Husky Oil Operations Limited

Tucker Thermal Project

Commercial Scheme Approval No. 9835

Annual Performance Presentation

Alberta Energy Regulator

September 4, 2019

3.1.1. Subsurface

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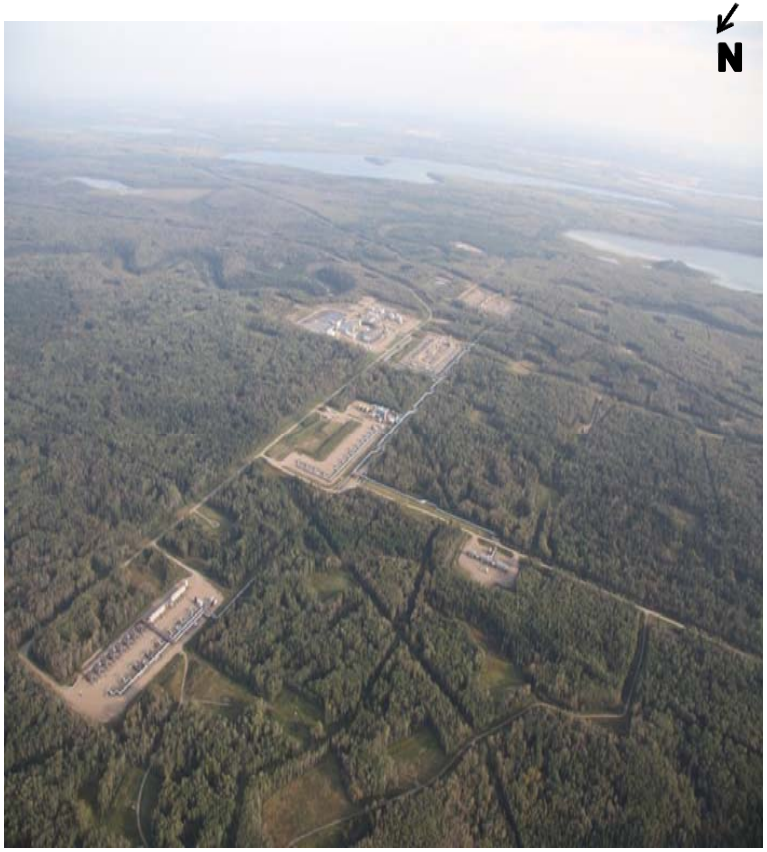
1. Brief Background

PROJECT OVERVIEW/SITE OVERVIEW

- AER Commercial Scheme Approval No. 9835
- 30,000 BOPD SAGD Project
- Clearwater, Grand Rapids and Colony Reservoirs
- 9-10º API Bitumen
- Integrated with Husky Pipeline & Upgrader
- First Steam August 20, 2006
- First Production November 29, 2006

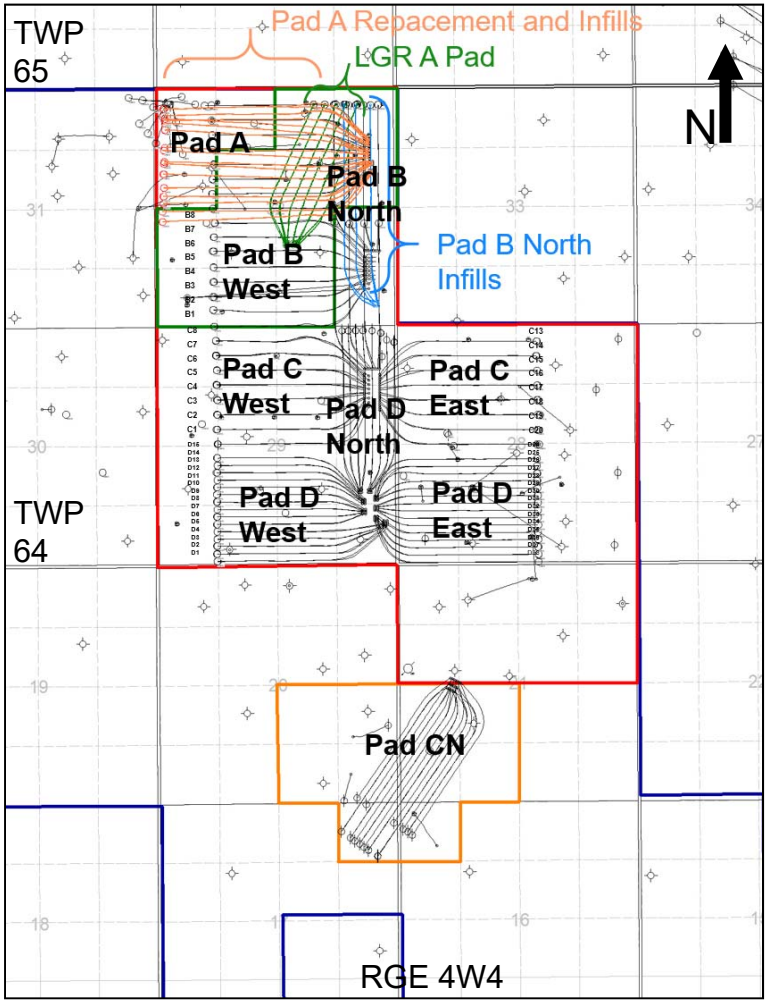


- Field Facilities:
  - Six well pads, infield pipelines and central pump station
- Central Plant:
  - Emulsion treating
  - Water Treatment – 120,000 bbl/day
  - Steam Generation – 99,000 bbl/day CWE
  - Utilities and Off -sites
- Water Source & Disposal Wells
- Metering and Export Pipelines to Cold Lake Terminal

1. Brief Background

PROJECT DEVELOPMENT AREA

- Approval Area:
  - Sections 28, 29, 32 & N/2 of 21 in 064-04 W4M
  - SE ¼ Section 23, SW ¼ Section 21, Section 17 LSD 16 & Section 16 LSD 13
- 35 Year Project Life
- 109 Horizontal Well Pairs & 7 Infill Producers
  - 32 original well pairs (Pads A, B, C)
  - Well pairs added:
    - Pad C East 2007 - 8 well pairs
    - Pad B Infill 2009-2010 - 3 well pairs
    - Pad A Infill & Replacements 2010/2011) - 16 well pairs
    - Pad Lower Grand Rapids (GA) 2011 - 1 well pair; 2012-2013 – 5 well pairs
    - Pad D East 2014 - 15 well pairs
    - Pad Colony (CN) 2015 - 6 well pairs & 7 infill producers
    - Pad D North 2016 - 8 well pairs
    - Pad C West Replacement 2016 – 8 injectors
    - Pad D West 2017 - 15 well pairs



2. Geology/Geosciences

AVERAGE RESERVOIR CHARACTERISTICS AND OBIP

CLEARWATER	OBIP ($X10^6$ m^3)	Thickness (m)	Φ	So	Viscosity (cP @ 20°C)	Original Pressure (kPa)	Original Temperature (°C)	Depth (m)	Vertical Permeability (mD)	Horizontal Permeability (mD)
Approval Area	72.0	45	0.31	0.57	50,000-1,000,000	3,200	16	440	1,800	3,000
Operating	40.9	46	0.32	0.57	50,000-1,000,000	3,200	16	440	1,800	3,000

LOWER GRAND RAPIDS	OBIP ($X10^6$ m^3)	Thickness (m)	Φ	So	Viscosity (cP @ 20°C)	Original Pressure (kPa)	Original Temperature (°C)	Depth (m)	Vertical Permeability (mD)	Horizontal Permeability (mD)
LGR Approval Area	5.7	26	0.28	0.54	100,000-300,000	2,600	14	370	1,300	1,800
Operating (Pad GA)	2.1	38	0.29	0.54	100,000-300,000	2,600	14	370	1,300	1,800

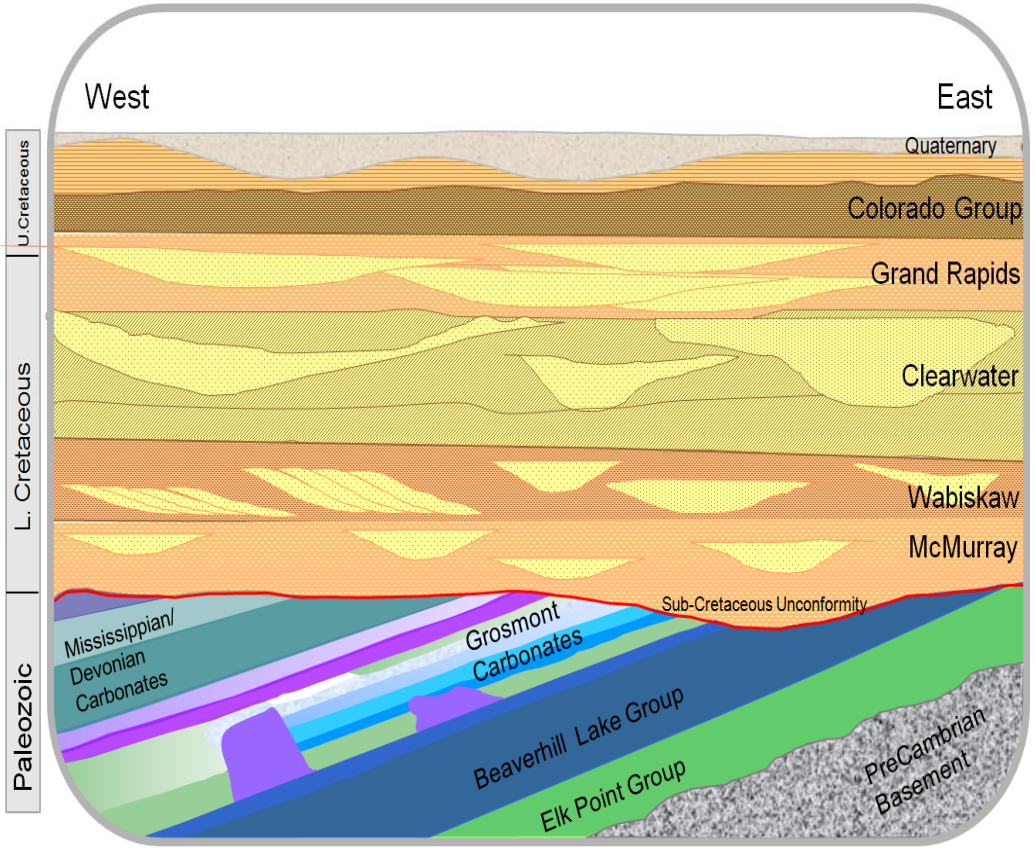
COLONY	OBIP ($X10^6$ m^3)	Thickness (m)	Φ	So	Viscosity (cP @ 20°C)	Original Pressure (kPa)	Original Temperature (°C)	Depth (m)	Vertical Permeability (mD)	Horizontal Permeability (mD)
CN Approval Area	2.8	10	0.30	0.79	25000	2,500	12	305	2,400	4,000

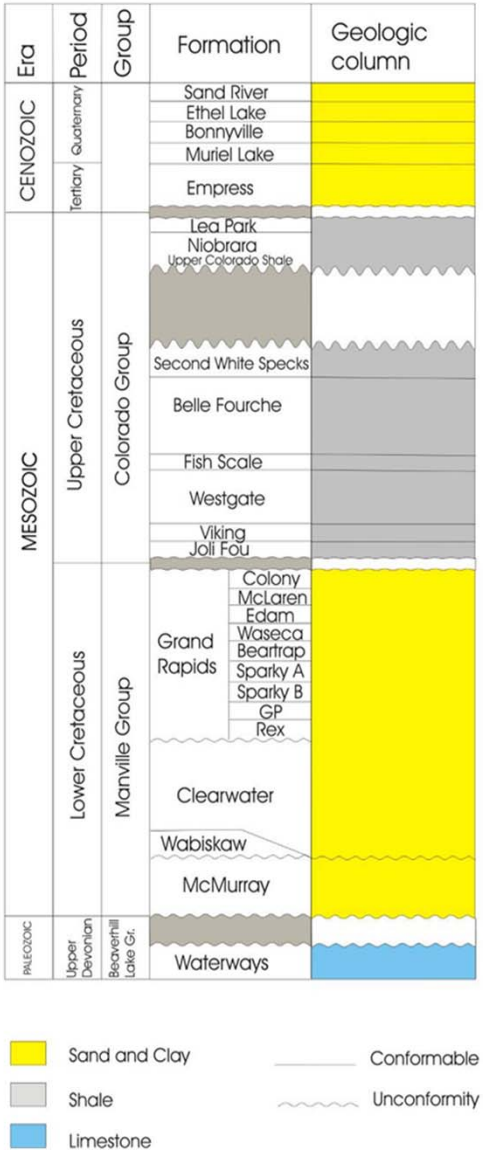
Notes:
OBIP – Original Bitumen in Place
Calculation: OBIP interval: Top of Formation → oil water contact
OBIP = Area x Thickness x Φ x S_o

2. Geology/Geosciences

REGIONAL STRATIGRAPHY

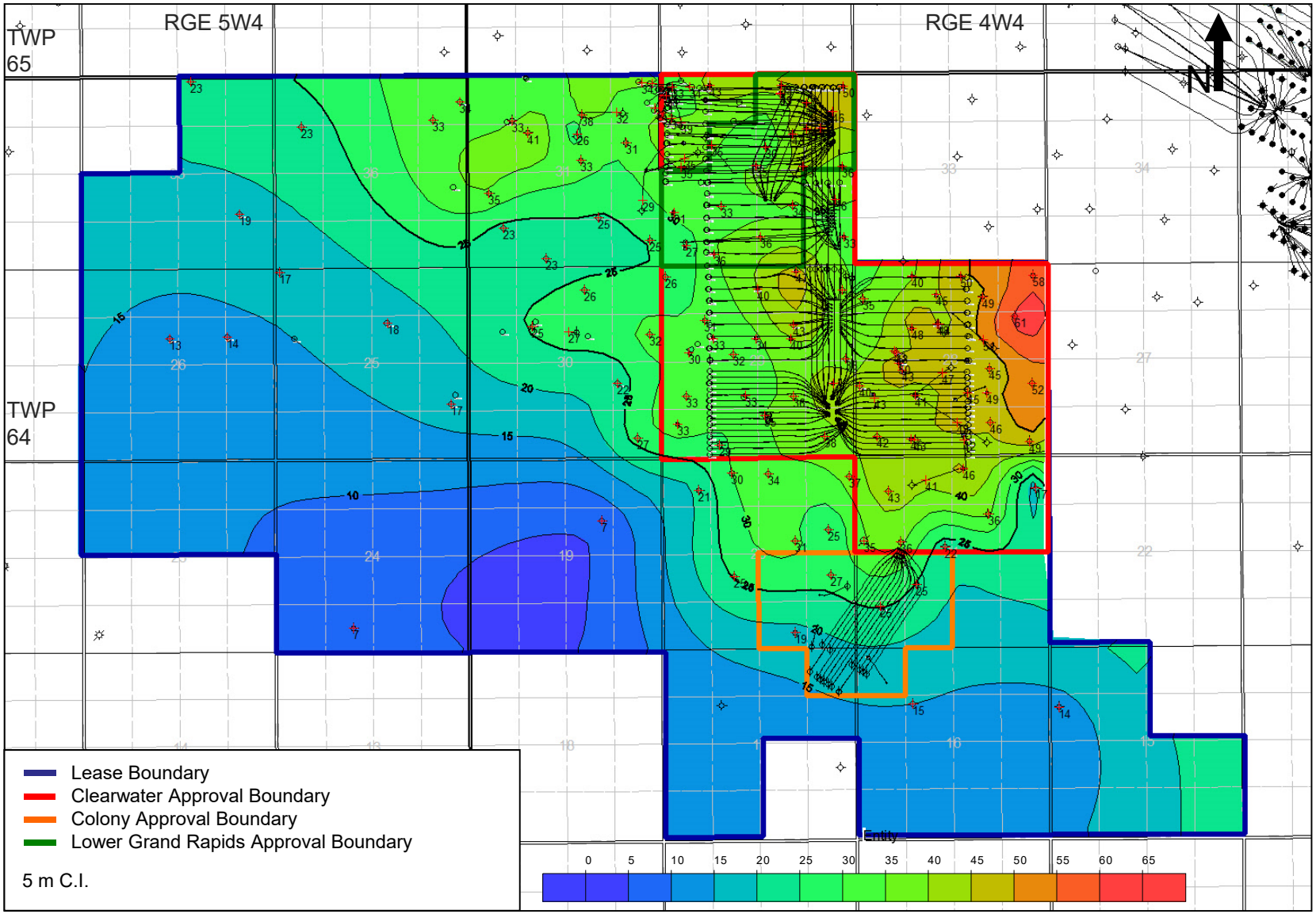
- Marginal marine deposits consisting of stacked incised valleys and shoreface deposits





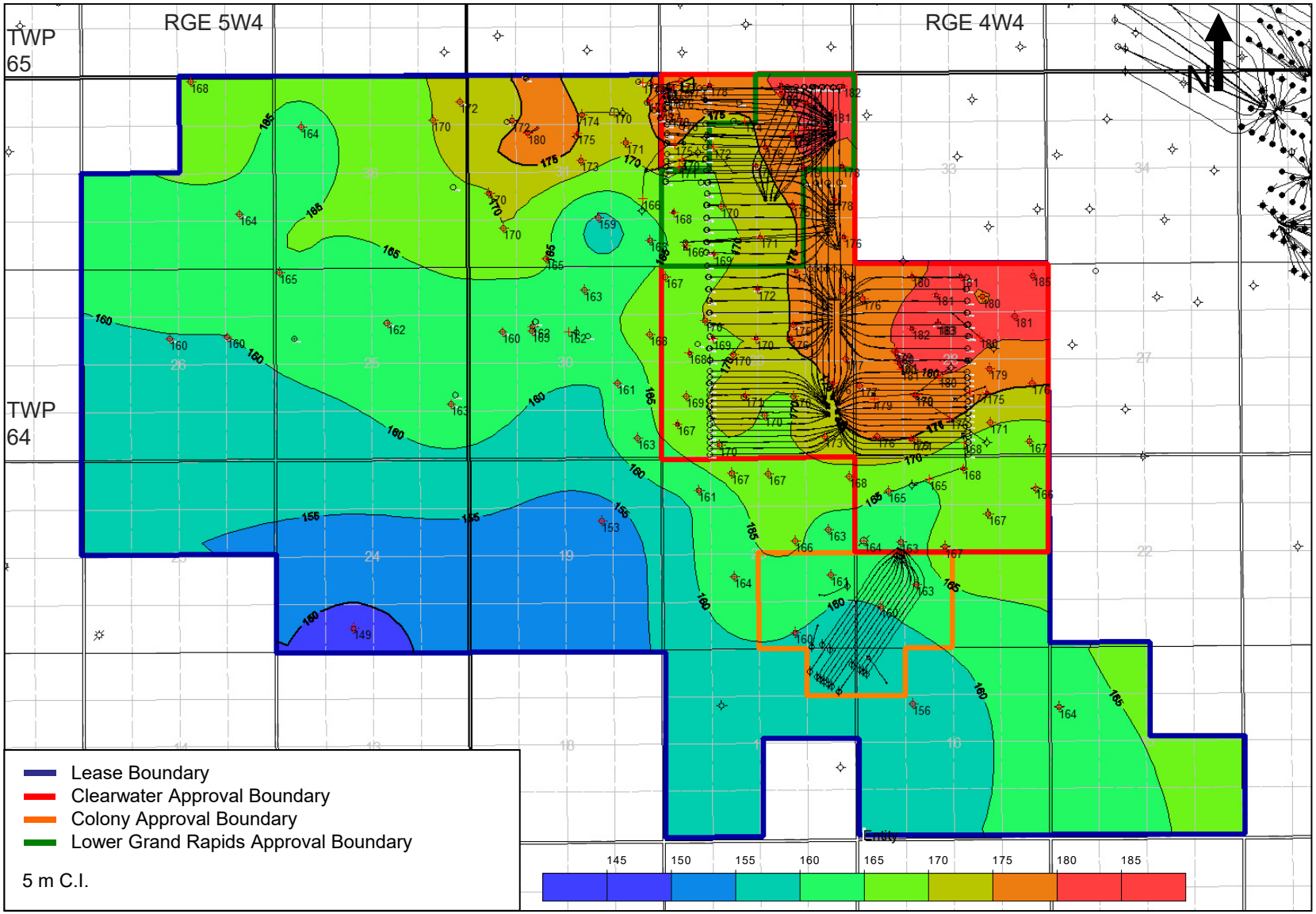
2. Geology/Geosciences

ISOPACH MAP OF CLEARWATER SAGD NET PAY



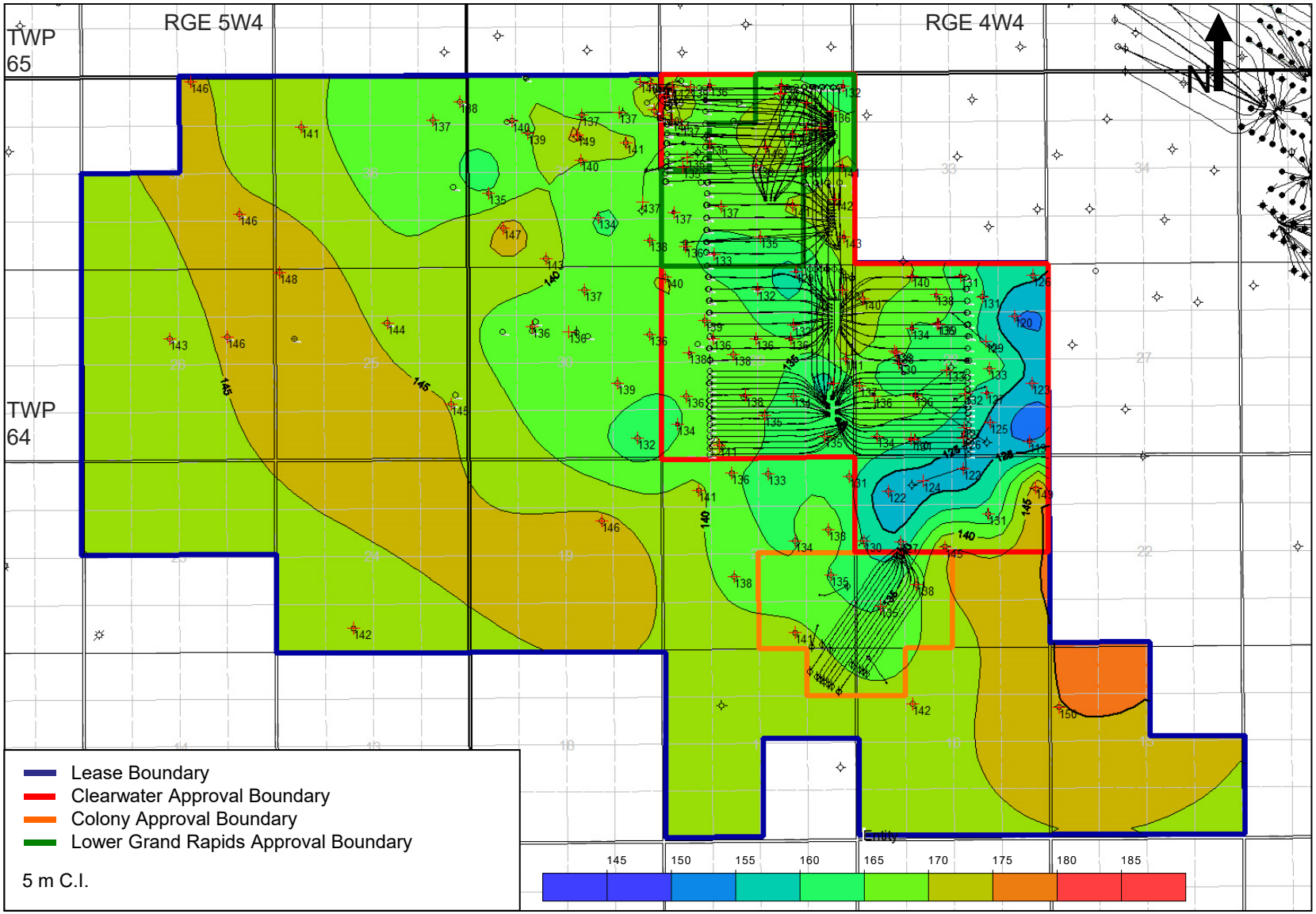
2. Geology/Geosciences

STRUCTURE MAP OF THE CLEARWATER TOP OF NET PAY



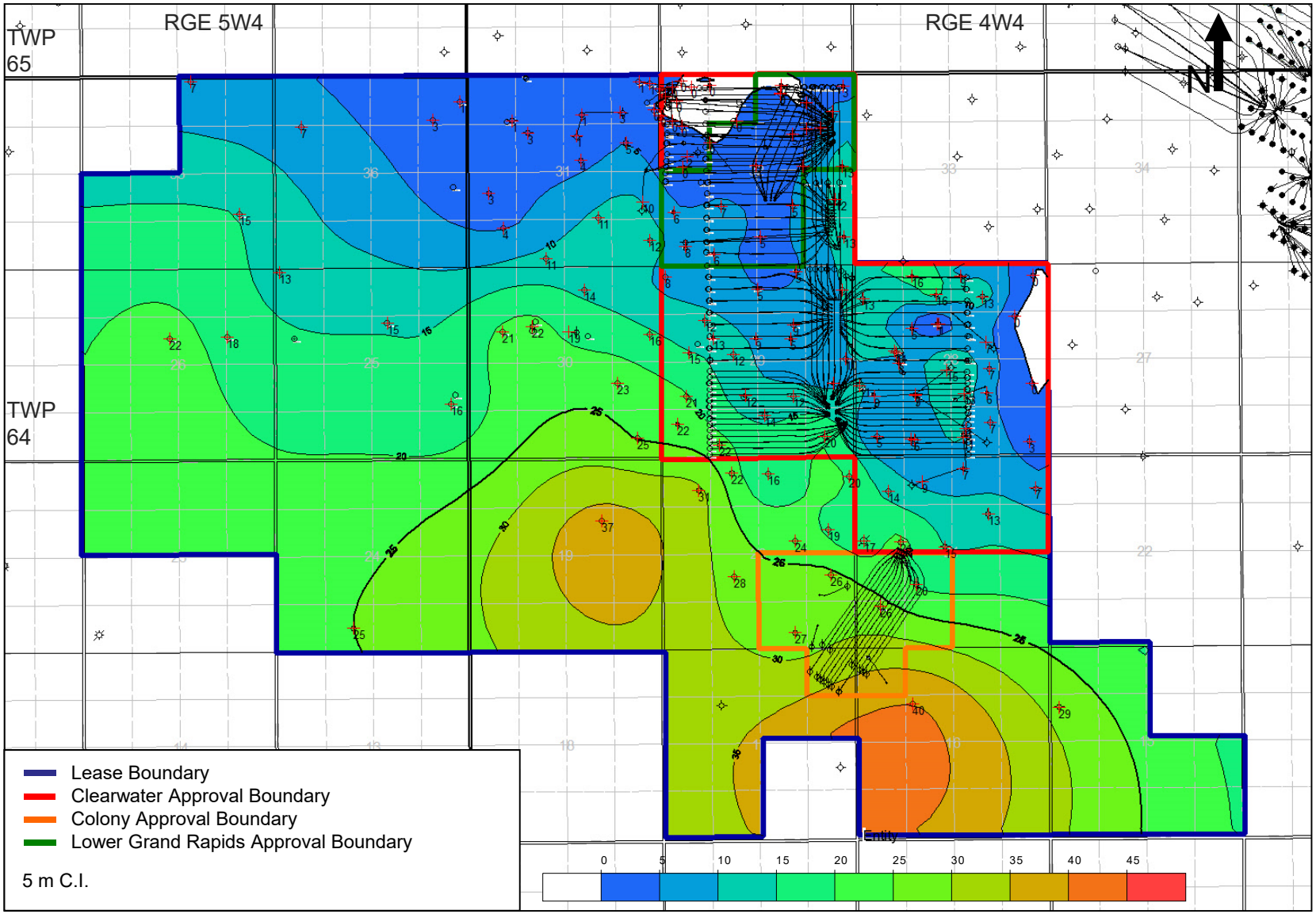
2. Geology/Geosciences

STRUCTURE MAP OF THE CLEARWATER BASE OF NET PAY



2. Geology/Geosciences

ISOPACH OF CLEARWATER BOTTOM WATER



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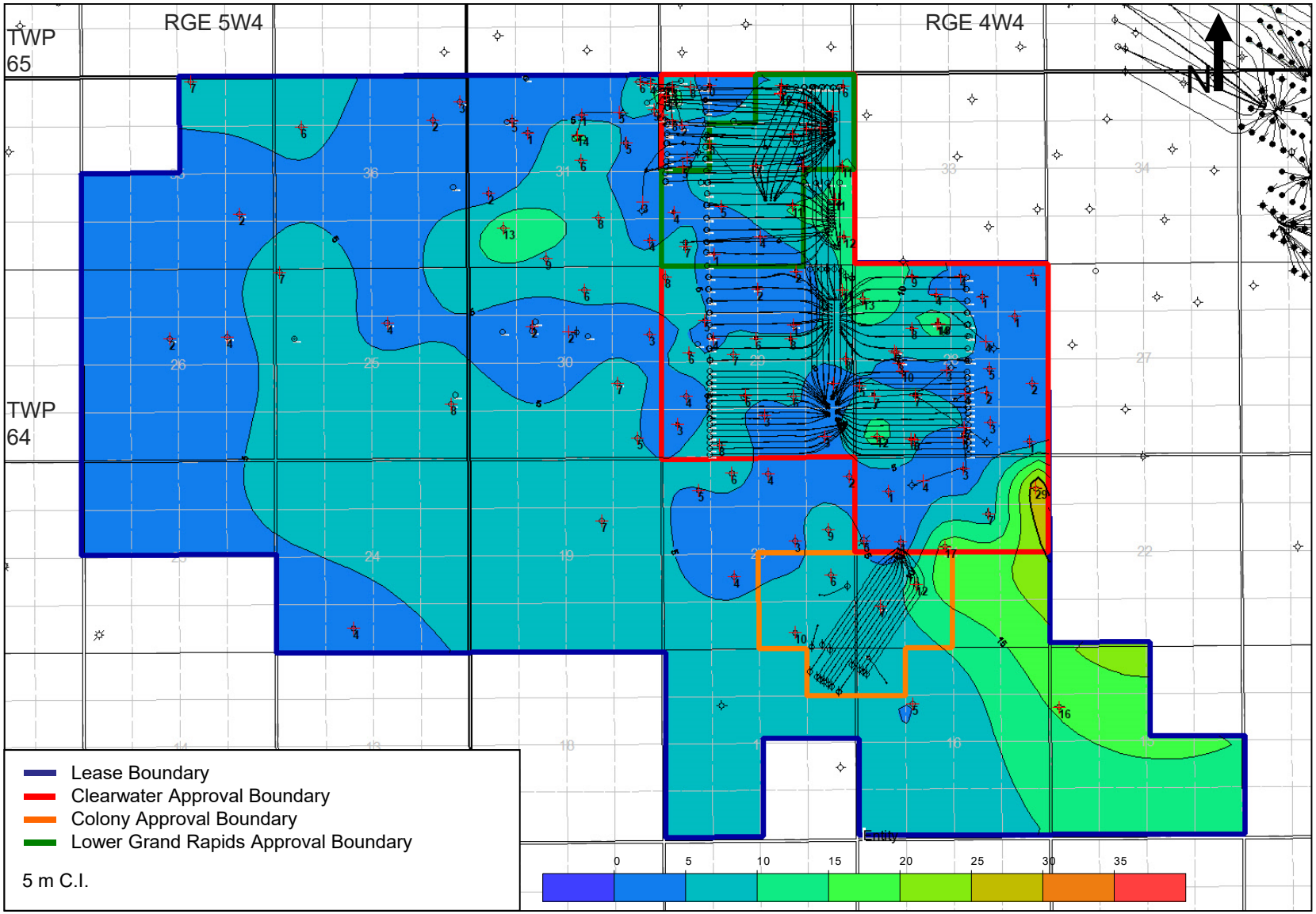
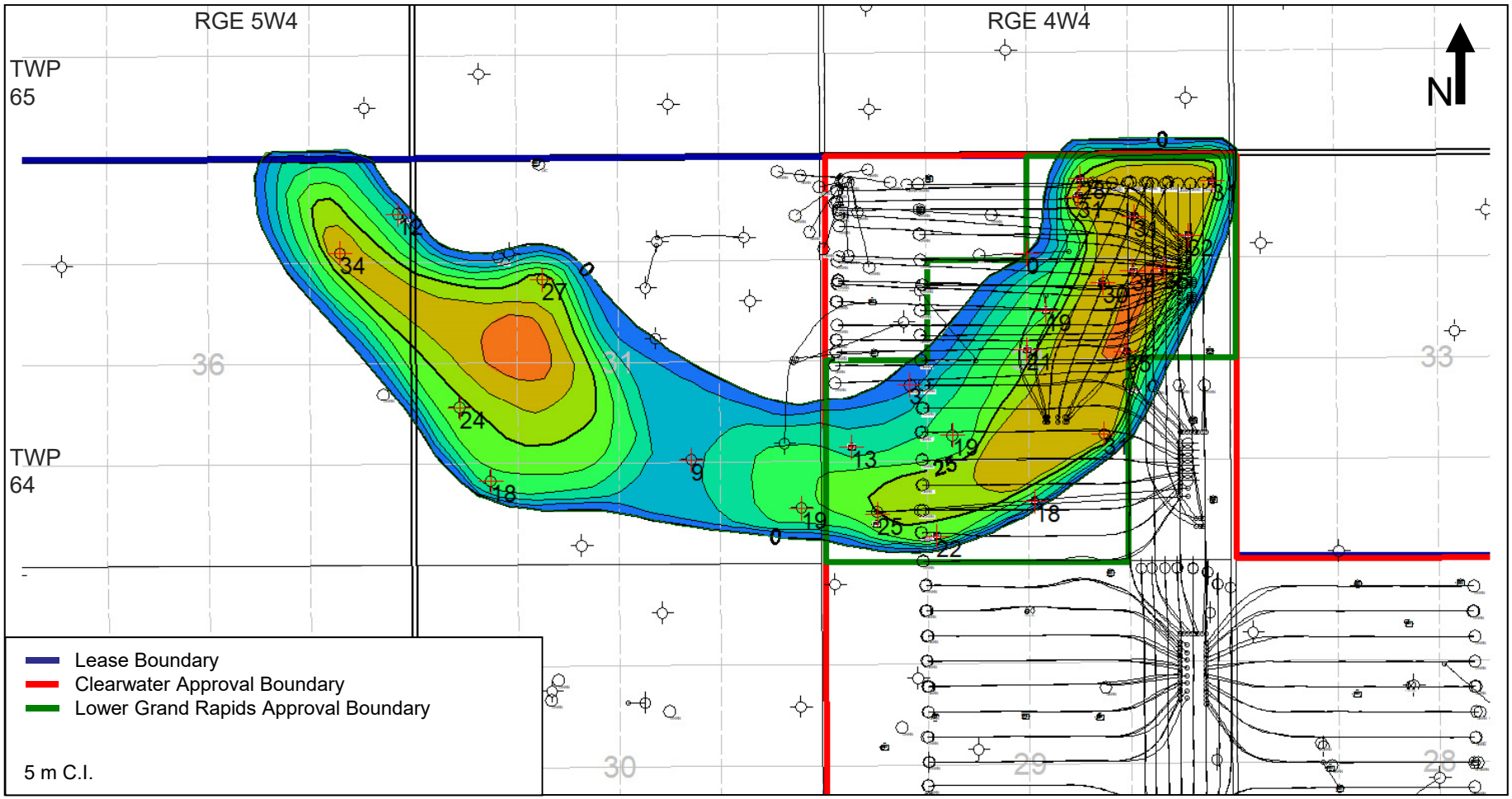
2. Geology/Geosciences

ISOPACH OF CLEARWATER TRANSITION ZONE



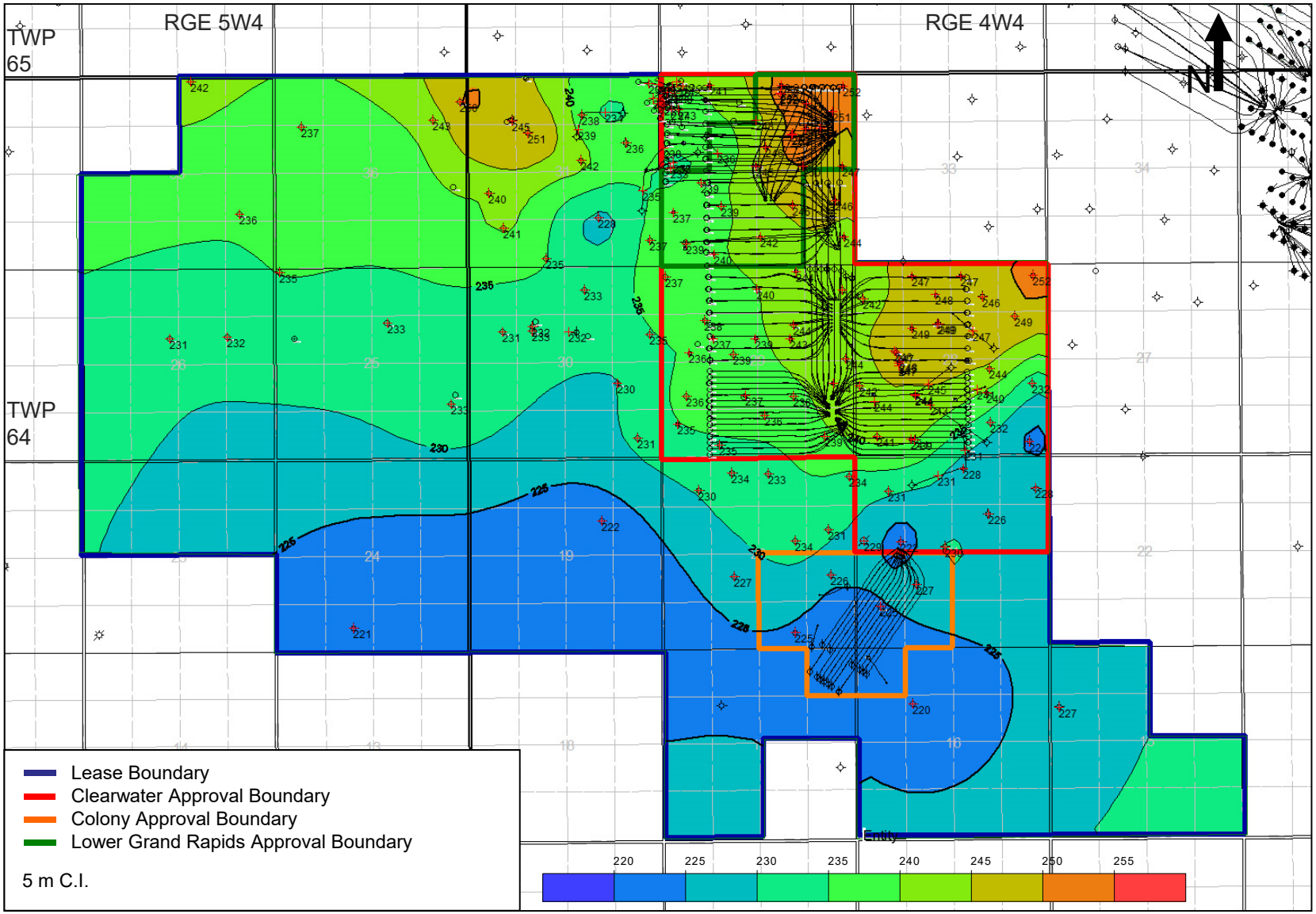
2. Geology/Geosciences

ISOPACH MAP OF LOWER GRAND RAPIDS SAGD NET PAY



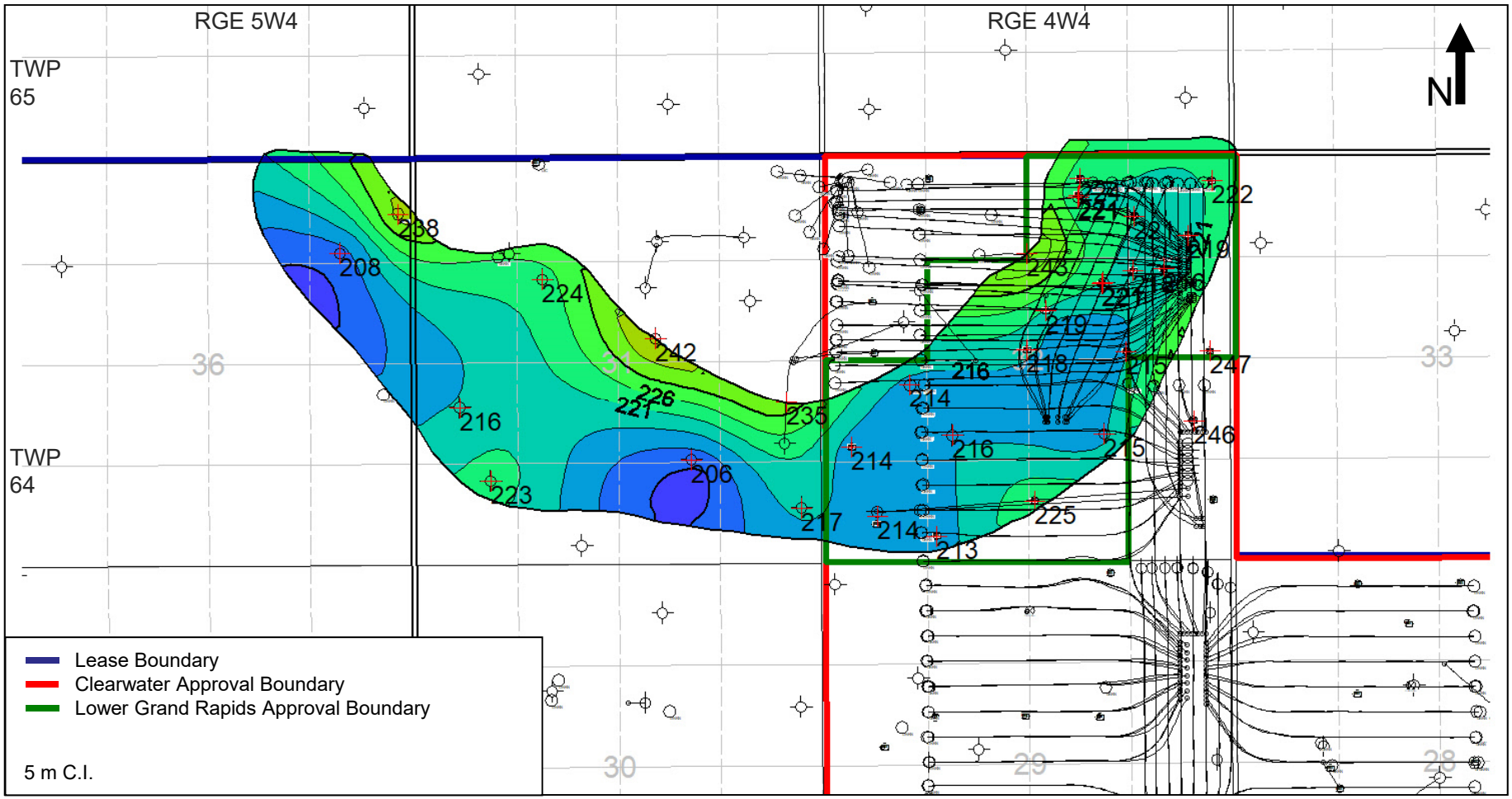
2. Geology/Geosciences

STRUCTURE MAP OF THE LOWER GRAND RAPIDS



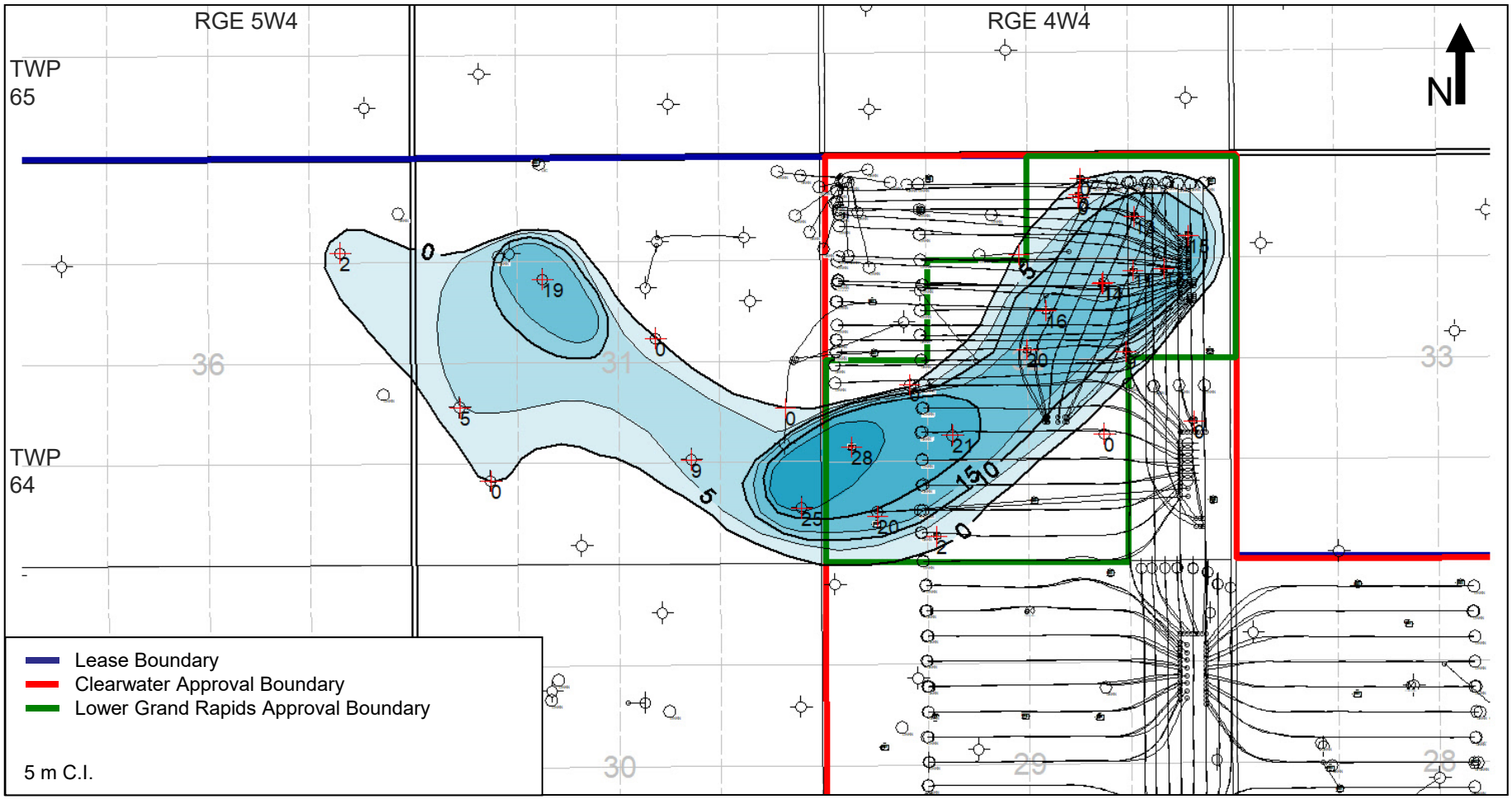
2. Geology/Geosciences

STRUCTURE MAP OF THE LOWER GRAND RAPIDS BASE OF NET PAY



2. Geology/Geosciences

ISOPACH MAP OF LOWER GRAND RAPIDS BOTTOM WATER



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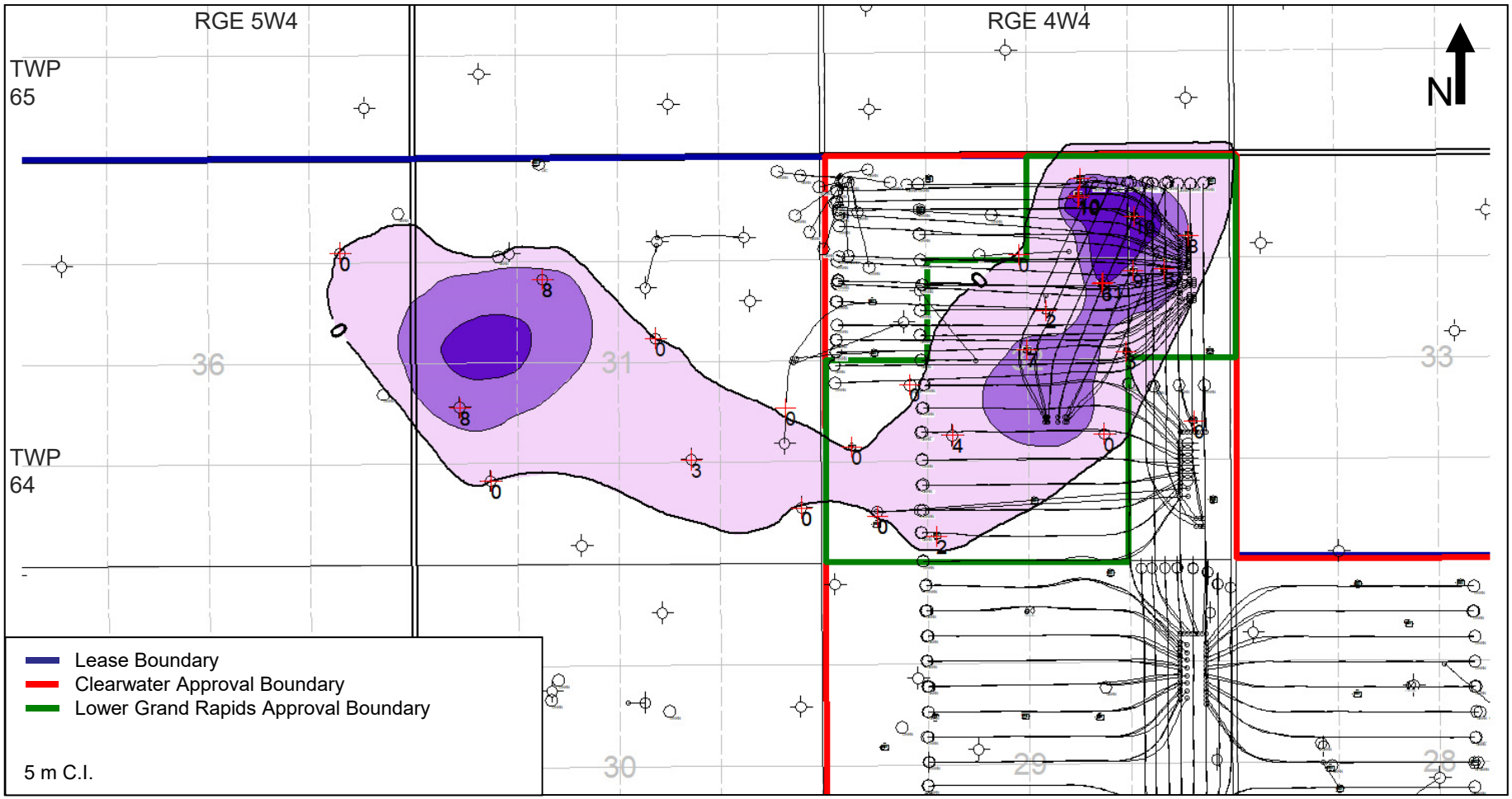
2. Geology/Geosciences

ISOPACH MAP OF LOWER GRAND RAPIDS TRANSITION ZONE



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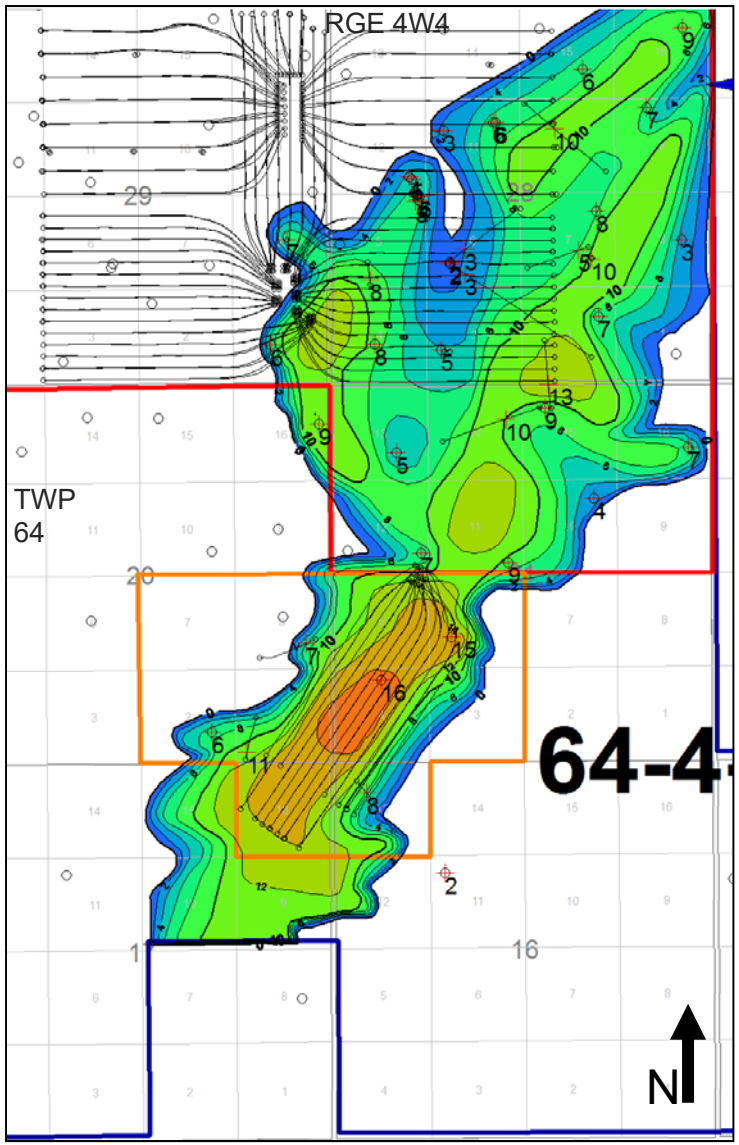
2. Geology/Geosciences

ISOPACH MAP OF COLONY SAGD NET PAY



Lease Boundary
Clearwater Approval Boundary
Colony Approval Boundary

5 m C.I.

Entity

0 2 4 6 8 10 12 14 16 18

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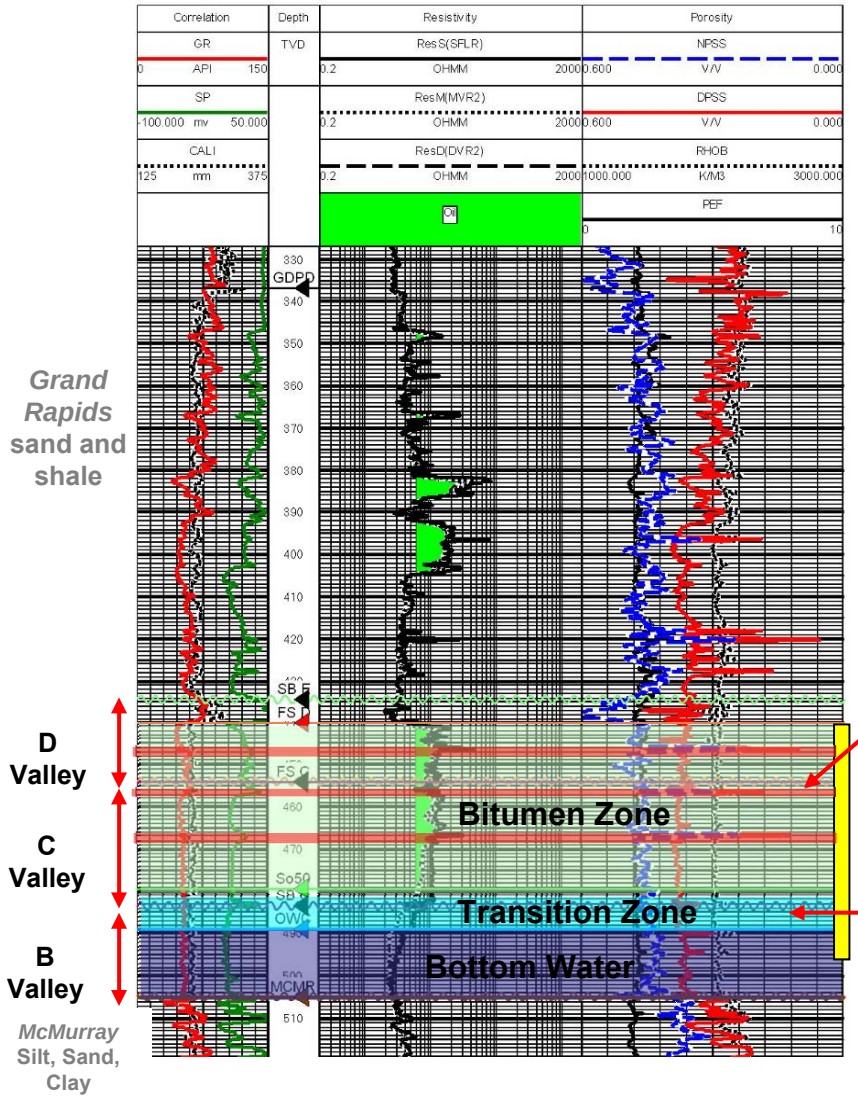
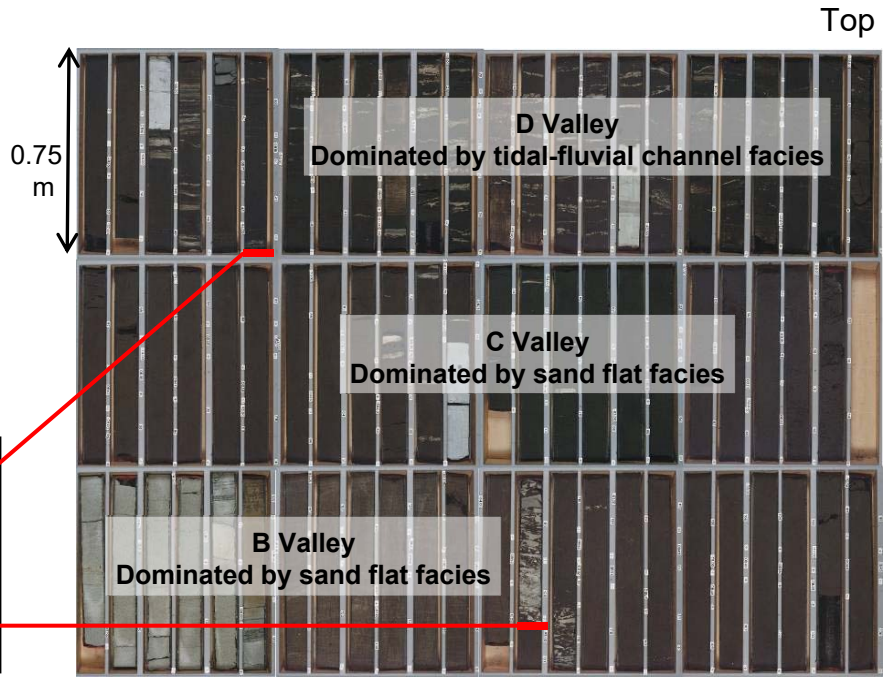
2. Geology/Geosciences

CLEARWATER FORMATION TYPE LOG



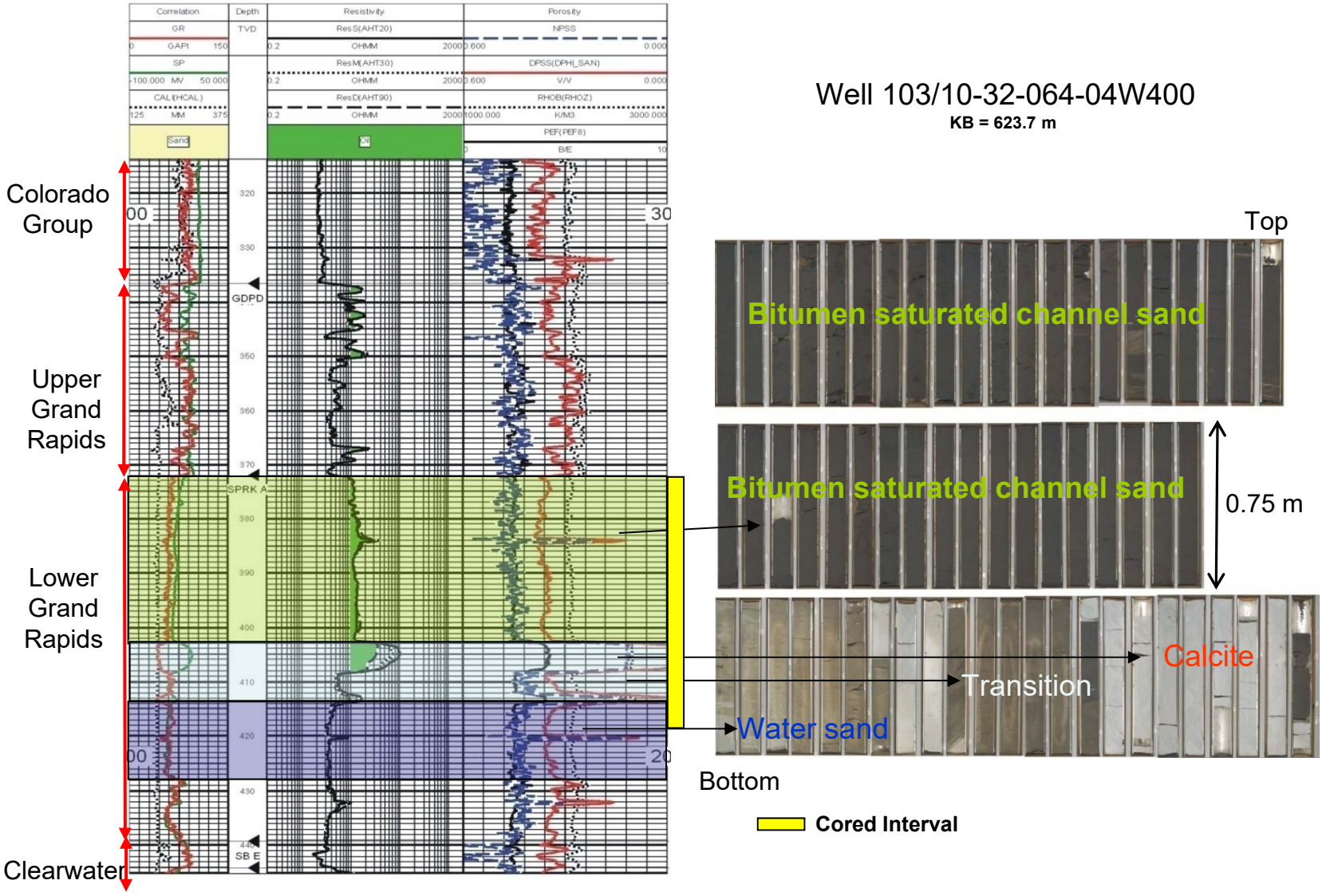
Well 100/14-28-064-4W400

KB 619.5m



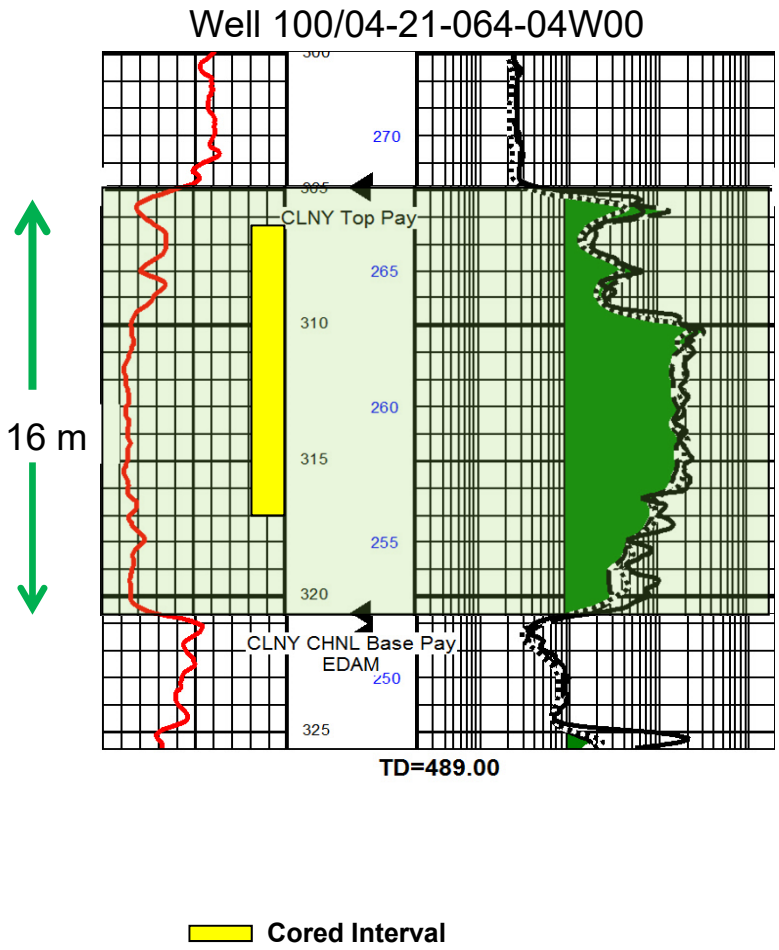
2. Geology/Geosciences

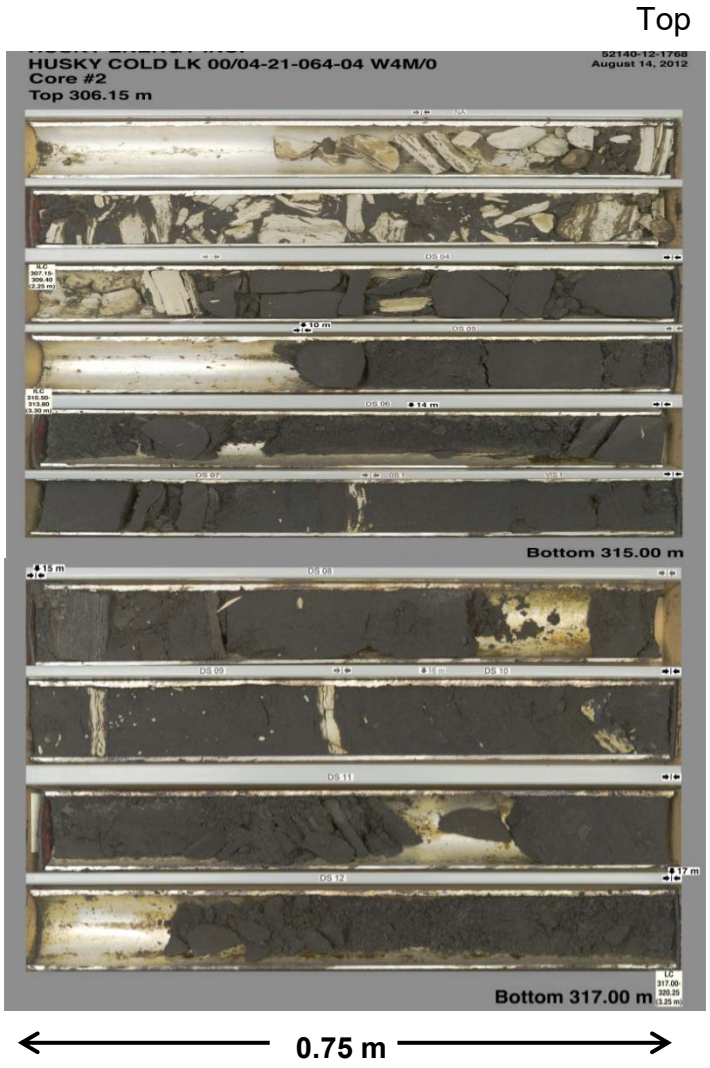
SPARKY FORMATION TYPE LOG



2. Geology/Geosciences

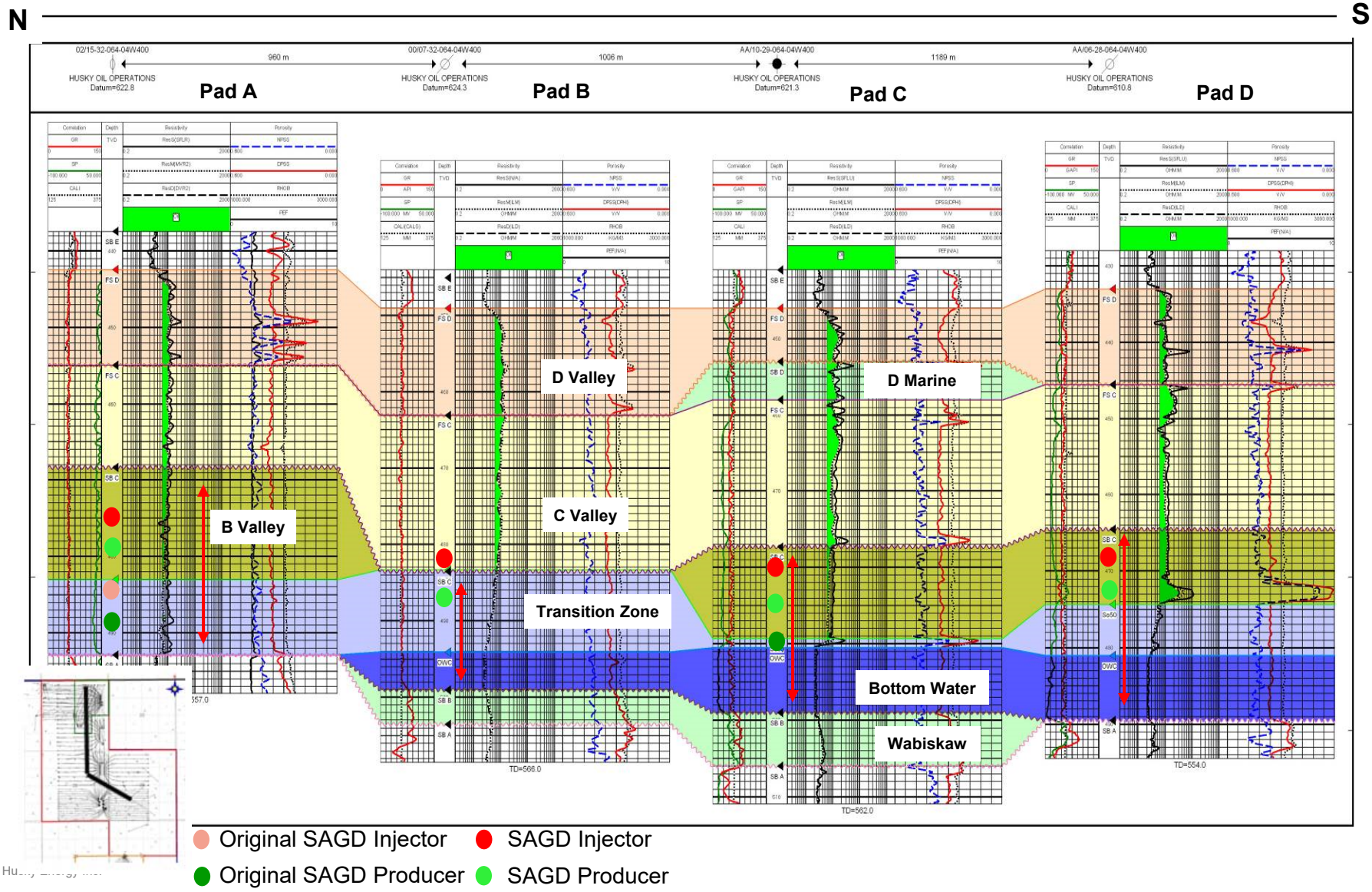
COLONY FORMATION TYPE LOG





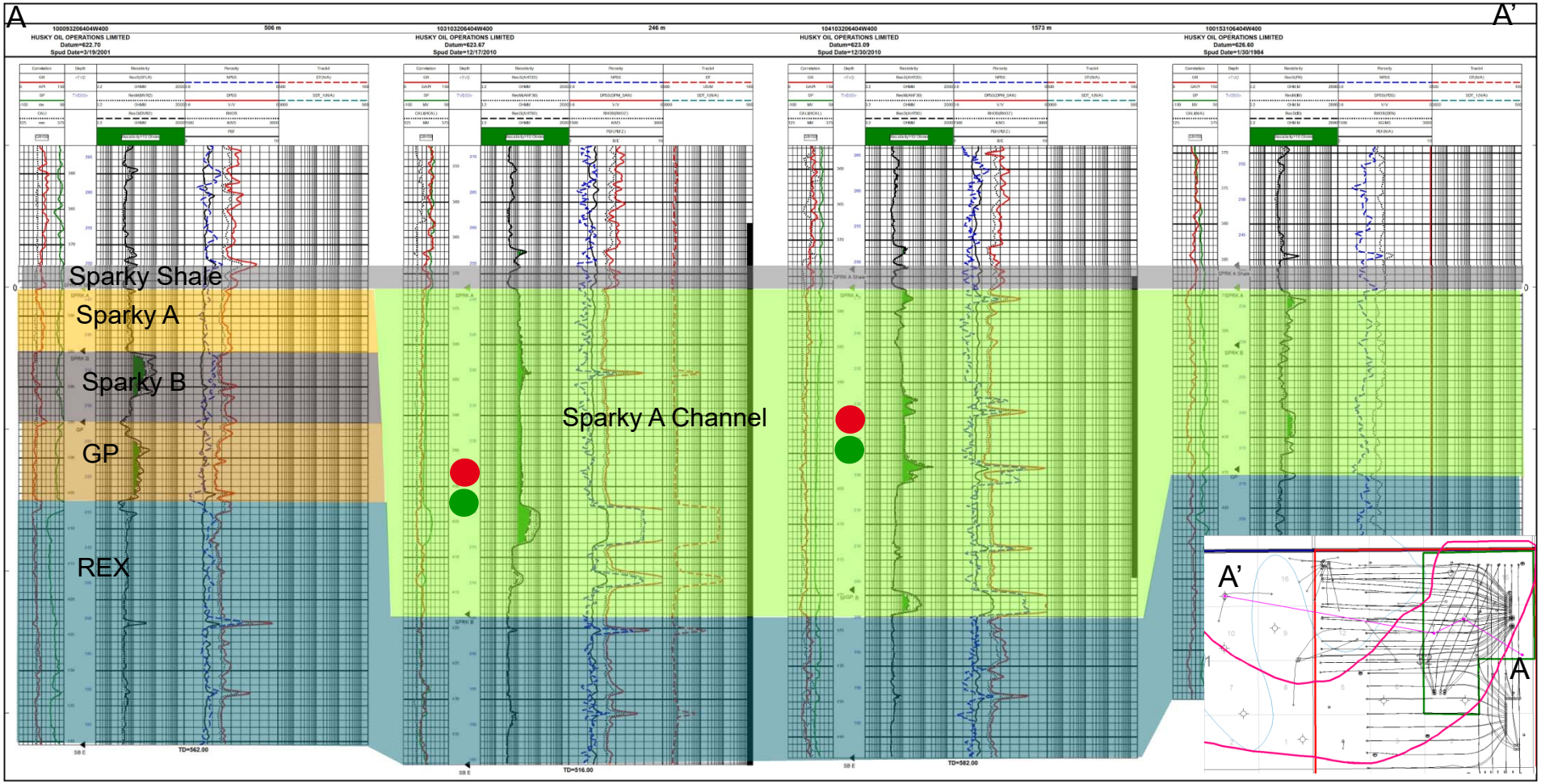
2. Geology/Geosciences

REPRESENTATIVE STRUCTURAL N-S CROSS-SECTION THROUGH THE APPROVAL AREA



2. Geology/Geosciences

REPRESENTATIVE STRIKE CROSS-SECTION THROUGH THE SPARKY CHANNEL

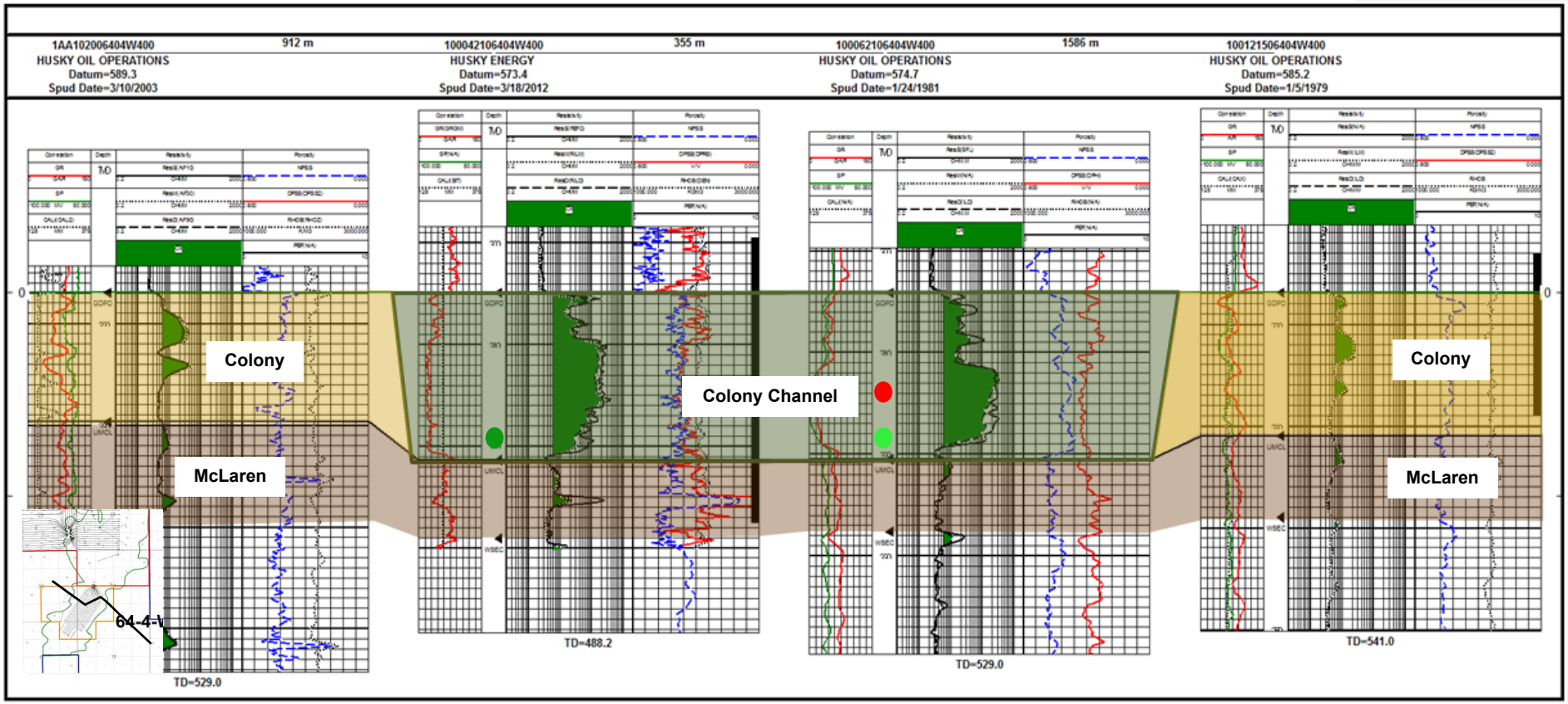


SAGD Injector

SAGD Producer

2. Geology/Geosciences

REPRESENTATIVE STRIKE CROSS-SECTION THROUGH THE COLONY CHANNEL



- SAGD Injector
- SAGD Producer
- Infill Producer

2. Geology/Geosciences

SURFACE/SUBSURFACE GEOMECHANICAL DATA/ANALYSIS

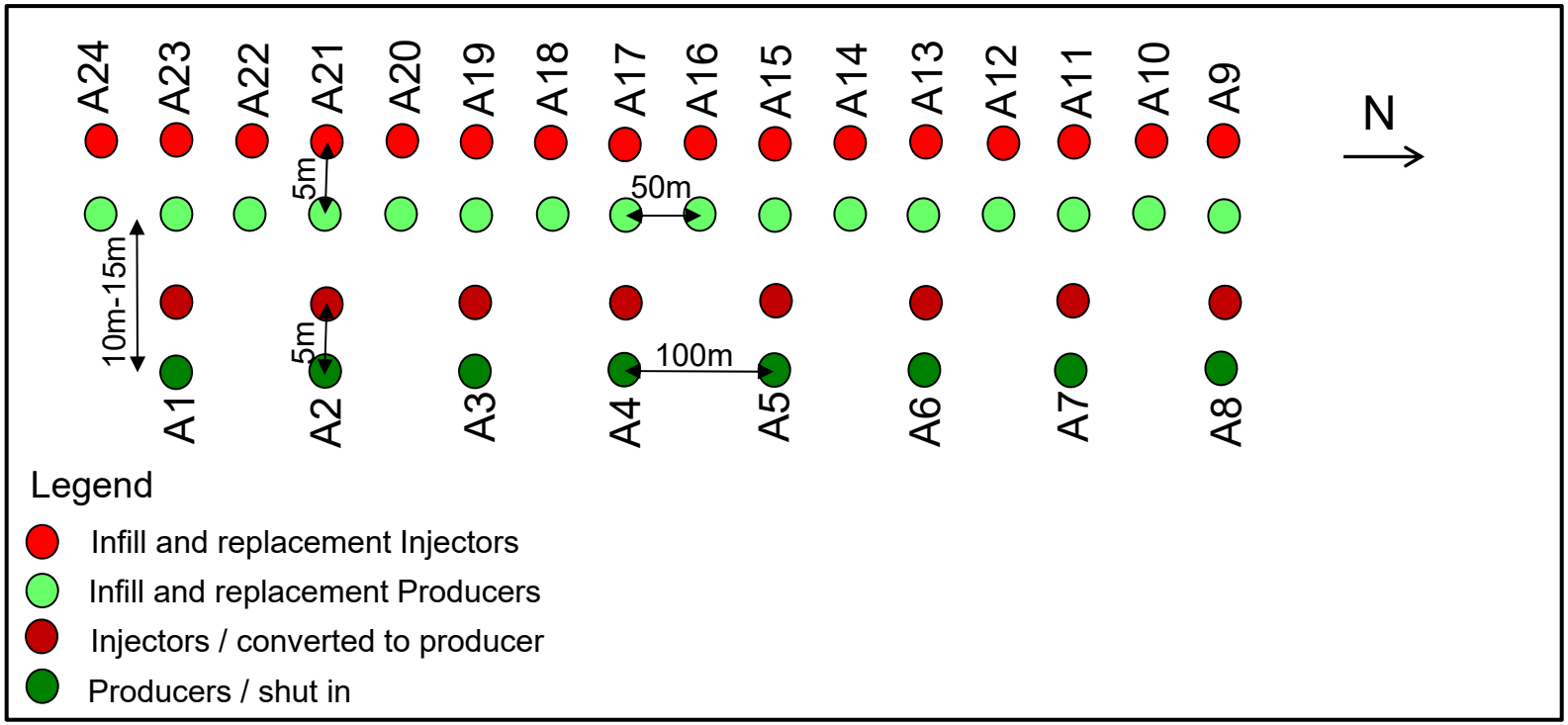
Capping Shale Properties						
Well Pad	Capping Shale Issues to date	Capping shale Fracture Pressure Exceeded	Shale Depth (m)	Measured Fracture Gradient (kPa/m)	Measured Fracture Pressure (kPa)	Fracture Regime
CN	No	No	305	20.0	6,100	Horizontal
GA	No	No	357	19.9	7,120	Horizontal
Clearwater	No	No	426	21.8	9,280	Horizontal

Sand Properties				
Well Pad	Sand Depth (m)	Measured Fracture Gradient (kPa/m)	Measured Fracture Pressure (kPa)	Fracture Regime
GA	375	17.0	6,360	Vertical
Clearwater	446	16.0	7,140	Vertical

2. Geology/Geosciences

PAD A WELL SPACING SCHEMATIC

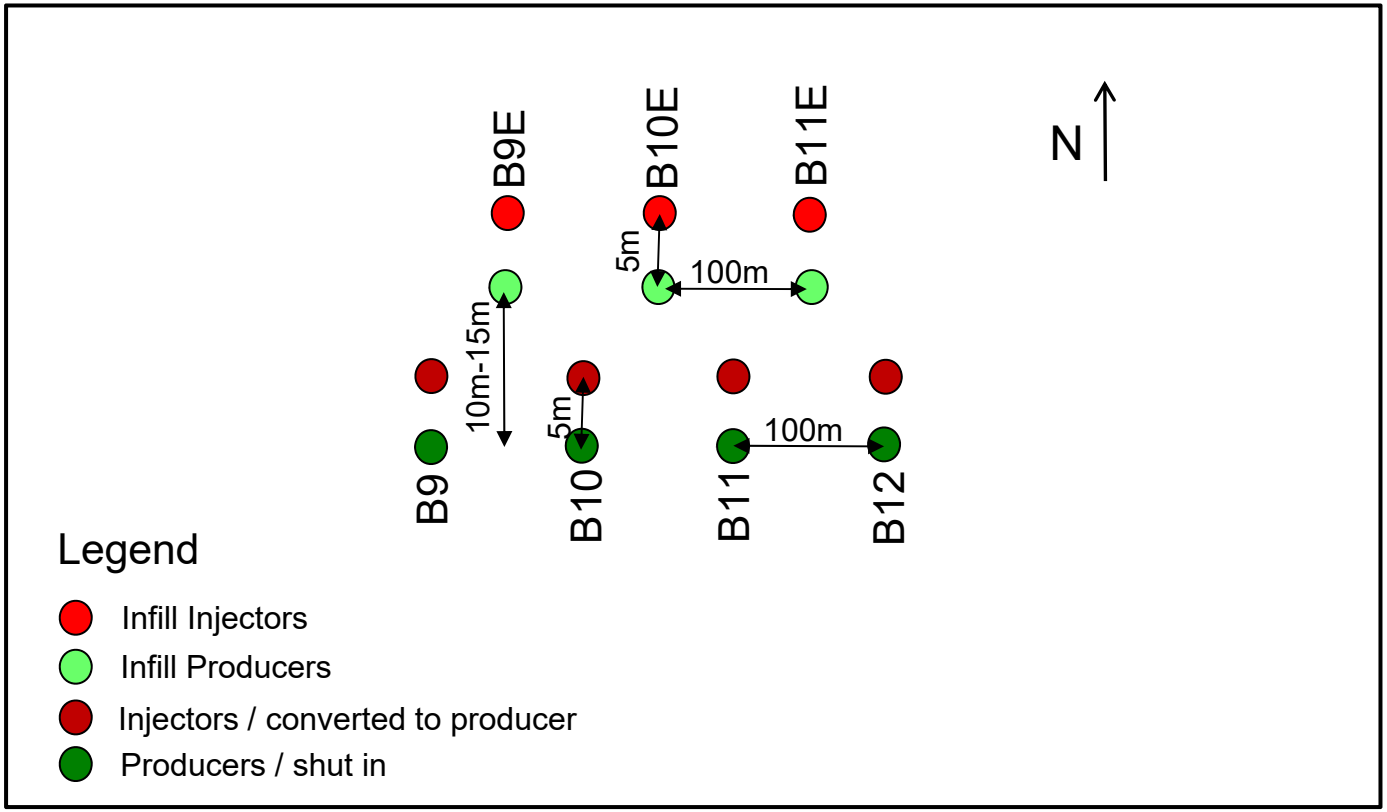
- Pad A original (A1 – A8 drilled 2005) injectors were converted into producers in 2015
- Pad A replacement producers (A9 – A24 drilled 2010/2011) are 10m - 15m directly above Pad A original producers
- Pad A infill producers are 10m - 15m above and mid distance from Pad A original producers



2. Geology/Geosciences

PAD B NORTH WELL SPACING SCHEMATIC

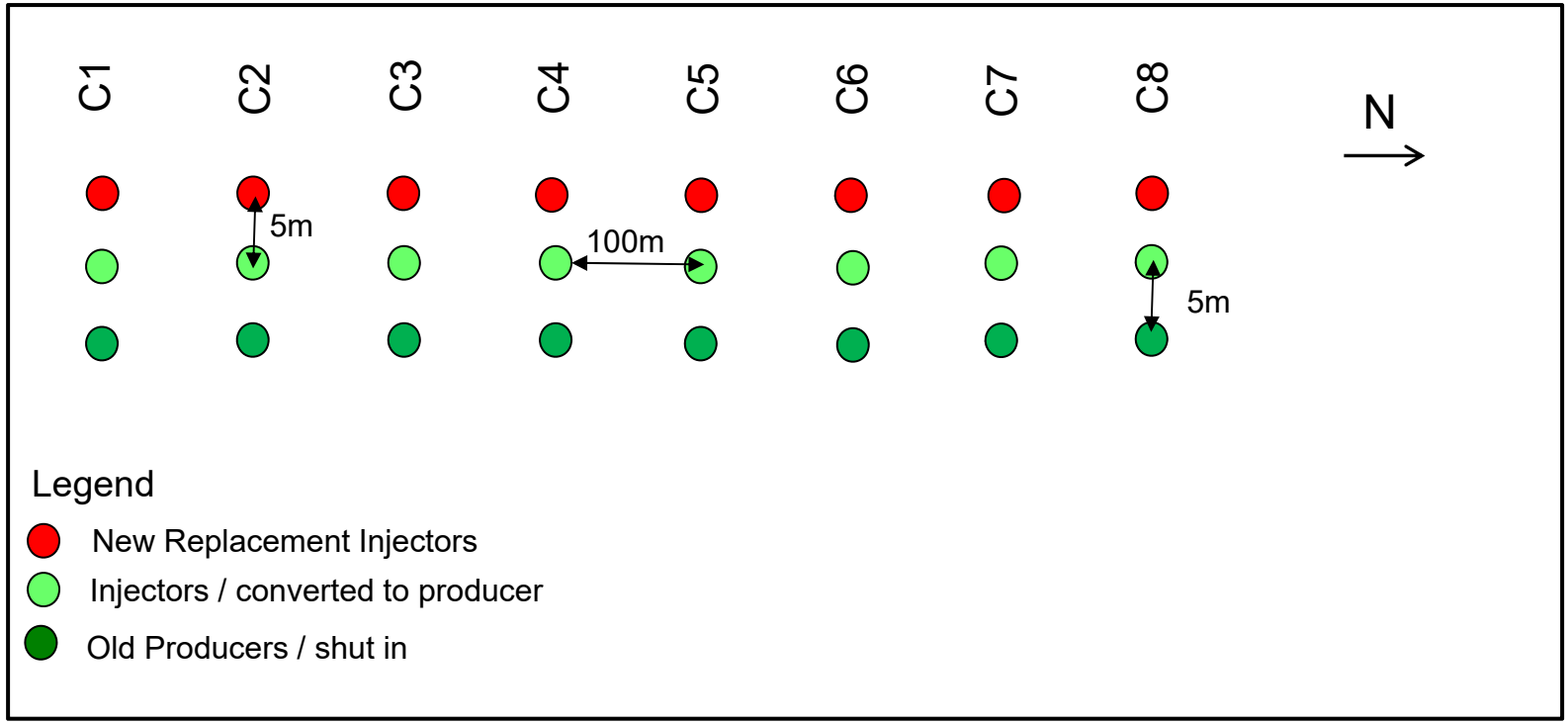
- Pad B North injectors (B9 – B12 drilled 2005/2006) converted into producers in 2014
- Pad B North infill producers (B9 – B11 drilled 2009/2010) are 10m - 15m above and mid distance from Pad B North



2. Geology/Geosciences

PAD C WEST WELL SPACING SCHEMATIC

- Pad C West (C1 – C8 drilled 2005)
- Pad C West replacement injectors (C1R – C8R drilled 2016) are 5m directly above injectors



2. Geology/Geosciences

PAD INTER-WELL SPACING

Well Pad	Inter-well Spacing (meters)
A Original	100
A Infill and Replacements	50
B West	100
B North	100
B North Infill	100
C North	100
C West	100
C East	100
D East	50
D North	50
D West	50
GA (LGR)	75
CN (SAGD)	75
CN Infill	37.5*

* Spacing to SAGD producer

2. Geology/Geosciences

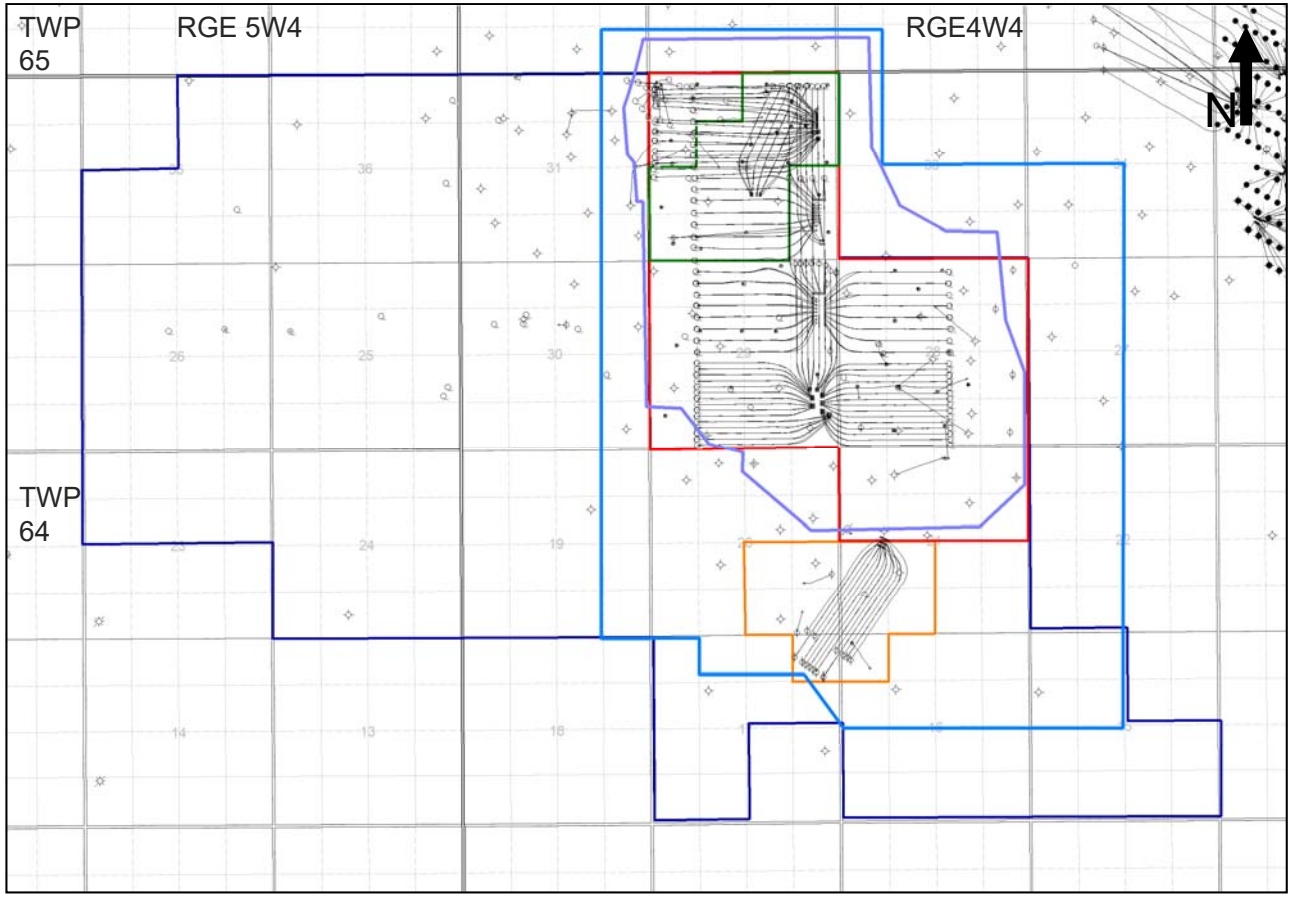
SURFACE HEAVE MONITORING PROGRAMS

- No surface heave monitoring programs have been conducted
- Operating near reservoir pressure, therefore unlikely to be any surface heave
- Husky is committed to further investigate the possible extent of surface heave if a change in operating conditions occurs

2. Geology/Geosciences

3D SEISMIC DATA

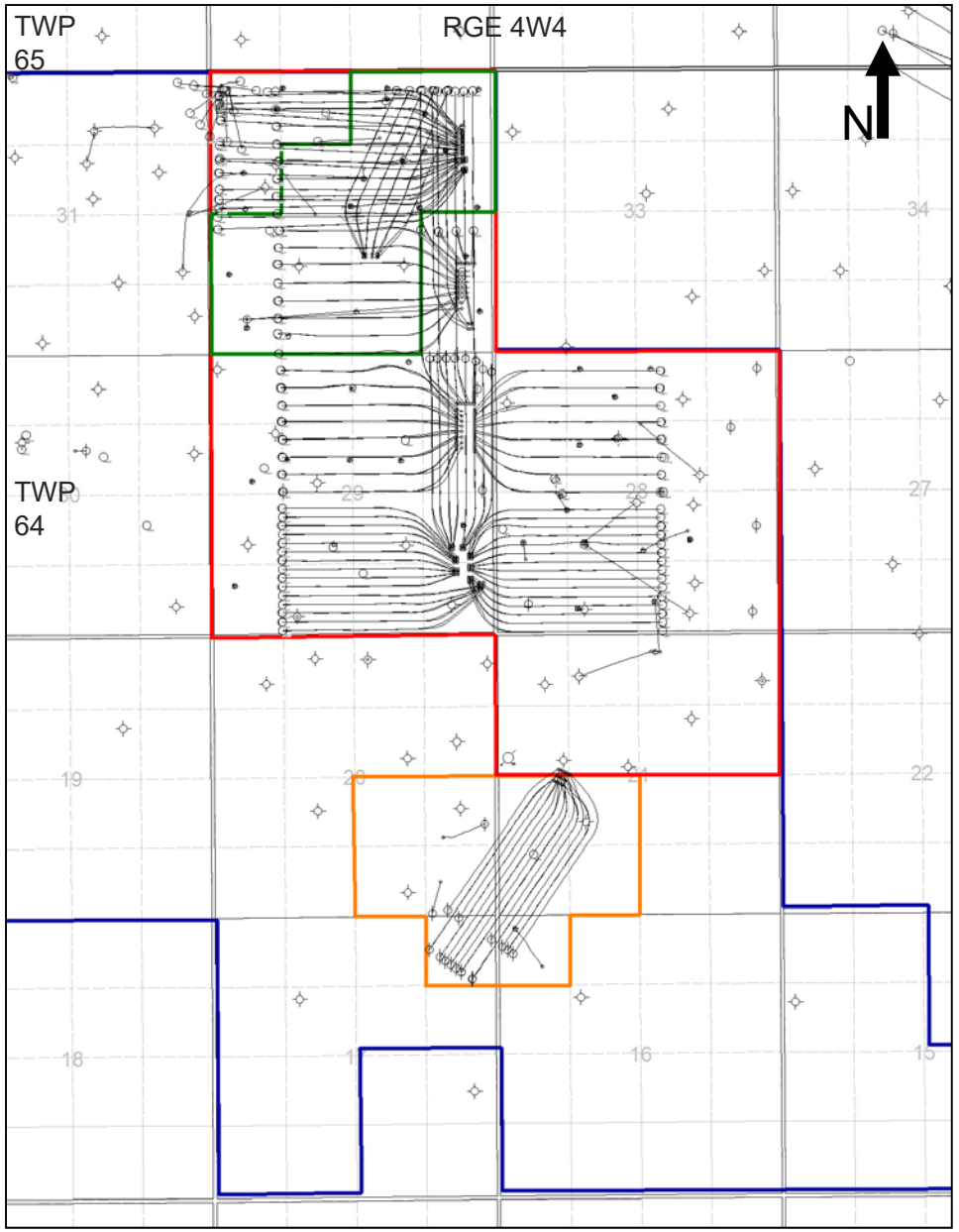
- No new seismic acquisitions during the reporting period



3. Drilling and Completions

DRILLING RESULTS

- No wells drilled during the reporting period



3. Drilling and Completions

SUMMARY OF WELL COMPLETIONS

Injectors (109 SAGD Injectors):

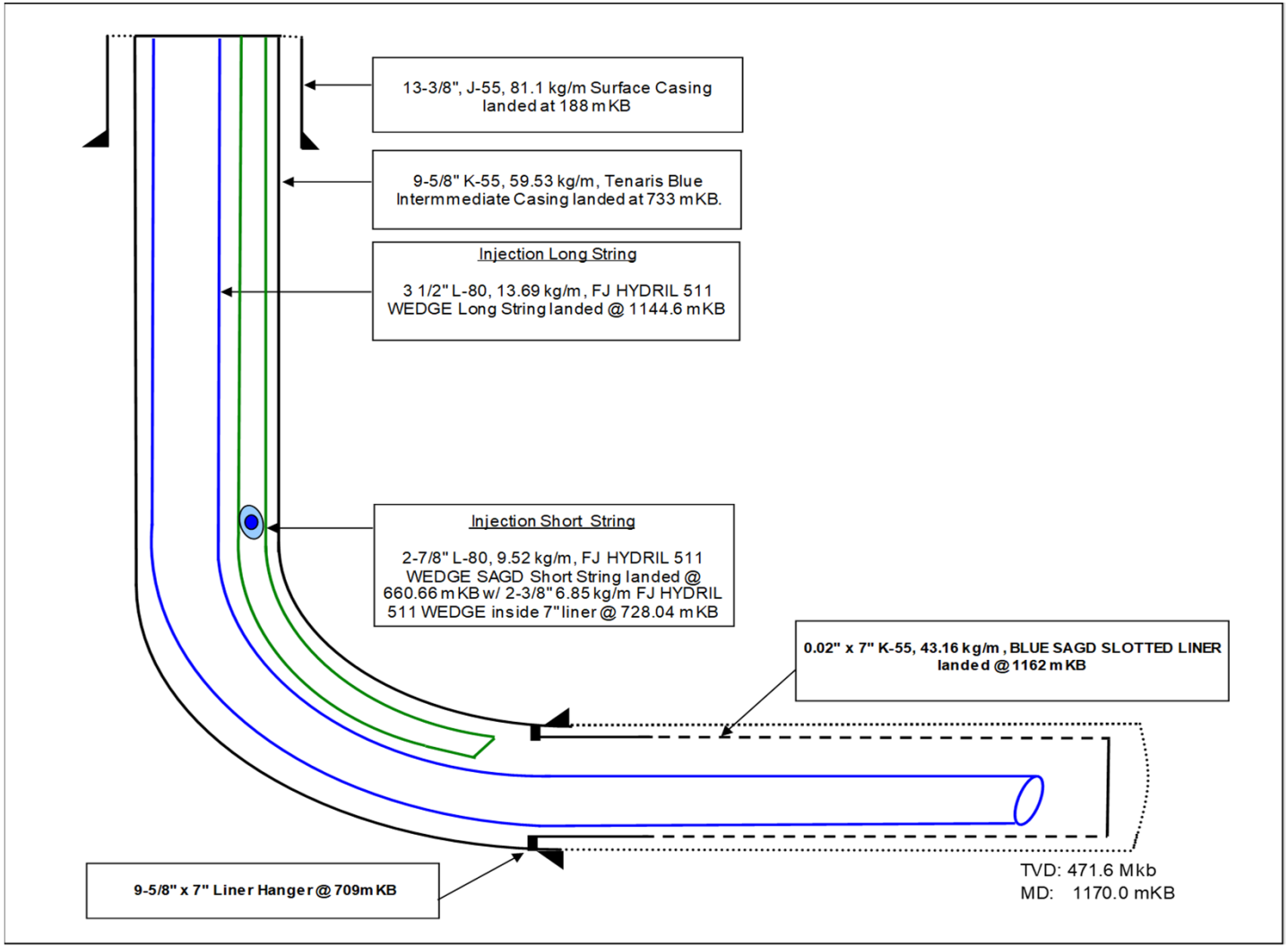
- All injectors completed with Slotted Liner: 109 (includes Pad D West)
- Injectors completed with Vacuum Insulated Tubing (VIT): 45
  - Pad C: 2
  - Pad D: 37
  - Pad CN: 6
- Injectors completed with Steam Splitters: 51
  - Pad B: 7
  - Pad D: 38
  - Pad CN: 6

Producers (116 Producers: 109 SAGD Producers and 7 Infill Producers):

- Producers completed with Slotted Liner: 38
  - Pad A: 8
  - Pad B: 12
  - Pad C: 18
- Producers completed with Wire Wrap Screen (WWS): 78
  - Pad A: 16
  - Pad B: 3
  - Pad C: 2
  - Pad D: 38
  - Pad GA: 6
  - Pad CN: 13

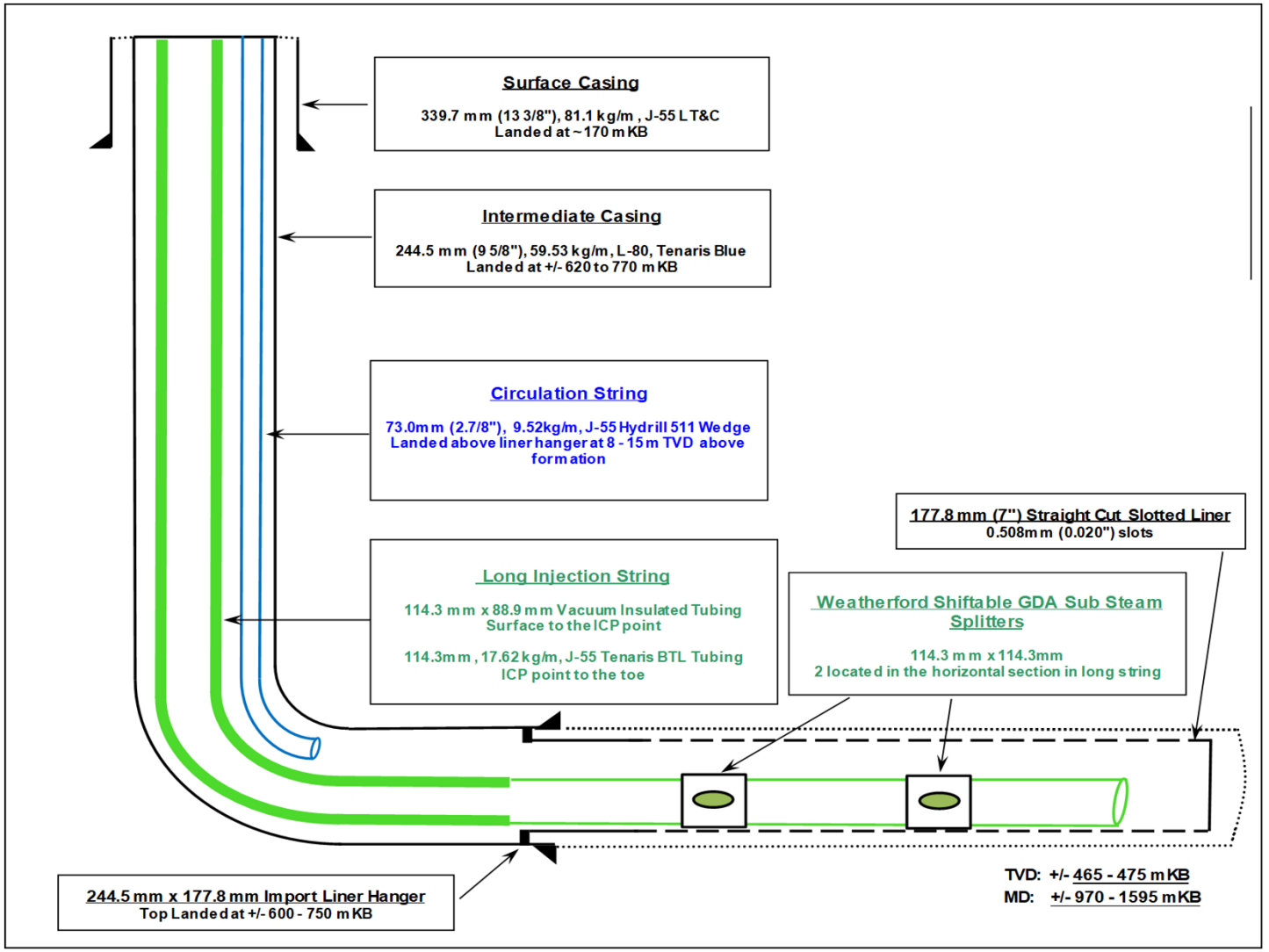
3. Drilling and Completions

SAGD WELL – INJECTOR WITHOUT VACUUM INSULATED TUBING (VIT)



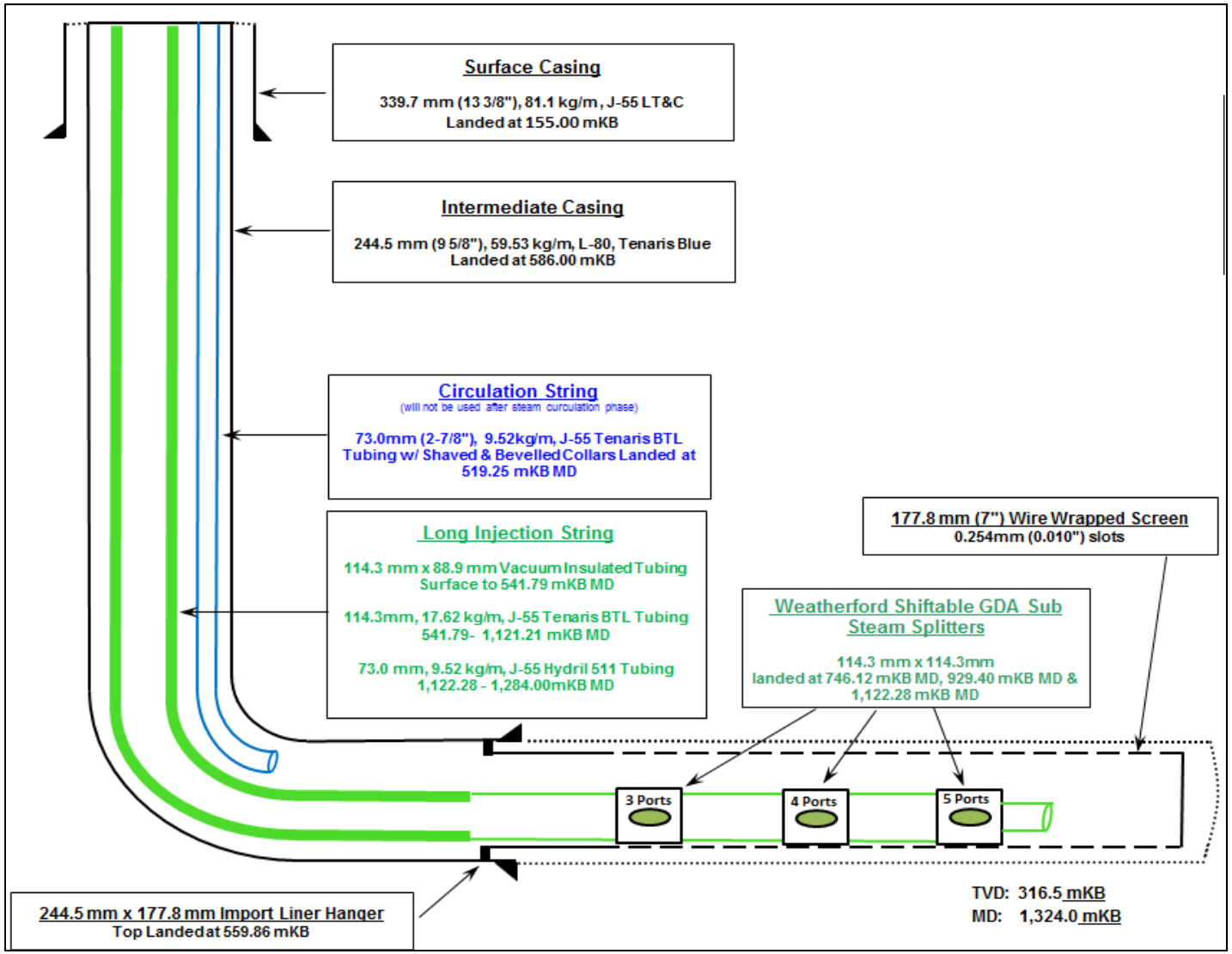
3. Drilling and Completions

SAGD WELL – INJECTOR WITH VIT



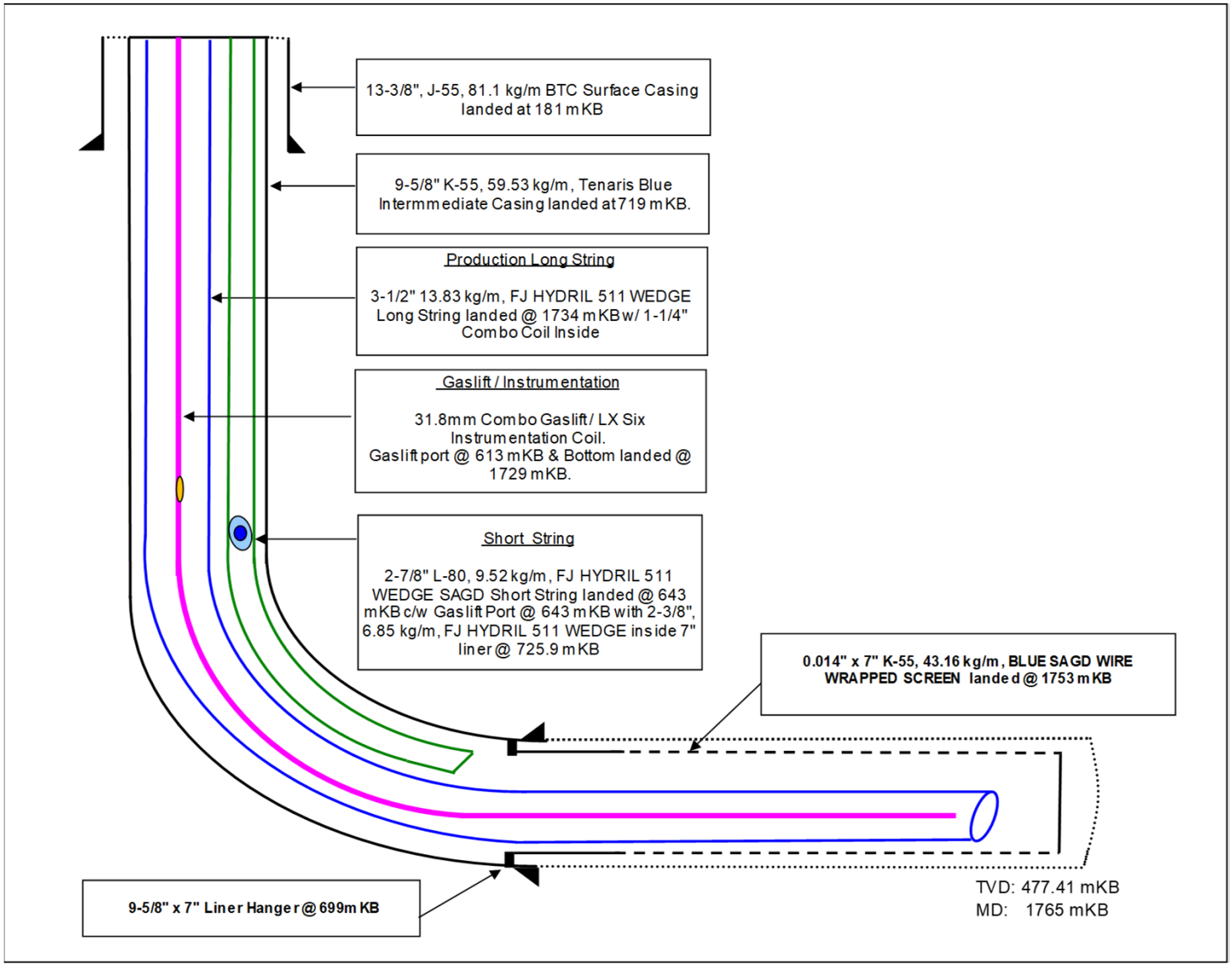
3. Drilling and Completions

SAGD WELL PAD CN – INJECTOR WITH VIT



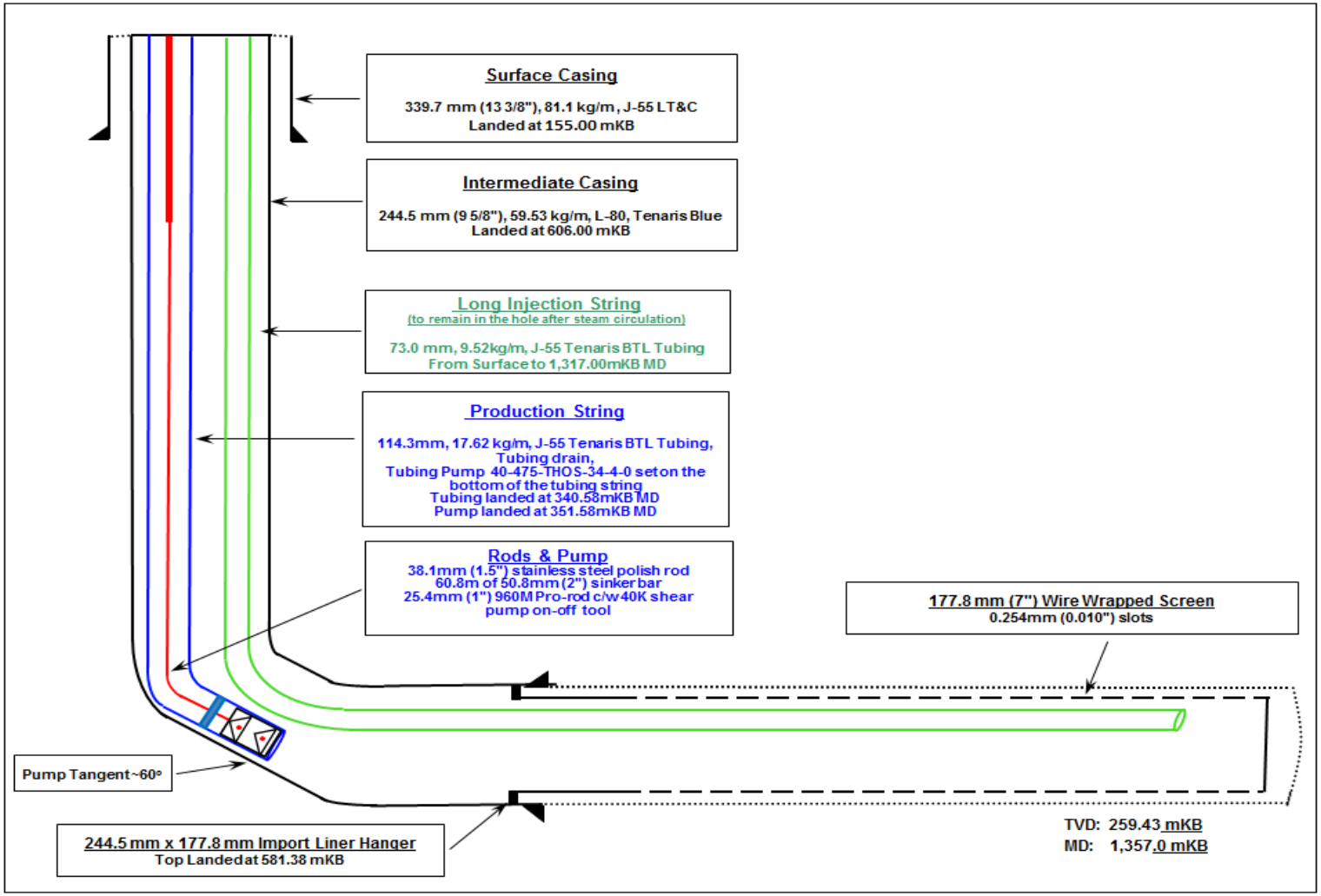
3. Drilling and Completions

SAGD WELL – PRODUCER WITH GAS-LIFT



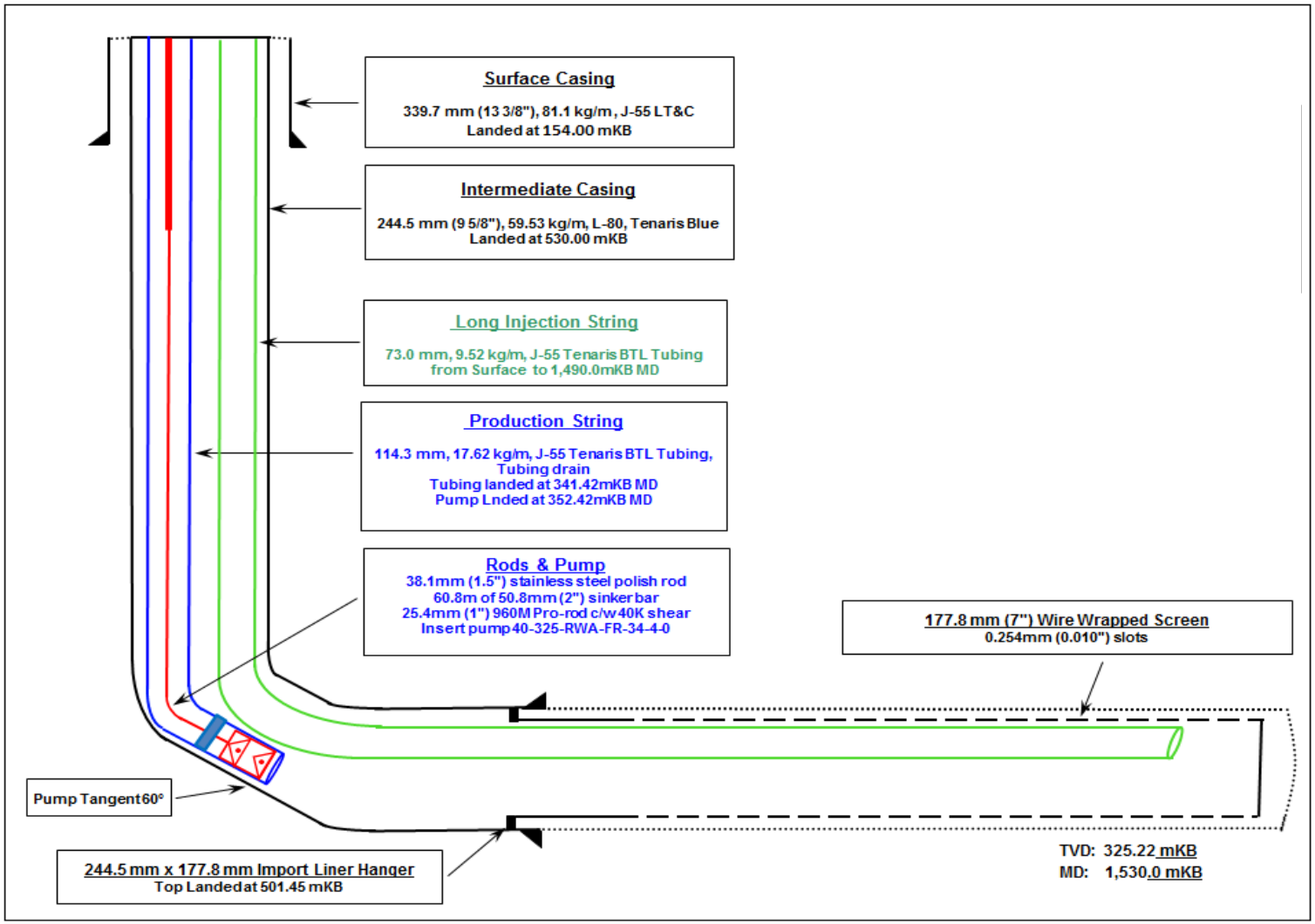
3. Drilling and Completions

SAGD WELL PAD CN – PRODUCER WITH ROD-PUMP



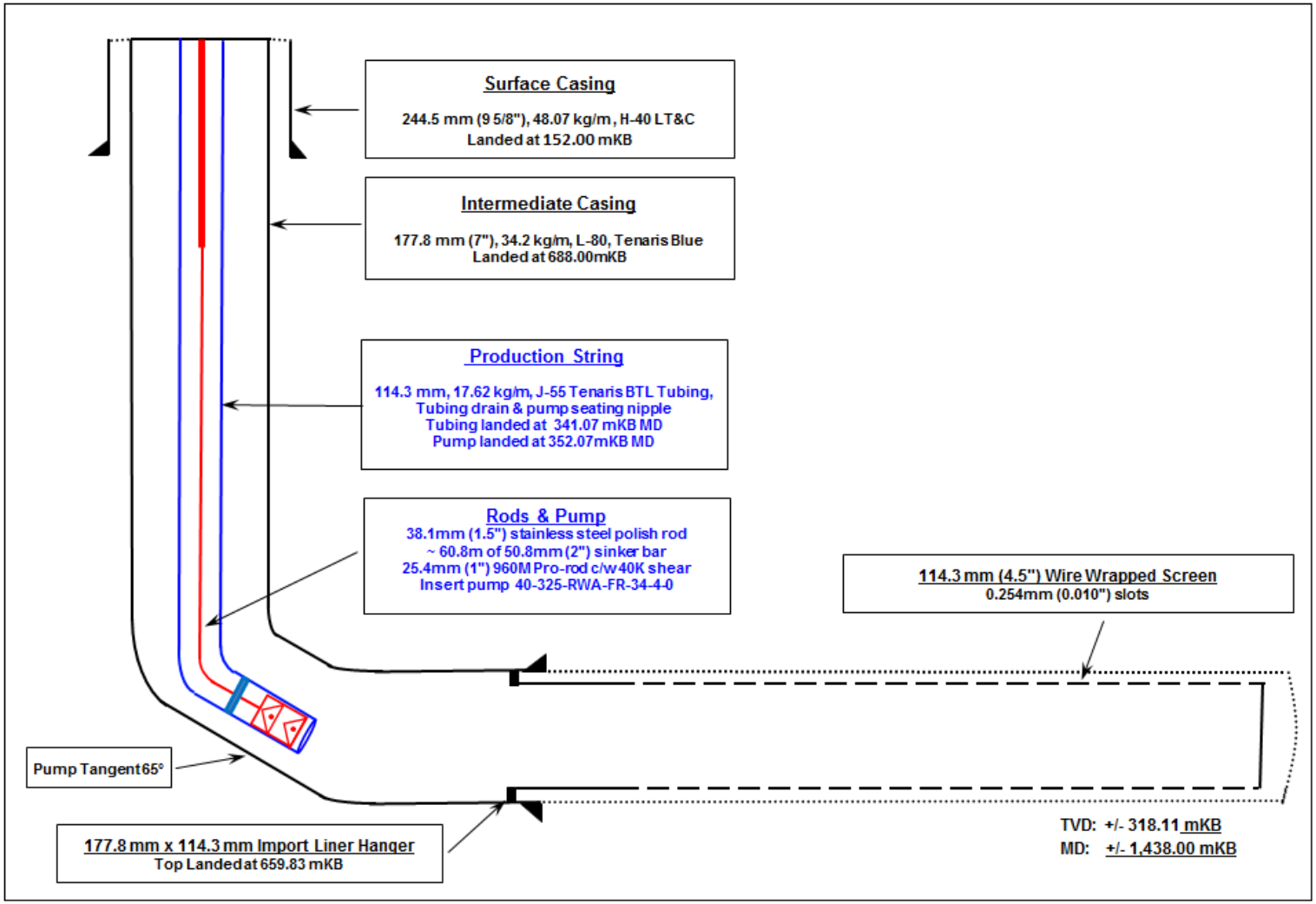
3. Drilling and Completions

INTERMITTENT STEAM STIMULATION WELL PAD CN – PRODUCER WITH ROD-PUMP



3. Drilling and Completions

INFILL WELL PAD CN – PRODUCER WITH ROD-PUMP



3. Drilling and Completions

COMPLETIONS – KEY LEARNINGS

Production - Slotted Liners vs Wire Wrap Screens (WWS):

- Slotted liner scaling has been a chronic problem:
  - Short term solution - Acidization
  - Long term solution - perforated liners
- WWS, which increase the open area, used in producers drilled since 2009:
  - No scaling issues observed in these wells
- Current plan to complete future producers with WWS

Injection - Vacuum Insulated Tubing (VIT) and Steam Splitters:

- VIT:
  - Improve the wellbore integrity by slowing heat transfer through tubing
  - Deliver high quality steam downhole and improve production
- Steam Splitters:
  - Shift-able steam splitters enable proper circulation and allow steam distribution adjustments
- VIT combined with Steam Splitters:
  - Improve steam quality and distribution into the reservoir

4. Artificial Lift

WELL PADS

Rod-pump: 13 (Pad CN only)

- 6 SAGD producers (tubing liner pump)
- 2 ISS producers (insert pump)
- 5 Infill producers (insert pump)
- Rod-pump operational parameters:
  - Pressure: 1,500 – 2,500 kPa
  - Bottom hole temperature: 130 – 180 ºC
  - Fluid production range: 65 – 420 m^3/day

Gas-lift: 103, all producers except Pad CN

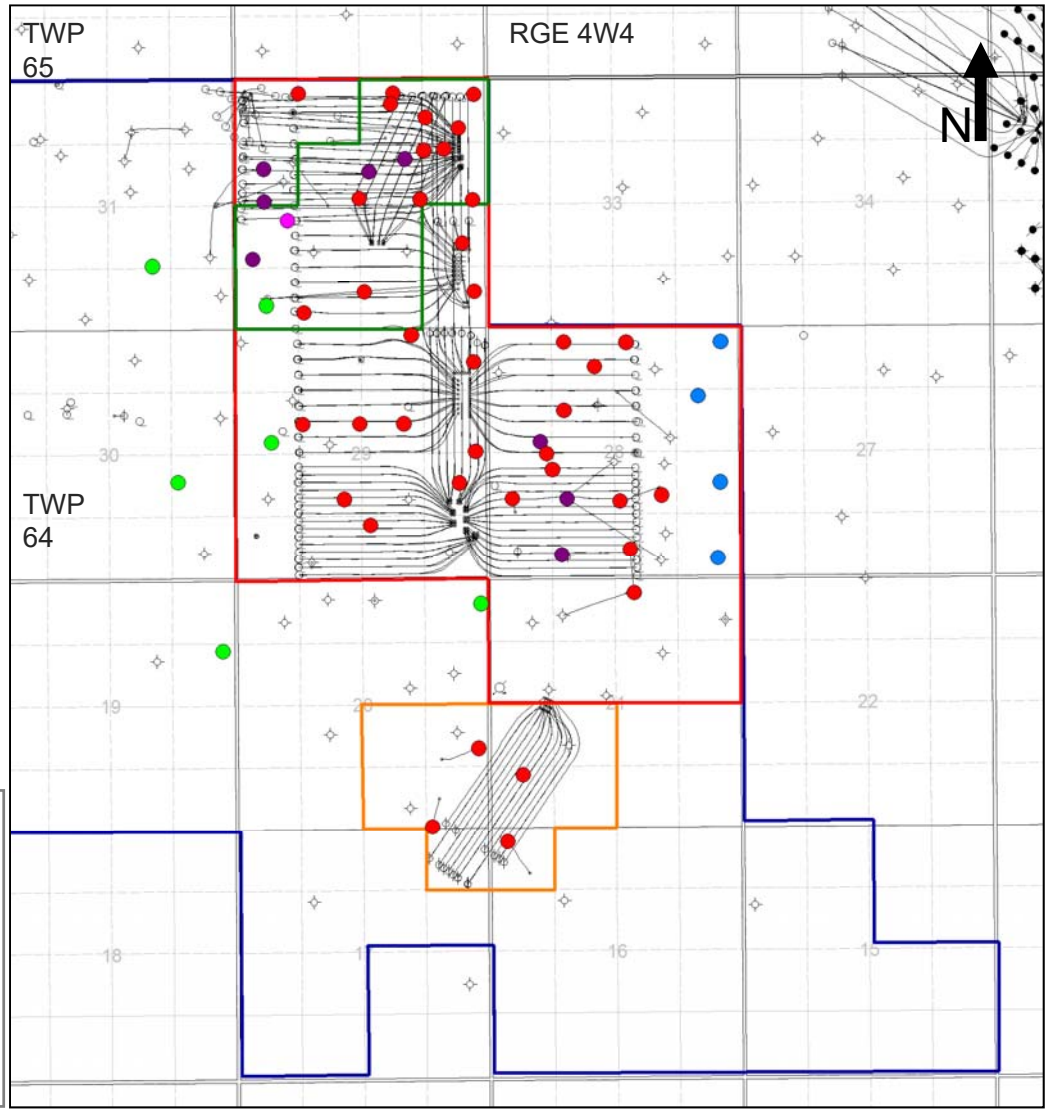
- 103 SAGD producers
- Gas-lift operational parameters:
  - Pressure: 2,400 kPa – 4,000 kPa
  - Bottom hole temperature: 200 – 240 ºC
  - Gas injection rate: 1,200 – 10,800 m^3/day

5. Instrumentation in Wells

OBSERVATION WELL MAP

2018/2019:

- No new observation wells drilling/converted during the reporting period



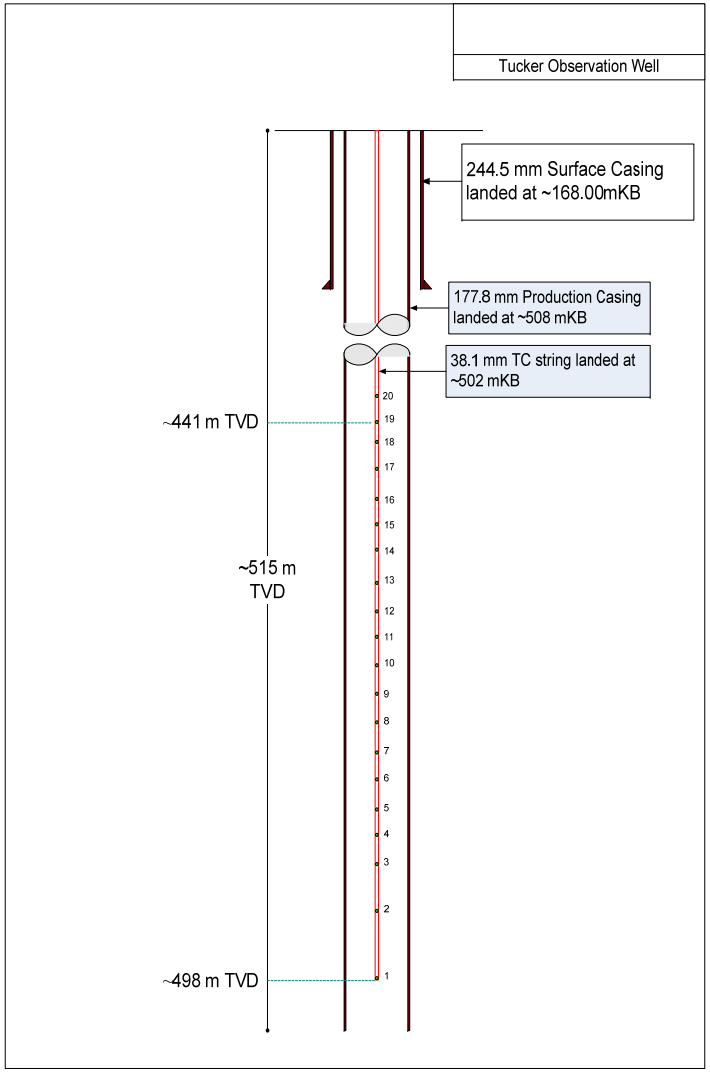
- Cased Wells
- Observation Wells With Thermocouples
- Observation Wells With Planned Thermocouples
- Observation Wells With Thermocouples and Piezometers
- Observation Wells With Planned Thermocouples and Piezometers
- Lease Boundary
- Clearwater Approval Boundary
- Colony Approval Boundary
- Lower Grand Rapids Approval Boundary

5. Instrumentation in Wells

OBSERVATION AND SAGD WELLS

- 47 OBS Wells with Instrumentation:
  - 39 wells (thermocouple only)
  - 8 wells (both thermocouple & piezometer)
- Planned: OBS Wells (convert existing well):
  - 1 well (Pad GB thermocouple and piezometers)
  - 4 wells (future Clearwater development thermocouples)
- SAGD Injectors – wells use blanket gas to measure pressure and for insulation
- SAGD Producers – equipped with combo instrumentation coil (gas lift & thermocouple or fiber)
  - Combo coil installed in the long production string delivers lift-gas for the long string and provides temperature measurement in the horizontal section
  - Pressure at the heel of producers is estimated from the gas pressure of the lift-gas injected into the annulus (annulus injection provides lift-gas for the short production string)

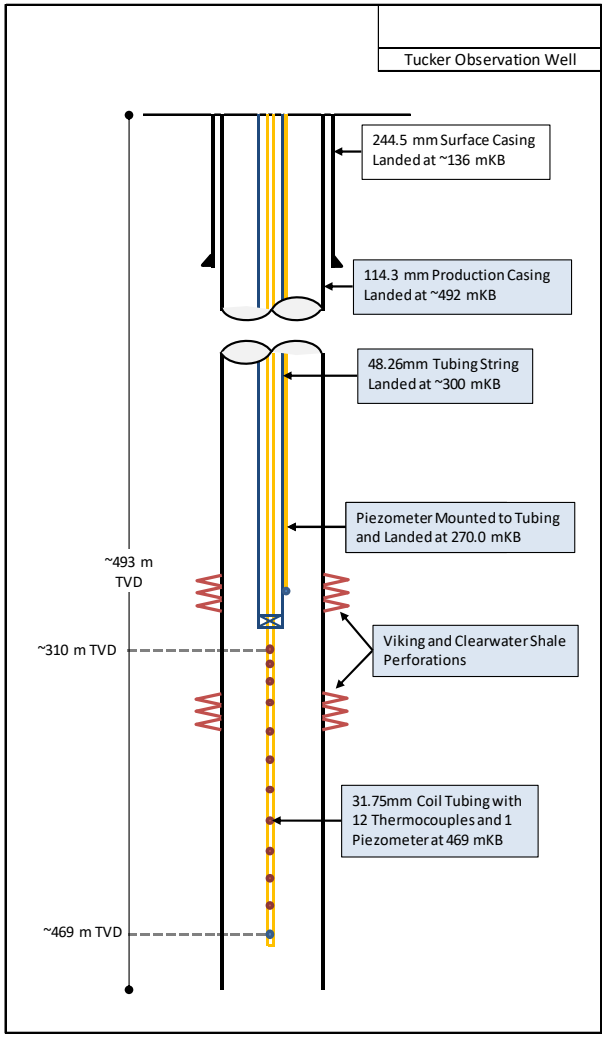
Thermocouple only OBS well



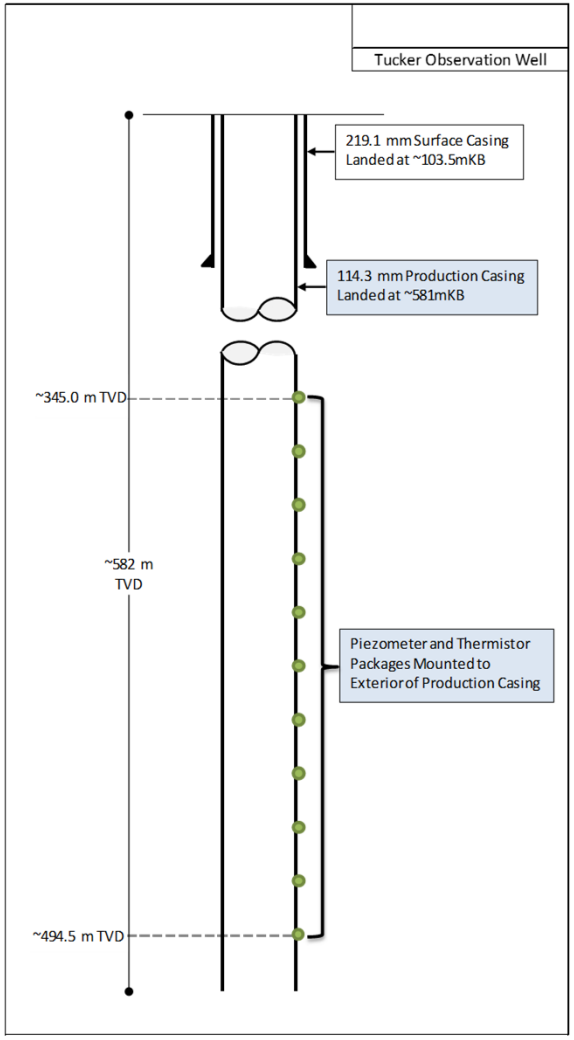
5. Instrumentation in Wells

THERMOCOUPLES AND PIEZOMETER OBSERVATION WELLS

Type 1 – Instrumentation Inside Tubing



Type 2 – Instrumentation Outside of Casing



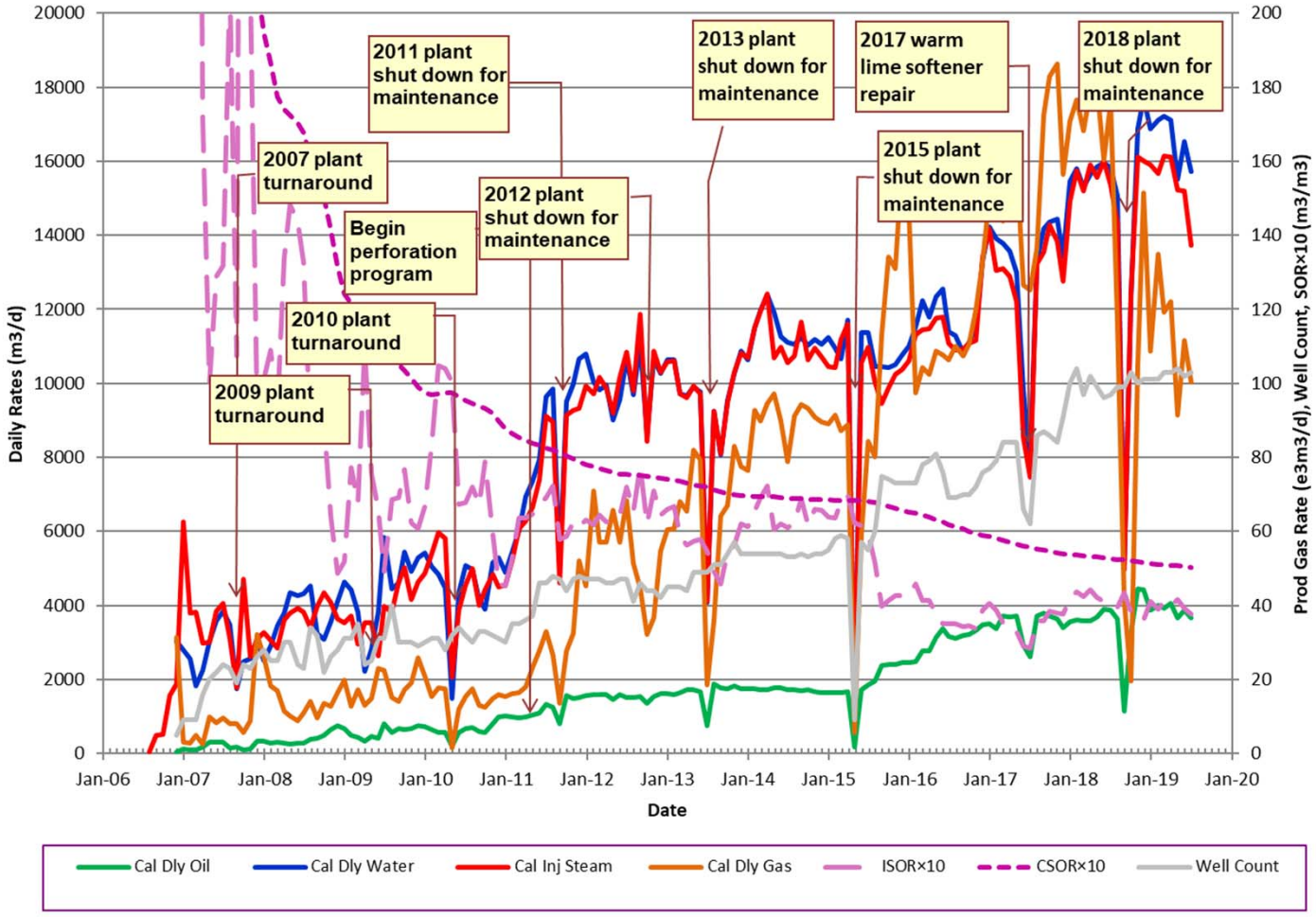
6. 4D Seismic

4D SEISMIC DATA

- No 4D seismic data acquired during the reporting period

7. Scheme Performance

PRODUCTION AND INJECTION HISTORY



7. Scheme Performance

PRODUCTION VS. APPROVAL CAPACITY VARIANCE

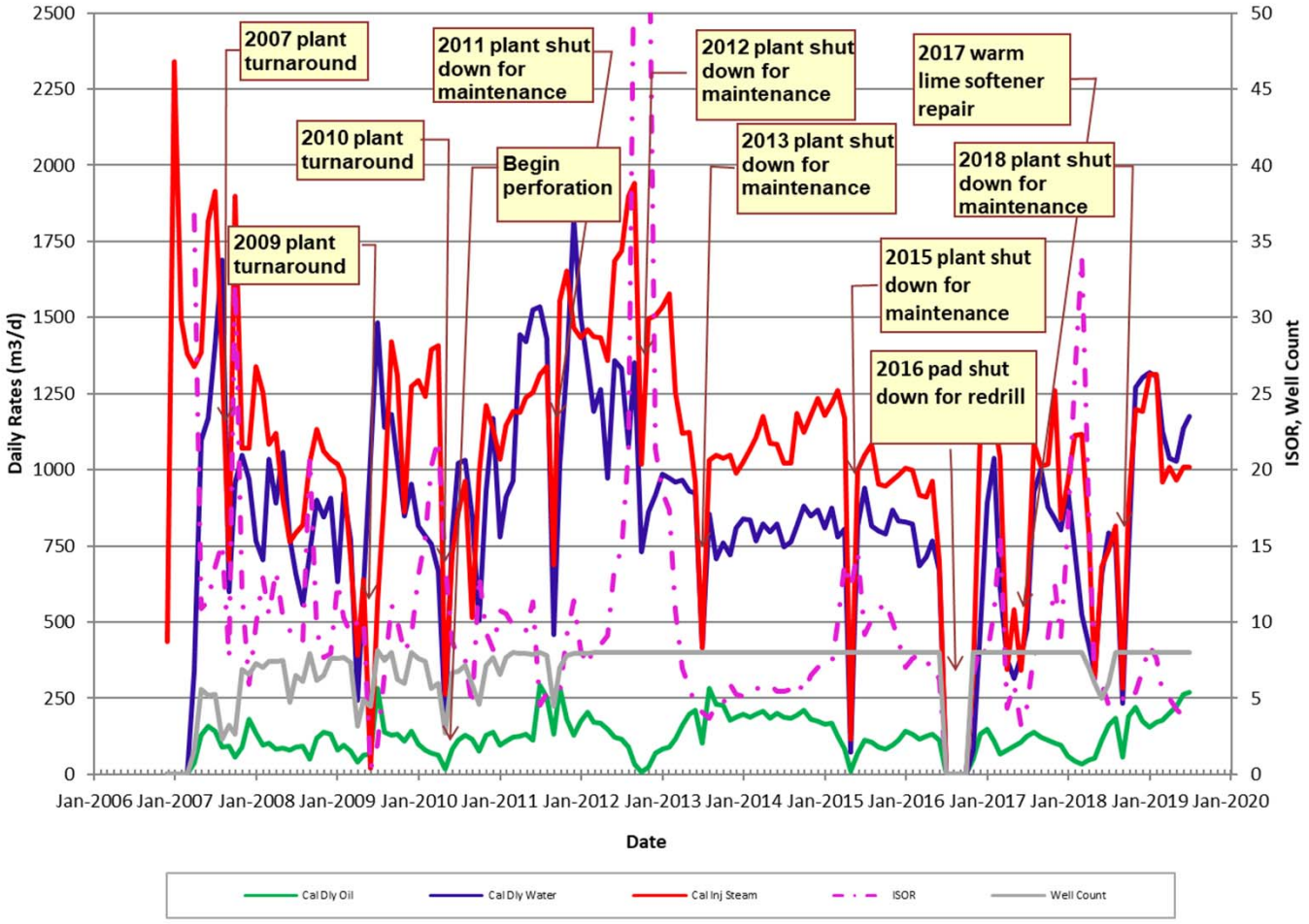
- 32 original well pairs had poor performance due to:
  - Placement in the transition zone where oil saturation is low
  - Poor start-up strategy (bull-heading); currently use circulation

- Since 2008 all well pairs drilled to the base of SAGD net pay

- Revised completion of new wells
  - Dual string completions in both injector and producer
  - Injectors completed with VITs and steam splitters for Pads D and CN
  - Wire Wrapped Screens installed for all new producers to increase open area
  - Blanket gas installed on all wells to provide
    - Insulation
    - Casing protection
    - Down hole pressure measurement

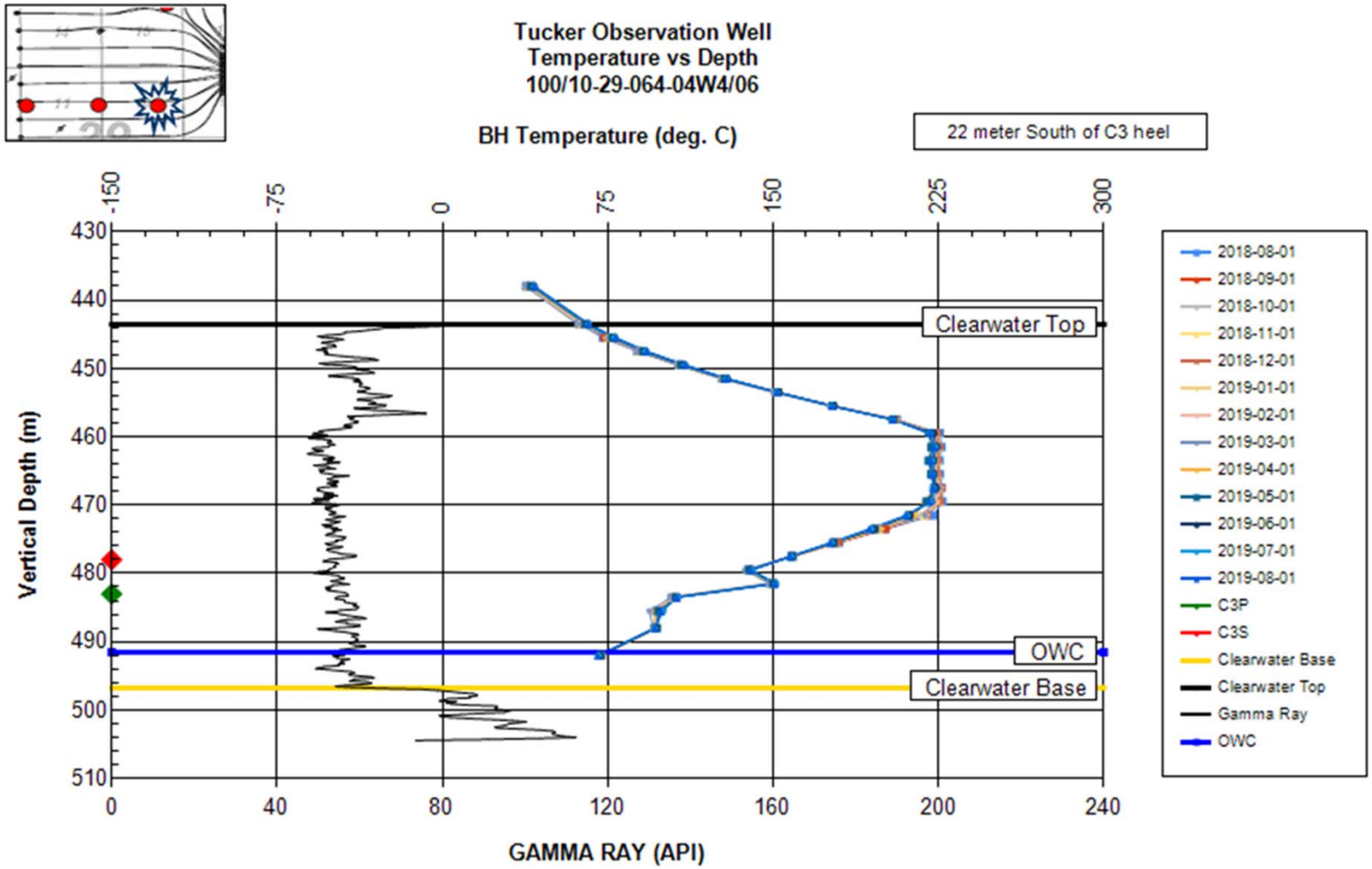
7. Scheme Performance

PAD C WEST PERFORMANCE – LOW RECOVERY EXAMPLE



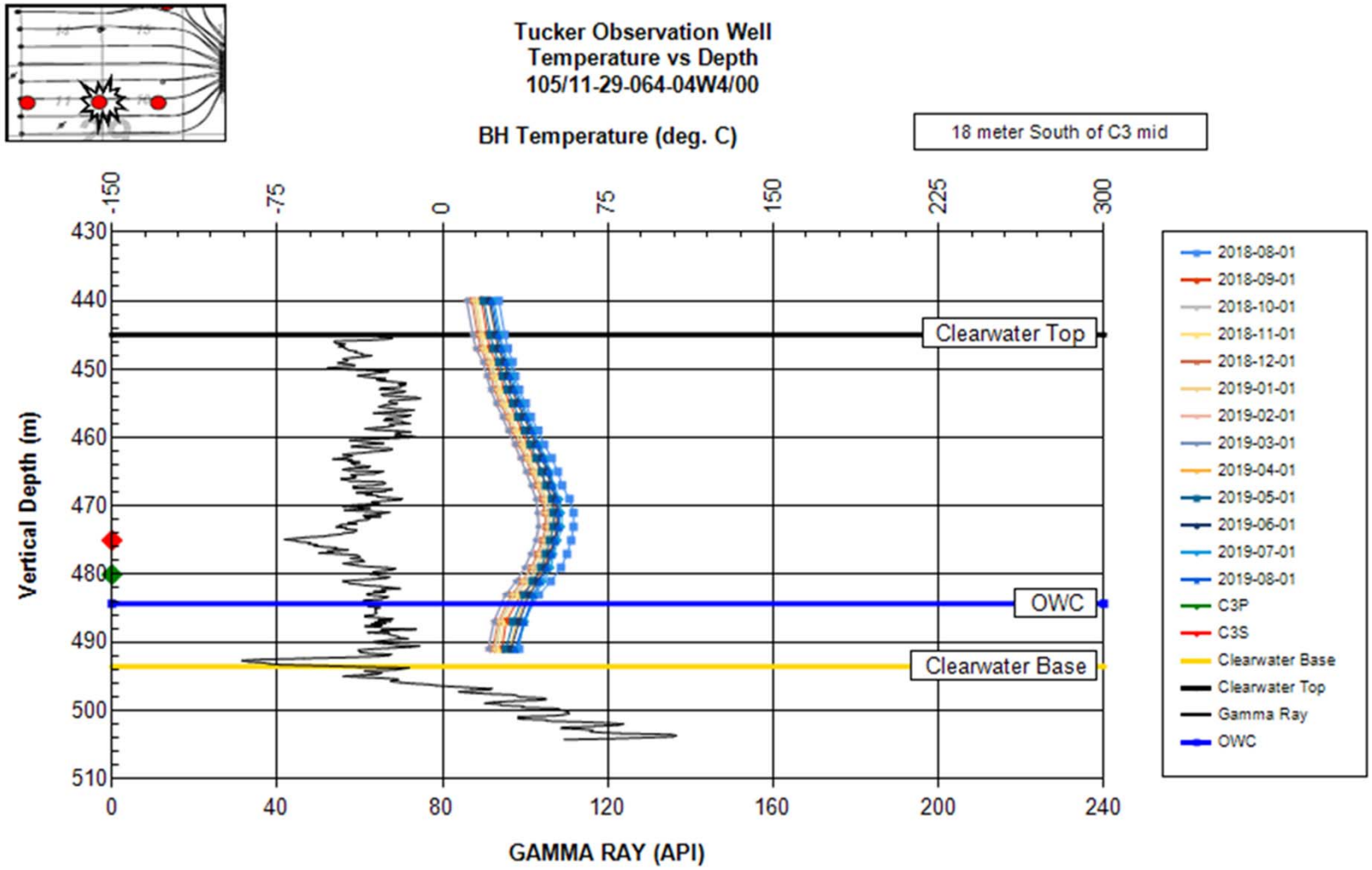
7. Scheme Performance

PAD C WEST HEEL OBSERVATION WELL



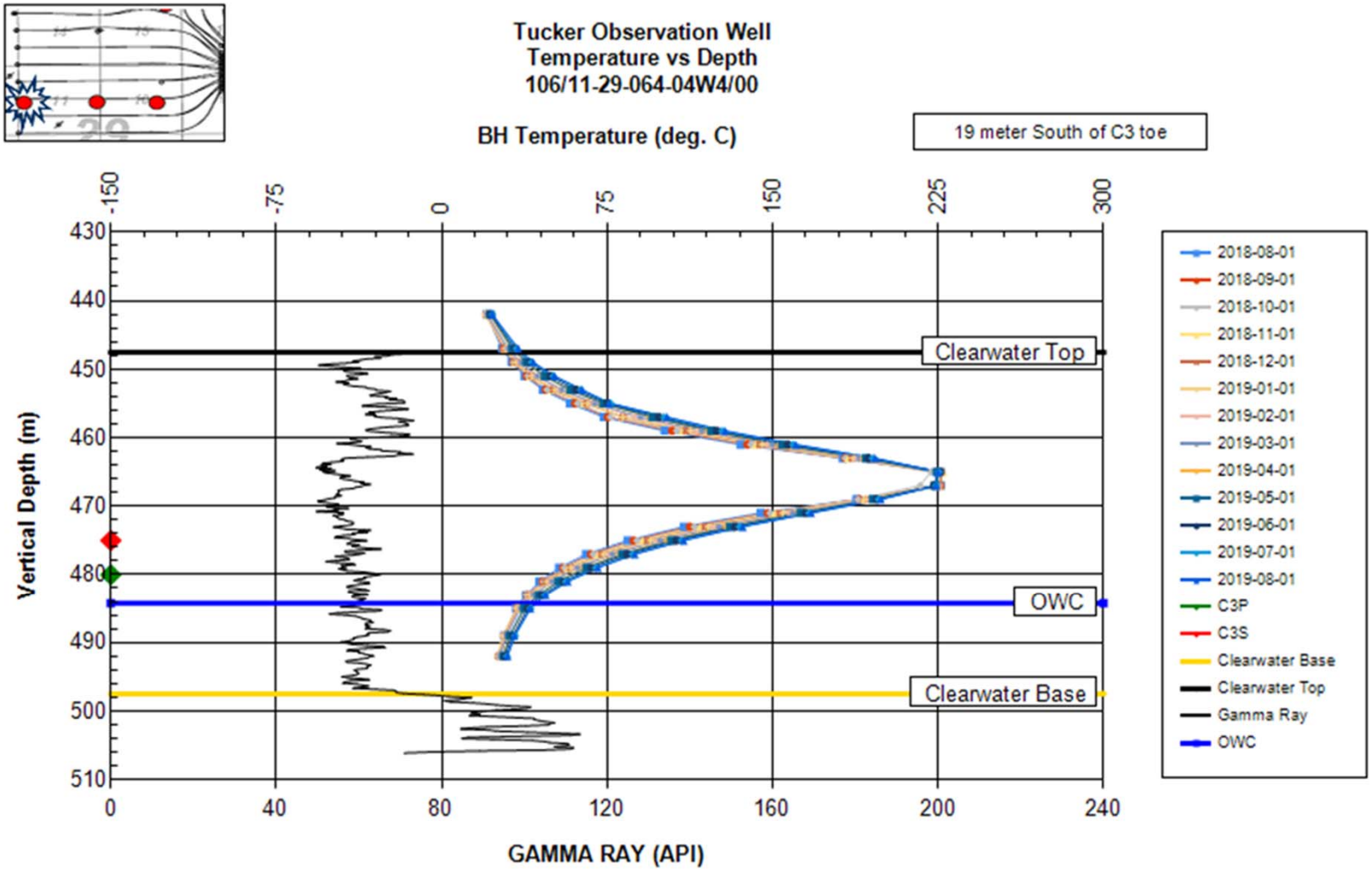
7. Scheme Performance

PAD C WEST MID OBSERVATION WELL



7. Scheme Performance

PAD C WEST TOE OBSERVATION WELL



7. Scheme Performance

DISCUSSION OF PAD C WEST WELL PERFORMANCE

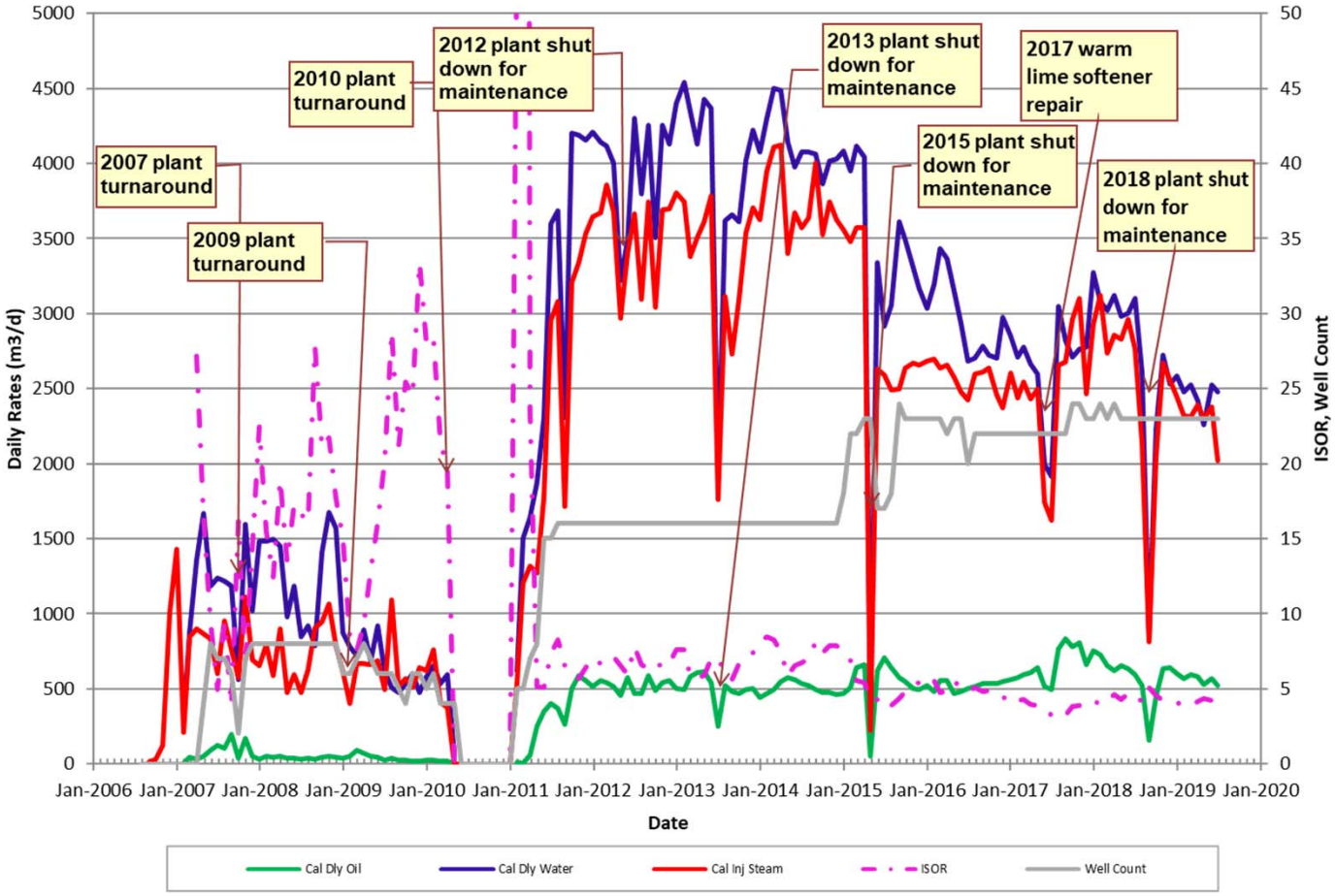
- The 3 OBS wells along well pair C3 indicates non-uniform steam chamber development

- Pad C West performance indicators as of July 31, 2019:
  - Cum Oil: 565,171 m^3
  - Cum Steam Injected: 4,851,564 m^3
  - Cum Water Produced: 3,878,196 m^3
  - CSOR: 8.6

- Pad C West performance for the reporting period:
  - Cum Oil: 69,644 m^3
  - Oil Rate per well: 23.8 m^3/day
  - SOR: 5.2

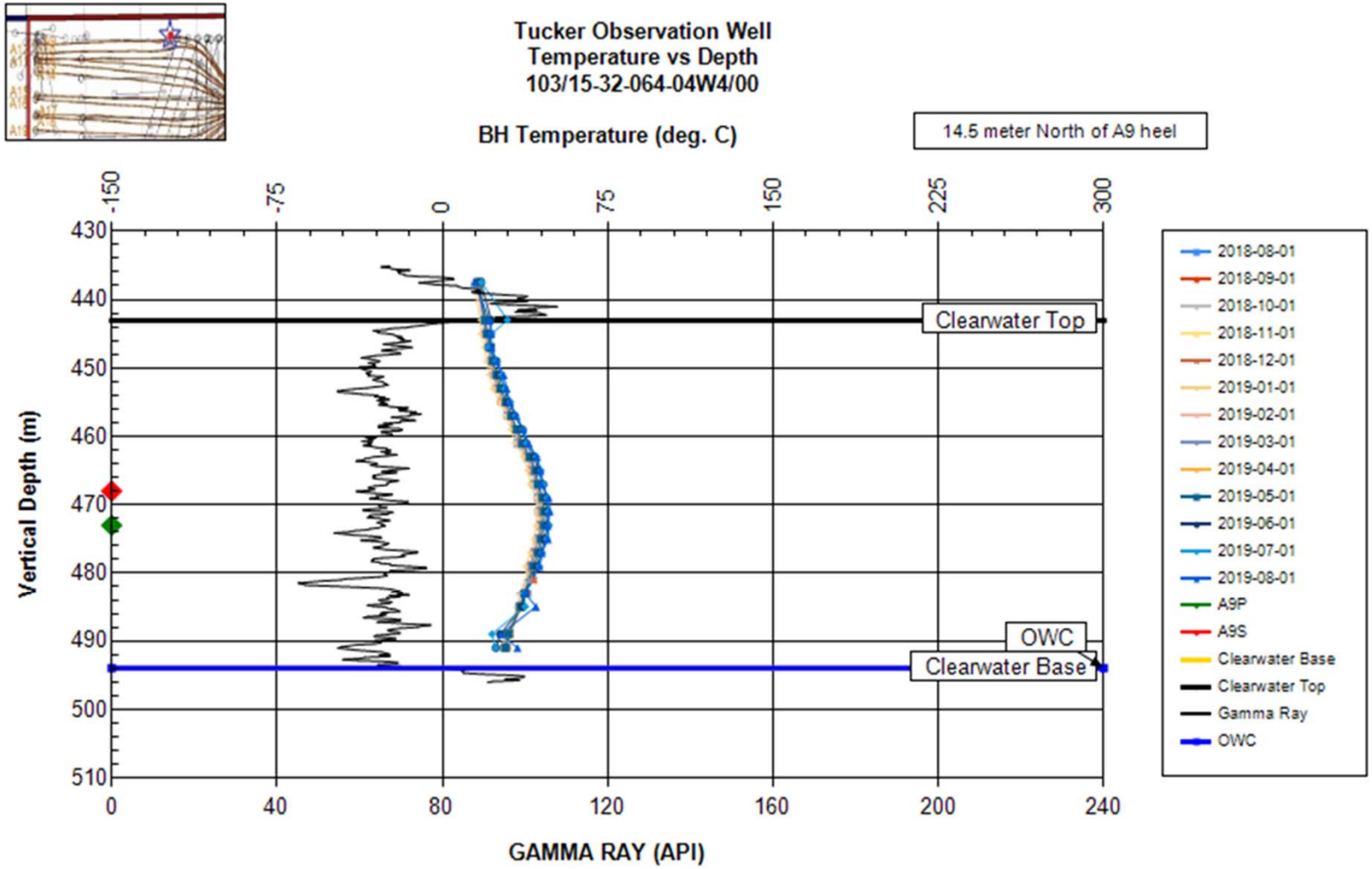
7. Scheme Performance

PAD A PERFORMANCE – MEDIUM RECOVERY EXAMPLE



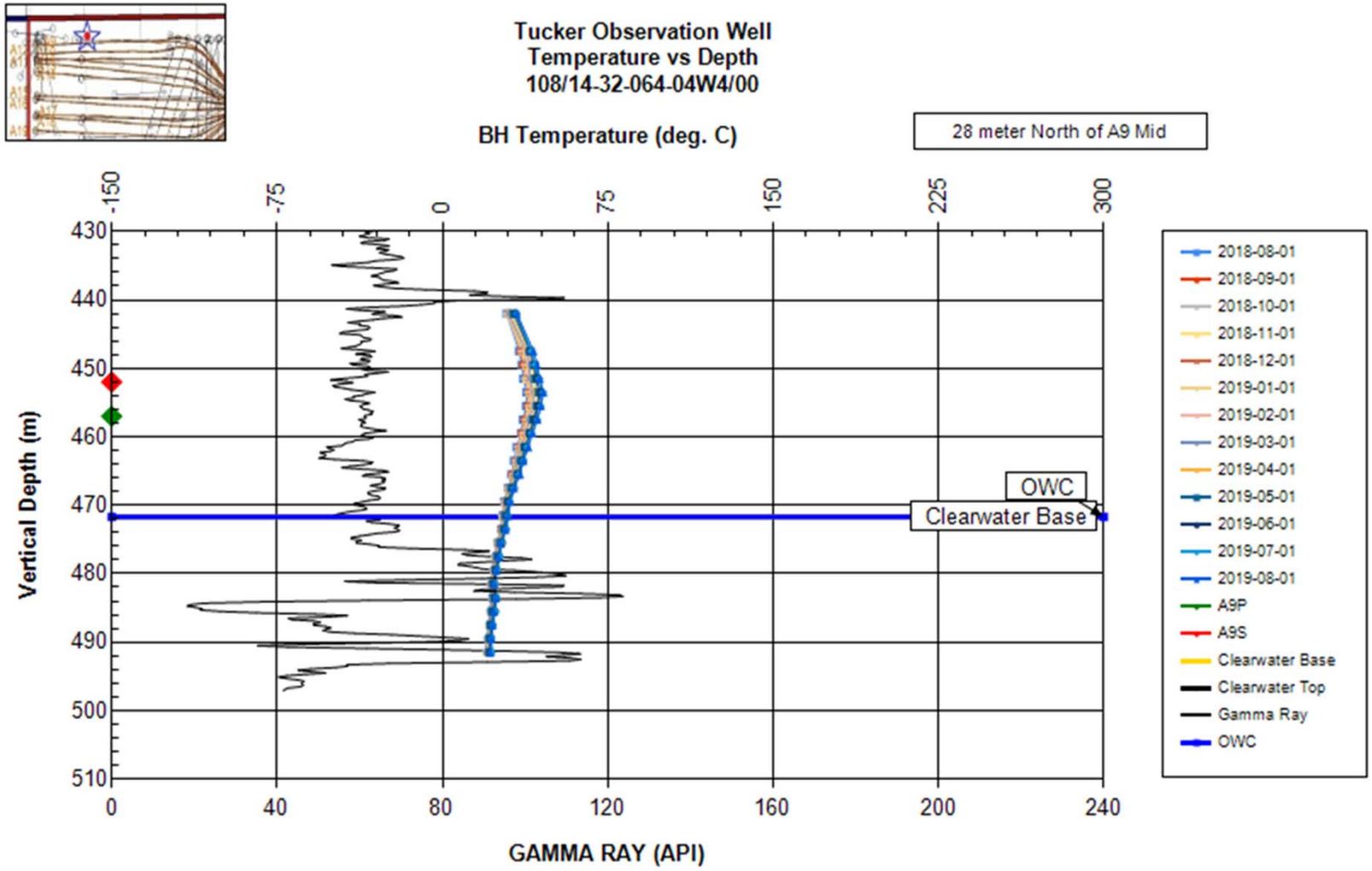
7. Scheme Performance

PAD A WELLS HEEL OBSERVATION WELL



7. Scheme Performance

PAD A WELLS MID OBSERVATION WELL



7. Scheme Performance

DISCUSSION OF PAD A WELL PERFORMANCE

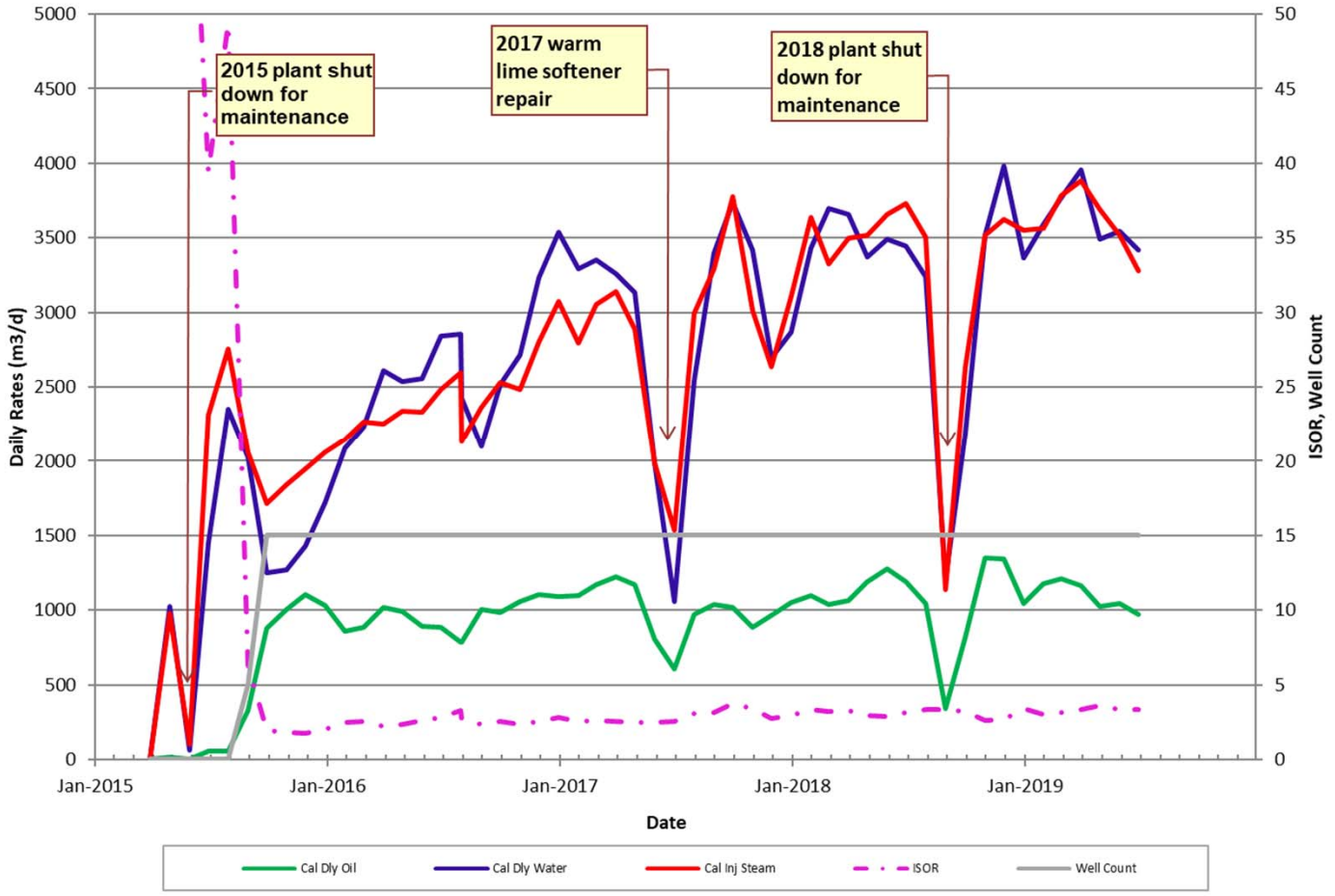
- The 2 OBS wells near well pair A9 indicates minimal steam chamber development

- Pad A performance indicators as of July 31, 2019:
  - Cum Oil: 1,669,491 m^3
  - Cum Steam Injected: 11,025,038 m^3
  - Cum Water Produced: 9,532,943 m^3
  - CSOR: 5.7

- Pad A performance for the reporting period:
  - Cum Oil: 193,996 m^3
  - Oil Rate per well: 23.1 m^3/day
  - SOR: 4.1

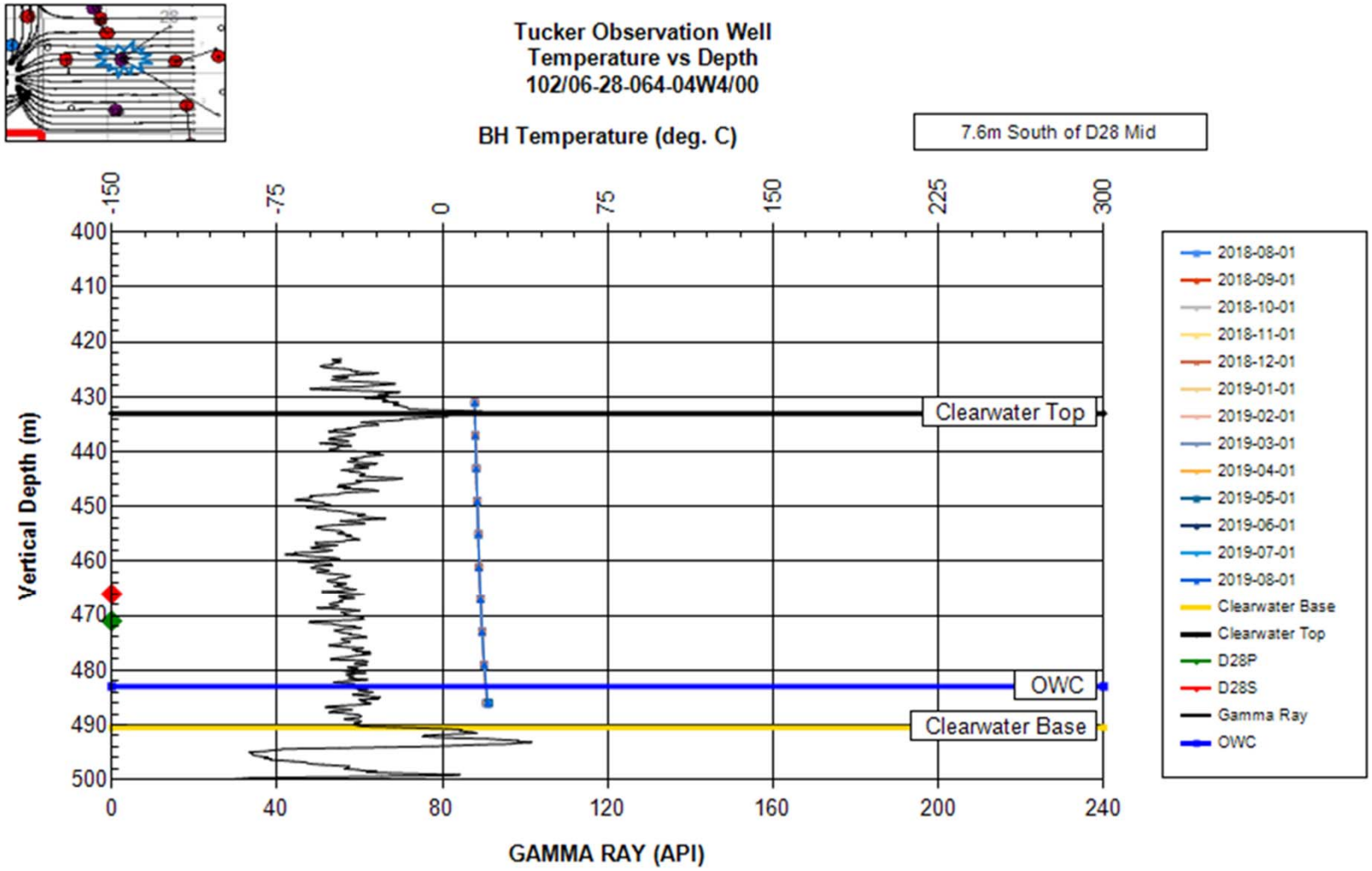
7. Scheme Performance

PAD D EAST PERFORMANCE – HIGH RECOVERY EXAMPLE



7. Scheme Performance

PAD D EAST MID OBSERVATION WELL



7. Scheme Performance

DISCUSSION OF PAD D EAST PERFORMANCE

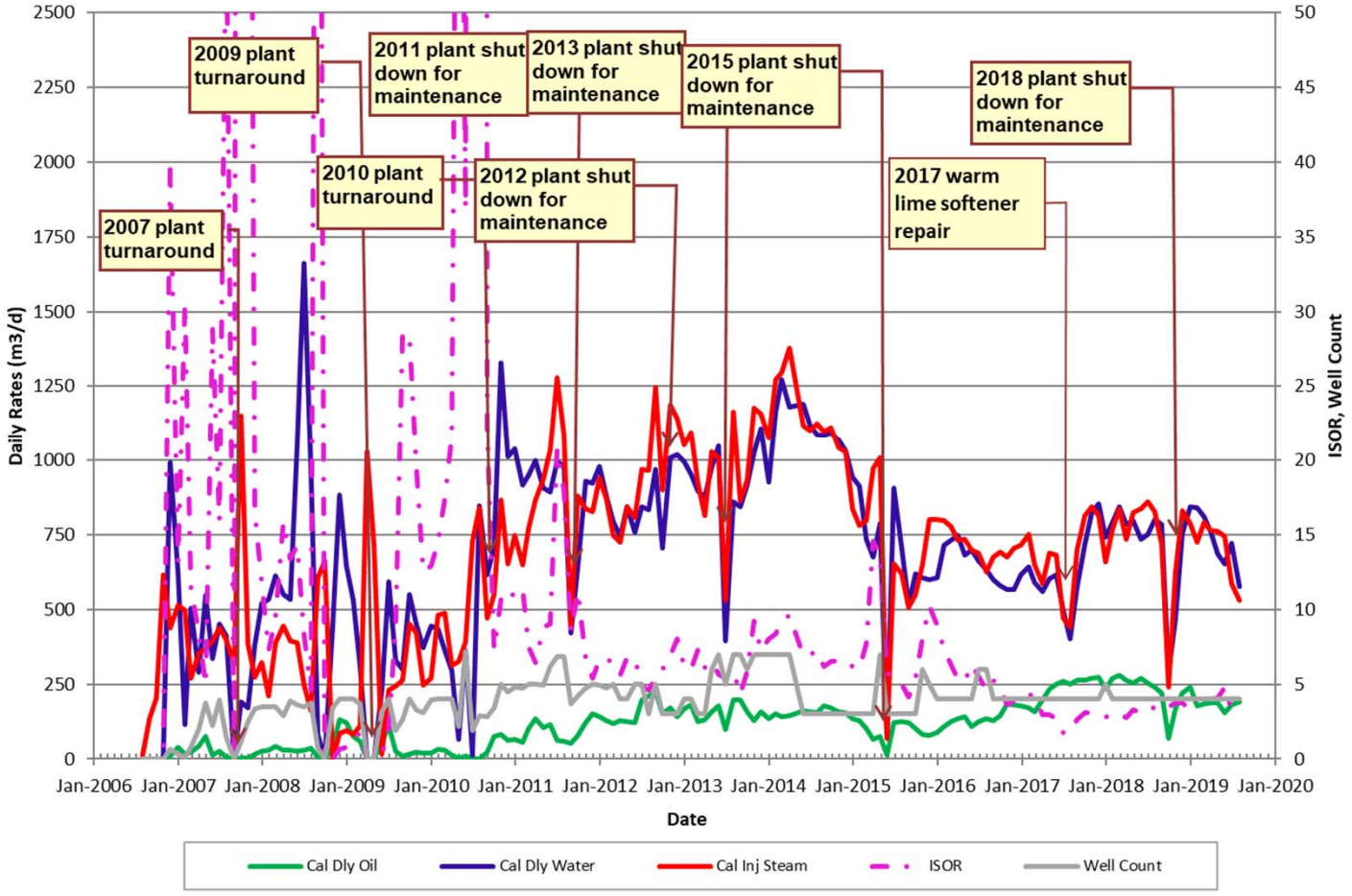
- Since steam injection commenced in Q2 2015, high temperature has not been observed at the OBS well

- Pad D East performance indicators as of July 31, 2019:
  - Cum Oil: 1,467,273 m^3
  - Cum Steam Injected: 4,348,673 m^3
  - Cum Water Produced: 4,320,229 m^3
  - CSOR: 3.0

- Pad D East performance for the reporting period:
  - Cum Oil: 381,437 m^3
  - Oil Rate per Well: 69.6 m^3/day
  - SOR: 3.2

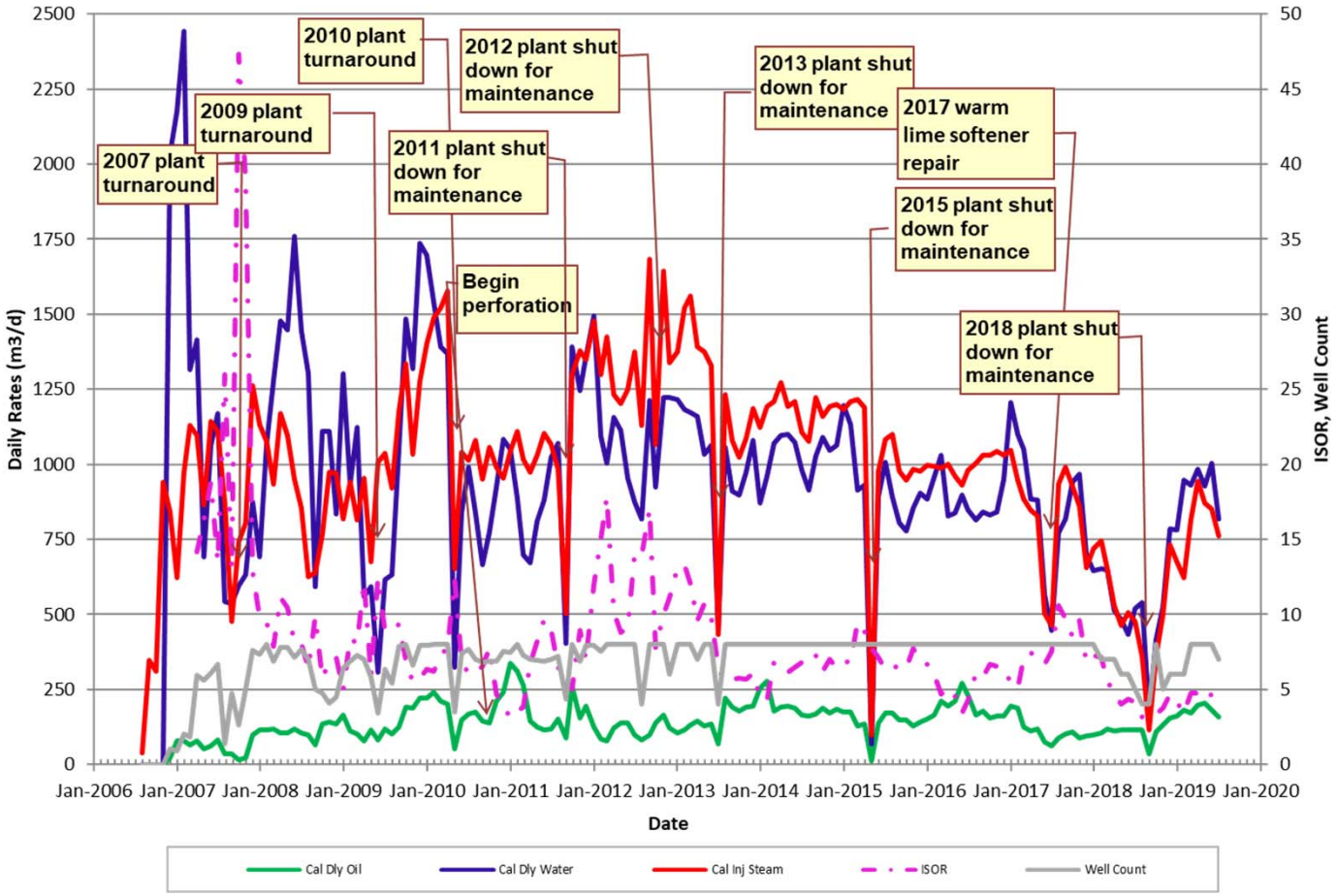
7. Scheme Performance

PAD B NORTH PERFORMANCE



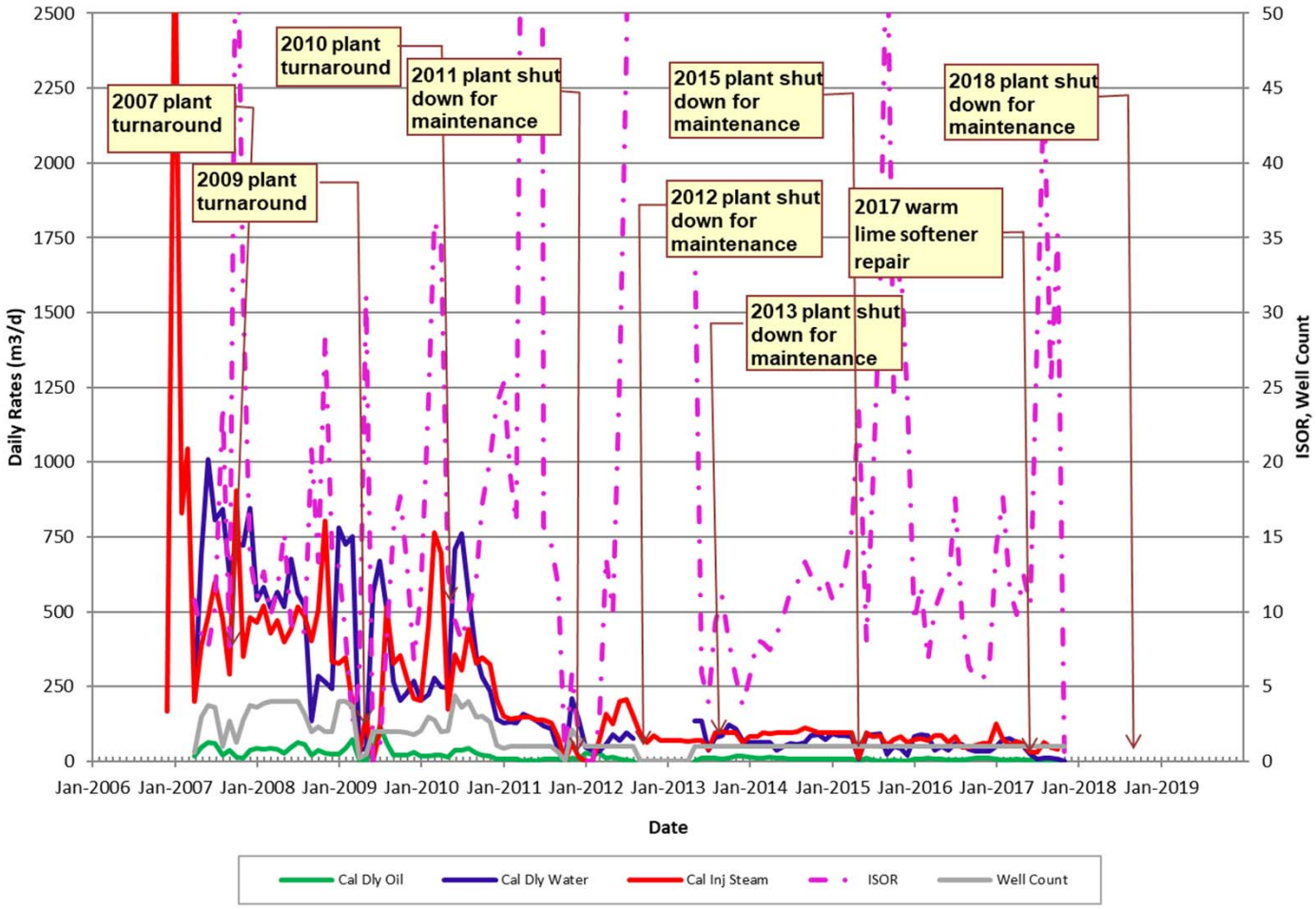
7. Scheme Performance

PAD B WEST PERFORMANCE



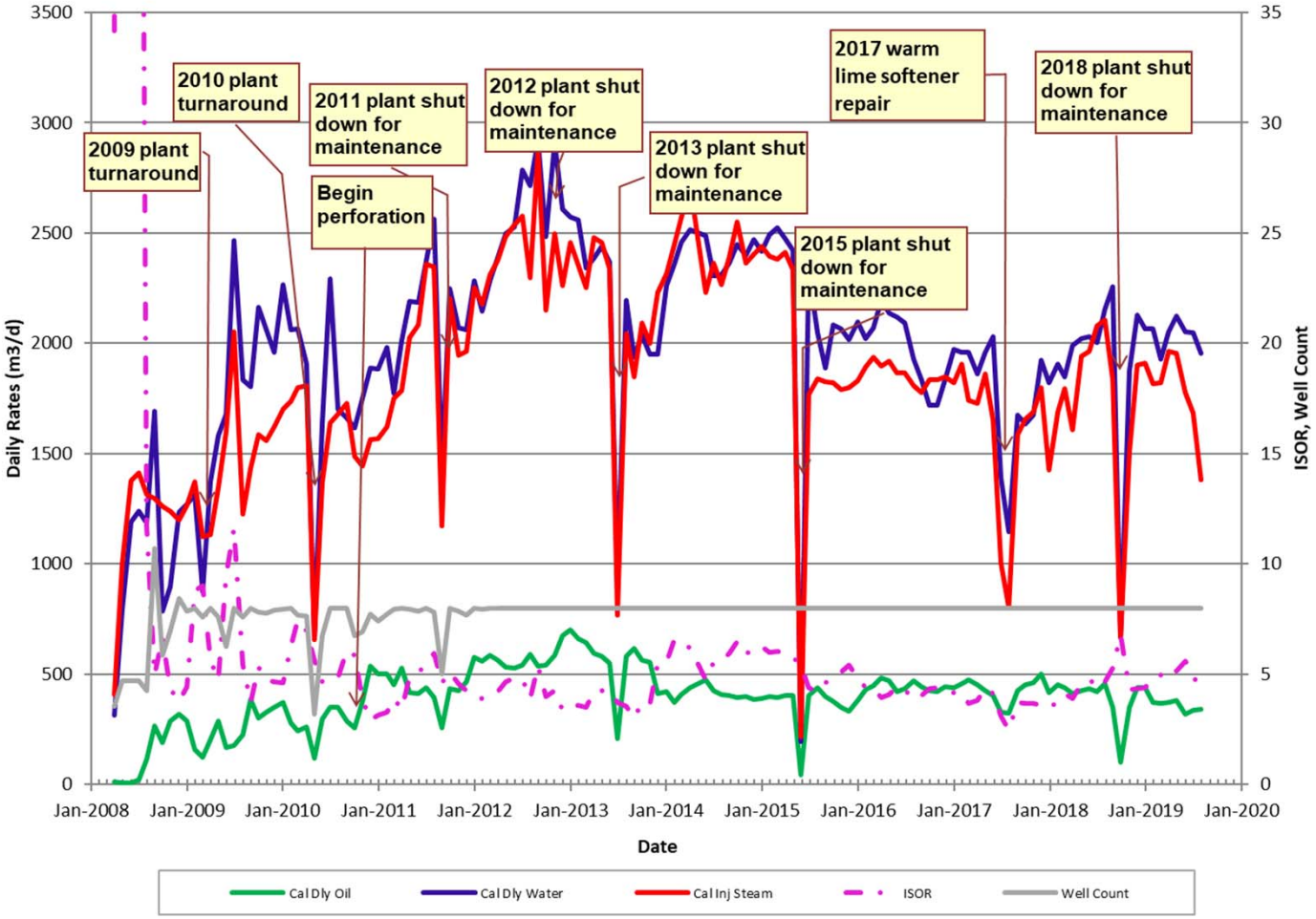
7. Scheme Performance

PAD C NORTH PERFORMANCE



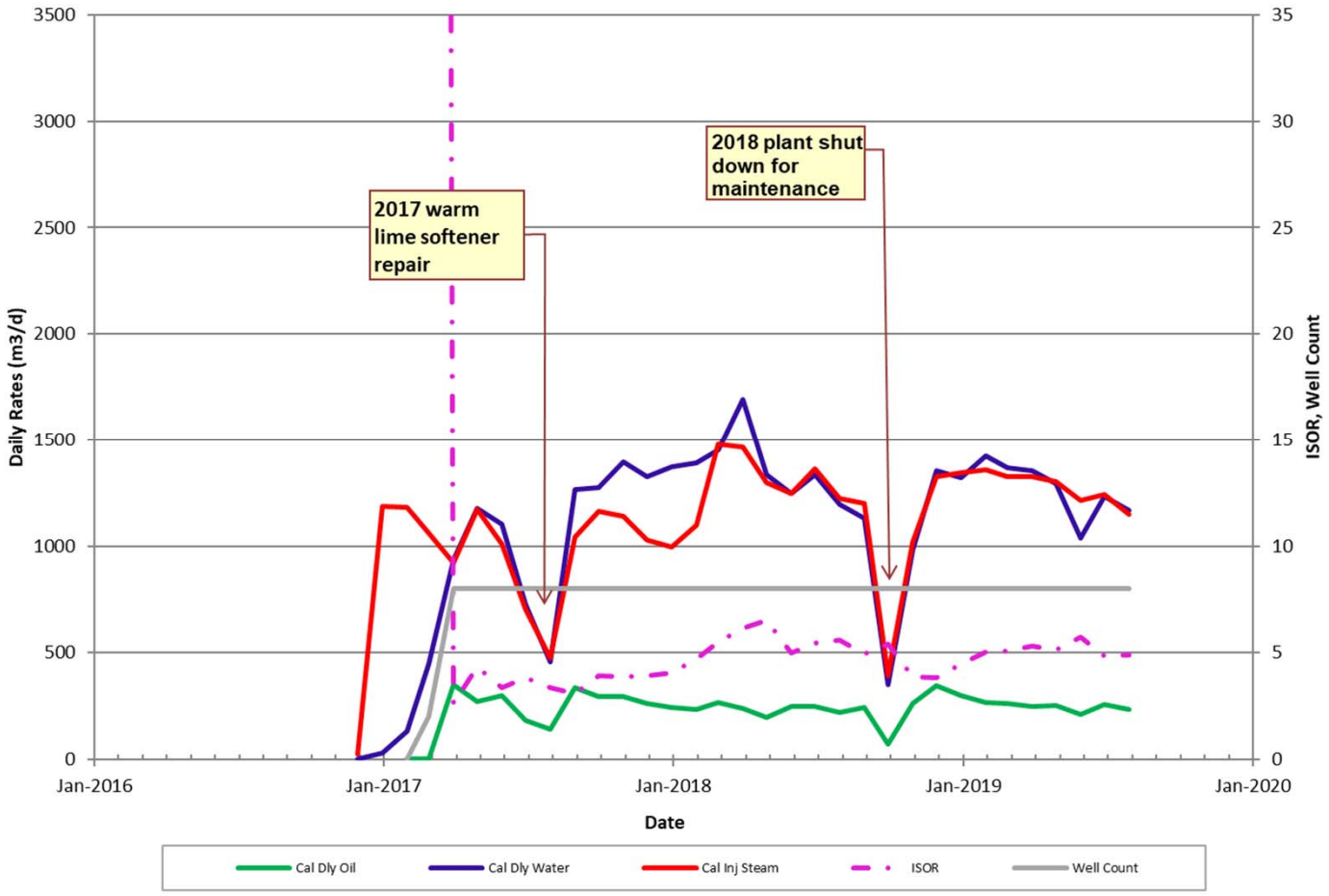
7. Scheme Performance

PAD C EAST PERFORMANCE



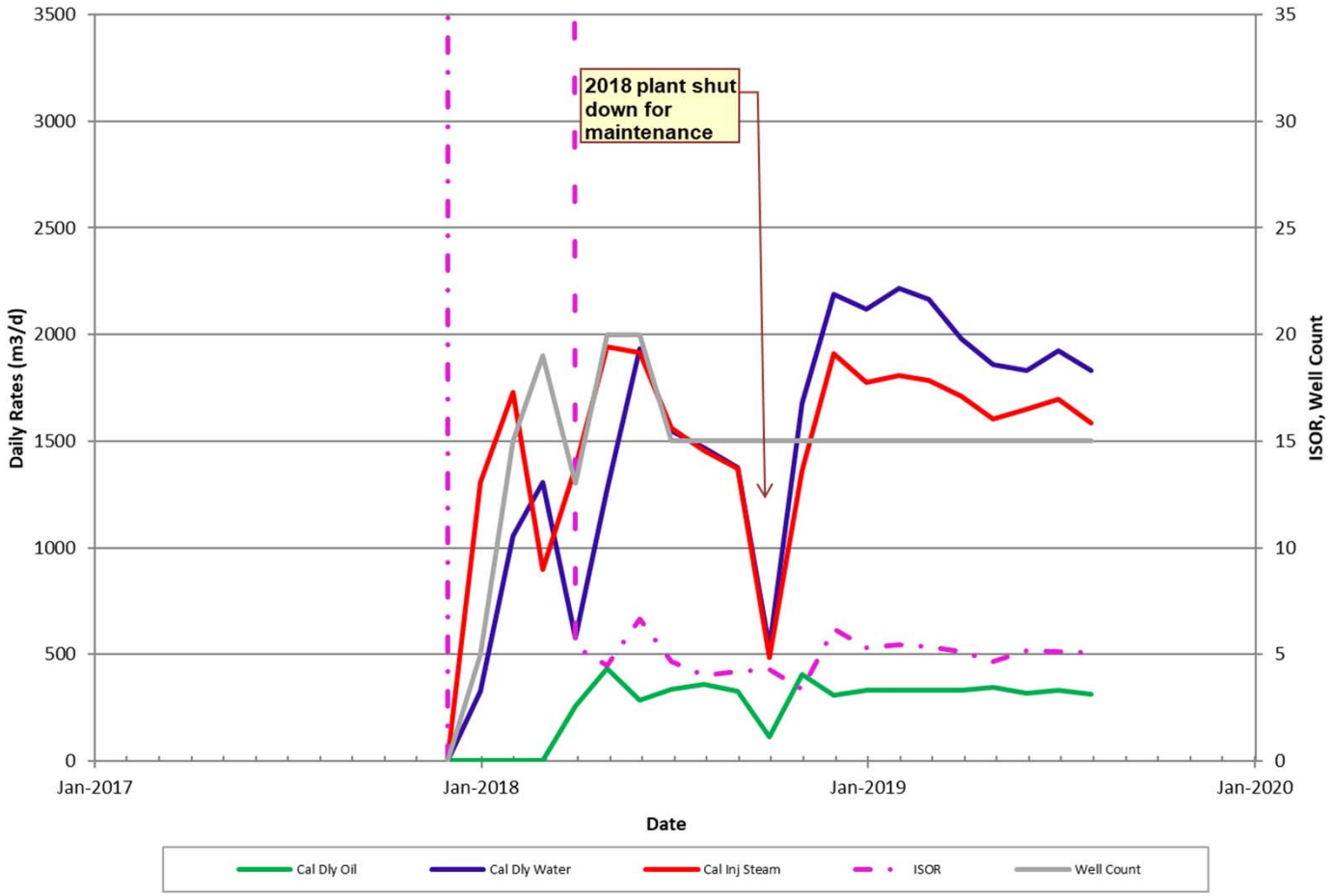
7. Scheme Performance

PAD D NORTH PERFORMANCE



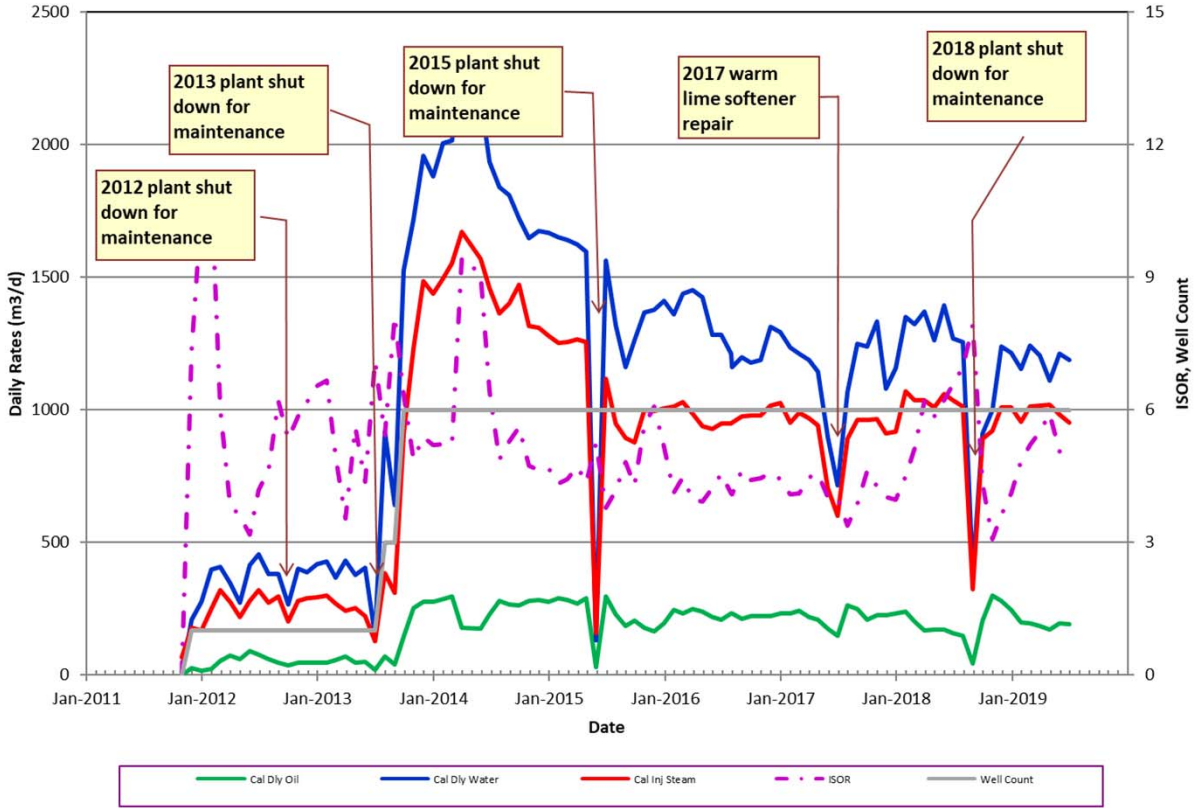
7. Scheme Performance

PAD D WEST PERFORMANCE



7. Scheme Performance

PAD LOWER GRAND RAPIDS (GA) PERFORMANCE



- The water-steam-ratio is attributed to high water mobility and bottom water
- Operating strategy at or slightly below the bottom water pressure to maintain the reservoir pressure and optimize steam efficiency
- Steam injection rates are optimized on a weekly basis based on well performance and total water produced from each well pair

7. Scheme Performance

DISCUSSION OF PAD GA PERFORMANCE

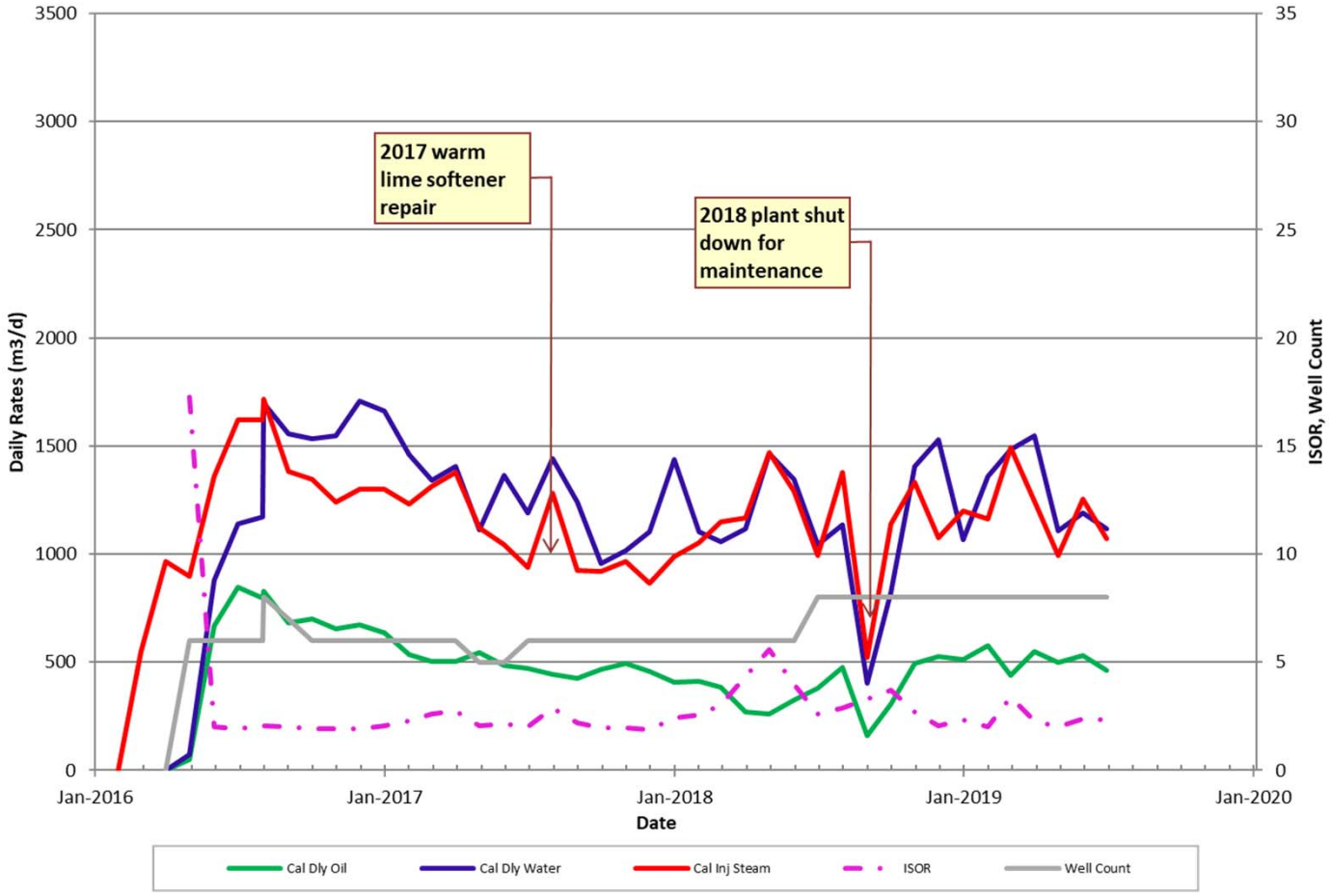
- Pilot well started in September 2011
- Remaining 5 well pairs started up September 2013

- Pad GA performance indicators as of July 31, 2019:
  - Cum Oil: 501,771 m^3
  - Cum Steam Injected: 2,422,842 m^3
  - Cum Water Produced: 3,167,203 m^3
  - CSOR: 4.8

- Pad GA performance for the reporting period:
  - Cum Oil: 71,510 m^3
  - Oil Rate per well: 32.6 m^3/day
  - SOR: 4.7

7. Scheme Performance

PAD COLONY (CN) PERFORMANCE



7. Scheme Performance

DISCUSSION OF PAD CN PERFORMANCE

- First steam in February 2016
- 6 SAGD well pairs and 7 infill wells
- 2 infill wells started in August 2018

- Pad CN performance indicators as of July 31, 2019:
  - Cum Oil: 603,506 m^3
  - Cum Steam Injected: 1,499,616 m^3
  - Cum Water Produced: 1,502,240 m^3
  - CSOR: 2.5

- Pad CN performance for the reporting period:
  - Cum Oil: 168,426 m^3
  - Oil Rate per well: 57.6 m^3/day
  - SOR: 2.5

7. Scheme Performance

NEW DEVELOPMENT

- Pad Lower Grand Rapids B (GB) Amendment Application (1913172) submitted to AER in September 2018; received approval October 31, 2018
  - Category 1 Amendment Application (1919681) submitted to AER on March 12, 2019; received approval March 14, 2019
- Clearwater Development Amendment Application (1920247 and 010-00147753) submitted to AER on April 4, 2019; pending approval

7. Scheme Performance

OBIP AND RECOVERIES BY WELL PAD

- OBIP for each pad is calculated from the formula:

$$OBIP = L \times W \times H \times (1-S_w) \times \Phi \times 1/B_o$$

Where

L = Effective Average Length of wells
W = Lateral Width covered by the wells
H = Thickness from the top of pay to the producer elevation
Φ = Average Porosity in the Pay zone
S_w = Average Water Saturation in the Pay zone
B_o = Oil Volume factor/Shrinkage factor (taken as 1)

7. Scheme Performance

OBIP AND RECOVERIES BY WELL PAD

Well PAD		Thickness (m)	Area (10^3 m^2)	Pad Volume[1] (10^3 m^3)	So	PhiE	OBIP (10^6 m^3)	Recovery to Date 7/31/2019 (10^3 m^3)	Recovery Factor to Date (%)	Estimated Ultimate Recovery (10^6 m^3)	Ultimate Recovery Factor (%)
Pad A	A Infills and Replacement (16 well pairs)	30	880	30.6	0.56	0.32	5.5	1680	31	2.7	50
	A original (8 well pairs)	7	640								
Pad B	B West (8 well pairs)	37	640	39.8	0.57	0.32	7.3	1198	16	3.6	50
	B North (4 well pairs)	8	320								
	B North Infills (3 well pairs)	40	345								
Pad C	C West (8 well pairs)	36	640	53.8	0.60	0.32	10.3	2255	21	5.2	50
	C North Original[2] (4 well pairs)	10	320								
	C East (8 well pairs)	43	640								
Pad D	D East (15 well pairs)	43	660	28.1	0.61	0.32	5.5	1466	27	2.7	50
	D North (8 well pairs)	36	330	11.8	0.61	0.33	2.4	222	9	1.2	50
	D west (15 well pairs)	31	578	17.9	0.63	0.32	3.6	167	5	1.8	50
Pad GA (6 well pairs)		30	355	10.6	0.62	0.30	2.0	502	25	1.0	50
Pad CN (6 well pairs + 7 infill)		13	502	6.5	0.82	0.29	1.6	604	38	0.8	50

Note:
OBIP – Volume x So x Phi-E (Thickness defined from top of pay to 8% bitumen weight or producer level where wells are below 8% bitumen weight)
[1] Due to rounding of values, the calculated values may not equal the individual values presented in the table
[2] Pad C North future development not included in the table. The OBIP is equal to $1.1X10^6$ m^3

7. Scheme Performance

5-YEAR OUTLOOK OF EXPECTED PAD ABANDONMENT

- No pad abandonment anticipated in the next 5 years

7. Scheme Performance

TEMPERATURE, PRESSURE AND QUALITY OF STEAM

- High pressure steam separator delivers steam at a 100% quality
- Steam quality losses are experienced during transportation to the pads
- Steam quality at the wellhead is estimated to be 95%

7. Scheme Performance

COMPOSITION OF OTHER INJECTED/PRODUCED FLUIDS

- Not applicable for the reporting period

7. Scheme Performance

SUMMARY OF KEY LEARNINGS

- Well placement is key for well performance
- Circulation is the optimal start-up strategy for establishing thermal communication
- Wire-wrapped screens are used to avoid scaling problem of the production liner
- Steady operating conditions are key to obtaining good steam chamber conformance
- To maintain steady operations and prevent water inflow a constant operating pressure is needed

8. Future Plans

FUTURE PLANS 2019/2020

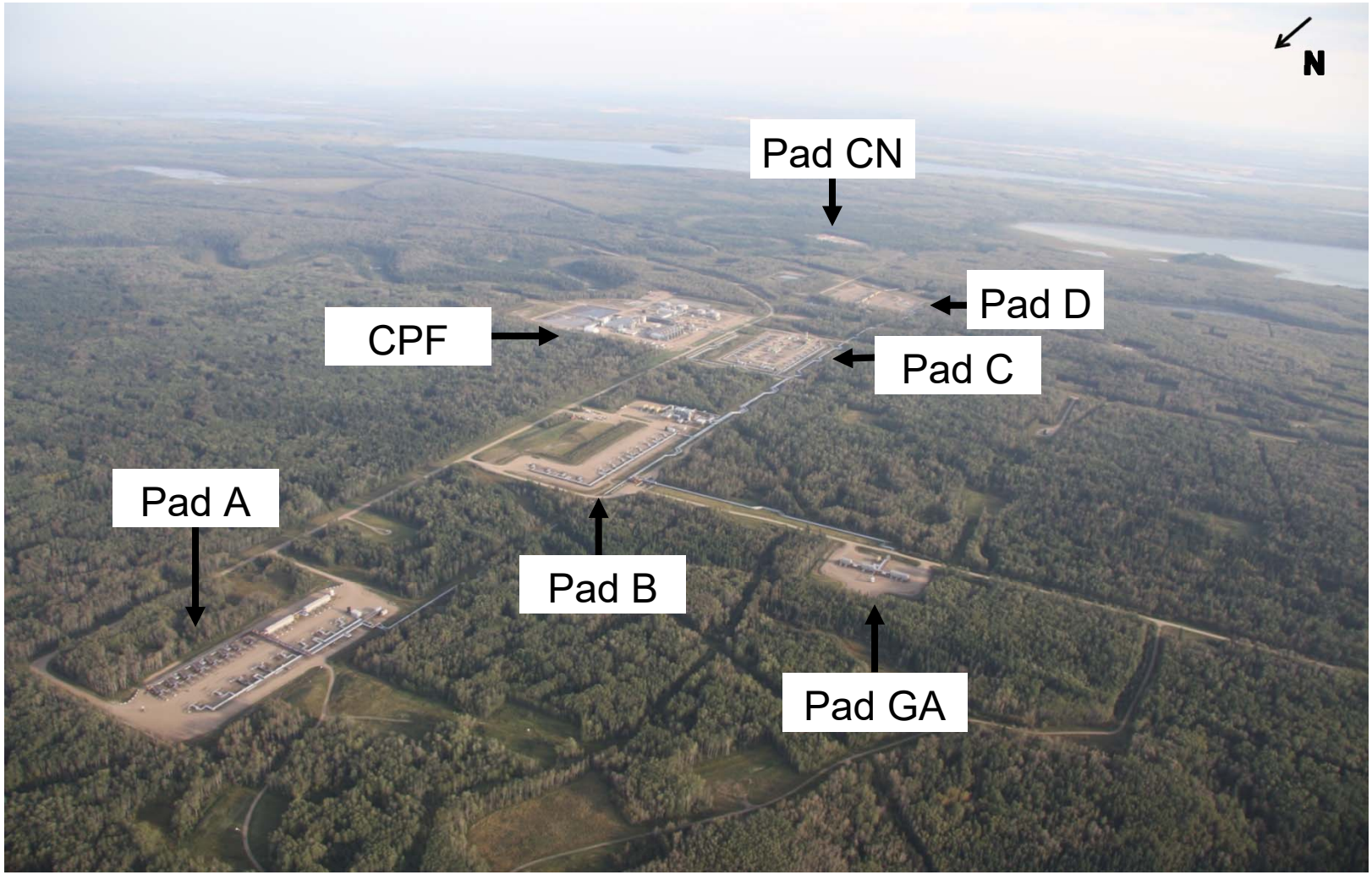
- Pad Colony Infill Wells:
  - Commence start-up in Q4 2019
- Pad B West Replacement Wells:
  - Future development based upon the performance of Pad C West Replacement wells
- Pads E and F (Clearwater Development):
  - Lease construction Q4 2019; pending AER Approval
  - Drilling to commence in Q2/Q3 2020; pending AER Approval
- Strat Well Drilling Program:
  - 1 well in Q4 2019
  - 2 wells in Q1/Q2 2020
- Pad C North Future Development:
  - On-going evaluation of strategies for optimizing the resource recovery

3.1.2 Surface

TABLE OF CONTENTS

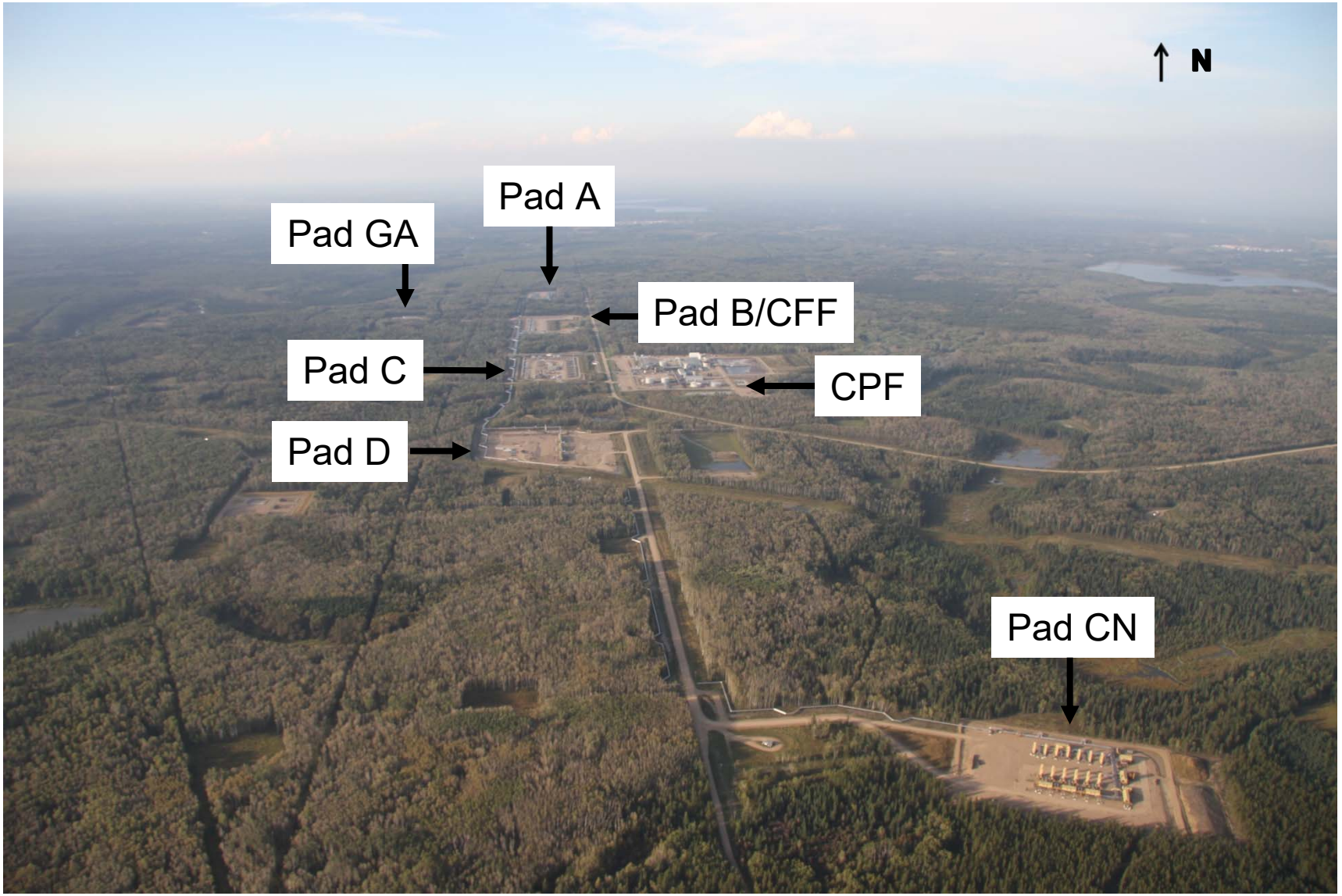
1. Facilities

LAYOUT – SOUTHEAST



1. Facilities

LAYOUT - NORTH



1. Facilities

CENTRAL PROCESSING FACILITY (CPF)

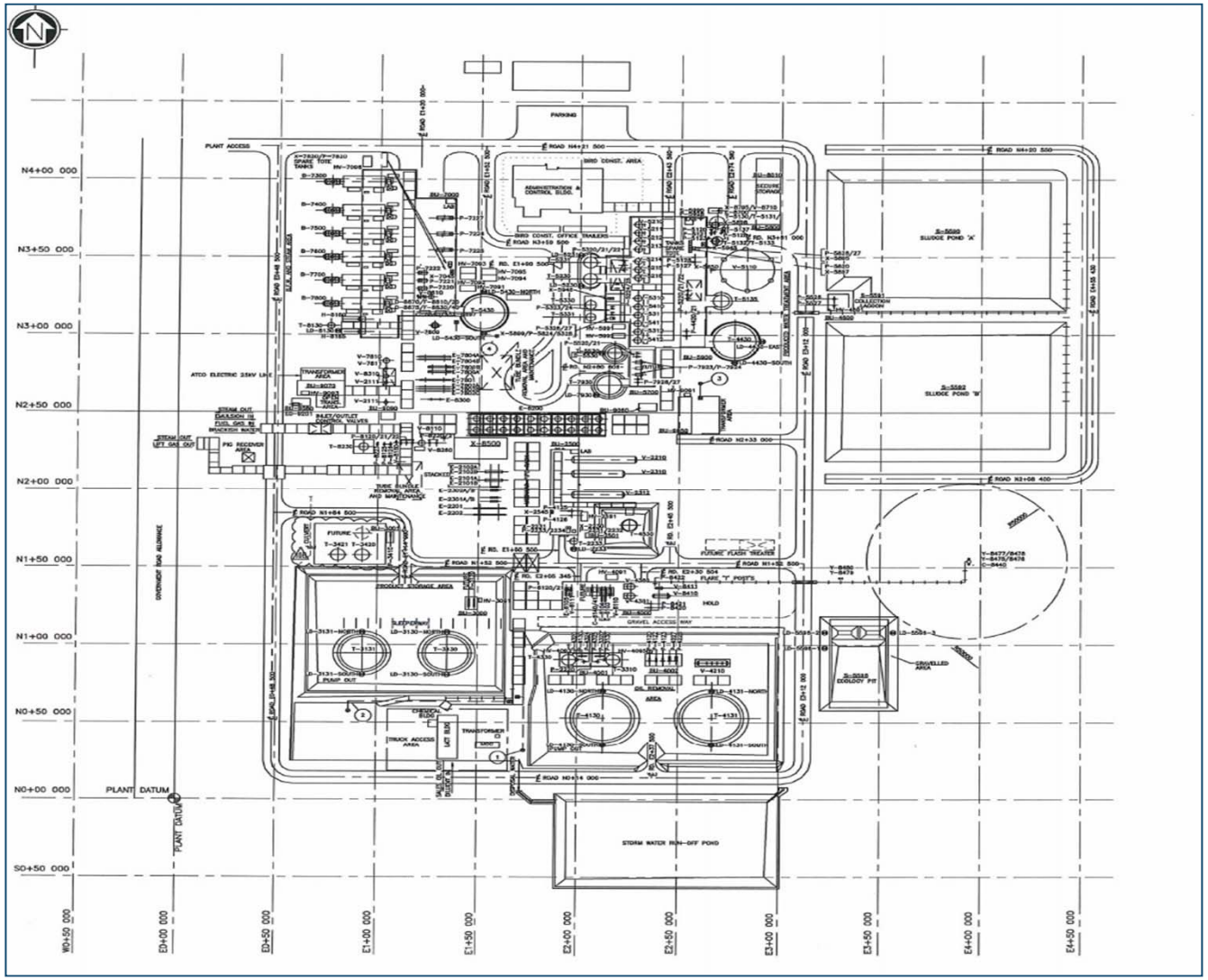
1. Facilities

CENTRAL FIELD FACILITIES (CFF)

N

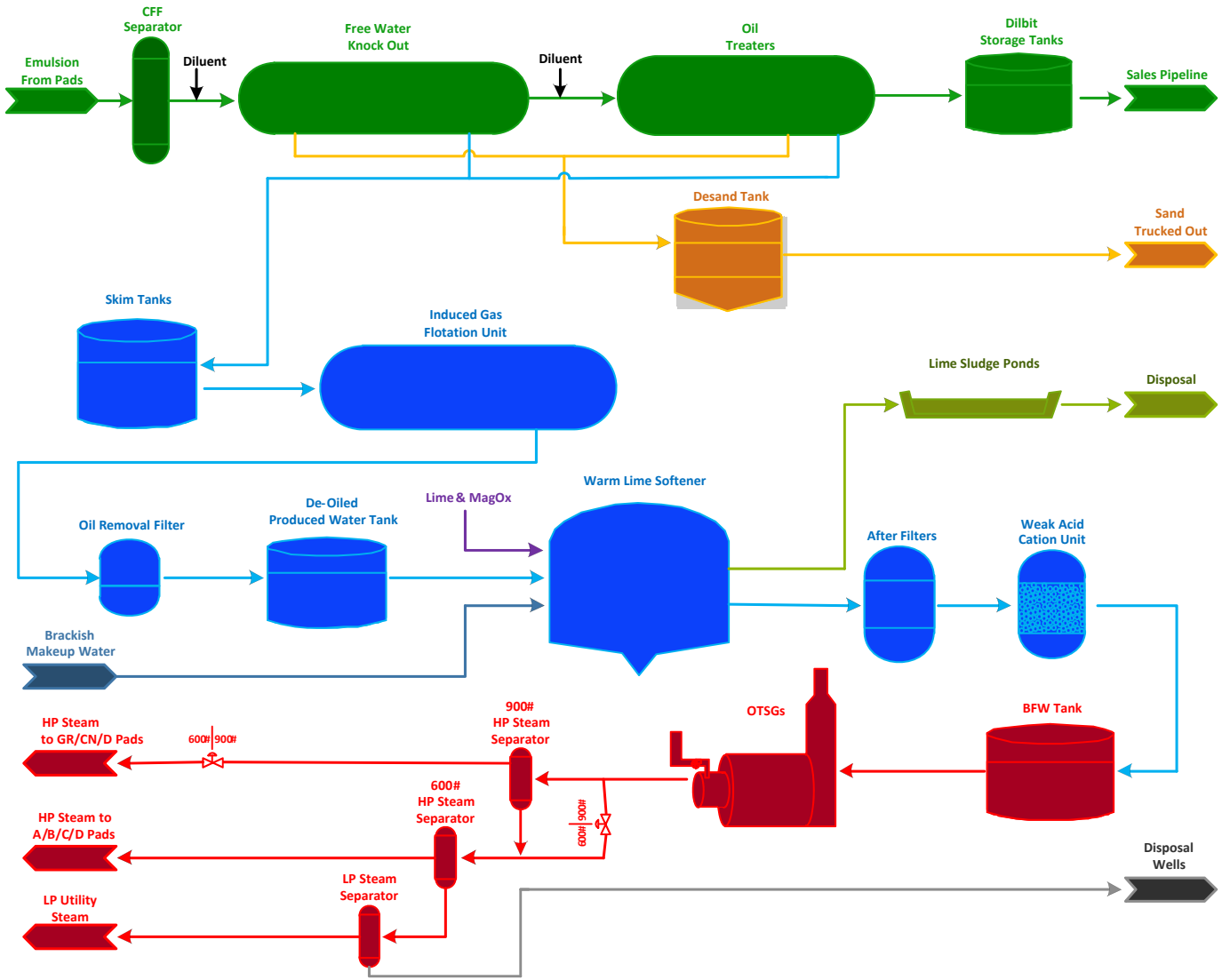
1. Facilities

CENTRAL PROCESSING FACILITY - PLOT PLAN



1. Facilities

FACILITY SCHEMATIC



1. Facilities

FACILITY MODIFICATIONS

- Produced Gas Handling System (AER Approval No. 9835U) - Debottleneck (CPF and associated CFF modifications): to increase the capacity of handling produced gas from the field and to increase the volume of lift gas being used by:
  - CPF:
    - Replaced the existing produced gas scrubber, including associated modifications to piping and valves
    - Replaced the low pressure/high pressure (LP/HP) flare stack, flare header, and the flare knock out drum
    - Expanded the existing glycol cooler by adding two glycol cooler bays
  - CFF modifications: (AER authorization received via email December 13, 2017)
    - Installed a new 10'' produced gas pipeline, which will twin the existing 10'' line between the central process facility (CPF) and the central field facility (CFF) providing additional flow capacity
    - Increased the CFF Inlet Separator inlet nozzle size from 30" to 36"
    - Increased the CFF Produced Gas Separators (2) outlet nozzle size from 8" to 12"
    - Increased the produced gas piping line size from 10" to 16" from the CFF Produced Gas Separators to the existing and new 10" pipeline

2. Facility Performance

OPERATING LIMITATIONS

- Production curtailment initiated by the provincial government
- Temporary diluent supply outages
- Temporary low delivery-pressure of lift gas by third-party provider

2. Facility Performance

PROCESS WATER DE-OILING

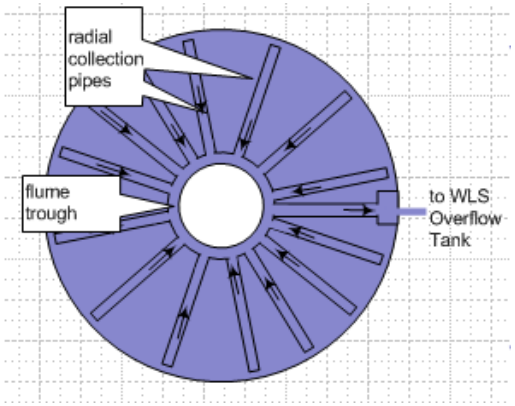
- The de-oiling process consists of 2 skim-tanks (in series), IGF and 2 oil-removal-filters

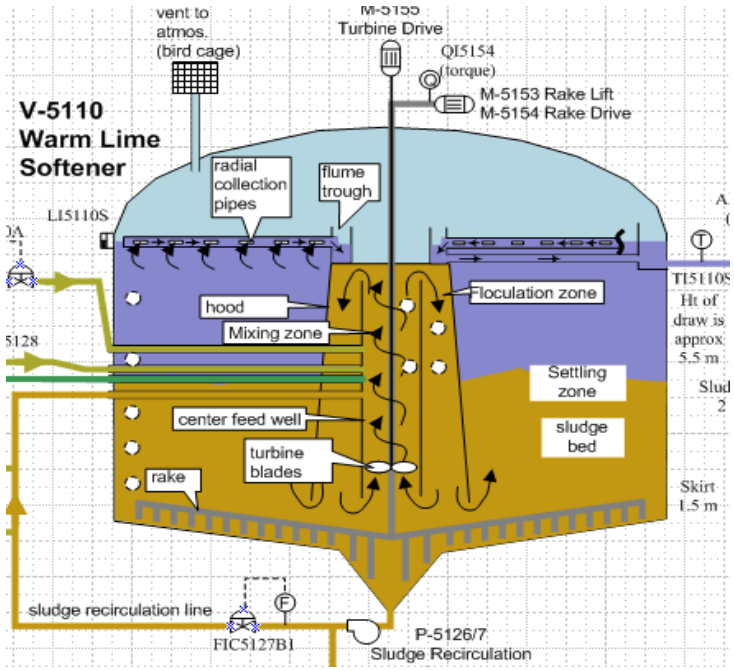
- De-Oiling TSO KPI's:
  - FWKO – 1,000 ppm (average 480 ppm)
  - IGF Inlet – 100 ppm (average 52 ppm)
  - IGF Out – 40 ppm (average 50 ppm)
  - ORF Outlet – 20 ppm (average 18 ppm)

2. Facility Performance

WARM LIME SOFTENER (WLS)

- Primary water treatment to produce boiler feed water
- Feed sources:
  1. De-oiled produced water
  2. Brackish water make-up
  3. Sludge pond water
- Reduces water contaminants:
  1. Hardness - primarily Calcium and Magnesium
  2. Silica - main contaminant due to thermal recovery process
  3. Turbidity - suspended solids
- Produces sludge as waste product - stored in ponds
- Mechanical turbine, rake drives
- Main zones: Mixing, Reaction, Settling
- Produces water effluent with hardness ~20 ppm and silica ~50 ppm





2. Facility Performance

WLS CHEMISTRY / PERFORMANCE

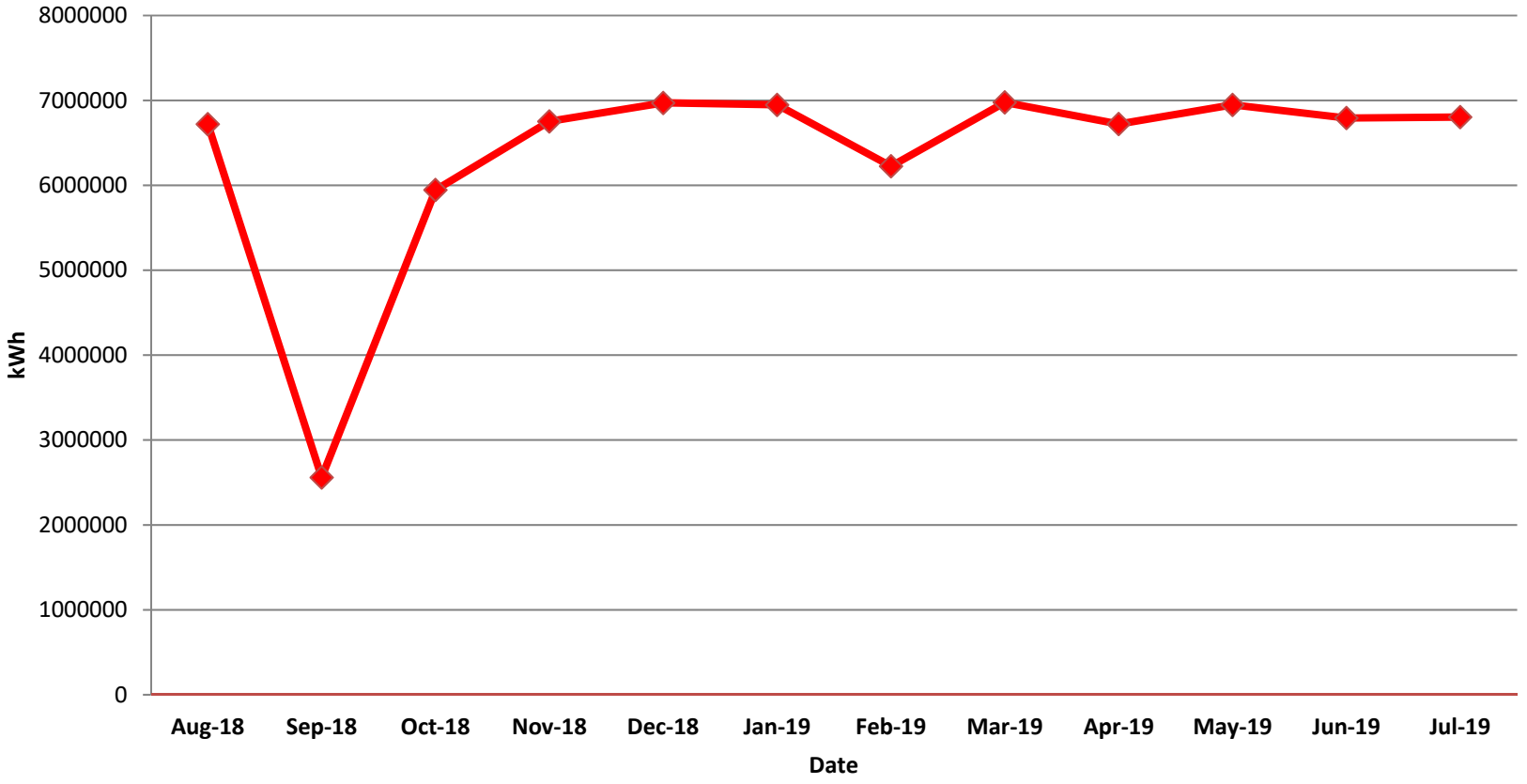
- Chemistry:
  - Lime – primary hardness control
  - Magnesium Oxide (MagOx) – primary silica reduction
  - Caustic – water pH control, aids softening
  - Sodium Carbonate (soda ash) – permanent hardness removal
  - Polymer – coagulants and flocculants establish sludge bed control

- Performance:
  - The WLS has performed well to date

- Key KPIs:
  - Soluble Hardness – 25 ppm (average 14 ppm)
  - Silica – 50 ppm (average 45 ppm)
  - Turbidity – 20 NTU (average 21 NTU)

2. Facility Performance

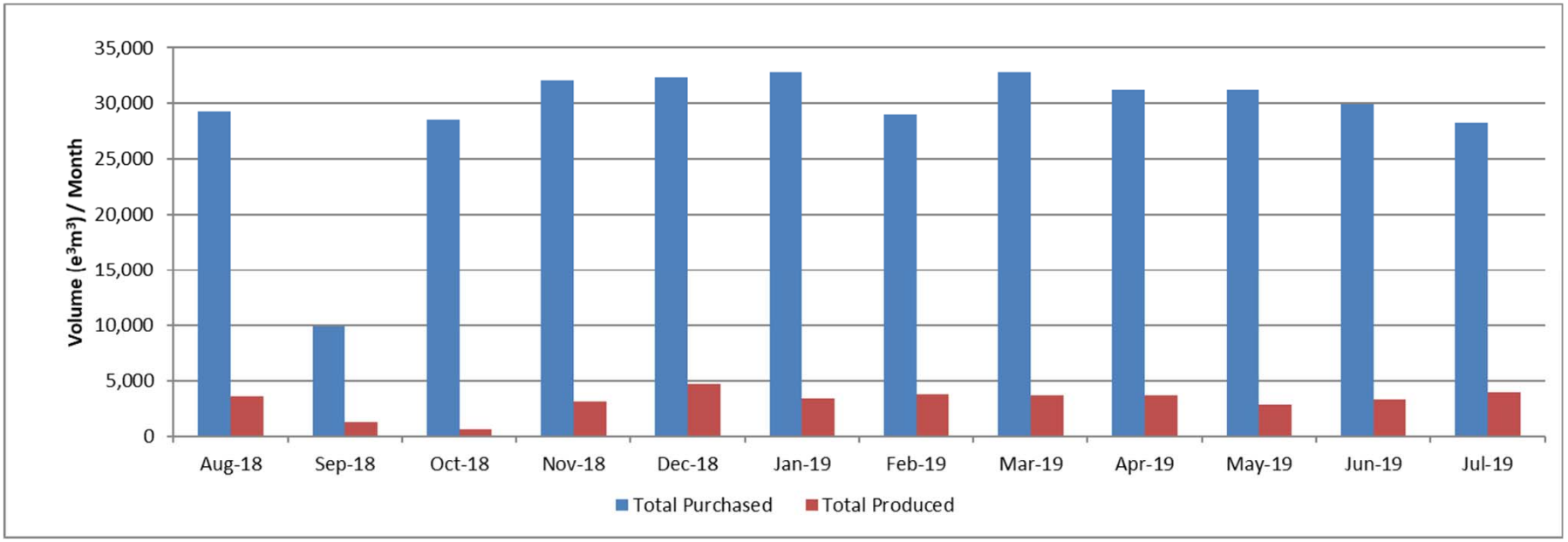
POWER CONSUMPTION



- September 2018 – lower power consumption due to facility shut-in for maintenance

2. Facility Performance

GAS USAGE

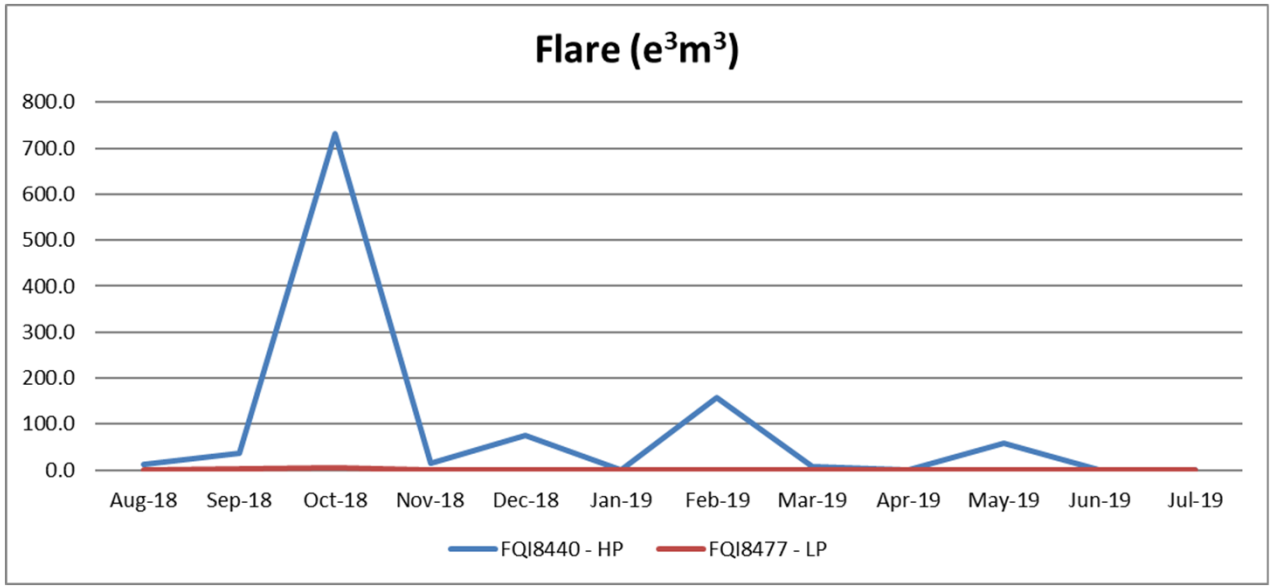


2. Facility Performance

FLARING AND VENTING

- 3 flaring events that were either over 4 hours in duration or over a volume of 30,000 m^3
  - October 5, 2018; OneStop ID 410668, Facility start-up; shut-in for maintenance
  - October 12, 2018; Onestop ID 413276, Facility start-up; shut-in for maintenance
  - October 23, 2018 – OneStop ID 417673, Facility upset

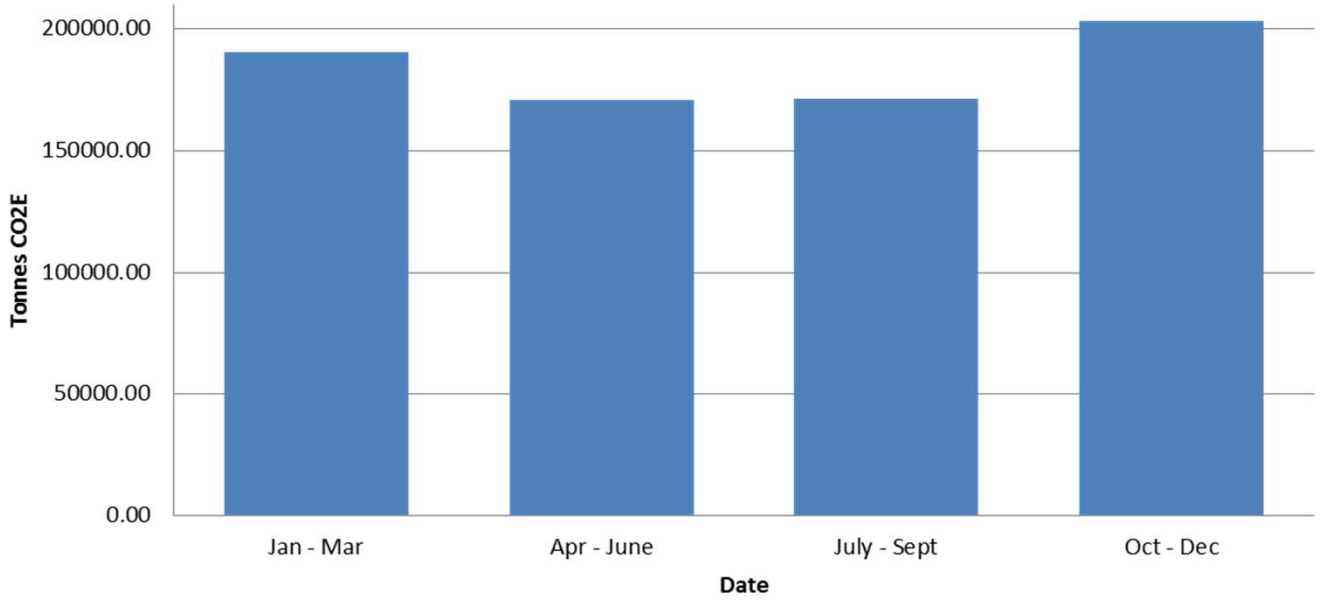
Flare Volumes (e3m3)		
Month	FQI8440 - HP	FQI8477 - LP
Aug-18	12.3	0.1
Sep-18	37.1	3.4
Oct-18	731.0	4.7
Nov-18	14.9	0.0
Dec-18	75.2	0.0
Jan-19	0.3	0.0
Feb-19	156.9	0.0
Mar-19	8.6	0.0
Apr-19	0.1	0.0
May-19	58.9	0.0
Jun-19	1.2	0.0
Jul-19	0.5	0.0



2. Facility Performance

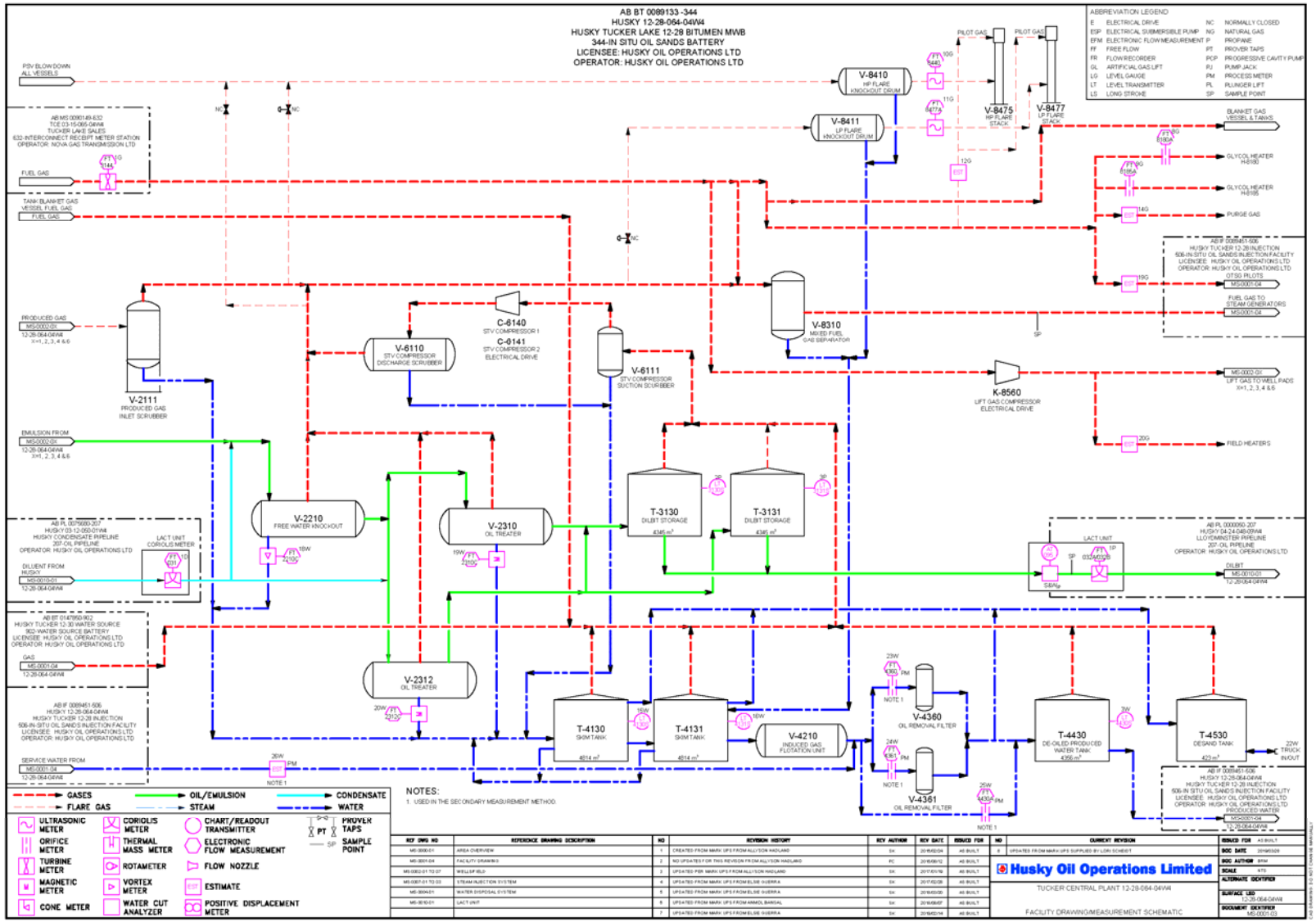
GREEN HOUSE GAS (GHG)

- Emission sources considered include stationary combustion associated with steam generators and glycol heaters, flaring, venting and fugitive emissions
- 794,067.15 tonnes of Carbon Dioxide Equivalent was emitted in 2018 (information taken from the Tucker Thermal 2018 Compliance report submitted under the Carbon Competitiveness Incentive Regulation)
- 67,791 emission performance credits requested by Husky



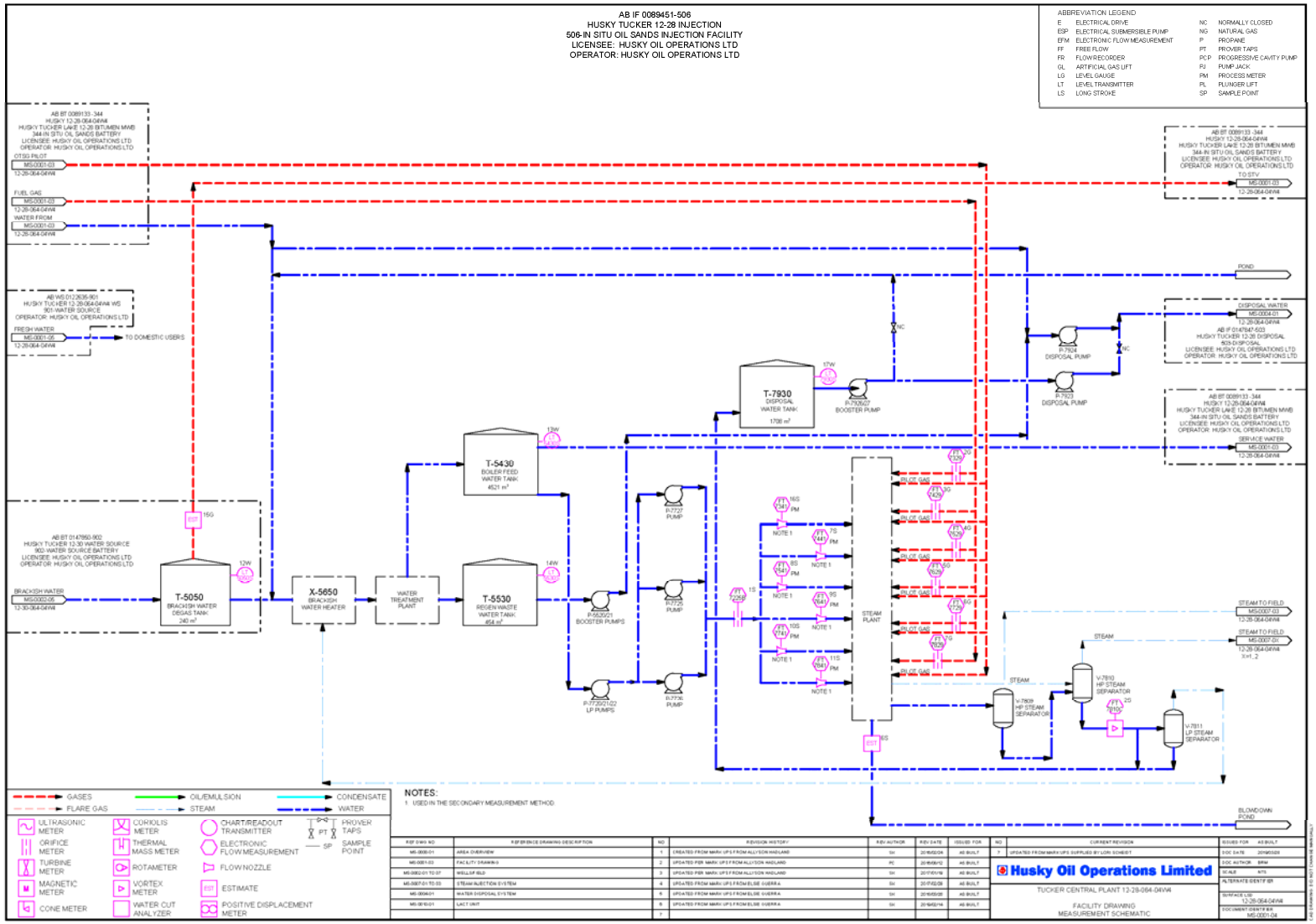
3. Measurement, Accounting and Reporting

BATTERY SCHEMATICS – AB BT 0089133-344



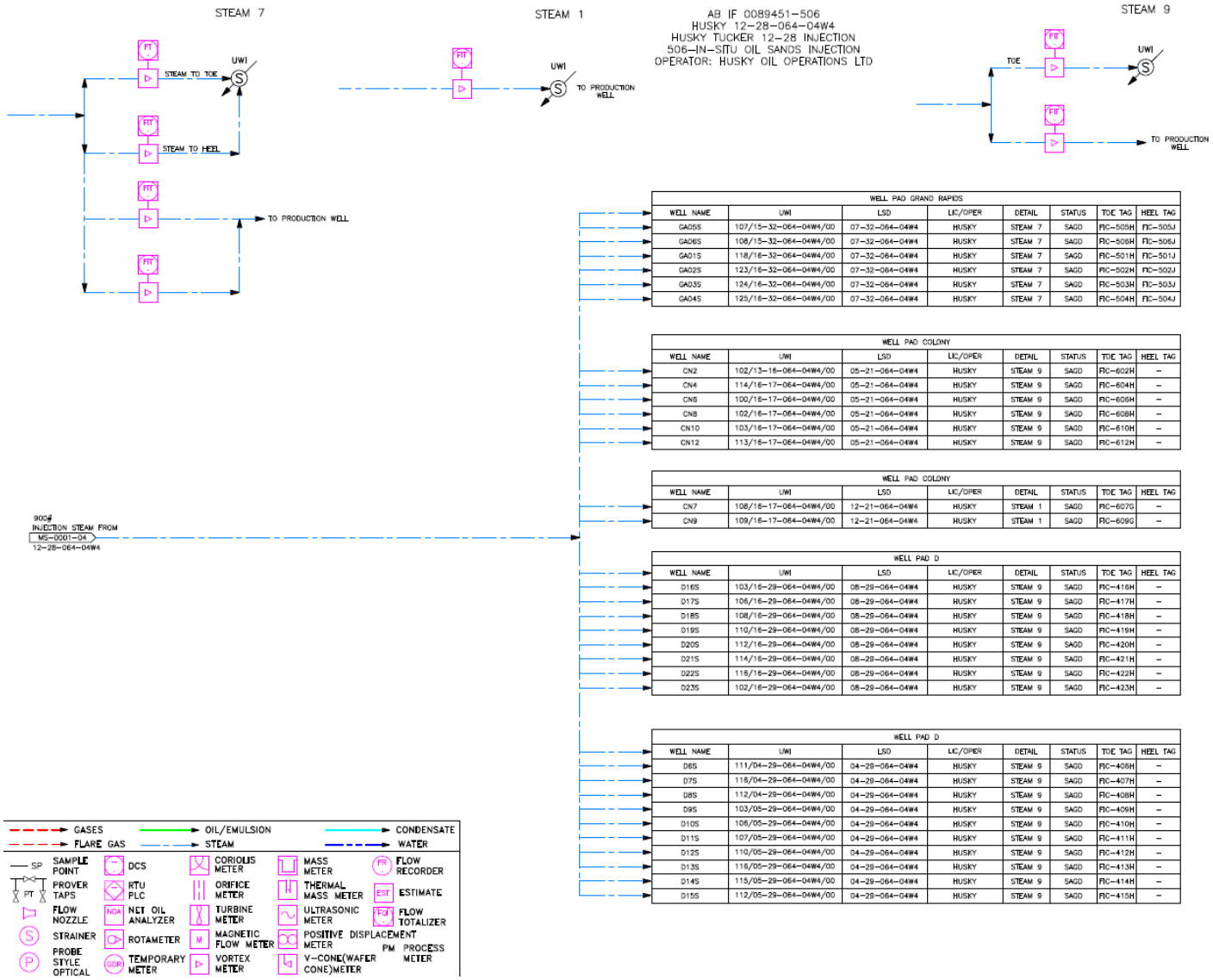
3. Measurement, Accounting and Reporting

INJECTION FACILITY SCHEMATIC – AB IF 0089451-506



3. Measurement, Accounting and Reporting

MEASUREMENT AND REPORTING – STEAM INJECTION



WELL PAD GRAND RAPIDS

WELL NAME	UWI	LSD	LIC/OPER	DETAIL	STATUS	TOE TAG	HEEL TAG
GA05S	107/15-32-064-04W4/00	07-32-064-04W4	HUSKY	STEAM 7	SAGD	FIC-505H	FIC-505J
GA06S	108/15-32-064-04W4/00	07-32-064-04W4	HUSKY	STEAM 7	SAGD	FIC-506H	FIC-506J
GA01S	118/16-32-064-04W4/00	07-32-064-04W4	HUSKY	STEAM 7	SAGD	FIC-501H	FIC-501J
GA02S	123/16-32-064-04W4/00	07-32-064-04W4	HUSKY	STEAM 7	SAGD	FIC-502H	FIC-502J
GA03S	124/16-32-064-04W4/00	07-32-064-04W4	HUSKY	STEAM 7	SAGD	FIC-503H	FIC-503J
GA04S	125/16-32-064-04W4/00	07-32-064-04W4	HUSKY	STEAM 7	SAGD	FIC-504H	FIC-504J

WELL PAD COLONY

WELL NAME	UWI	LSD	LIC/OPER	DETAIL	STATUS	TOE TAG	HEEL TAG
CN2	102/13-16-064-04W4/00	05-21-064-04W4	HUSKY	STEAM 9	SAGD	FIC-602H	–
CN4	114/16-17-064-04W4/00	05-21-064-04W4	HUSKY	STEAM 9	SAGD	FIC-604H	–
CN6	100/16-17-064-04W4/00	05-21-064-04W4	HUSKY	STEAM 9	SAGD	FIC-606H	–
CN8	102/16-17-064-04W4/00	05-21-064-04W4	HUSKY	STEAM 9	SAGD	FIC-608H	–
CN10	103/16-17-064-04W4/00	05-21-064-04W4	HUSKY	STEAM 9	SAGD	FIC-610H	–
CN12	113/16-17-064-04W4/00	05-21-064-04W4	HUSKY	STEAM 9	SAGD	FIC-612H	–

WELL PAD COLONY

WELL NAME	UWI	LSD	LIC/OPER	DETAIL	STATUS	TOE TAG	HEEL TAG
CN7	108/16-17-064-04W4/00	12-21-064-04W4	HUSKY	STEAM 1	SAGD	FIC-607G	–
CN9	109/16-17-064-04W4/00	12-21-064-04W4	HUSKY	STEAM 1	SAGD	FIC-609G	–

WELL PAD D

WELL NAME	UWI	LSD	LIC/OPER	DETAIL	STATUS	TOE TAG	HEEL TAG
D16S	103/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-416H	–
D17S	106/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-417H	–
D18S	108/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-418H	–
D19S	110/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-419H	–
D20S	112/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-420H	–
D21S	114/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-421H	–
D22S	116/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-422H	–
D23S	102/16-29-064-04W4/00	08-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-423H	–

WELL PAD D

WELL NAME	UWI	LSD	LIC/OPER	DETAIL	STATUS	TOE TAG	HEEL TAG
D6S	111/04-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-406H	–
D7S	116/04-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-407H	–
D8S	112/04-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-408H	–
D9S	103/05-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-409H	–
D10S	105/05-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-410H	–
D11S	107/05-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-411H	–
D12S	110/05-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-412H	–
D13S	116/05-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-413H	–
D14S	115/05-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-414H	–
D15S	112/05-29-064-04W4/00	04-29-064-04W4	HUSKY	STEAM 9	SAGD	FIC-415H	–

3. Measurement, Accounting and Reporting

ESTIMATING WELL PRODUCTION

- Oil and Water Estimated by well test:
  - Battery level measurement prorated to wells based on the estimates
  - Correction factor applied to calculated well steam fraction volume

- Three Test Separator Designs (well tests):
  1. Blow-Case (Pads A Original, B, C East, C West):
     - Load-cell or level
     - Vortex for steam + natural gas
     - AGAR water-cut analyzer
  2. Conventional (Pad B North, A Infill & Replacement Wells, Pad GA, Pad D):
     - Coriolis meter for liquid
     - Vortex for steam + natural gas
     - AGAR water-cut analyzer
  3. Horizontal (Pad CN)
     - Coriolis meter for liquid
     - Orifice plate for steam + natural gas
     - Phase Dynamics water-cut analyzer

- Steam fraction calculated (from P_{sat} / P_{meas}) for all three designs

- Gas Measured at the Battery (proration = 1):
  - GOR for August 1, 2018 to July 31, 2019 = 43.1 m^3/m^3

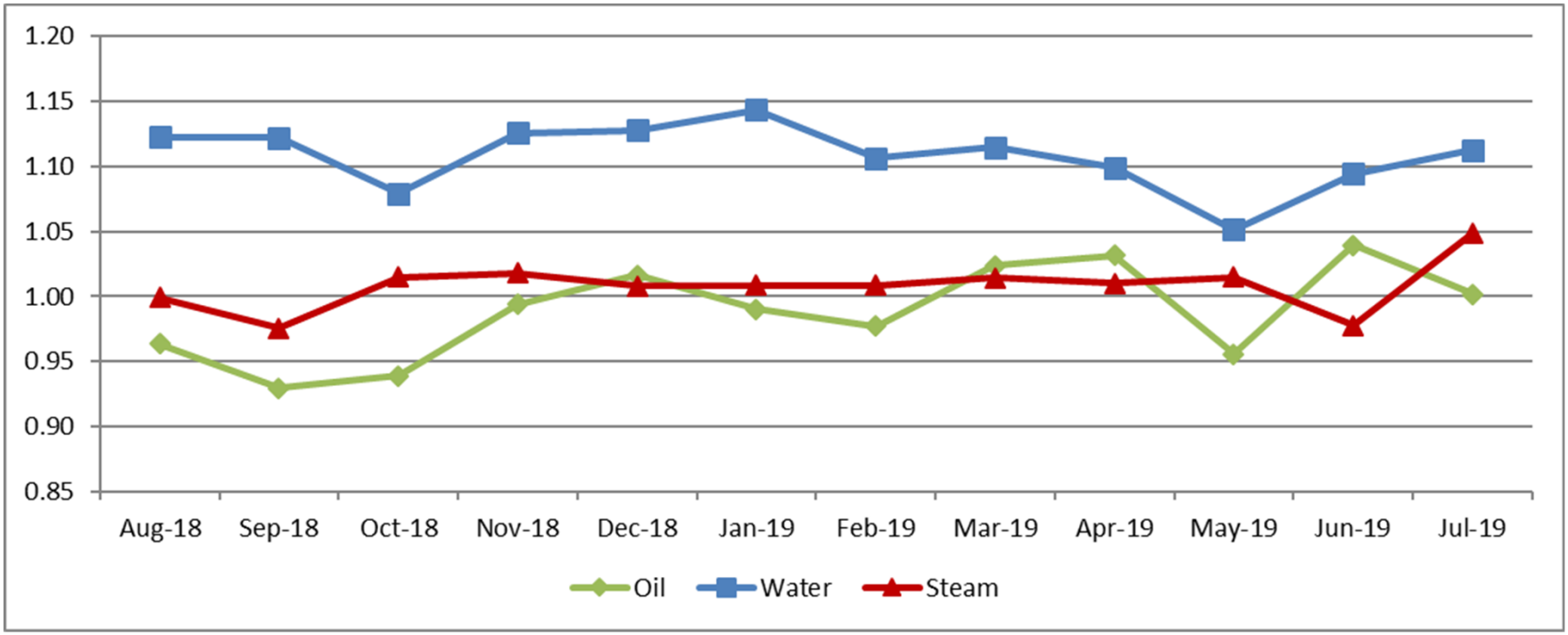
3. Measurement, Accounting and Reporting

WATER BALANCE

- Steam Injection:
  - Vortex meters on each well (toe and heel)
  - Total steam to field measured at the battery
  - Steam Proration = 1.008 m^3/m^3
- Water Proration Factors (see next slide):
  - Average 12-Month Rolling Proration Factors
    - Water = 1.108
    - Oil = 0.988
- Water/Steam Meter Calibrations:
  - Metering equipment inspected/calibrated annually
  - Annual well steam injection meters inspection as per Directive 017
  - AGAR water cut analyzer calibration program as per Directive 017
  - MARP updated to include all new measurement meters and changes
- Metering Accuracy:
  - Accounting meters meets requirements as per Directive 017 single point measurement accuracy

3. Measurement, Accounting and Reporting

ESTIMATING WELL PRODUCTION – PRORATION FACTORS



3. Measurement, Accounting and Reporting

WELL TEST AVERAGES

Test Separator	Wells	Average Test Duration (hours)	Average # of Tests for each Well Per Month
V-151/152	A1 - A8 (8)	6.2	8.6
V-170	A9 - A20 (12)	5.0	9.4
V-171	A21 - A24 (4)	6.0	19.8
V-213A	B9E (1)	23.5	25.8
V-214A	B10E (1)	23.5	25.7
V-215A	B11E (1)	23.5	26.5
V-251/252	B1 - B12 (12)	4.8	10.2
V-391/392	C13 - C20 (8)	4.4	15.9
V-420	D6 - D15 (10)	5.0	10.3
V-430	D16-D23 (8)	5.0	11.4
V-440	D24 - D33 (10)	5.0	11.4
V-450	D1 - D5, D34 - D38 (10)	5.0	11.4
V-540	GA1 - GA6 (6)	5.0	19.0
V-630	CN2/4/6/8/10/12	11.4	8.7
V-640	CN7/9	11.4	23.0

3. Measurement, Accounting and Reporting

SOLVENTS AND CONDENSABLE GAS

- Bitumen production accounts for diluent flash and volumetric shrinkage
- No solvent injection to reservoir during reporting period
- No non-condensable gas injection during reporting period

3. Measurement, Accounting and Reporting

MEASUREMENT INITIATIVES – CONTINUOUS IMPROVEMENT

- AER MARP audit (March 2018):
  - Information request 1 received January 29, 2019; responses submitted March 15, 2019
  - Information request 2 received March 21, 2019; responses submitted April 1, 2019
  - AER MARP audit completion letter received April 2, 2019

- Implemented improvements:
  - LP/HP flare gas meters upgraded to ultrasonic meters
  - Updated the produced gas calculation for AB BT 0089133-344
  - Permanent well license for fresh water well (Water Diversion License No. 00410609-00-00); received August 22, 2018
  - Updated 2D diluent flash shrinkage volume calculation. Now using HYSYS process simulation; more accurate as compared to calculated value
  - Implemented findings from the AER MARP audit

- Future opportunities:
  - Implement findings from internal Enhanced Protection Audit Program (EPAP) audit
  - Evaluate and improve Brackish Water Well Water Gas Ratio (WGR) validation

4. Water Production, Injection and Uses

BRACKISH WATER

- Make-up water for steam generation
- McMurray Formation
- 3 Source Wells:
  - 1F1/11-30-064-04 W4M
  - 1F1/12-30-064-04 W4M
  - 1F1/08-25-064-04 W4M

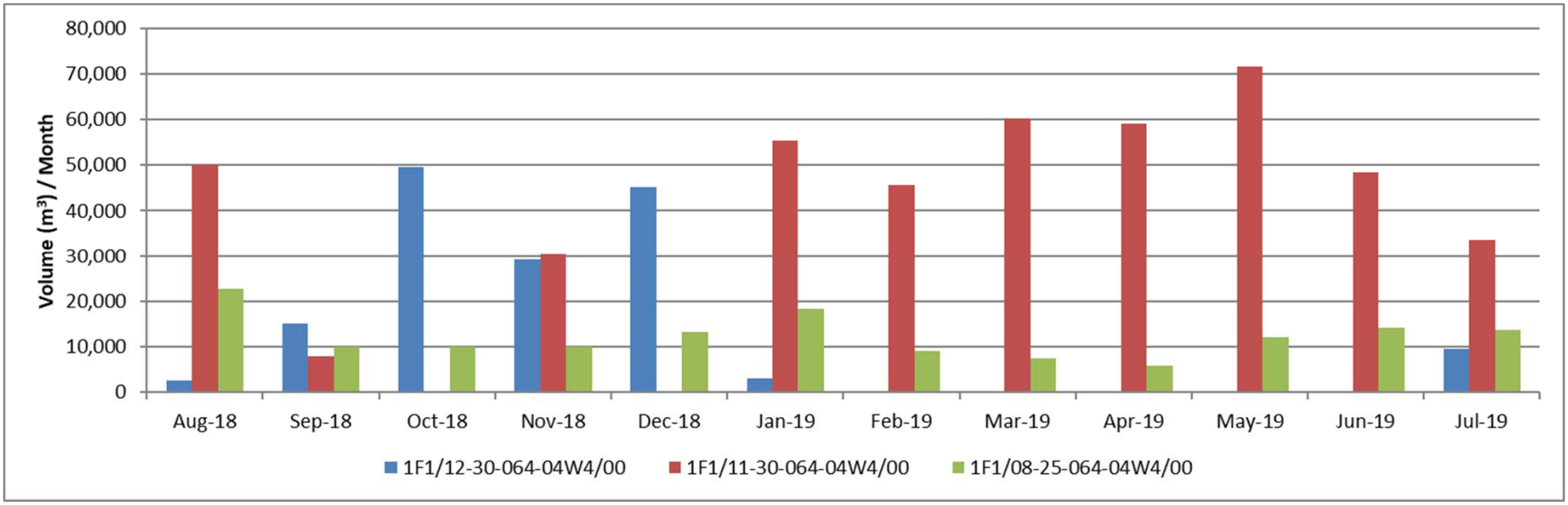
4. Water Production, Injection and Uses

WATER USAGE

- Brackish water ~20,000 ppm Total Dissolved Solids (TDS) for steam generation (as required)
- No fresh water is used in process

4. Water Production, Injection and Uses

BRACKISH WATER CONSUMPTION



4. Water Production, Injection and Uses

FRESH WATER

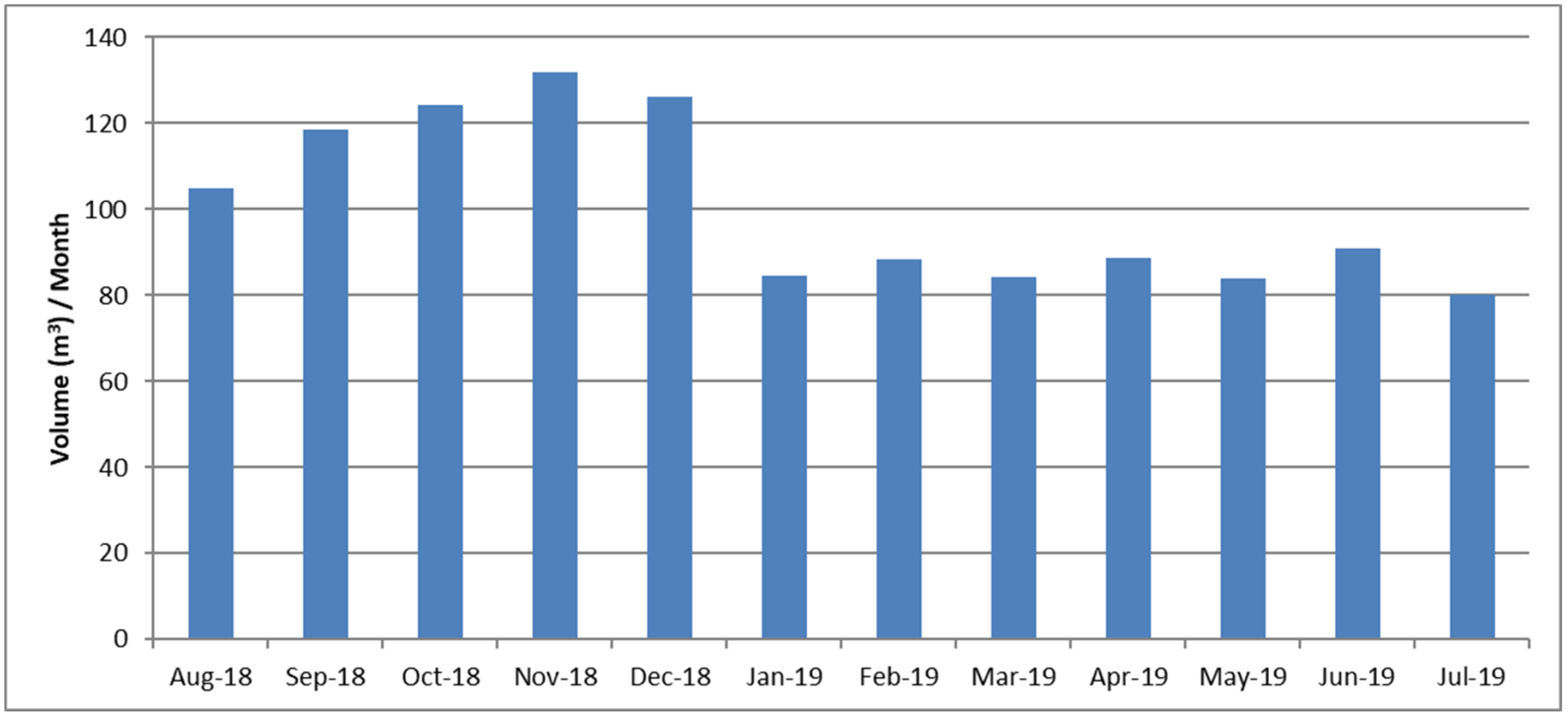
- Water Diversion License No. 00194427-00-01
  - Location well: 12-28-064-04-W4 (CPF)
  - Bonnyville Aquifer
  - Domestic use only:
    - Safety showers/eye-wash stations
    - Cleaning water
    - Washroom/kitchen use

- Water Diversion License No. 00410609-00-00
  - Location well: 12-28-064-04-W4 (CPF)
  - Bonnyville Aquifer
  - Industrial (utility, non-oilfield Injection)
  - Received August 22, 2018

- No Temporary Diversion License (TDL) required during the reporting period

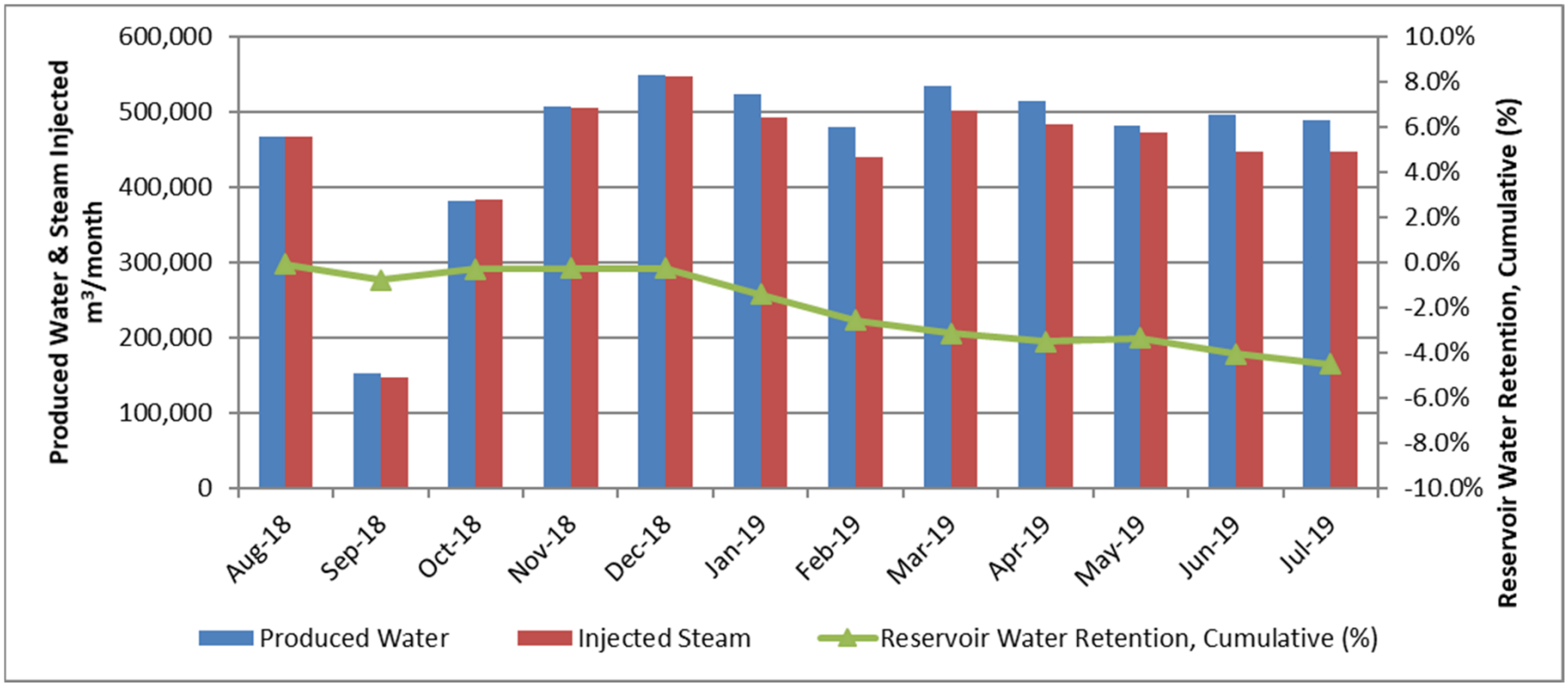
4. Water Production, Injection and Uses

FRESH WATER CONSUMPTION



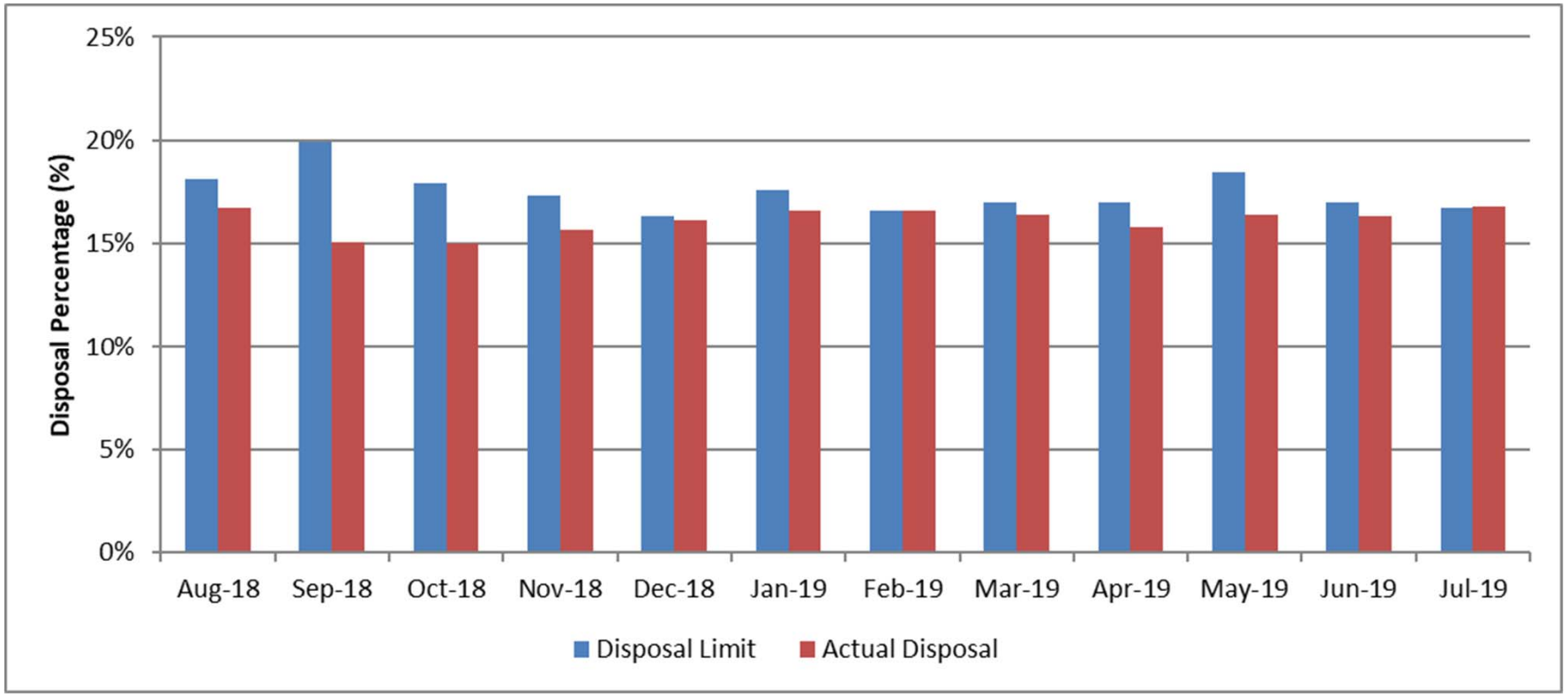
4. Water Production, Injection and Uses

PRODUCED WATER & STEAM INJECTED



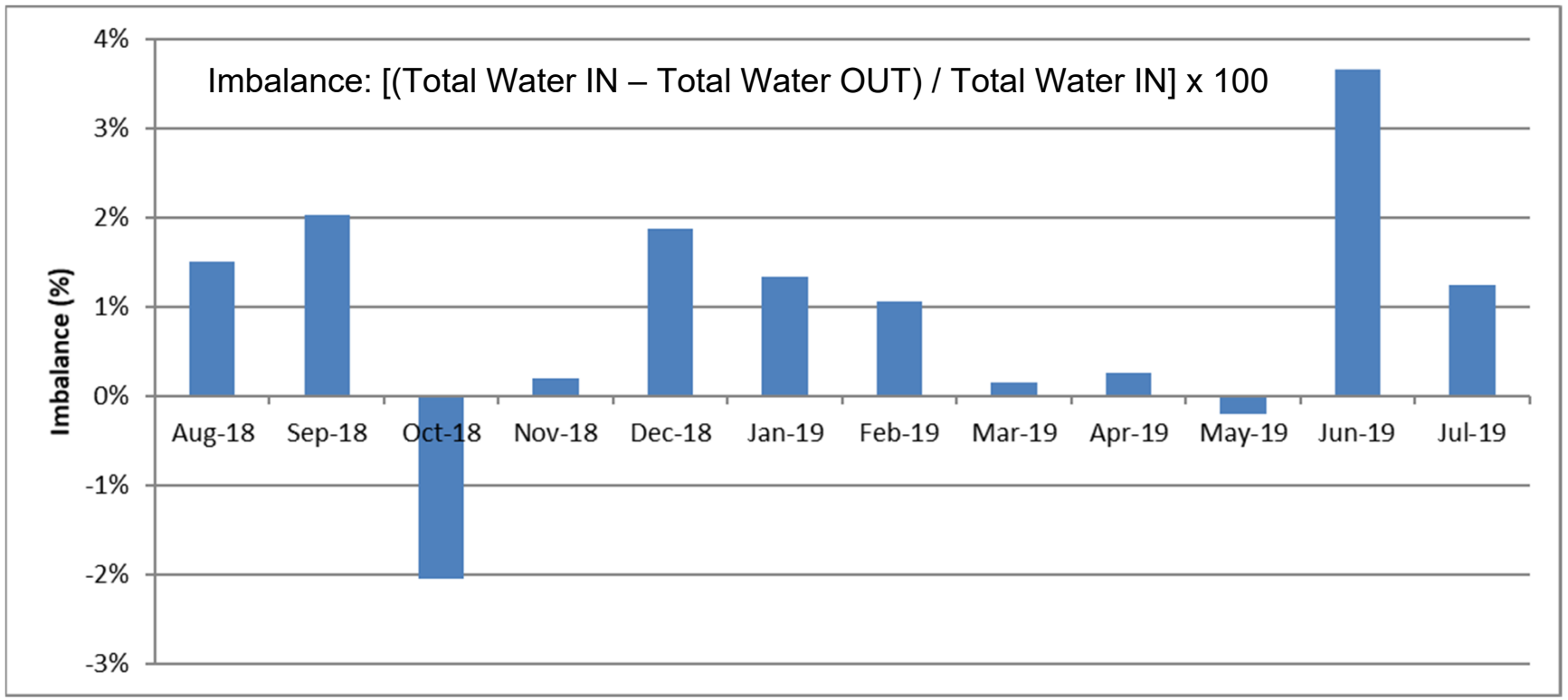
4. Water Production, Injection and Uses

WATER DISPOSAL LIMITS



4. Water Production, Injection and Uses

MONTHLY INJECTION WATER BALANCE



4. Water Production, Injection and Uses

OTSG BLOW-DOWN RECYCLE

- OTSG blow-down is recycled to the WLS at a percentage that allows the total dissolved solids, out of the OTSG, to remain below 50,000 uS/cm
- Brackish water make-up has a very high TDS and affects OTSG blow-down recycle
- Recycle approximately 31% of blow-down back to the WLS

4. Water Production, Injection and Uses

DISPOSAL WELLS

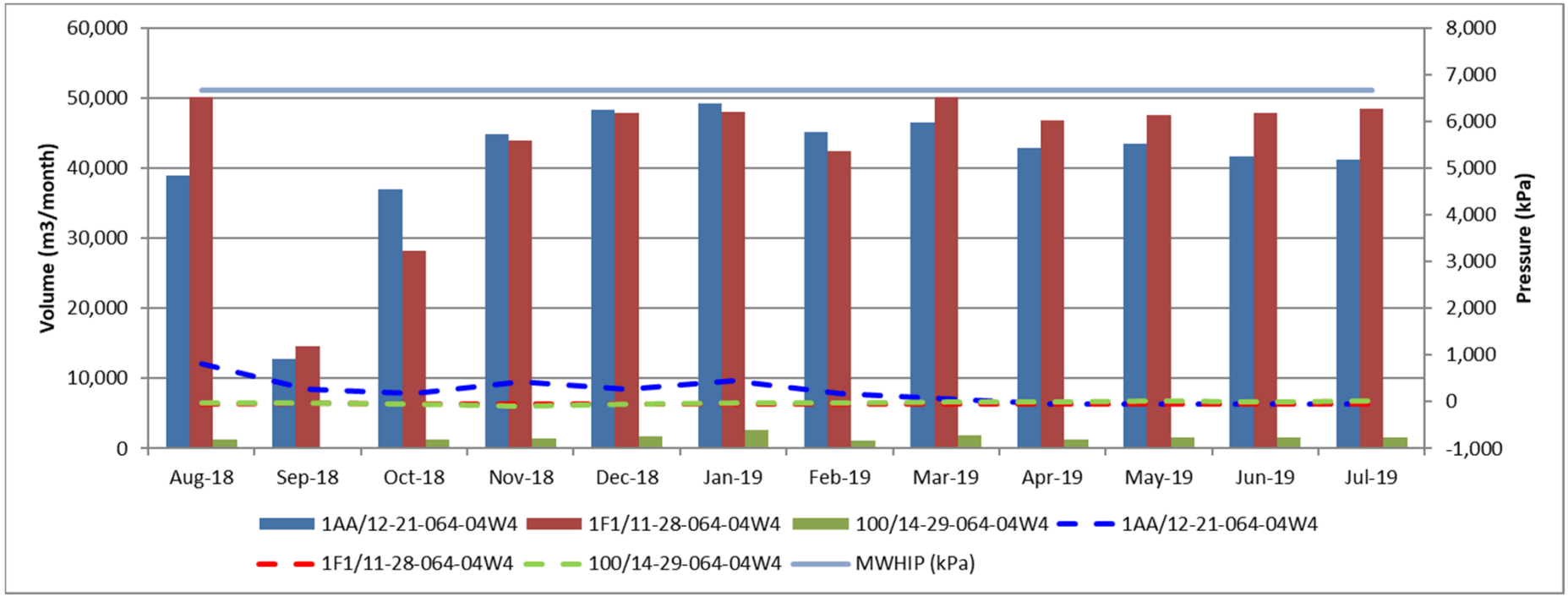
- AER Class 1 Wastewater Disposal Wells

- Boiler blow-down disposal wells:
  - 1AA/12-21-064-04 W4M (AER Approval 10591)
  - 1F1/11-28-064-04 W4M (AER Approval 10591)
  - 00/04-28-064-04W4/0 (AER Approval 10591A) – licensed

- Water treatment process disposal well:
  - 00/14-29-064-04 W4M (AER Approval 10591)

4. Water Production, Injection and Uses

DISPOSAL WELLHEAD INJECTION PRESSURE & VOLUMES



4. Water Production, Injection and Uses

LANDFILL WASTE HANDLING

- No landfill within facility
- All landfill waste streams disposed off-site at approved licensed facilities

4. Water Production, Injection and Uses

WASTE VOLUMES

- Waste summary for 12-28-064-04-W4 (CPF)

WasteCode	Description	Handling	volume	Units
	Waste - Miscellaneous	RBW Transfer Station	163.8	m3
	Waste - Miscellaneous	RBW Transfer Station	1.4	m3
EMPTY	Empty Container (rbw Container)	RBW Transfer Station	0.41	m3
EMTCON-A	Aerosol Cans - Empty	RBW Transfer Station	0.615	m3
BATT-ALK	Batteries - Alkaline	RBW Transfer Station	0.205	m3
SOILCO	Contaminated Debris and Soil - Crude Oil/Condensate	RBW Transfer Station	34.8	m3
OILRAG	Rags - Oily	RBW Transfer Station	1.025	m3
WSTCGS	Waste Compressed or Liquified Gases	RBW Transfer Station	0.08	m3
ACID	Acid Solutions - Unneutralized	RBW Transfer Station	0.04	m3
SOLARO	Solvents/Residues - Non-Halogenated, Aromatic	RBW Transfer Station	0.04	m3
ORGCHM	Chemicals - Organic	RBW Transfer Station	0.08	m3
WSTFLQ	Waste Flammable Liquid	RBW Transfer Station	0.08	m3
SOLARO	Solvents/Residues - Non-Halogenated, Aromatic	RBW Transfer Station	0.06	m3
LDDOPE	Lead Based Products - Pipe Dope/Greases	RBW Transfer Station	0.07	m3
METHNL	Hydrotest Fluids - Methanol	RBW Transfer Station	0.02	m3
WPAINT	Waste Paint	RBW Transfer Station	0.1	m3
SOLARO	Solvents/Residues - Non-Halogenated, Aromatic	RBW Transfer Station	0.04	m3
WSTCGS	Waste Compressed or Liquified Gases	RBW Transfer Station	0.06	m3
WSTFSD	Waste Flammable Solid	RBW Transfer Station	0.04	m3
METHNL	Hydrotest Fluids - Methanol	RBW Transfer Station	0.02	m3
SOLARO	Solvents/Residues - Non-Halogenated, Aromatic	RBW Transfer Station	0.02	m3
COEMUL	Crude Oil / Condensate Emulsions (residuals)	Tervita	639	M3
COEMUL	Crude Oil / Condensate Emulsions (residuals)	Tervita	254.79	M3

5. Sulphur Production

SULPHUR DIOXIDE (SO_2) SOURCES

- 6 Once-Through Steam Generators (OTSG)
- 1 High Pressure Flare Stack
- 1 Low Pressure Flare Stack

5. Sulphur Production

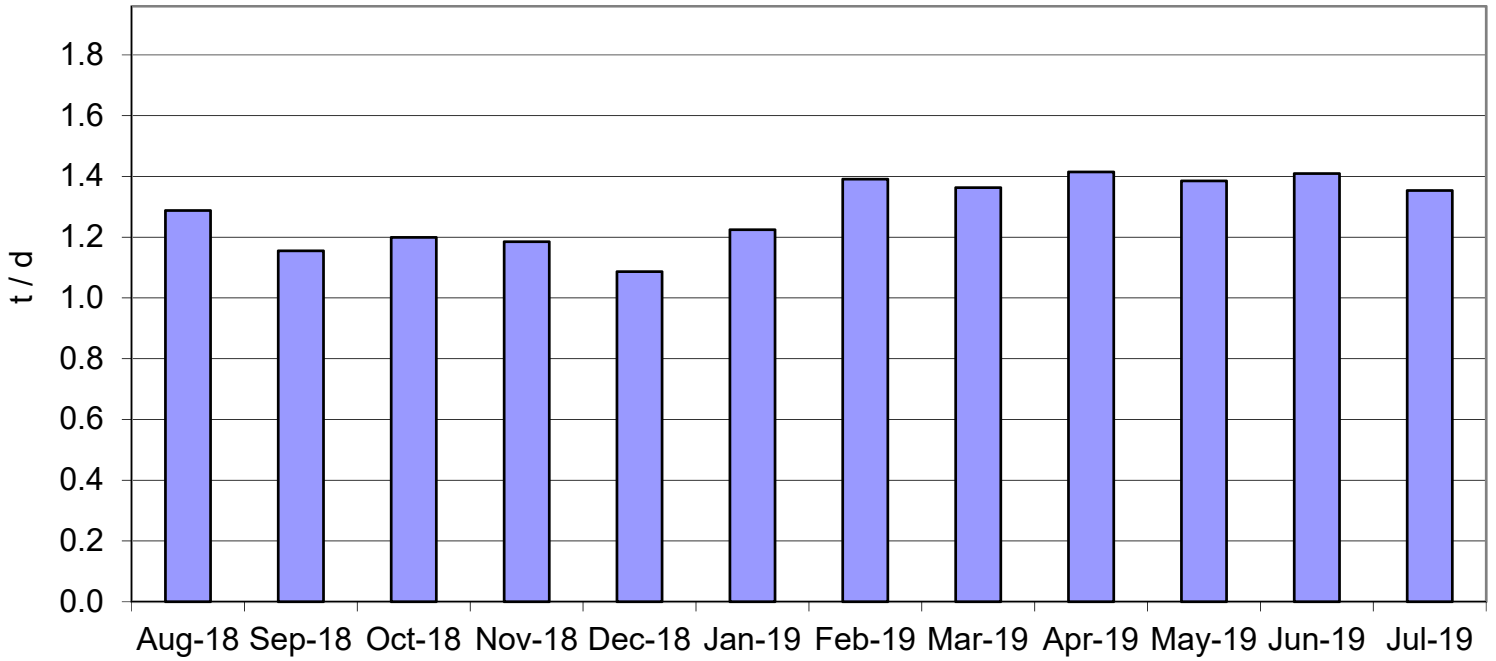
QUARTERLY SO_2 EMISSIONS

Q3 2018 (August 2018 – October 2018)	111.74 tonnes
Q4 2018 (November 2018 – January 2019)	107.20 tonnes
Q1 2019 (February 2019 – April 2019)	127.82 tonnes
Q2 2019 (May 2019 – July 2019)	127.19 tonnes

5. Sulphur Production

SO_2 EMISSION TRENDS

- SO_2 emission limit = 1.96 tonnes/day



5. Sulphur Production

PEAK AND AVERAGE SO_2 EMISSIONS

- August 1, 2018 to July 31, 2019:

SO_2 Emissions	
Average Daily (highest)	1.41 tonnes
Maximum Daily (highest)	1.79 tonnes

- Limit under EPEA Approval is 1.96 tonnes/day
- No exceedances were recorded during the reporting period

5. Sulphur Production

AMBIENT AIR MONITORING

- Ambient air quality is currently monitored by the Lakeland Industry and Community Association (LICA) - Air Shed committee. LICA is under contract from Alberta Environmental Monitoring and Science Division (EMSD) of Alberta Environment and Parks (AEP) to provide these services

- No exceedences were recorded during the reporting period

- Airshed quality results available on LICA website or Clean Air Strategic Alliance (CASA) Data Warehouse

- http://www.lica.ca/

- http://www.casadata.org/

6. Environmental Issues

ENVIRONMENTAL – COMPLIANCE TO APPROVALS

- EPEA Approval:
  - No compliance issues during this reporting period
- AER:
  - No compliance issues during this reporting period
- AEP:
  - No compliance issues during this reporting period
- DFO:
  - No compliance issues during this reporting period

6. Environmental Issues

ENVIRONMENTAL – AMENDMENT TO EPEA APPROVAL

- Produced Gas Handling System Amendment Application CFF (No. 1918225); submitted January 17, 2019; pending AER approval

6. Environmental Issues

ENVIRONMENTAL - WILDLIFE

- As part of the regulatory approval, Husky has developed and implemented a Wildlife Monitoring Program (WMP) for:
  - Canadian toad distribution, abundance and population status
  - Above Ground Pipeline (AGP) monitoring to ensure wildlife can cross under the lines
  - Wildlife Habitat Enhancement Program (WHEP)
- Annual WMP report describes the observations and results collected during the previous year
- Replacement bat houses installed in various locations

6. Environmental Issues

ENVIRONMENTAL – INDUSTRIAL WASTEWATER

- Disposal Locations:
  - Boiler blow-down disposal wells 12-21-064-04W4M and 11-28-064-04W4M
  - Water treatment process disposal well 14-29-064-04W4M
  - 966,806.9m^3 water disposed

- Domestic Wastewater:
  - Domestic waste sludge is disposed of at the Cold Lake Municipal Treatment Facility or the Bonnyville Municipal Treatment Facility

- Industrial Run-off (from 2018 Annual Waste Water Report):
  - Total of six discharge locations (Well Pads: A, B, C, D, GA, CN and the run-off retention pond located on CPF)
  - A total of 47,443 m^3 surface water was discharged due to a very wet year
  - All discharges were in compliance with EPEA approval

6. Environmental Issues

ENVIRONMENTAL - SOILS

- No soil sampling complete during the reporting period

6. Environmental Issues

ENVIRONMENTAL - AIR

- Air related monitoring, reporting and studies are conducted by Lakeland Industry and Community Association (LICA) under contract from Alberta Environmental Monitoring and Science Division (EMSD)

- The LICA airshed monitoring network consists of:
  - 4 continuous monitoring stations
  - 26 passive monitoring stations
  - 2 volatile organic compound and polycyclic aromatic hydrocarbon samplers, and
  - 2 soil acidification monitoring plots

6. Environmental Issues

ENVIRONMENTAL – GROUND WATER

- Groundwater monitoring program includes:
  - CPF Groundwater: monitors shallow groundwater quality beneath the CPF
  - Pad-specific Groundwater: monitors possible impacts to groundwater quality
  - Regional Groundwater: monitors possible effects on regional groundwater quality between the project areas and the local lakes and streams

- Expansion to Groundwater Monitoring Program:
  - No additional expansion to the monitoring network occurred during the reporting period

6. Environmental Issues

ENVIRONMENTAL - INITIATIVES

- Alberta Environmental Monitoring and Science Division (EMSD)

- Participation in the Lakeland Industry and Community Association (LICA)
  - Board of Directors
  - Beaver River Watershed Alliance
  - Airshed

- Participation in Alberta Biodiversity Monitoring Institute (ABMI)

6. Environmental Issues

ENVIRONMENTAL - RECLAMATION

- Objectives of the Annual Report (demonstrate and document):
  - Compliance with the development and reclamation approval
  - Site conditions and successful reclamation
  - General project development (surface disturbances) and reclamation activities
  - Problem areas and resolution

- Site Clearing and Timber Salvage:
  - No site clearing or timber salvage occurred during the reporting period

- Vegetation Monitoring:
  - Annual weed monitoring and control as per Husky's best practices

- Reclamation Activities:
  - No permanent reclamation activities were completed during the reporting period

7. Compliance Statement

COMPLIANCE

AER:

- All conditions of AER License F-32143 as well as all scheme approvals for the Project were met during the reporting period
- All conditions of the EPEA approval 147753-01-01 were met during the reporting period

7. Compliance Statement

SELF DECLARATIONS

- No self declaration recorded during the reporting period

8. Non-Compliance Events

AER REPORTABLE

- AER Contravention report - CIC # 342543:
  - August 15, 2018 – Cylinder Gas Audit (CGA) on B7300 failed due to error in reporting software and contamination in cylinder gas. Software reconfigured for proper reporting criteria and calibration gas replaced.
- AER Contravention report - CIC # 343866:
  - September 12, 2018 – Hydrocarbon spill from a temporary tank that was used during turnaround. During the tank inspection a bull plug was missed and when the tank began to fill hydrocarbon was released to the ground. Spill was contained onsite and clean up completed

8. Non-Compliance Events

SCVF/GM UPDATE SUMMARY – WELL C13S

- No SCVF reported during the reporting period
- Submitted request cease SCVF well monitoring to AER on July 23, 2019; received AER authorization on August 1, 2019
- Well C13S closed off in AER DDS; suspending well

9. Future Plans

FUTURE PLANS 2019/2020

- Produced Gas Handling System – Debottleneck CFF (Q4 2020)
  - Submitted application (1918225) to AER Q1 2019; pending AER approval
- Scheduled full facility (CPF and CFF) turn-around (Q2 2020)
- Lease construction on Clearwater development (sustaining Pads E and F) and associated infrastructure (Q4 2019/Q2 2020); pending AER Approval
- Drill and tie-in Clearwater development (sustaining Pads E and F) (Q2/2020 – Q2/2021); pending AER Approval
- Diluent storage (CPF) Amendment Application (Q4 2020)