

ORF	oil removal filter
PEP	Primrose East Plant
PNP	Primrose North Plant
PSP	Primrose South Plant
PAW	Primrose and Wolf Lake
Profac	proration factor
QAP	Quality Assurance Program
SO_2	Sulphur Dioxide
SR	Sand River
t/d	tonnes per day
tCO2e	tonnes of carbon dioxide equivalents
TDS	total dissolved solids
UWI	unique well identifier
VRU	vapour recovery unit
WDW	water disposal well
WLP	Wolf Lake Plant
WSW	water source well

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:
  - 30” Emulsion pipeline add-in to Wolf Lake Plant
  - Wolf Lake Plant U1 ORFs Addition
  - New Pad Addition: P72A/B Tie-ins

Specific Project Update

- 30” Emulsion Pipeline Addition
  - Debottlenecking emulsion line from Primrose/Wolf Lake fields to Wolf Lake Plant Central Processing Facility
- WLP U1 ORFs Addition
  - Addition of two new ORFs in Wolf Lake Unit One to improve water handling capabilities
- New Pad Additions: P72A/B Tie-ins
  - New Pad additions as part of asset growth

Wolf Lake CPF Performance

- Bitumen and water treatment
  - Overall water quality and oil treating targets were met
  - Exceeded emulsion treating records

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
  - Aug 2019 TA Flaring due to Wolf Lake Plant OTSG Outage
  - Various non-routine flaring event notifications submitted via OneStop
  - High solution gas conservation all remaining months for normal operation
- Facility Venting Compliance
  - No routine venting in the field
  - No routine venting at Primrose North, South, East and Wolf Lake plants
  - Vapour recovery on all major sources of solution gas at Wolf Lake
    - Troubleshooting high venting events from Unit 2 skim tank

Flaring and Venting

- Gas Usage, Venting and Flaring on a monthly basis

Month	Total Purchased Gas[1] e3m3	Total Solution Gas Conserved e3m3	Total Vented Gas e3m3	Total Solution Gas Flared[2] e3m3	Solution Gas Conserved %
January	157,236	9,128	0.6	107	98.8%
February	142,107	10,856	1.2	62	99.4%
March	153,509	12,360	1.0	48	99.6%
April	145,056	12,560	1.9	80	99.4%
May	149,162	14,283	2.0	48	99.7%
June	114,676	10,769	15.6	75	99.3%
July	122,048	8,434	9.0	86	99.0%
August	128,421	11,935	6.2	1421	89.4%
September	140,508	13,949	16.2	112	99.2%
October	148,636	18,258	29.9	119	99.4%
November	139,664	16,093	2.1	96	99.4%
December	152,699	19,086	3.1	57	99.7%

NOTES:

1. Total purchased gas does not include gas from site gas wells
2. Solution gas flared volumes are corrected to remove purchased gas to flare
   - Flare volumes in August 2019 due to the Wolf Lake plant steam outage for OTSG header repairs

Measurement and Reporting

- Measurement, Accounting & Reporting Plan (MARP) for Wolf Lake / Primrose Thermal Bitumen Scheme Approved May 1st, 2007. Annual updates in March
- 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.
    - Total Battery Oil (Water) / Total Test Oil (Water) at Wells = Oil (Water) Proration Factor
    - Oil (Water) Proration Factor * Each Well Test Oil (Water) Volume = Oil (Water) Allocated to Each Well

Measurement and Reporting (con't)

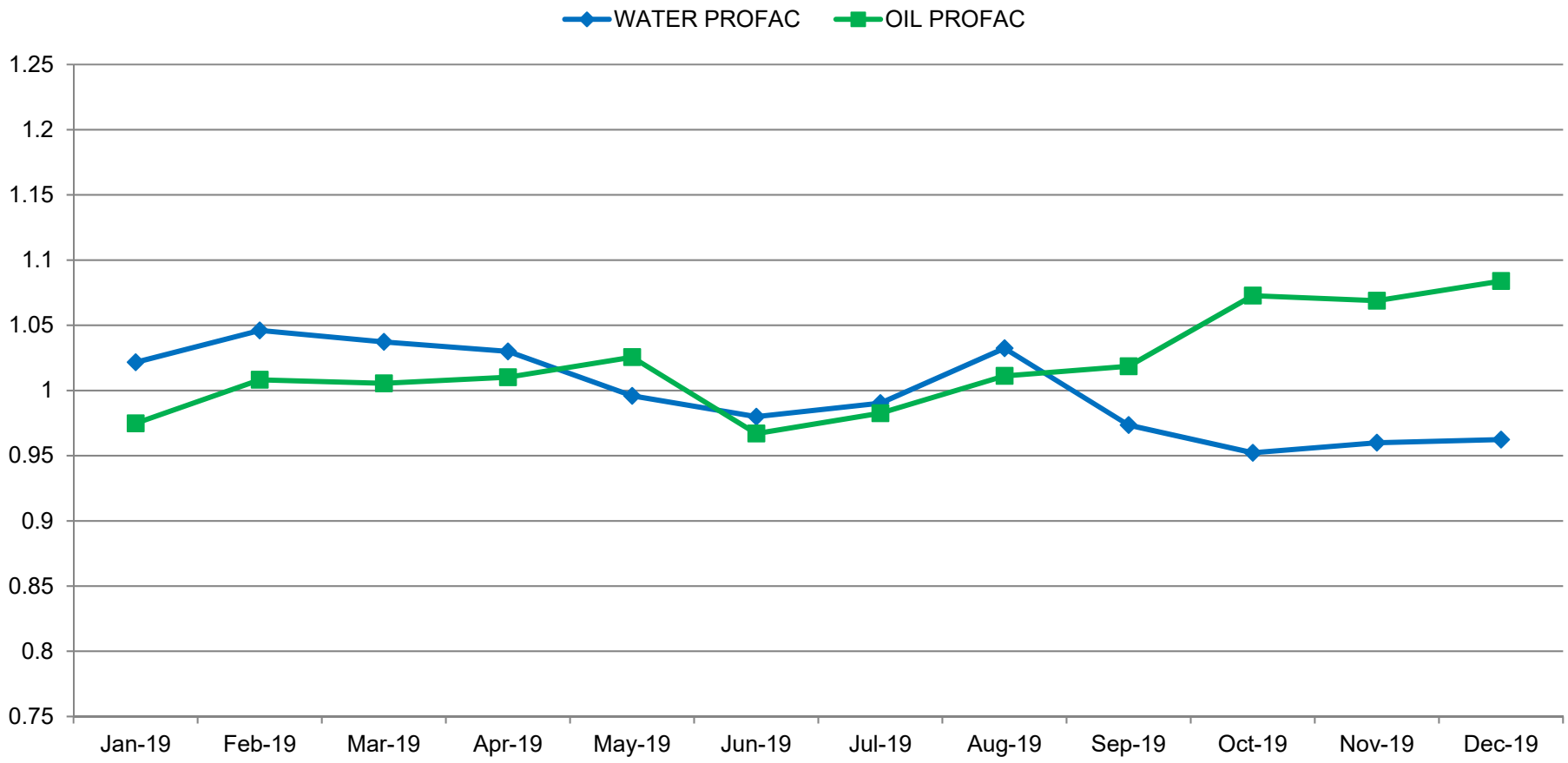
- Gas allocated to each well is determined by GOR (gas oil ratio) for the battery
  - Total Solution Gas Produced / Total Battery Oil = Gas Oil Ratio
  - Gas Oil Ratio * Oil Allocated to Each Well = Gas Allocated to Each Well
- Injected volumes of steam and water are not estimated, they are continuously 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

- 2019 Monthly Average Oil and Water Profac



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
    - Burnt Lake Plant historically used Fish Hatchery effluent for boiler feed water. Due to pipeline integrity concerns Fish Hatchery effluent for Burnt Lake boiler feed water stopped early 2017. Primrose East E-pond water usage stopped end of April 2018
    - 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
    - Average TDS = 147 mg/L
  - Quaternary Water Source Wells – Empress Unit 3 & Muriel Lake Formation Aquifers
    - 2019 Average TDS = 606 mg/L
  - McMurray Fm. Water Source Wells
    - Average TDS = 7,276 mg/L

Water Production, Injection, and Uses

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

Primrose and Wolf Lake - 2019 Monthly Average Water and Steam Volumes

Month	Surface Water [1]	Non-Saline Groundwater [2]	Saline Groundwater [3]	Produced Water	Steam Injection	Actual Water Disposal	Water Disposal Limit [4]
	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d	%	%
January	275	2,954	23,631	53,687	79,534	6.0	27.1
February	65	2,765	13,167	76,300	83,387	12.7	25.8
March	20	2,423	12,816	83,227	81,581	18.6	25.7
April	68	2,271	9,777	84,171	79,993	20.4	25.5
May	325	2,763	10,389	82,797	81,701	20.4	25.4
June	552	2,486	13,445	61,660	63,792	25.6	26.0
July	747	2,792	15,008	62,807	68,012	23.1	26.0
August	464	2,853	10,796	76,757	69,916	22.9	25.5
September	146	2,403	9,828	79,842	76,554	19.7	25.5
October	106	2,539	5,353	79,775	77,846	16.6	25.0
November	29	2,401	8,116	78,507	74,614	20.4	25.3
December	27	2,503	6,367	74,662	78,608	11.7	25.1
Average	**235**	**2,596**	**11,558**	**74,516**	**76,295**	**18.2**	**25.7**

Notes:

1. Surface water comprised of diversion from Primrose East E-Pond and surface water runoff.
2. Non-saline groundwater from Wolf Lake water source wells
3. Saline groundwater from McMurray Formation aquifer
4. Dir. 81 Water Disposal Limit as per Approval No. 9140MM

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

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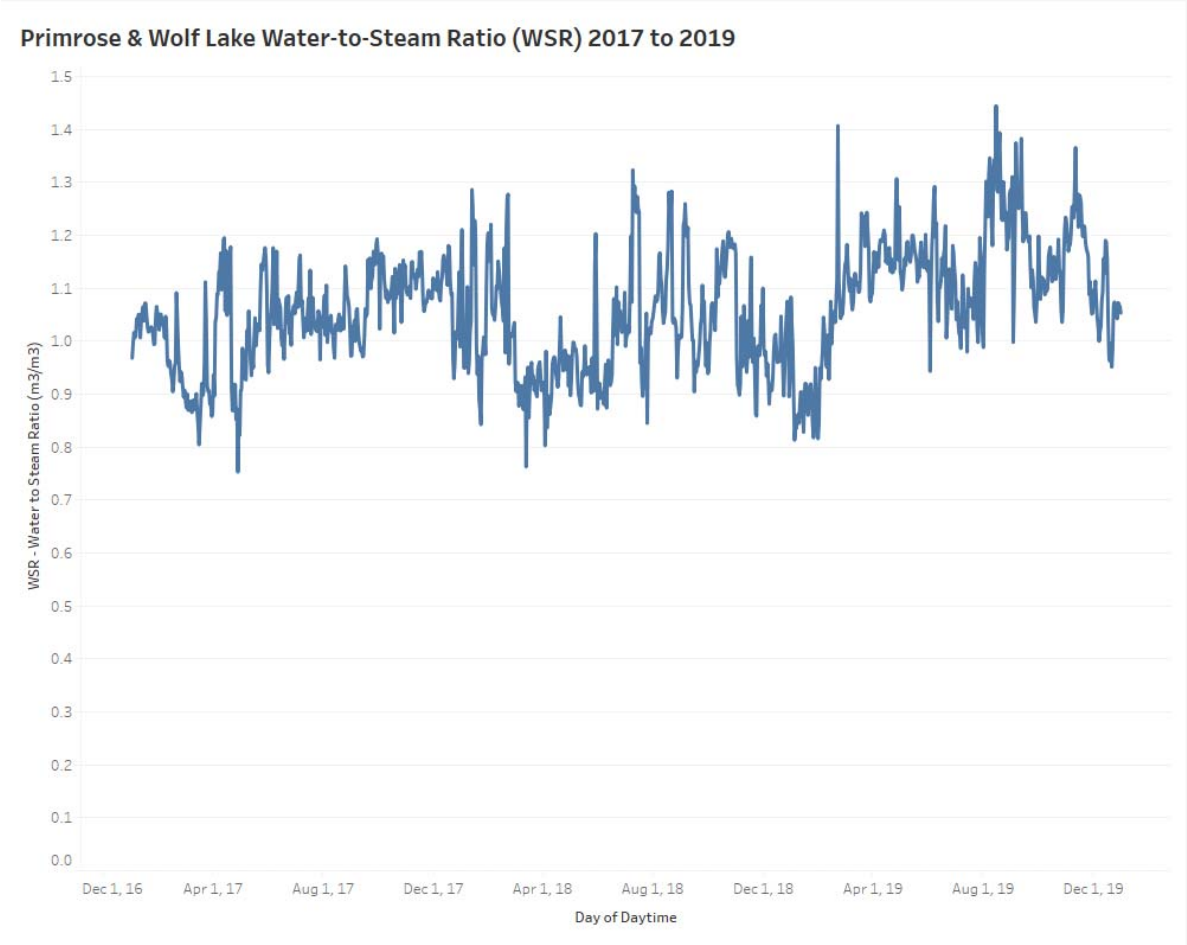
Directive 81 Amendment Update

- Historical Water-to-Steam Ratio (WSR) has increased
  - Expanded low pressure operations
  - Enhanced CSS steaming strategy
  - Fluctuations due to cyclic nature of CSS operations in PRN/PRS



Directive 81 Amendment Update

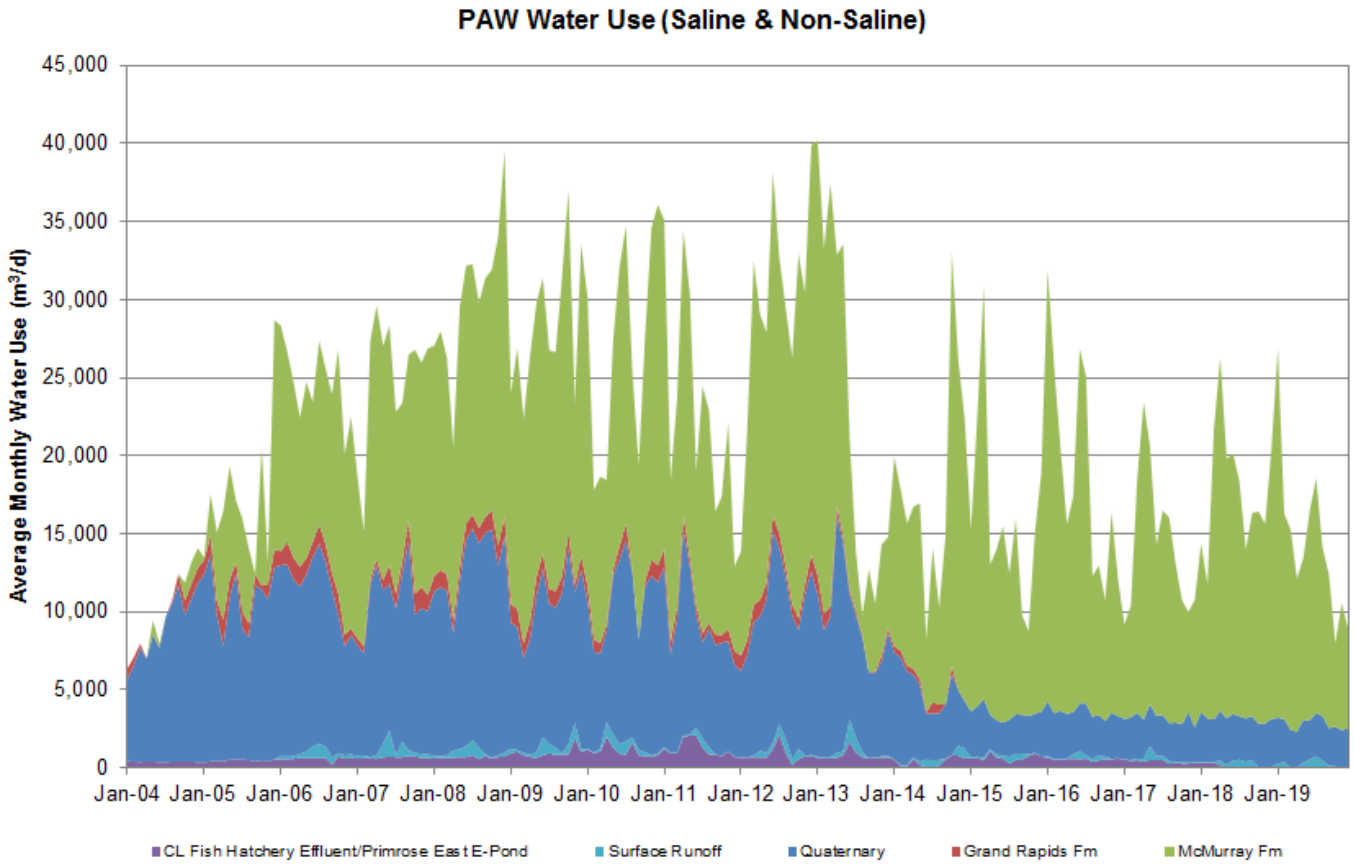
- Steam Demand
  - Turnaround activities and steam impacting outages in June, July and August 2019
- Disposal Usage
  - Turnaround activities TA and steam outages from June to August 2019 also resulted in higher disposal requirements

Month	Produced Water	Steam Injection	Actual Water Disposal	Water Disposal Limit [4]
	m^3/d	m^3/d	%	%
January	53,687	79,534	6.0	27.1
February	76,300	83,387	12.7	25.8
March	83,227	81,581	18.6	25.7
April	84,171	79,993	20.4	25.5
May	82,797	81,701	20.4	25.4
June	61,660	63,792	25.6	26.0
July	62,807	68,012	23.1	26.0
August	76,757	69,916	22.9	25.5
September	79,842	76,554	19.7	25.5
October	79,775	77,846	16.6	25.0
November	78,507	74,614	20.4	25.3
December	74,662	78,608	11.7	25.1
Average	**74,516**	**76,295**	**18.2**	**25.7**

Water Production, Injection, and Uses

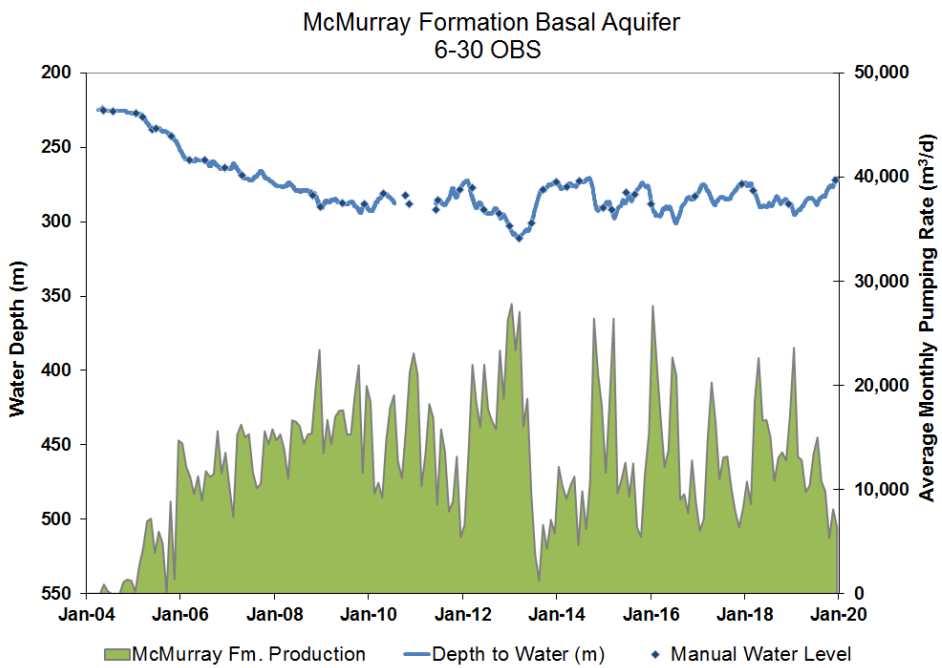
- 2019 PAW Water Use
  - McMurray Fm. Saline Water: 11,558 m^3/d (average)
  - Quaternary Non-Saline Water: 2,596 m^3/d (average)
  - Plant Runoff Surface Water: 235 m^3/d (average)

Note: Cold Lake Fish Hatchery Effluent pumping to Primrose East E-Pond ended in early 2017. Primrose East E-Pond usage ended in April 2018.

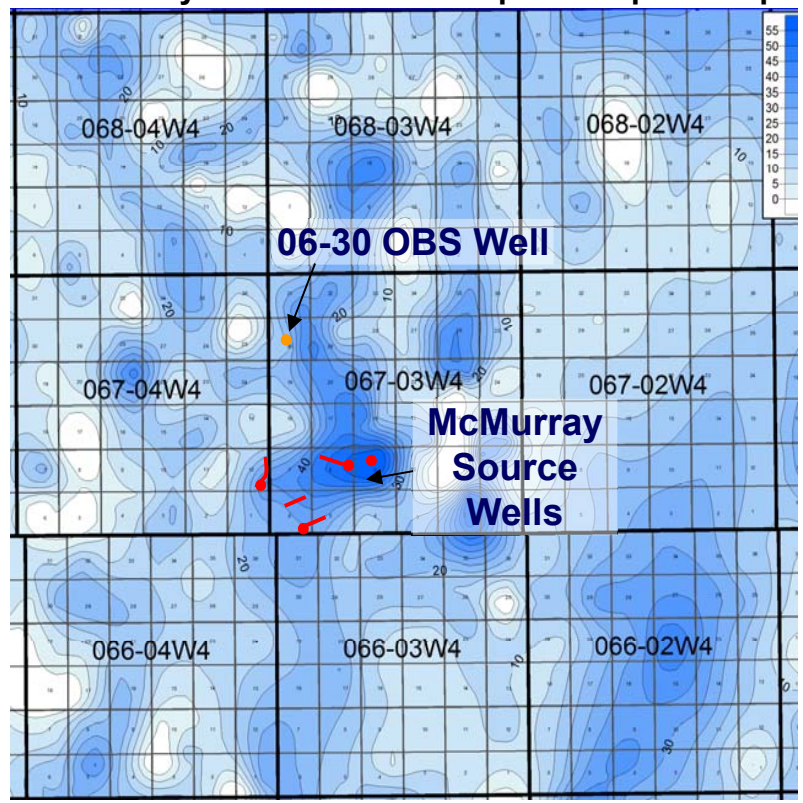


McMurray Saline Water Supply

- Producing wells:
  - 4 horizontal and 6 vertical wells
- 2019 production:
  - Average: 11,558 m^3/d
  - Maximum: 28,110 m^3/d
- Drawdown of approximately 47m in 6-30 OBS well



McMurray Formation Basal Aquifer Isopach Map



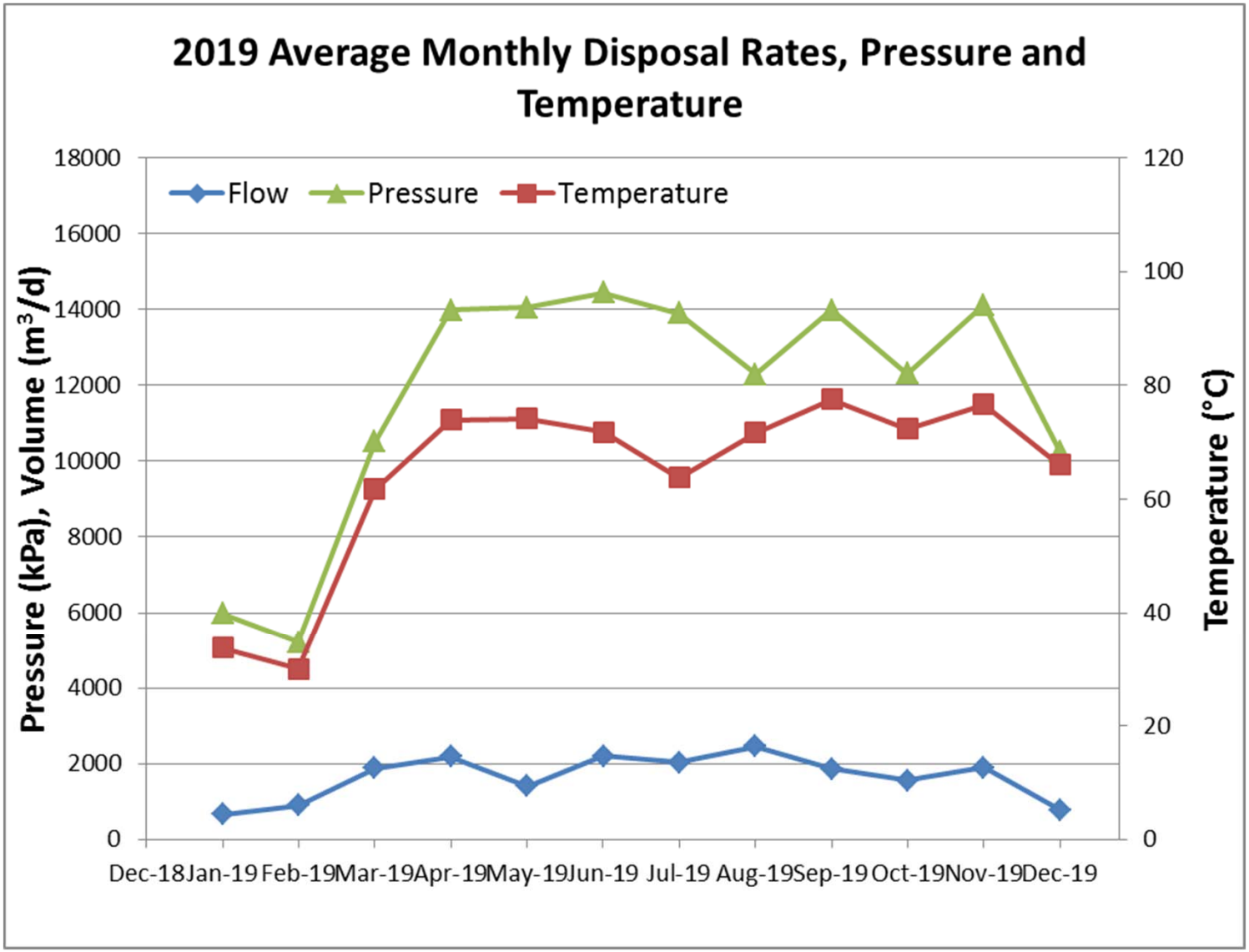
Water & Waste Disposal Wells, Landfill Waste UWI List & Disposal Compliance

- Wolf Lake Project Disposal Water Well UWI Listing

Wolf Lake	
Well	**Formation**
WDW #2 - 100/10-08-066-05W4	Mid Cambrian
WDW #4 - 100/05-08-066-05W4	Mid Cambrian
WDW #5 - 100/15-07-066-05W4	Mid Cambrian
WDW #6 - 100/14-06-066-05W4	Mid Cambrian
WDW #7 - 100/01-07-066-05W4	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
WDW #15 - 112/15-08-066-05W4	Mid Cambrian
WDW #16 - 100/16-05-066-05W4	Mid Cambrian
OBS WDW #1 - 100/09-08-066-05W4	Mid Cambrian

- Wolf Lake (WDW #2, 4, 5, 6, 7, 9, 11, 14, 15 and 16)
  - WDW #9 was re-activated in late 2015
  - Wells WDW #11 & 14 were drilled and completed in 2016
  - Suspended WDW #1 converted into an Obs well in 2018
  - Wells WDW #6, 7, 15 & 16 were drilled and completed in 2018

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



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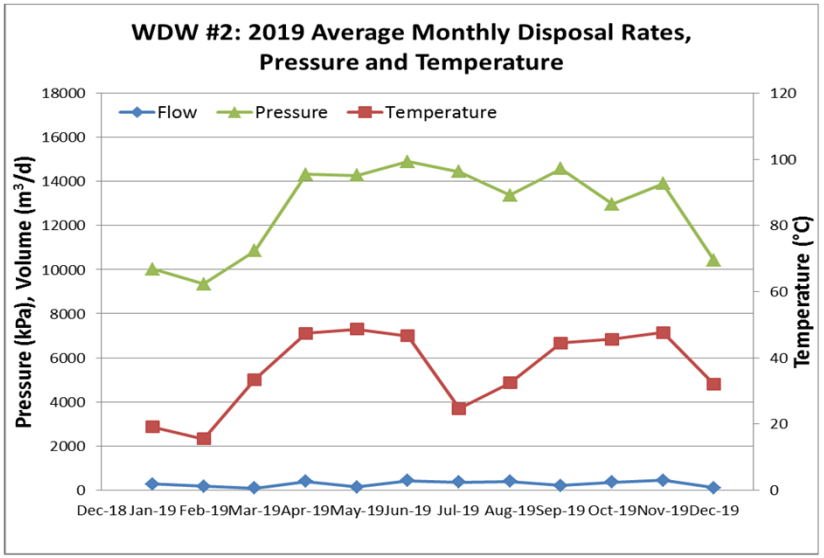
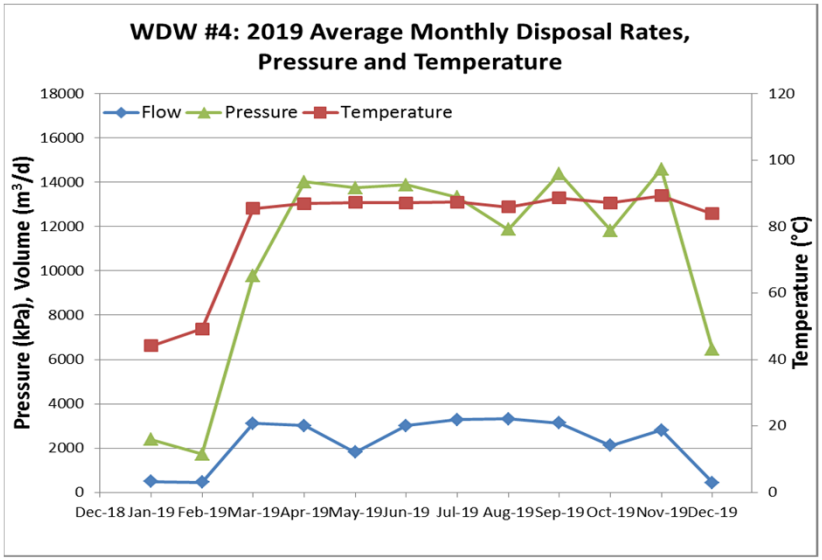
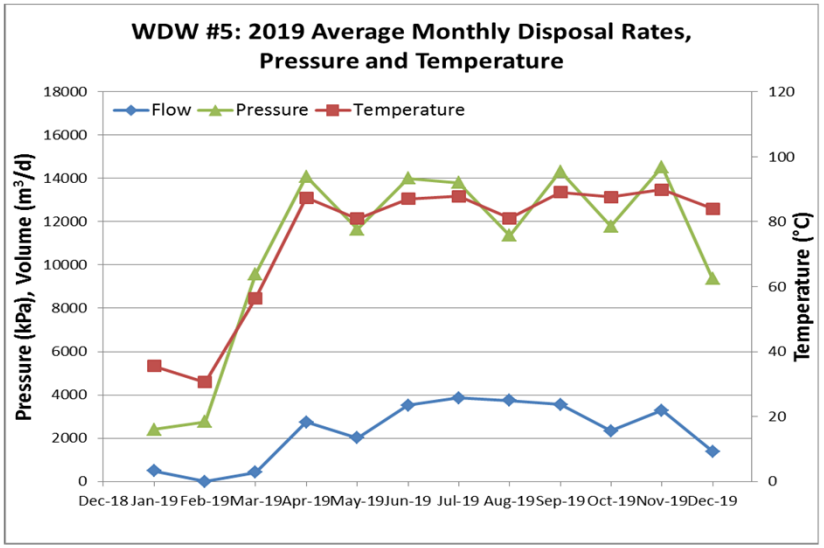
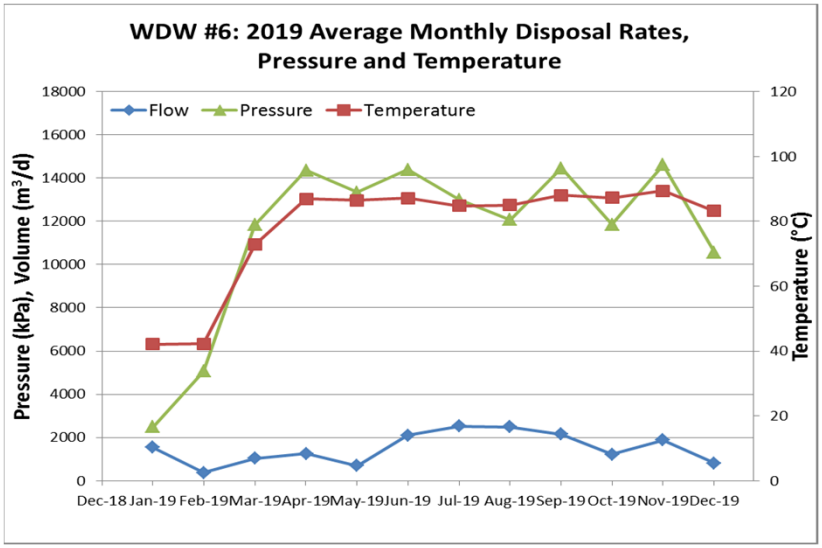
Water & Waste Disposal Wells, Landfill Waste Wolf Lake Disposal Volumes

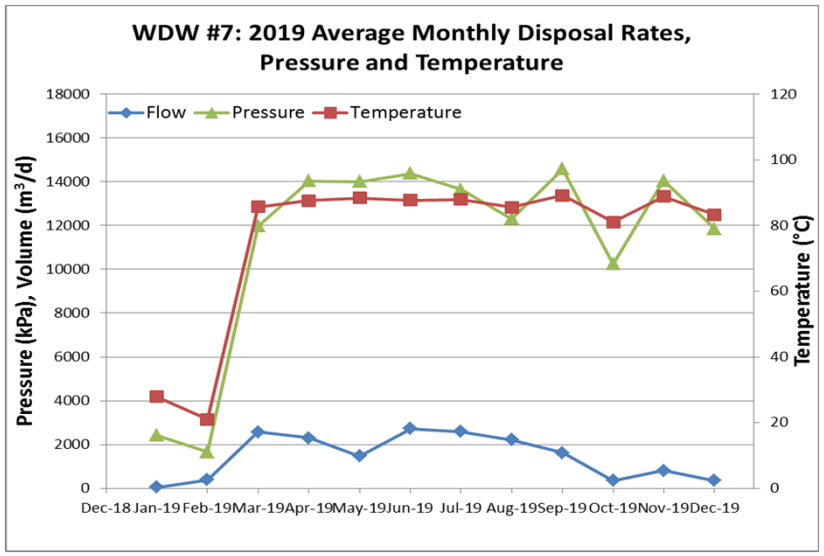


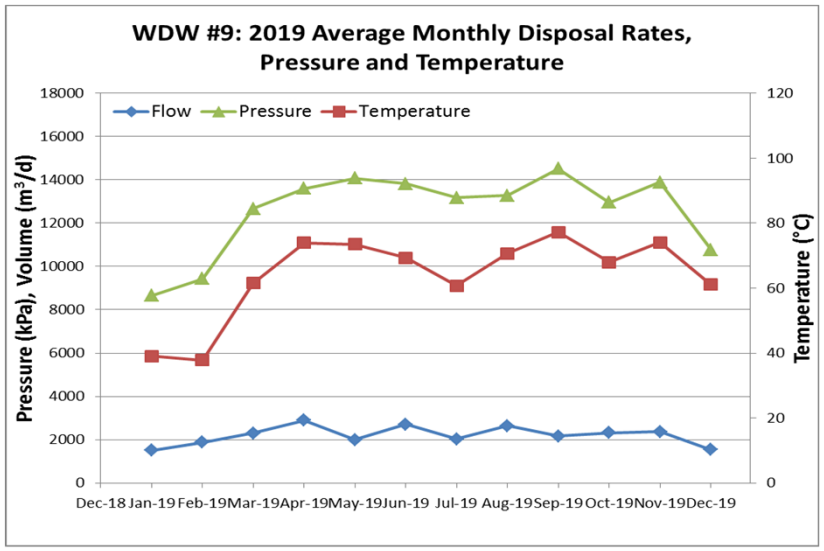


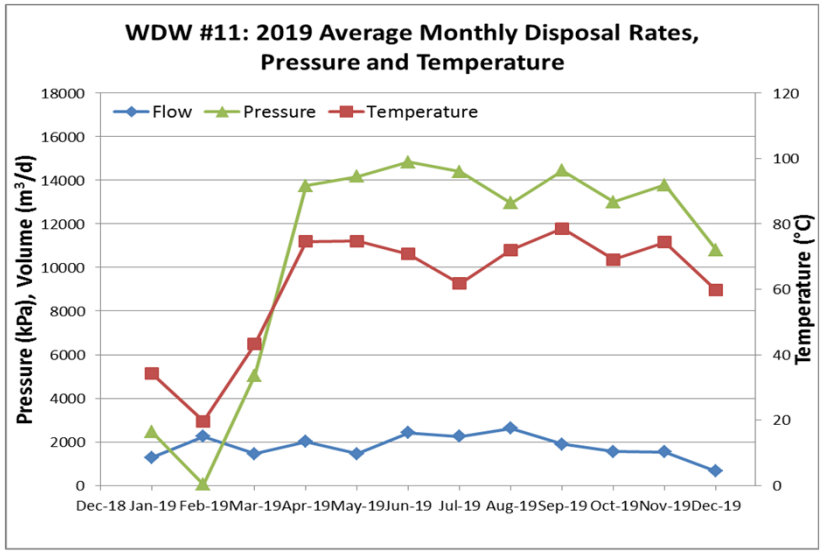


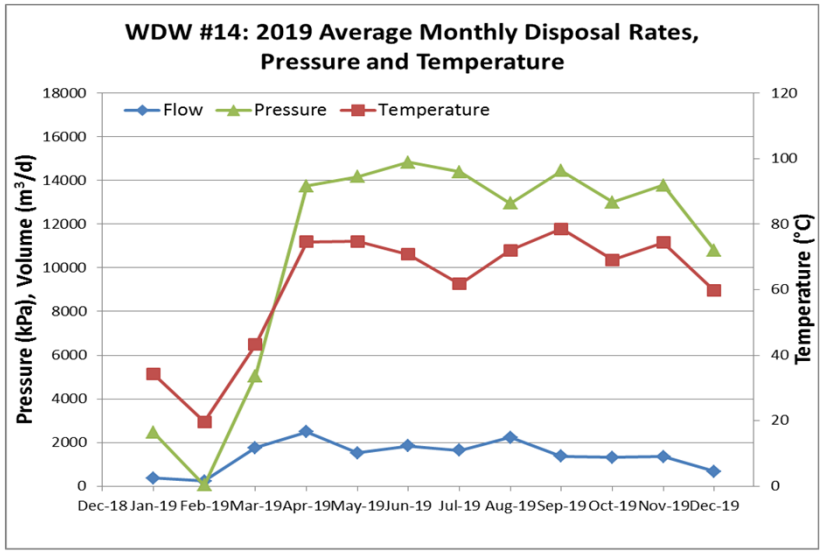


Water & Waste Disposal Wells, Landfill Waste Wolf Lake Disposal Volumes

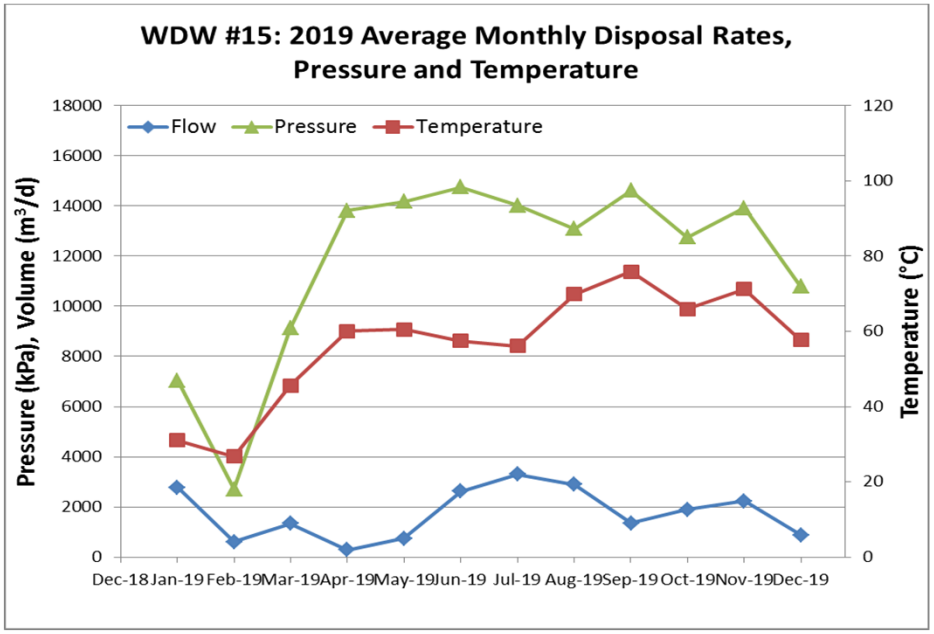


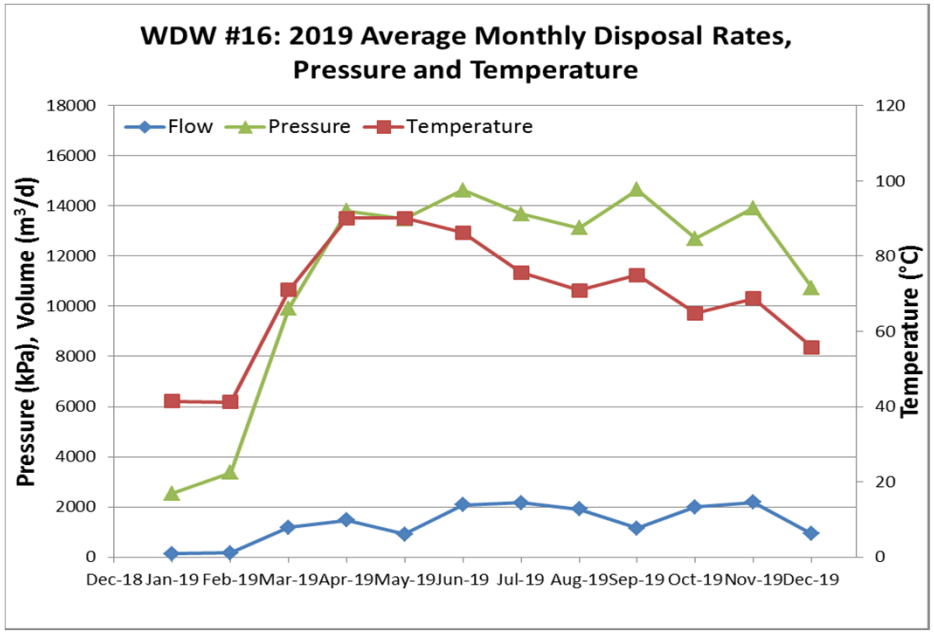






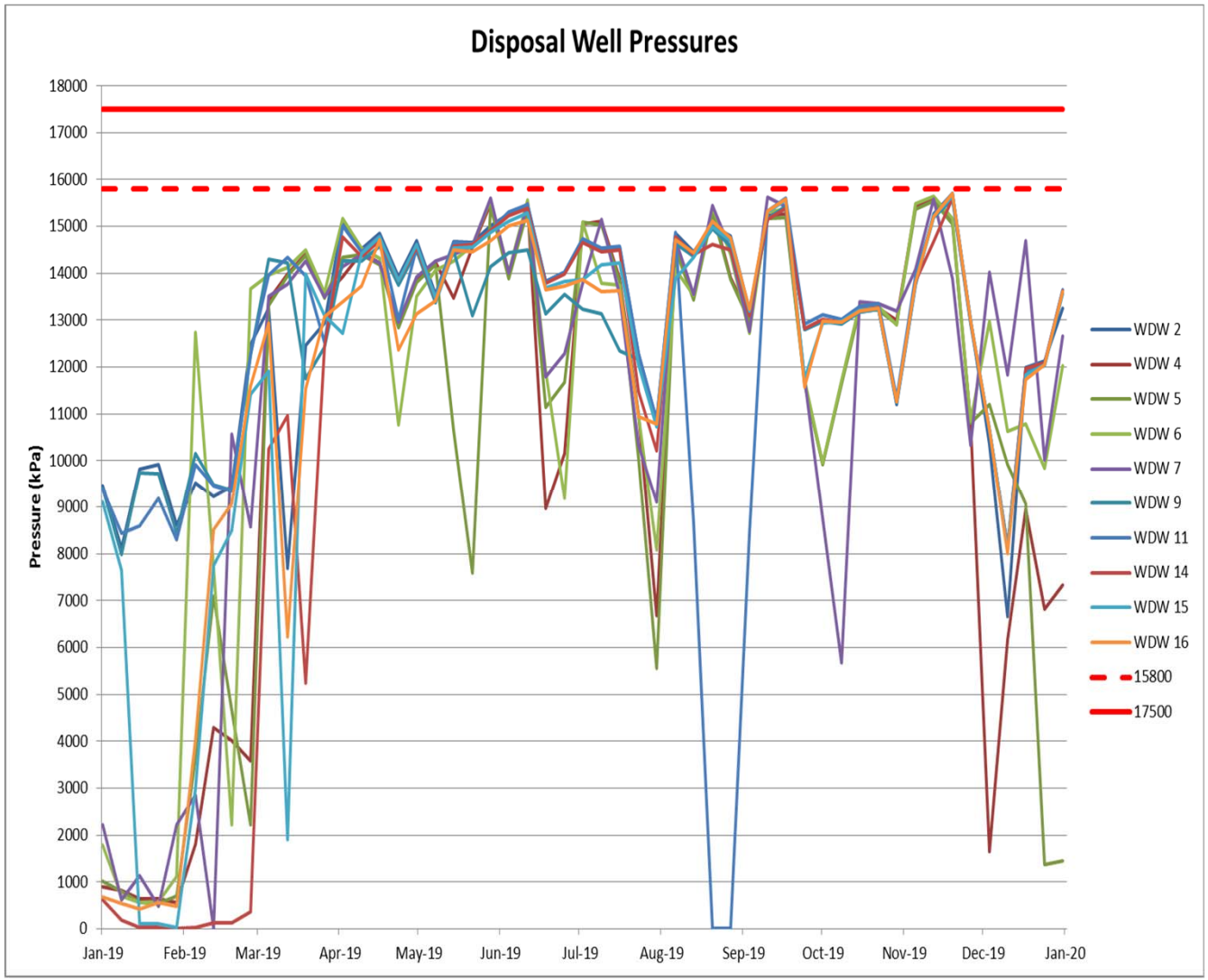
Water & Waste Disposal Wells, Landfill Waste Wolf Lake Disposal Volumes





Wolf Lake Disposal Well Pressures

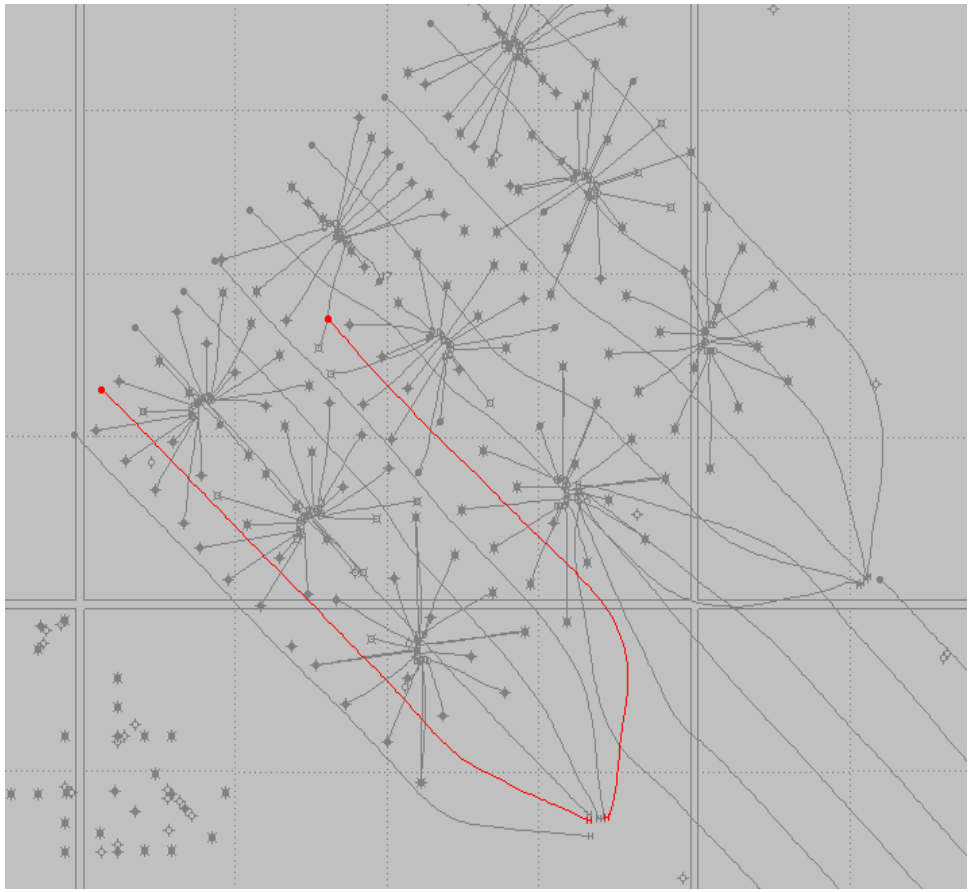
- Injection Pressures did not exceed 17,500 kPa in 2019
  - Pressures can exceed 15,800 kPa, up to 17,500 kPa for a maximum 24 hr. period for up to 2% of the operating time per calendar year (Approval 8672E) Injection Pressures did not exceed 17,500 kPa in 2019



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

- M2 Storage Approval No. 9108A
  - No activity in 2019
  - Storage has not been used since 2017
  - There are no immediate plans to reactive it

- Historical activities
  - M2-S well zonally suspended in Oct 2017
  - M2 Storage line abandoned



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

- Waste to Tervita Lindbergh Cavern
  - 23 m^3 – Lime Sludge
  - 1,950 m^3 – Hydrocarbon Sludge and Sand
  - 145 m^3 – Hydrovac Material
  - 22 m^3 – Contaminated Soil
  - 1,489 m^3 – Well Workover Fluids
  - 1,538 m^3 – Crude Oil/Condensate Emulsions
  - 548 m^3 – Filter Media
  - 334 m^3 – Waste Water
  - 544 m^3 – Acid
  - 22 m^3 – Boiler Blowdown Water
  - 22 m^3 – Glycol Solutions
  - 3 m^3 – Waste Corrosive Liquids
  - 262 m^3 – Waste Flammable Liquids
  - 26 m^3 – Non-Oilfield Waste

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

- Waste to Tervita TRD Facilities (Elk Point, South Wapiti)
  - 2,359 m^3 – Crude Oil/Condensate Emulsions
  - 13 m^3 – Contaminated Water
  - 22 m^3 – Sand/Sludge

- Waste to Secure Tulliby Lake TRD Facility
  - 241 m^3 – Hydrocarbon Sludges and Sand
  - 72 m^3 – Crude Oil/Condensate Emulsions
  - 16 m^3 – Well Workover Fluids
  - 38 m^3 – Waste Water
  - 103 m^3 – Filter Backwash Liquid

- Waste to CNRL Manatokan Landfill
  - 1,950 m^3 – Contaminated Soil

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

- Waste to Tervita Bonnyville Landfill
  - 3,184T – contaminated soil
  - 2,939T – Sludge/Sand (process, hydrocarbon)

- Waste to RBW (bins)
  - 89 m^3 – rags, absorbents, domestic waste, scrap metal, paint, hoses, asbestos, filters, used electronics and empty containers

- Waste to Tervita (bins)
  - 78T – contaminated soils, empty containers, filters, rags, absorbents, domestic waste & debris, non-PCB capacitors

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
    - The volume of domestic wastewater at the Wolf Lake Administration Building directed to the septic field is approximately 180 m^3. There have been no issues or concerns with regards to the treatment performance of the septic field.

- Surface Runoff Handling
  - The Primrose and Wolf Lake facilities have a total of 7 surface water runoff 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 (next submission due March 31, 2020)

Runoff Monitoring Results

- 2019 PAW Field & Plant/Facilities surface water releases
  - all field screening and lab analysis were with applicable limits.

2019 PAW Surface Water Release Summary

Location	Visible Oil & Grease (Y/N)	Field Cl (mg/L)	Field pH	Discharge Volume (m^3)
Primrose East Field	N	<500	6.0 - 9.5	117,606
Primrose North Field	N	<500	6.0 - 9.5	207,415
Primrose South Field	N	<500	6.0 - 9.5	652,616
Wolf Lake Field	N	<500	6.0 - 9.5	77,849
Primrose East Plant	N	<500	6.0 - 9.5	3,685
Primrose North Plant	N	<500	6.0 - 9.5	6,210
Primrose South Plant	N	<500	6.0 - 9.5	11,671
Wolf Lake Plant	N	<500	6.0 - 9.5	0
TOTAL				**1,077,052**

Sulphur Production

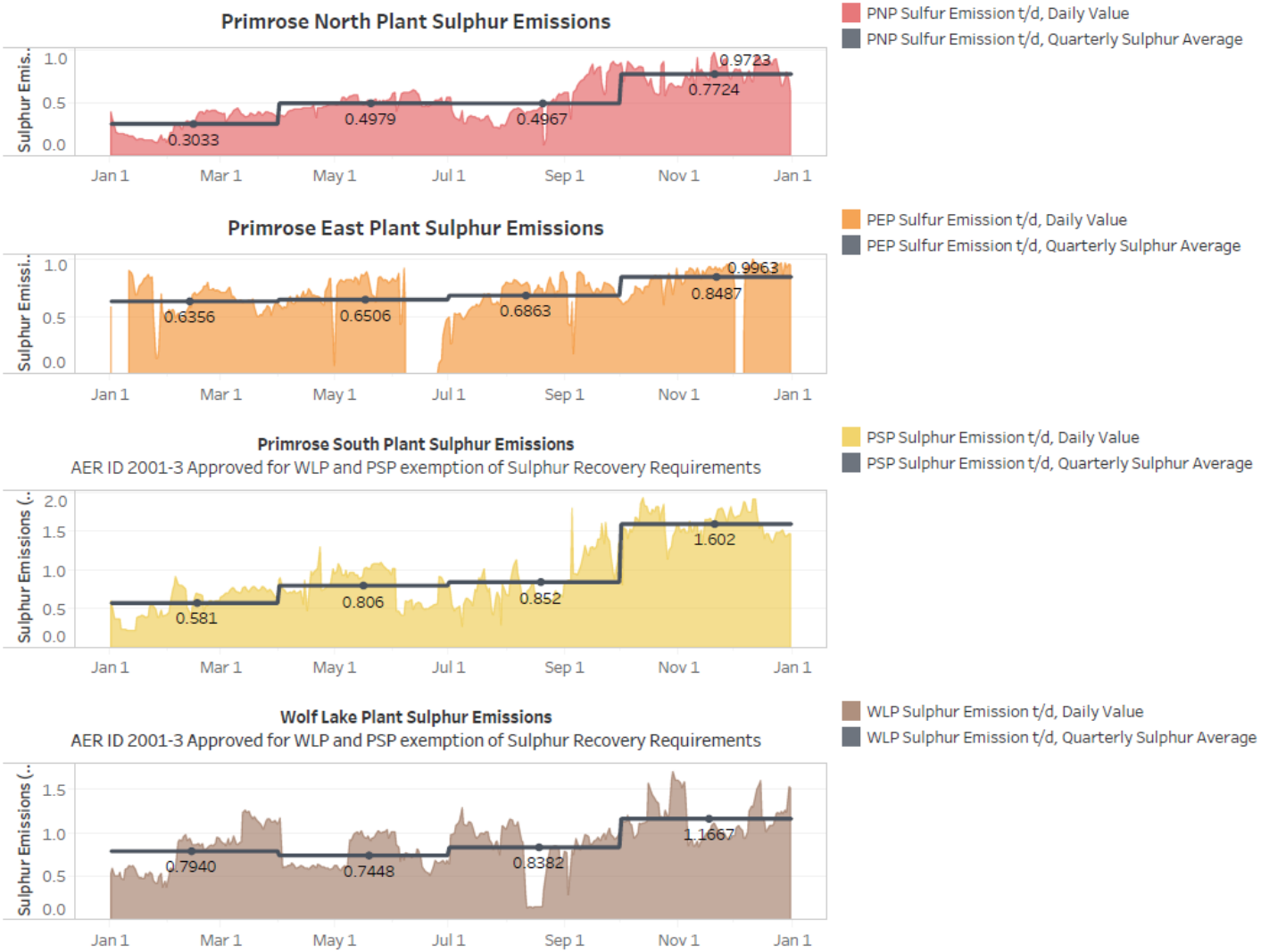
- EPEA approval limits for SO_2:
  - PSP + WLP = 6.7 t/d
  - PNP = 2.0 t/d
  - PEP = 2.0 t/d

- Quarterly averages inlet Sulphur for PEP and PNP < 1.0 t/d Sulphur
  - Contingency for compliance with ID 2001-3 for PEP and PNP is currently to restrict/delay production to maintain Sulphur level below 1 t/d quarterly average

- Approval received for the exemption of Sulphur recovery requirements as set out in AER *ID 2001-3* for the Wolf Lake and Primrose South Plants between Q4 2019 and Q4 2020
  - Canadian Natural is currently scoping Sulphur removal options for the PAW Project

Sulphur Production

- 2019 Primrose and Wolf Lake Sulphur Emissions



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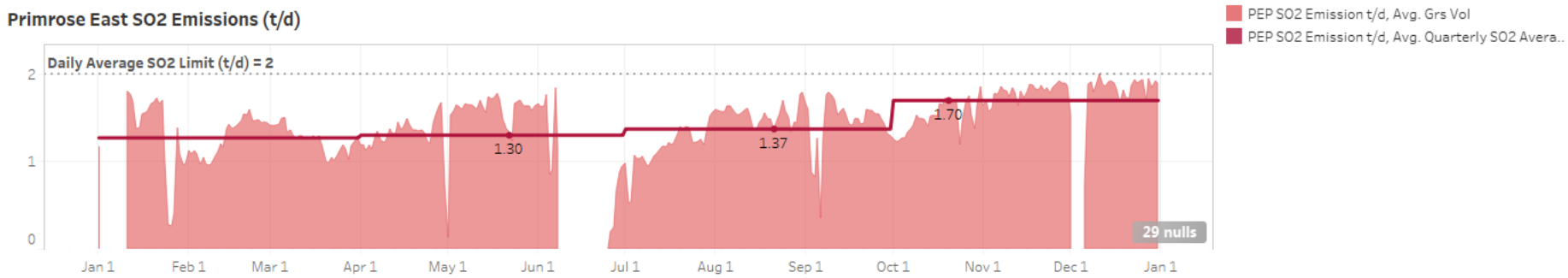
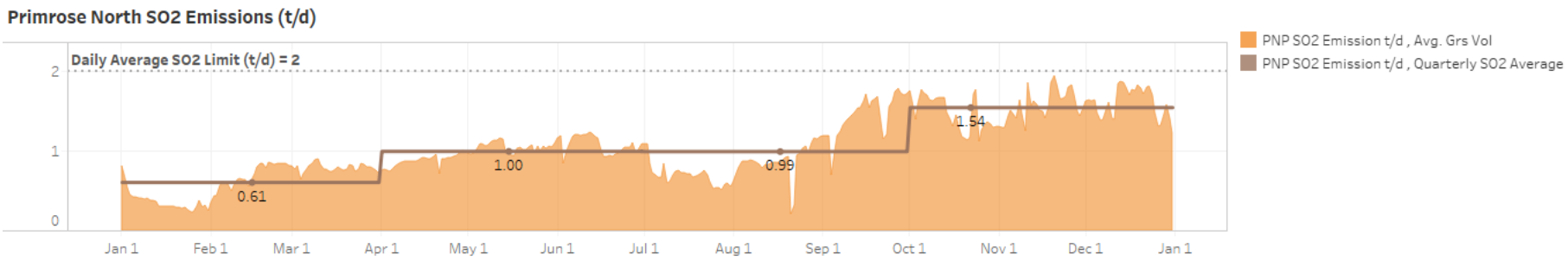
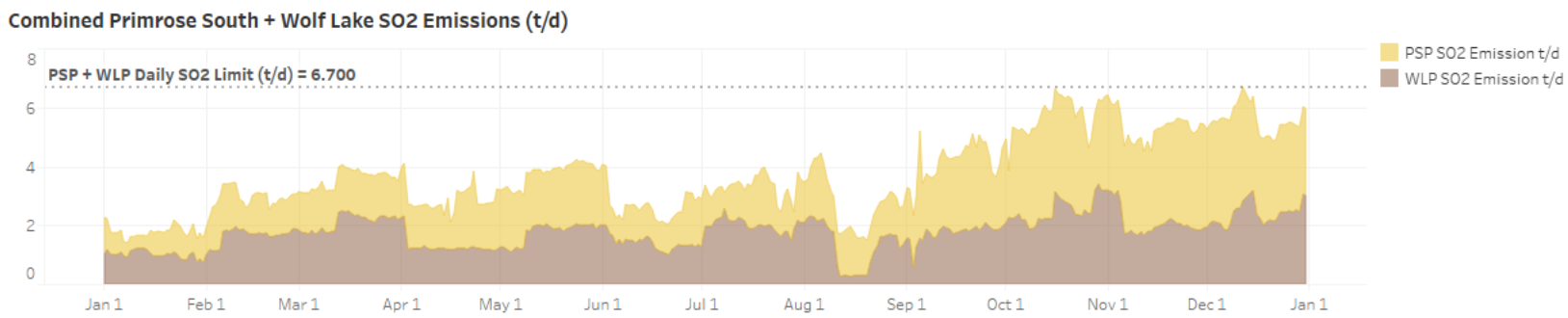
SO_2 Emissions

- 2019 Primrose and Wolf Lake SO_2







Environmental Summary
EPEA Approval and Amendments

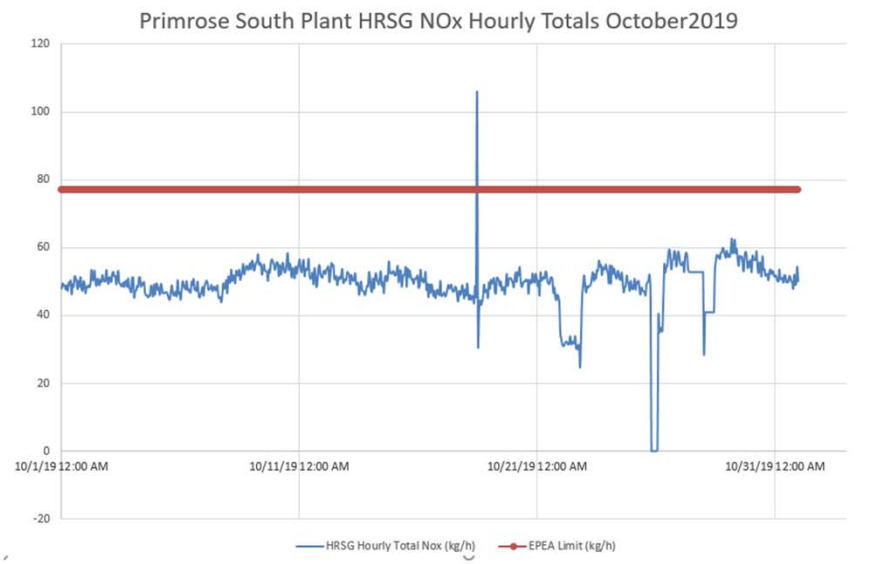
- The Primrose and Wolf Lake Project currently operates under EPEA Approval 11115-04-00, as amended
  - EPEA Approval amendment 11115-04-02 was approved November 26, 2019
    - Approval of Primrose North Pad Add Extension Project
  - Approval 11115-04-00 expires September 30, 2025

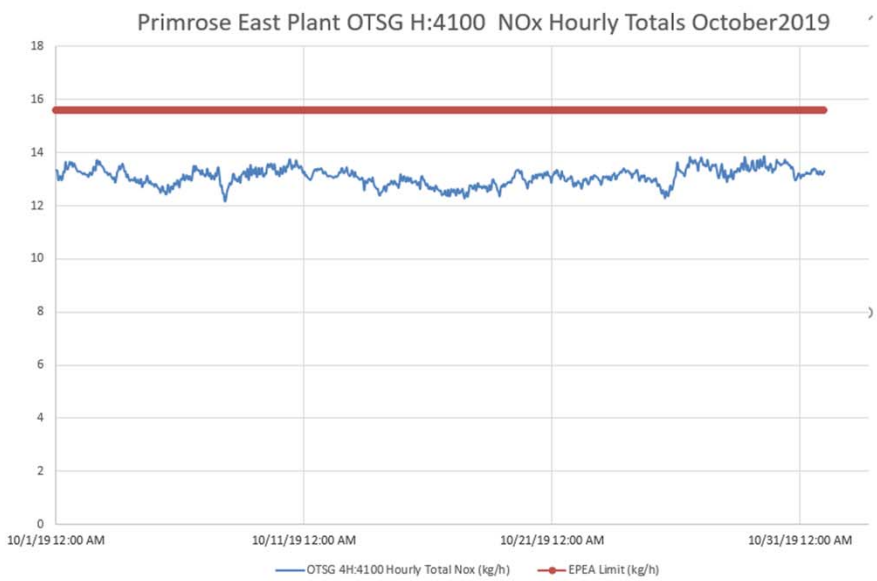
Environmental Summary Compliance

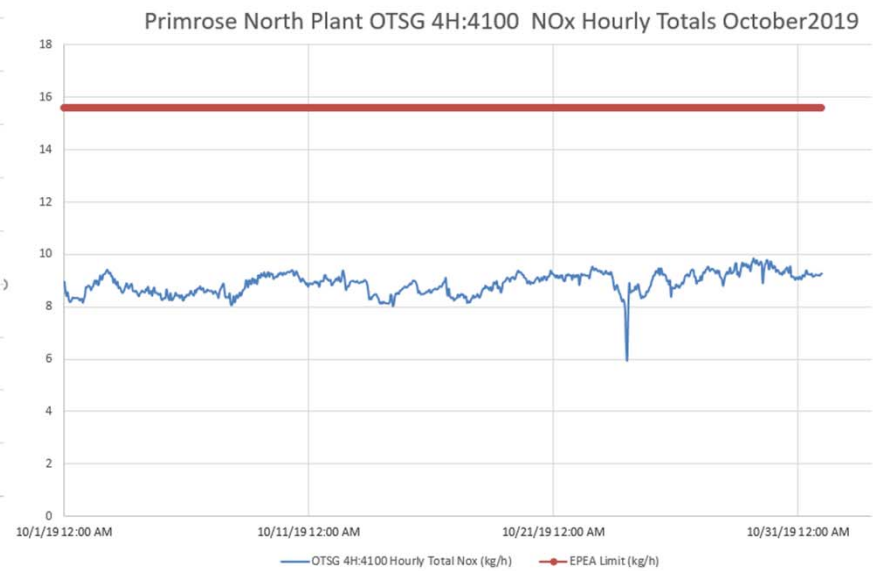
- Compliance Issues
  - EPEA Approval: Air Related
    A third party audit was completed on the CEMS QAP January 14, 2019
  - No SO_2 exceedances in 2019
  - There were two NO_x exceedances in 2019 on the HRSG when the gas turbine switched out of its normal firing mode (February 1, 2019 and October 18, 2019)
  - There was less than 90% availability in the month of May on the HRSG CEMS.
    - The calibration was unable to be performed May 7, 2019 due to a cuvette failure. The part required replacement exceeding 10% of the available hours that month

Environmental Summary Compliance

- Comparison of NOx emission rates vs. EPEA Approval limits
  - Example of CEMS data vs. NOx EPEA Approval at Primrose South, East and North Plants for October 2019 is provided







Environmental Summary Compliance

- Compliance Issues – Water Related
  - AER Reference # 357784, Diversion License 238513-02-00
    - Location: Wolf Lake Source Well WSW 03 (06-10-066-05 W4M)
    - The water level dropped below the depth of the pressure transducer for 4 weeks during July 10 to August 12. The water level dropped below the depth of the pressure transducer, which is installed at the top of the pump, a few metres above the pump intake. Pumping was stopped to allow water levels to recover above the transducer
    - Contravention Date: July 14, 2019

Environmental Summary Monitoring Programs

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

Environmental Summary Monitoring Programs

- Amphibian Monitoring
  - Amphibian Monitoring surveys completed in May and July of 2019 using autonomous recording units (ARUs)
  - The ARU surveys targeted amphibians and incidental wildlife species in the PAW study area. Western Toad was the primary species targeted
- Wildlife Response to Linear Features
  - A total of 15 treatment and 16 reference remote cameras were deployed in the study area as part of the habitat enhancement program monitoring
    - Continuation of the Remote camera program for cameras deployed along treated (e.g., mounding, tree felling, and seedling planting) and reference seismic lines documented predator and human use of the linear features in portions of the PAW study area
  - Camera maintenance was performed three times in 2019 (January/May/September) to check/replace batteries and download photos
- Wildlife Response to Linear Features
  - A preconstruction survey was conducted along the proposed aboveground pipeline corridor for Pads 160 and 161.
    - The purpose of the survey was to document wildlife use of the area and to identify areas along the proposed corridor where wildlife crossing opportunities would be most effectively placed to facilitate wildlife movement

Environmental Summary Monitoring Programs

- Remote Camera Surveys
  - 26 remote cameras are deployed throughout the PAW study area as part of the general remote camera monitoring program
    - documents the presence, spatial distribution and relative abundance of mammals in relation to anthropogenic disturbance on the landscape
    - Remote cameras visited three times in 2019 to replace batteries and download photos
- Maintenance of Nest boxes and Bat Boxes
  - Boxes provide supplemental habitat for wildlife
  - 11 bird nest boxes and 2 bat roosting boxes maintained across the Project area
    - Boxes visited twice during 2019 in May and September
    - Evidence of bird use was noted at nine of the boxes in 2019 (up from 4 in 2018) while northern flying squirrel use was noted at one additional box
- Wildlife Sighting Cards
  - Canadian Natural staff and contractors are required to record wildlife sightings while working on site.

Environmental Summary Monitoring Programs

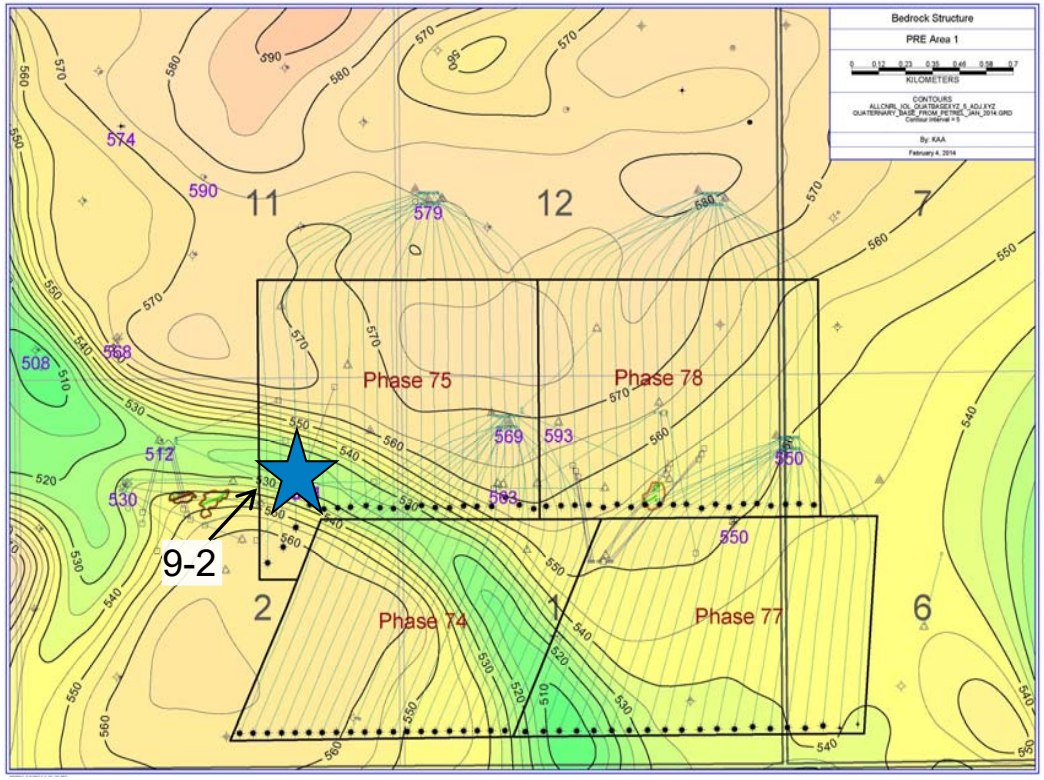
- Hydrology, Wetlands and Water Quality Monitoring Program
  - Wetland Monitoring Component
    - Plant species percent cover and vigour recorded in 2019 were consistent with data from 2007 to 2018
  - Hydrology Monitoring Component
    - During the 2019 monitoring program all lakes appeared to exhibit hydrological regimes similar to those of past years.
  - Water Quality Component
    - Surface water quality samples from Burnt Lake and Sinclair Lake in 2019 indicate there were no large deviations observed in the analytical results when compared with those from previous years

Environmental Summary
Arsenic Mobility Investigation

- Arsenic Mobility Research Program Description
  - Long-term research program at Z8 Pad ongoing since 2001
  - Evaluating the liberation of naturally occurring 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 2019
  - Empress aquifer results consistent with historical findings
    - Thermal and arsenic plumes associated with historical CSS are migrating downgradient of the pad
    - Temperature and arsenic concentrations continue to increase at on-pad monitoring wells associated with steamflood operations
  - On-going groundwater data collection to understand flow system and geochemistry of the Sand River aquifer
  - Groundwater data collected during current steamflood will be compared to findings from previous CSS operations
- The liberation of arsenic at PAW is managed under the AER *Assessment of Thermally-Mobilized Constituents in Groundwater for Thermal In Situ Operations* Directive

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 observed
  - In situ temperature reflects 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
  - On-going shallow groundwater monitoring and annual reporting
- 2013 FTS:
  - On-going deep groundwater monitoring program including quarterly monitoring and sampling, and annual reporting
  - On-going shallow groundwater monitoring and annual reporting
- Groundwater monitoring results indicate very limited subsurface impacts associated with FTS events

FTS Update

- 2019 FTS Monitoring Activities Summary:
  - 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)

- 2019 FTS Milestone Summary:
  - Submission of Interim Reclamation Plan for all FTS sites which includes the removal of perimeter berms to facilitate surface water drainage

- 2020 FTS Proposed Plan:
  - Proposed submission request to close both the Environmental Protection Order and Environmental Enforcement Order

Environmental Summary Monitoring Programs

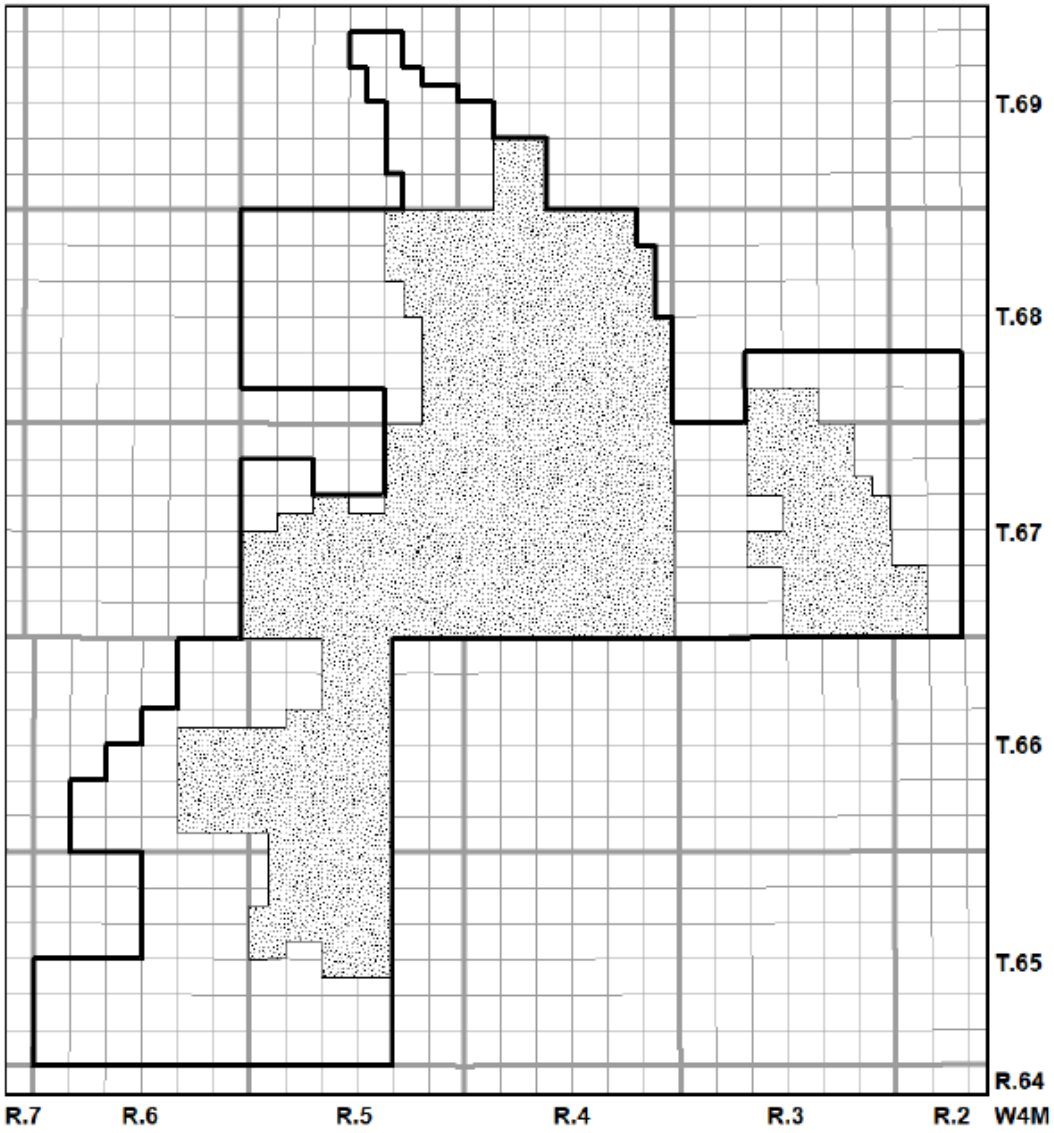
- Reclamation activities in 2019:
  - No borrows were reforested in 2019. Work was completed on recontouring of various borrow pits associated with the construction of Pads 44 and 46 and 72A and 72B
  - The PAW Reclamation Monitoring Program and Wetlands Reclamation Trial was kicked off in 2019. All reclaimed areas from 2018 are on positive trajectory towards reclamation certification

- Proposed activities in 2020:
  - Continuation of Reclamation and reforestation of borrow pits in Primrose North

Environmental Summary Regional Initiatives

- 2019 LICA Highlights:
  - 103 school programs from K – 12 were delivered including:
    - X-Stream Science which is a water quality testing program developed for high school students
    - Little Green Thumbs where students care for an indoor garden and learn about the environment and their community
    - Stream of Dreams is an eco-education program that creates a lasting community, while helping students discover their local watershed, learn about human impacts to water bodies, and become stewards for all aquatic creatures
    - Clean Air Responsible School where students receive an interactive presentation about air quality and then given the chance to collect air quality data around their school
    - 10 different workshops and events covered topics such as vermicomposting, invasive species, and beavers in our landscape. Other events included the Gauge and Save and 2 Jessie Lake Shoreline Clean-ups with Notre Dame High School as part of the Great Canadian Shoreline Clean-up
    - LICA also provided a significant number of programs to summer camps and presented at numerous community events (i.e. fishing derbies and Canada Day celebrations) throughout the summer
  - LICA continued to partner in it's 12th year with Alberta Lake Management Society (ALMS) to conduct water quality sampling programs, with help from community volunteers, at 10 lakes throughout the region
    - LICA hosted a shoreline clean-up and weed pull event, which removed litter, invasive plant species and shore-washed algae and vegetation from the shore of Jessie Lake. In addition, 5,200 seedlings were planted along the riparian area on the north side of Jessie Lake. The end goal for the restoration project is to improve the water and air quality for the Town of Bonnyville
  - LICA has monitored regional air quality for over 15 years with a network of continuous and passive monitoring stations
    - During 2019, to help educate the public on air quality, LICA installed air quality displays in the Cold Lake Energy Centre and the Bonnyville and District Centennial Centre. The displays include wooden lanterns and posters with information to promote clean air for the Lakeland region. LICA partnered with the City of Edmonton to develop these lanterns, which illustrates the Air Quality Health Index (AQHI) scale designed to help residents understand what the outdoor air quality means to their health

Approval 9140UU – Oil Sands Primrose Wolf Lake



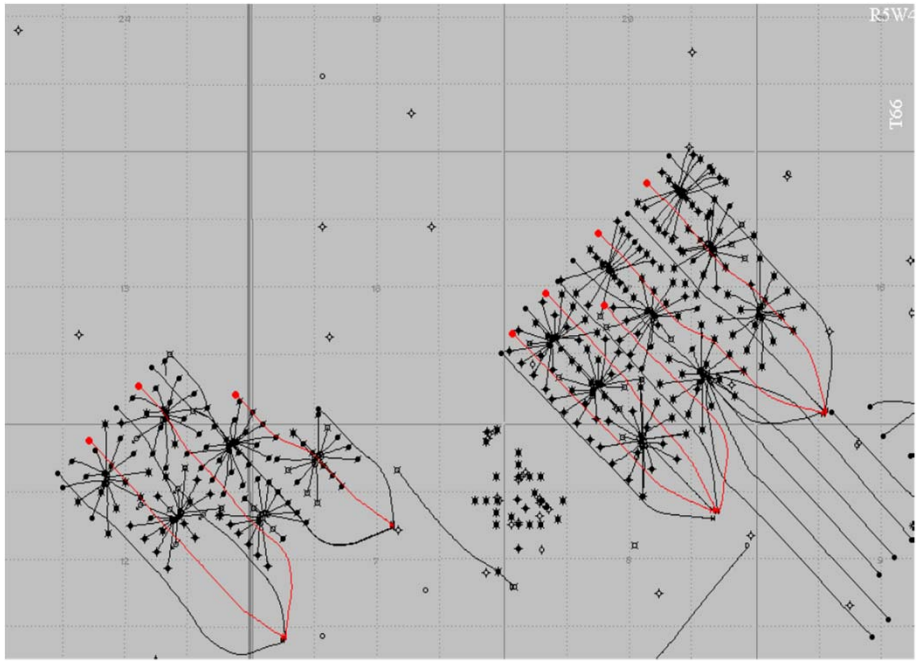
Approval 9140 – 2019 Amendments

- Amendment RR
  - Primrose East Area 1 Steaming Application
- Amendment SS
  - Primrose East Area 2, Phases 90-95 Modified Steaming, Risk Assessment and Mitigation
- Amendment TT
  - Primrose North Pad Add Extension Project
- Amendment UU
  - Wolf Lake and Primrose South Plants ID 2001-3 waiver

Approval 9108A – Wolf Lake Water Storage Amended October 2015

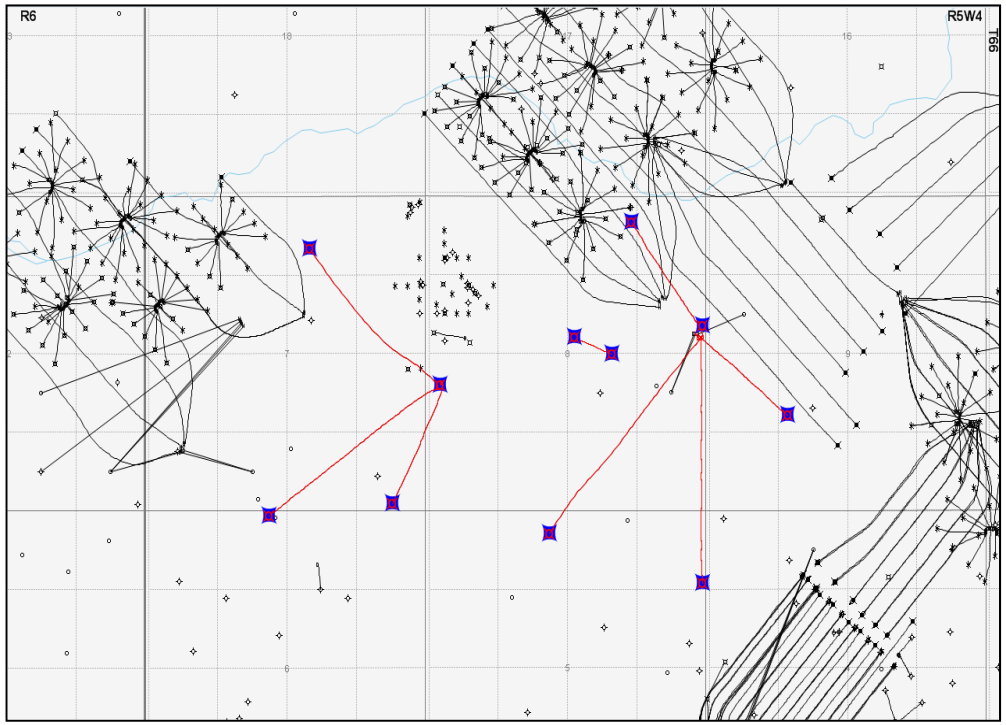
- Approval 9108A was amended in October 2015 at the request of the AER
  - The Operator must install daily pressure monitoring in the Lower Grand Rapids Formation at the 07/02-17-066-05W4M/2 well by December 31, 2015
  - In the event that fluid migration is detected at this well, the Operator must immediately 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 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)
- 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
  - 8672F – Addition of WDW#6, WDW #7, WDW#15 and WDW#16



- Disposal wells under Approval 8672F:
  - OBS 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#6 - 100/14-06-066-05W4/0
  - WDW#7 - 100/01-07-066-05W4/0
  - WDW#9 - 100/14-05-066-05W4/0
  - WDW#11 - 100/07-08-066-05W4/0
  - WDW#14 - 102/06-09-066-05W4/0
  - WDW#15 - 112/15-08-066-05W4/0
  - WDW#16 - 100/16-05-066-05W4/0

Approval 8673A – Cavern Disposal
Approved October 2000

- Approval Compliance Requirements
  - Monitoring Maximum Injection Pressures
    - Did not exceed maximum allowable injection pressure

- Salt Cavern 1 – 118/12-8-66-5W4
  - Cavern volume (as of November 2019 sounding) 136,804 m^3
  - Wash water 1,348 m^3
    - Cavern wash water is sent to disposal wells
  - Oily waste (bitumen) 100 m^3
  - Solid waste 203 m^3
  - Next Cavern sounding expected in June 2020

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

- Salt Cavern 2 - 119/12-8-66-5W4
  - Cavern volume (as of December 2019 sounding) 106,024 m^3
  - Wash water 175,929 m^3
    - Cavern wash water is sent to disposal wells
  - Oily waste (bitumen) 152 m^3
  - Solid waste 32,215 m^3
  - Next Cavern sounding expected in June 2020

Environmental Summary Compliance

- Compliance Issues – Water Related
  - AER Reference # 357784, Diversion License 238513-02-00
    - Location: Wolf Lake Source Well WSW 03 (06-10-066-05 W4M)
    - The water level in the source well dropped below the depth of the pressure transducer from July 10 to August 12, 2019
    - Contravention Date: July 2019

Compliance Disclosures

- Reportable spills
  - 3 reportable spills were reported during 2019 including;
    - 2 steam condensate
    - 1 water source well (hydrotesting pipeline)
- Digital Data Submissions (DDS)
  - Notifications/Submissions were entered into the DDS as per Directives in 2019
- Dam Safety Act
  - Dam Safety Inspection was conducted by Terracon on June 25 and September 19, 2019 and at the Lime Sludge Ponds (LSP license 00400948-00-00)

Future Plans

- Wolf Lake Slop Handling Improvements
  - Trialing new oil treatment chemistry
  - Improvements to skim oil handling
- Wolf Lake Expansion Scoping
- Wolf Lake Plant BFW Quality Improvements Project
- WLP OTSG Controls Upgrades (CSA Compliance)
- Primrose East Steam Expansion (Cogen) Scoping
- Burnt Lake Upgrades
- Integrity pipeline pigging
- Various small sustaining capital projects
  - To replace aging infrastructure and equipment
  - To reduce operating costs
  - To improve environmental performance

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