Imperial

2016 Annual Performance Review

Cold Lake Approvals 8558 and 4510

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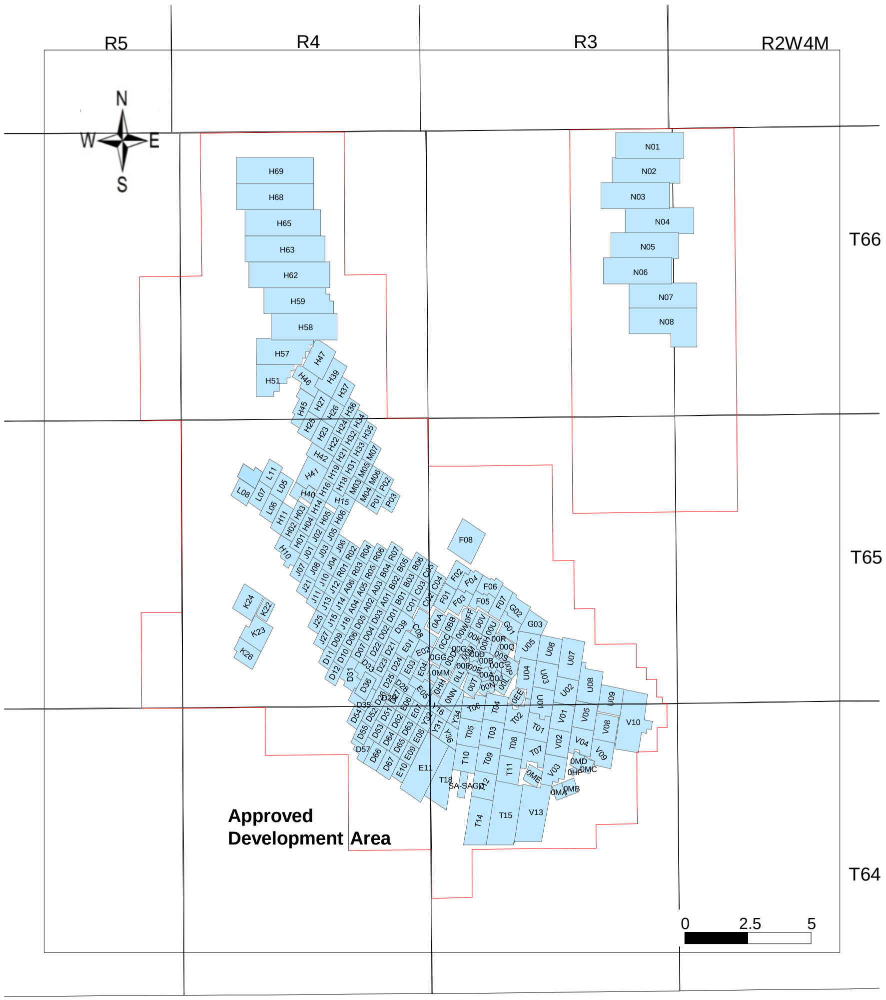
2016 Annual Performance Review

Table of Contents

Note: The following information covers the period from September 30th 2015 to September 30th 2016, unless otherwise stated.

Acronyms	Definitions
BTEX	Benzene Toluene Ethylbenzene Xylenes
BIS	Bitumen In Shale
BHL	Bottom Hole Location
BTC	Buttress Thread Collar
CDWQG	Canadian Drinking Water Quality Guidelines
CW(T)	Clearwater (Top)
CLO	Cold Lake Operations
CS(T)	Colorado Shale (Top)
CEW	Colorado Shale Evaluation Well
CI	Contour Interval or Casing Integrity
(HP) CSS	(High Pressure) Cyclic Steam Stimulation
(O)EBIP	(Original) Effective Bitumen in Place
EUE	External Upset Tubing
FTD	Final Total Depth
FLIR	Forward Looking Infra-red
GM	Gas Migration
(U)/(L)GR	(Upper)/(Lower) Grand Rapids
GEW	Groundwater Evaluation Well
GW	Ground Water
HW	Horizontal Well
HRSG	Heat Recovery System Generator
(H)PSW	(Hybrid) Passive Seismic Well
IOI	Injector Only Infill
LASER	Liquid Addition to Steam for Enhanced Recovery
LTC	Long Thread Collar
MD	Measured Depth
NS-CC	Nippon Steel-Casing Connection
OV	Oilsand Valuation Well
PIMFET	Production Injection Management Fatigue Estimation Toolkit
RFC	Regulated Fill-up Cement
STC	Short Thread Collar
ST	Side Track
(SA)-SAGD	(Solvent Assisted) Steam Assisted Gravity Drainage
SCVF	Surface Casing Vent Flow
TVD	True Vertical Depth
VOF	Volume Over Fill-Up

Background



Development History

60's-70's	Lease acquisition Small scale research pilots
1975	10 kbd commercial pilot
'85-'94	Phase 1-10 > Maskwa > Mahihkan
2002	Phase 11-13 Mahkeses > Cogeneration facility
2004	Approval area expanded > Nabiye, Mahihkan North
2015	Phases 14-16 Nabiye > Cogeneration facility

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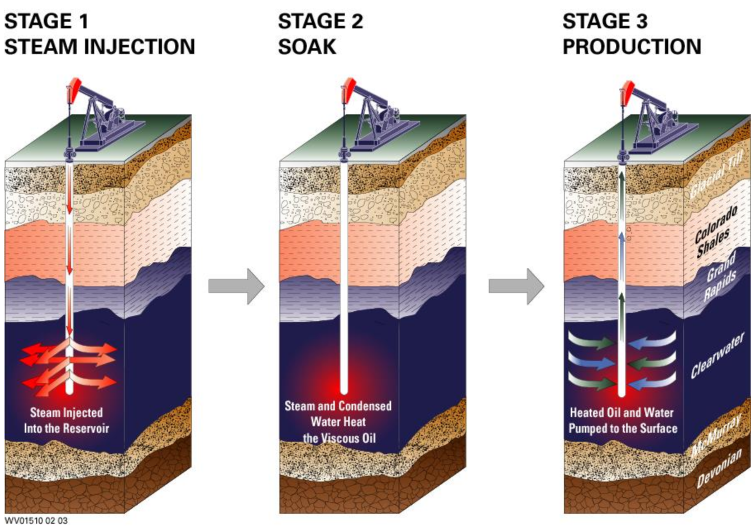
CSS Process Overview



Mobilizing Agent:	Heat
Mobilizing Agent Delivery System:	Steam
Drive Mechanisms:	Compaction, solution gas drive, gravity drainage
Wells Required:	1
Well Type:	Deviated or horizontal
Operating Pressure:	Above fracture pressure

Cyclic Steam Stimulation

- High-pressure, high-rate, cyclic process with multiple drive mechanisms
  - > compaction
  - > solution gas drive
  - > gravity drainage
- Steam injection heats bitumen to reduce its viscosity (4 - 6 weeks)
- Brief soak phase to confirm casing integrity and control inter-well communication (3 days – several weeks)
- Length of the production period increases from a few months in early cycles to multiple years in late cycles
- Full well life: 8 -17 cycles and up to 50 years including follow-up processes

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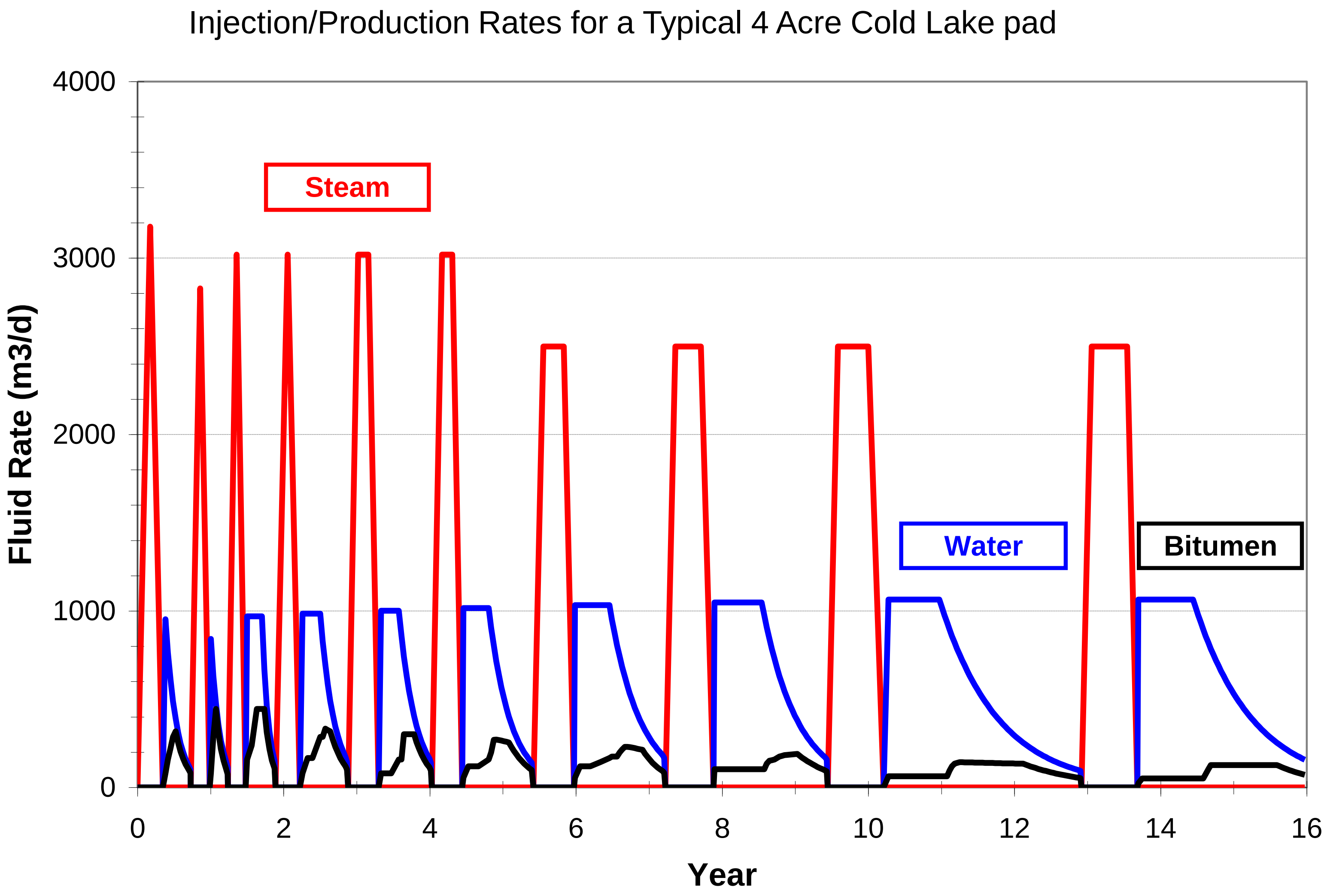
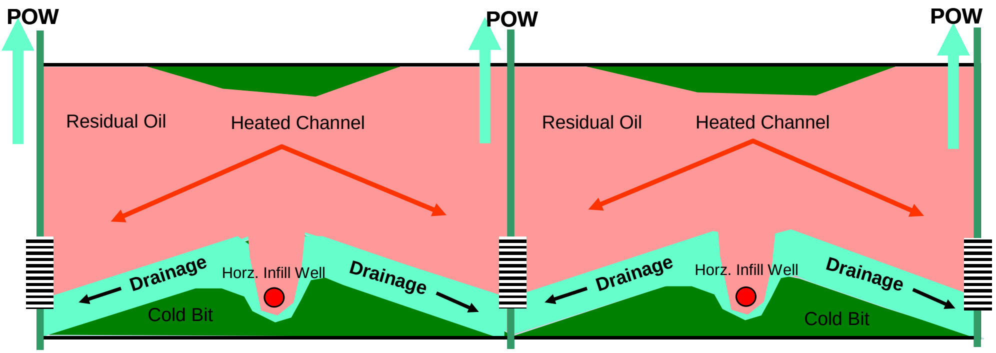
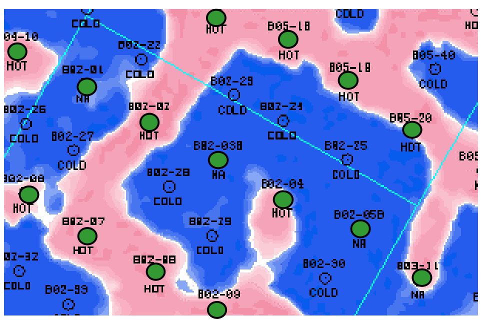
CSS Process Overview

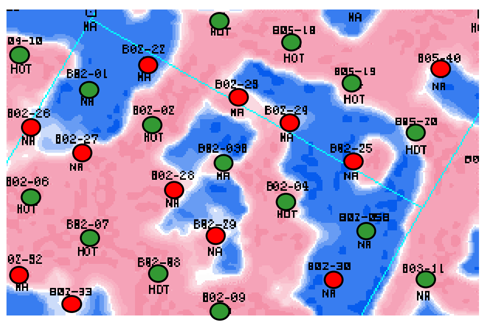


Injector Only Infills (IOI)





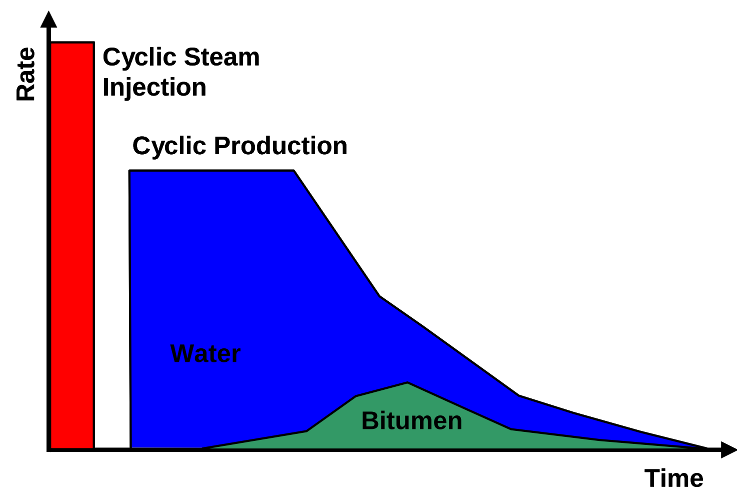
Pre-Infill 3D Seismic



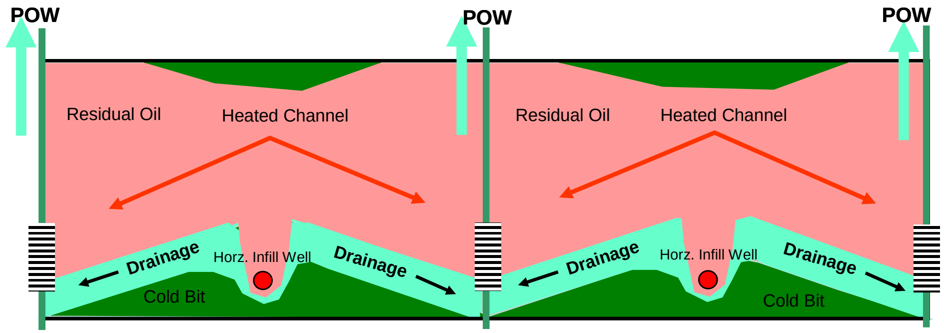
Post-Infill 3D Seismic

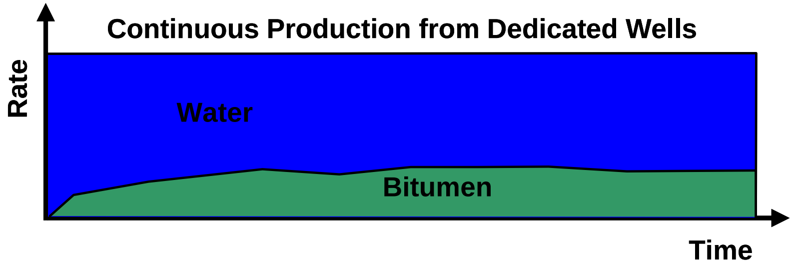
- Hot reservoir (partially depleted)
- Cold reservoir (undepleted)
- CSS wells
- Infill wells

- Injector only Infill wells direct cyclic steam to cold bitumen
- Steam distribution in horizontal wells controlled by limited entry perforations (~20 holes/1000 m well)
- Existing deviated wells operate as cyclic producers



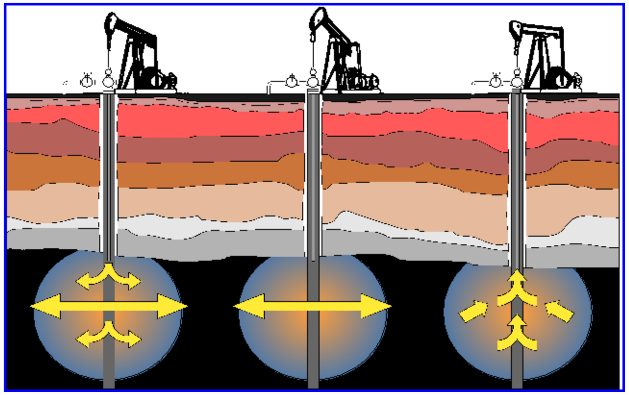
Steamflood Process Overview



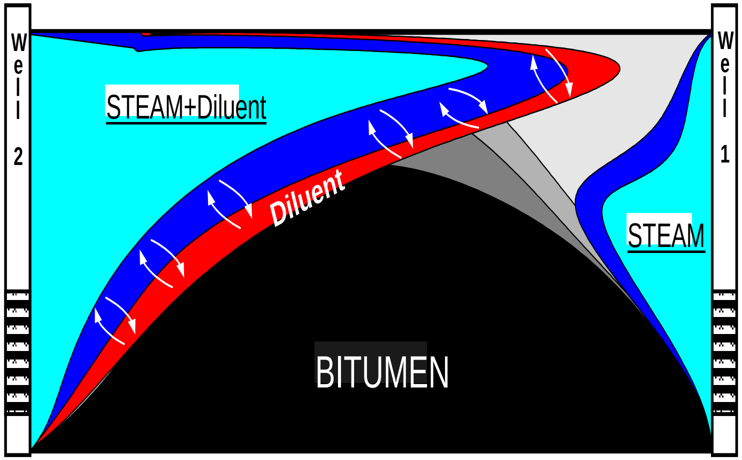


- Continuous steam injection, at low rates has the potential to:
  - > Lower operating costs
  - > Improve well operability
  - > Reduced casing stress
- Target reservoir pressure between 0.5 to 1.5 MPa
- Continuous rather than cyclical steam injection through dedicated injection-only and production-only wells

LASER Process Overview



CSS Thermal Process



Liquid Addition to Steam for Enhancing Recovery

- LASER is a late-life technology
  - > Follow-up process for CSS (cyclic steam stimulation)
  - > Implemented with 2-3 cyclic cycles remaining
  - > Alternative to purely thermal processes
- LASER is a cyclic steam process with the addition of a C5+ condensate to the steam during injection
  - > Enhances gravity drainage efficiency by reducing in-situ viscosity beyond thermal limit
  - > Potentially increases the recovery by >5% of EBIP
- Key process performance indicators
  - > Incremental OSR over a purely thermal baseline
  - > Fractional recovery of injected solvent

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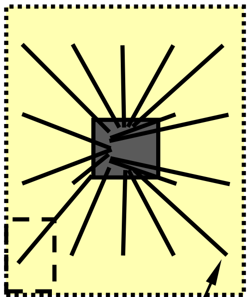
Pad Design

Original Pad Design

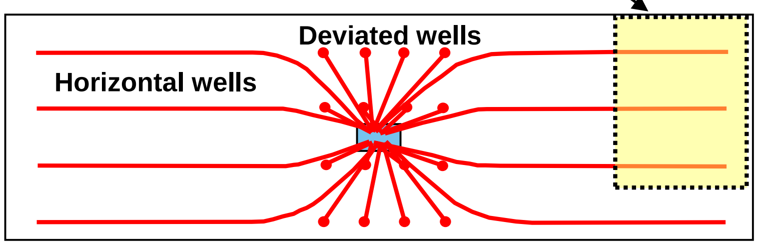


4 Acre Spacing

Downhole well locations

Mega Pad

Subsurface area of original Cold Lake Pad design



- Wells drilled directionally from central lease location
  - > Reduced environmental disturbance
  - > Improved development economics
  - > Increased operational efficiencies
- Original pad design 20 wells on 4 acre spacing
- Current pad designs
  - > Up to 35 wells on 4 or 8 acre spacing
  - > Mix of deviated and horizontal wells

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Geoscience Overview

Average Reservoir Properties and OBIP

Reservoir and Fluid Properties

Depth	Clearwater @ 400M	
Depositional Facies	Continental scale fluvial-deltaic system	
Sands	Unconsolidated, reactive, clay clasts	
Diagenetic Cements	Mixed-layer clays	
Bitumen API Gravity	10.2	
Bitumen Viscosity	100,000 cp @ 13 C 8 cp @ 200C	
Bitumen Saturation	Average 70%	
	Range	*Average*
Porosity	27 - 35%	32%
Permeability	1 - 4 Darcies	1.5 Darcies
Bitumen Wt %	6 - 14%	10.5%
Total Net Pay	0 - 60m	30m

Original-Bitumen-in-Place (OBIP)

Clearwater Fm	*8 Wt %*		*6 Wt %*	
	(E6m3)	*(MBO)*	*(E6M3)*	*(MBO)*
Entire Approval Area	2,250	14,150	2,609	16,410
Operating Portion[1]	1,888	11,875	2,185	13,740

[1] Volume of main approved development area (i.e. excluding Nabiye)

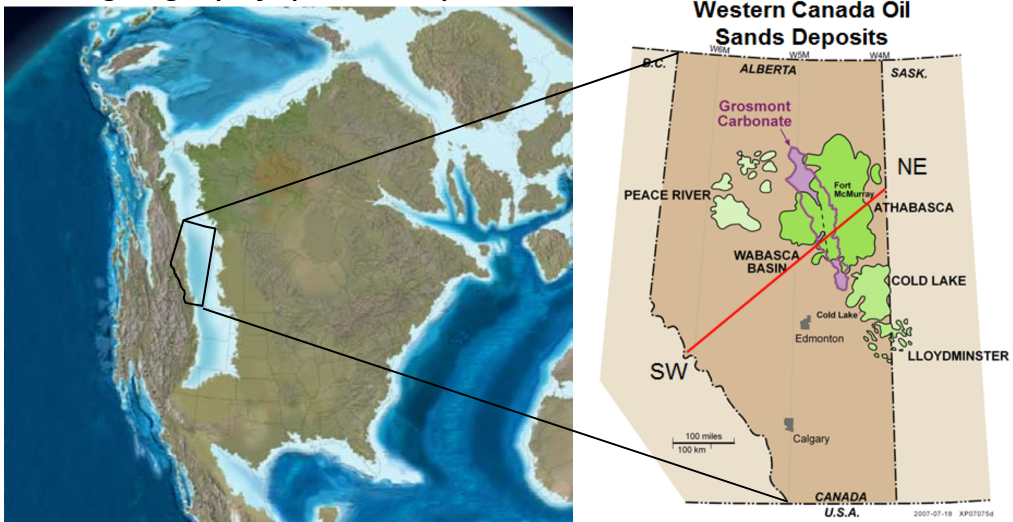
CALCULATION METHOD

OBIP = A * H * V

A = area (m2)
H = Net pay (m)
V = Volumetric Factor = W * (2.64 – (1.64 * P))
W = Saturation (avg Wt %)
P = avg Porosity

Mannville Group: Geologic Setting

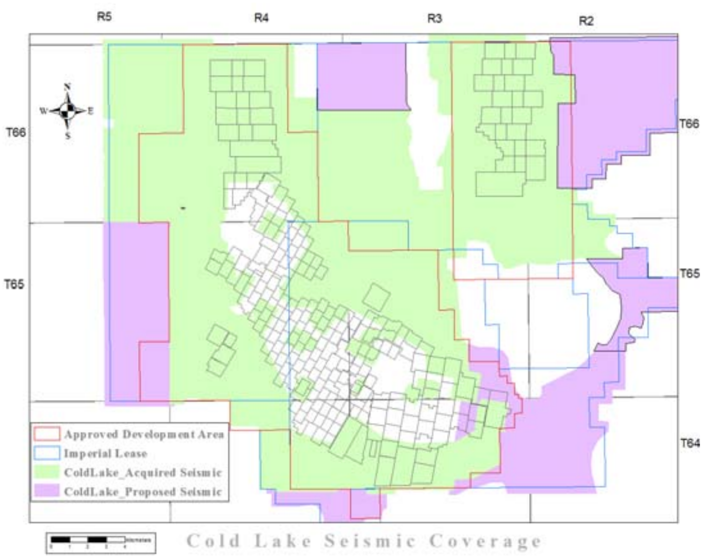
Paleogeography (~100 Ma)

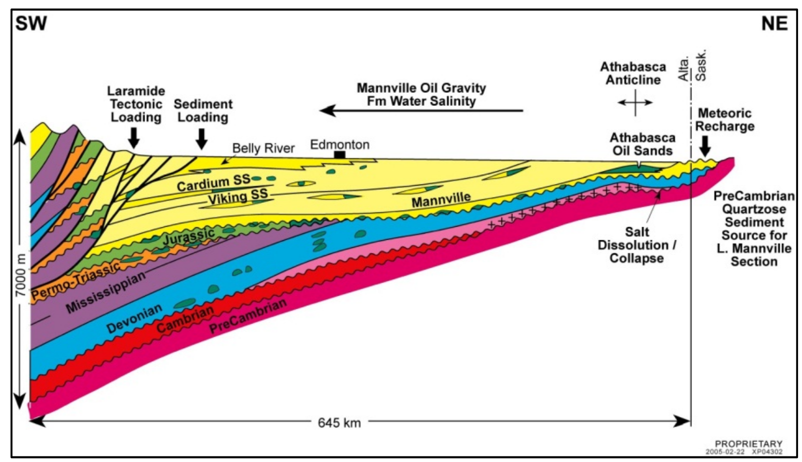


Blakey, www2.nau.edu/rcb7/index.html

Depositional Environment

- Mannville group deposited during Barremian to Albian time associated with fluvial drainage to the north toward the boreal sea (Western Interior Seaway)
- Western Canada Basin is a large foreland basin thickening to the west; marine & non-marine deposits
- Sub-divided into two lithostratigraphic units: 1) Lower tidally influenced fluvial (McMurray); and 2) Upper estuarine/shelf dominated (CLW & GR)
- Regional high to the east due to backbulge where salt dissolution and underlying Paleozoics likely controlled subsidence - Athabasca anticline





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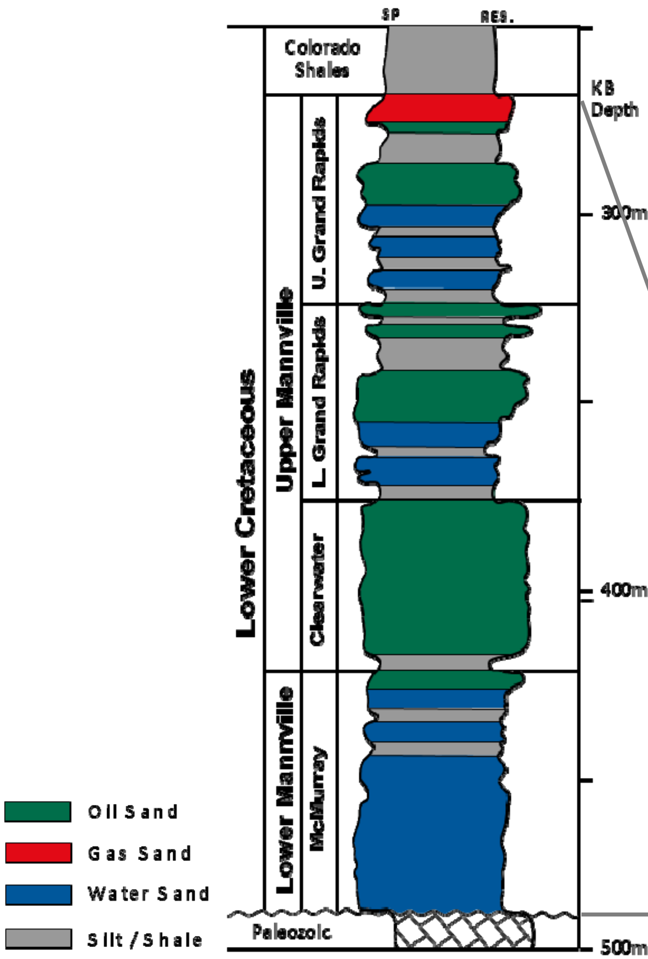
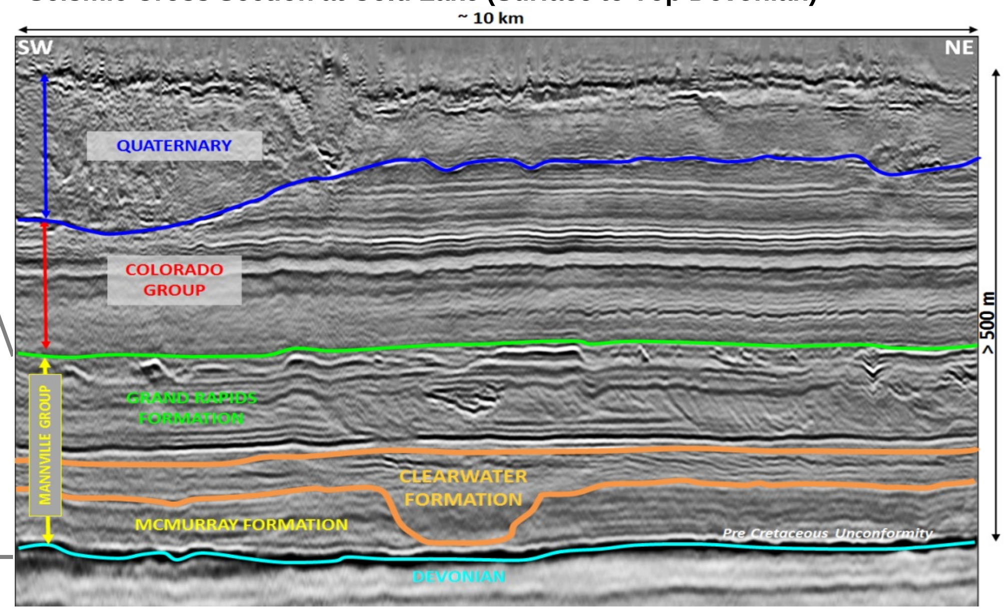
Representative Type Log

Representative Well Log Response – Mannville Group



- Schematic type well log through the Mannville Group, (Albian) of Cold Lake field, Alberta
- Primary reservoir is the Clearwater Formation, secondary targets comprise the Grand Rapids and McMurray formations
- Clearwater Formation is a reservoir with a complex stratigraphic architecture that consists of a succession of deltaic and tidally influenced distributive fluvial systems
- Development to date has focused on the Clearwater in the central axis of the main fluvial valley complex

Seismic Cross Section at Cold Lake (Surface to Top Devonian)



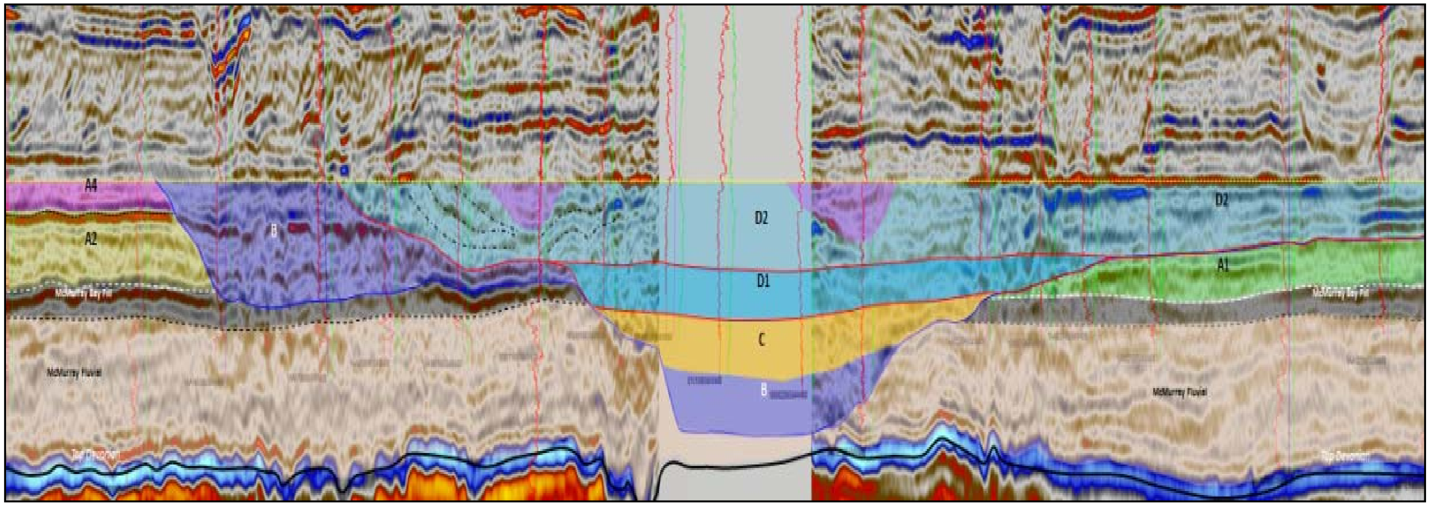
2014 Stratigraphic Framework

History

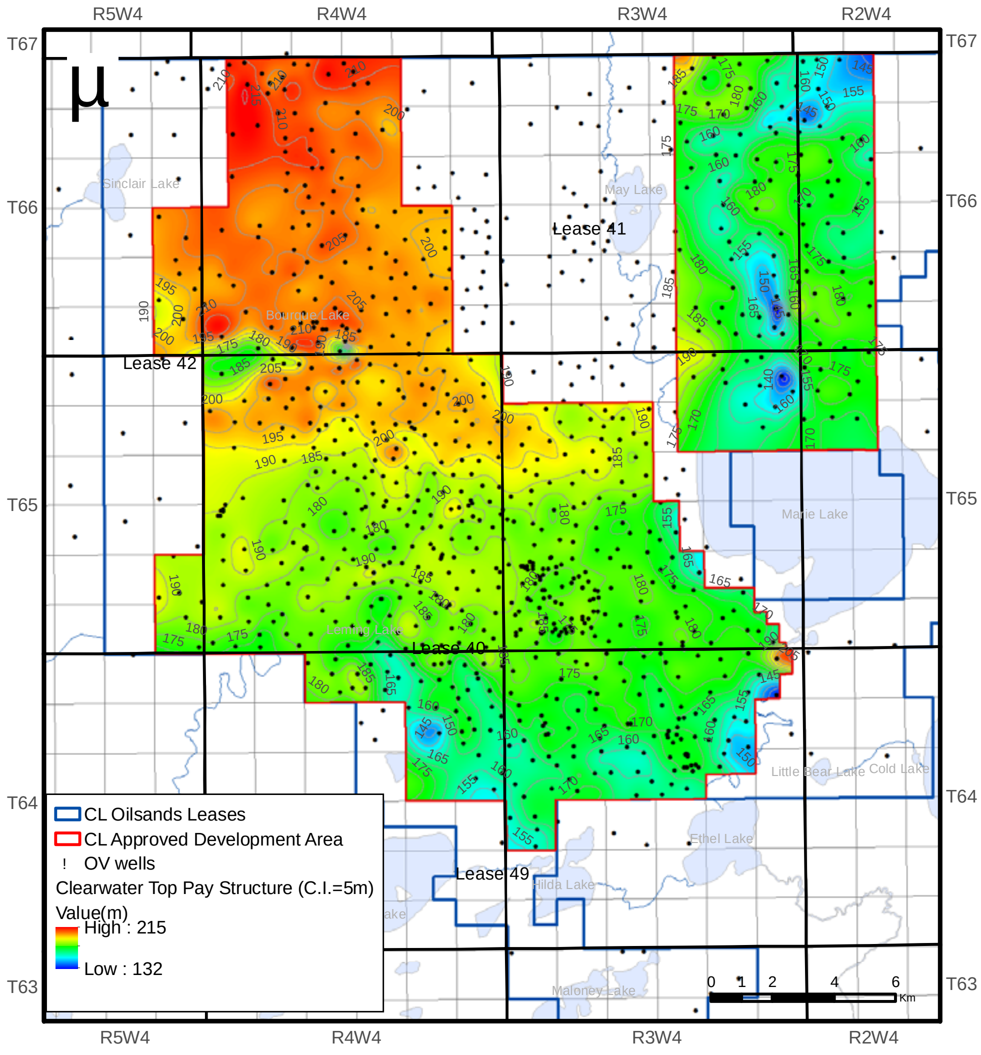
- Previous Cold Lake Clearwater stratigraphic framework developed in 1998
  - Adequate framework for majority of Cold Lake development projects
- Increasing complexity of recent & future development opportunities requires more predictive framework. Revised framework integrates 370 km^2 of hi-res 3D seismic and 1500 cores/logs
  - Identified four genetic units within the Clearwater that were mappable sub-regionally

Ongoing Implementation

- Application of framework to Nabiye is providing insights into pad performance variations
- Improved predictability of EOD distribution and impact on RQ has assisted with understanding production characteristics at Mahihkan North & K26
- Broader application in the field is fundamental to assessing potential for future development opportunities

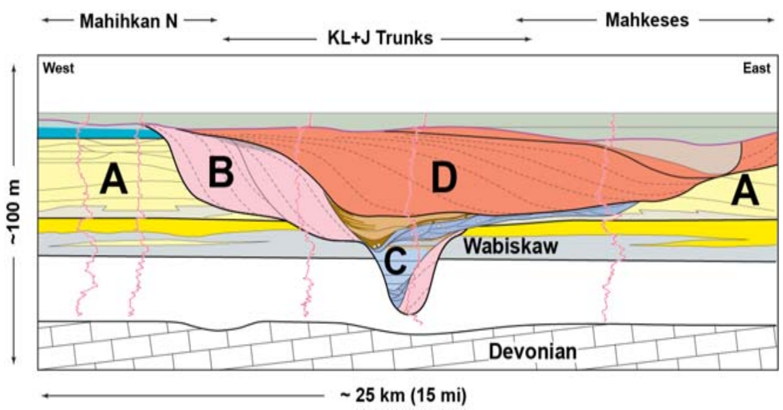


Top Bitumen Pay Structure



- Top of bitumen pay is a smoothly varying surface which gently dips from a high of 220m above sea level (A.S.L.) in the NW to a low of 136m A.S.L. in the SE
- Top of bitumen structure varies more greatly in the Nabiye area
- Mapped surface is either a rock/bitumen or a gas/bitumen contact

Clearwater Formation Stratigraphic Framework



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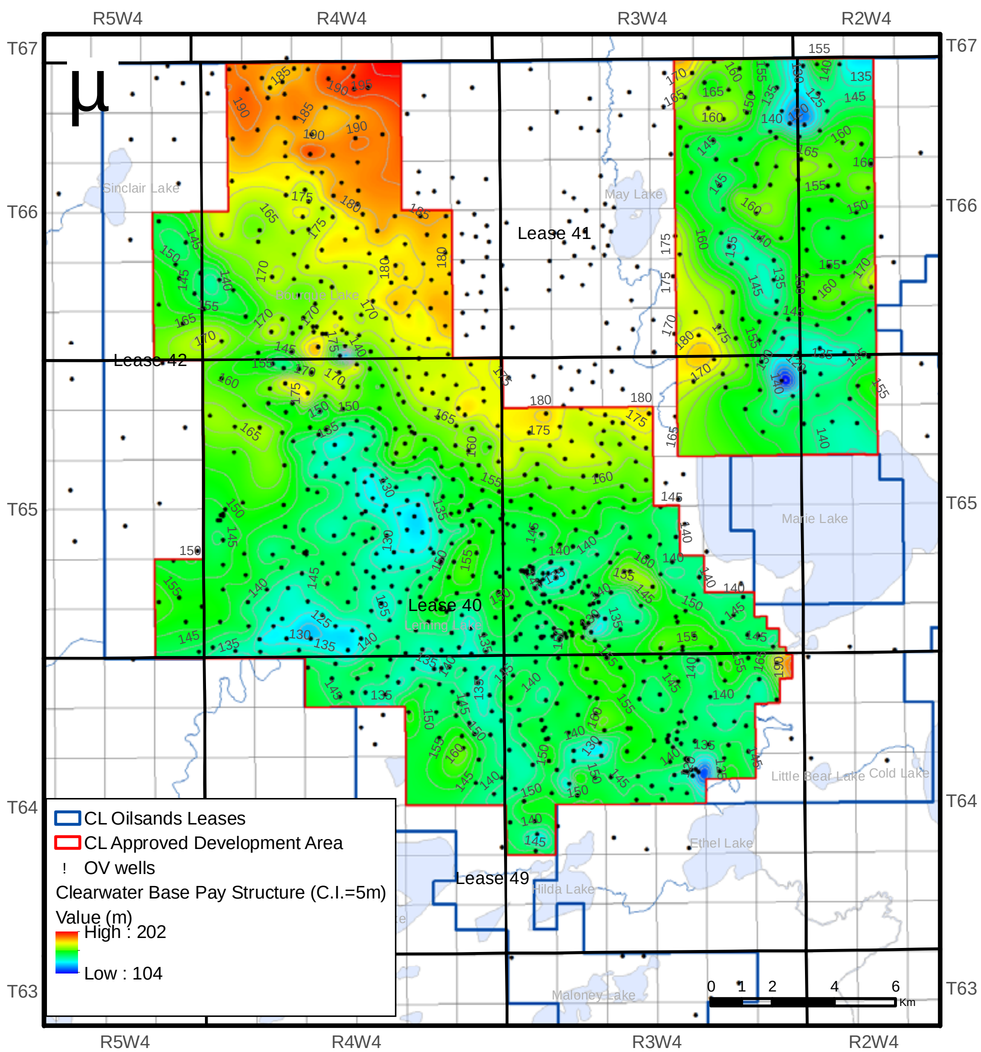
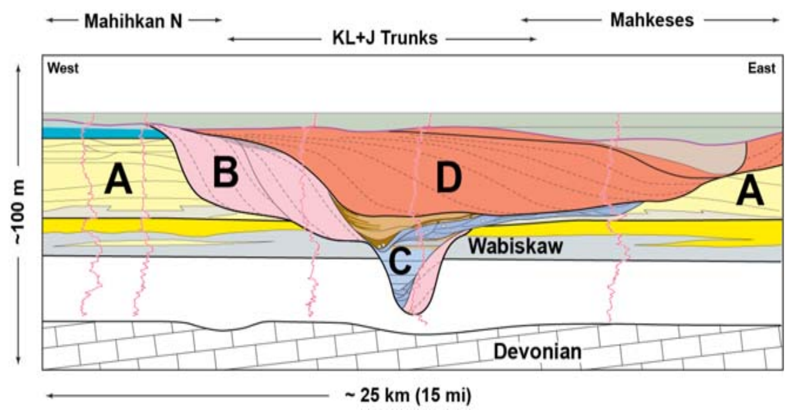
Base Bitumen Pay Structure



- Map represents amalgamated incised valley fills associated with low-stand erosional events
- Different successions, depending on their depositional environment are filled with varying amounts of sand and shale.
- Mapped surface is either a bitumen/rock, a bitumen/water transition zone or a bitumen/water contact

Clearwater Formation Stratigraphic Framework



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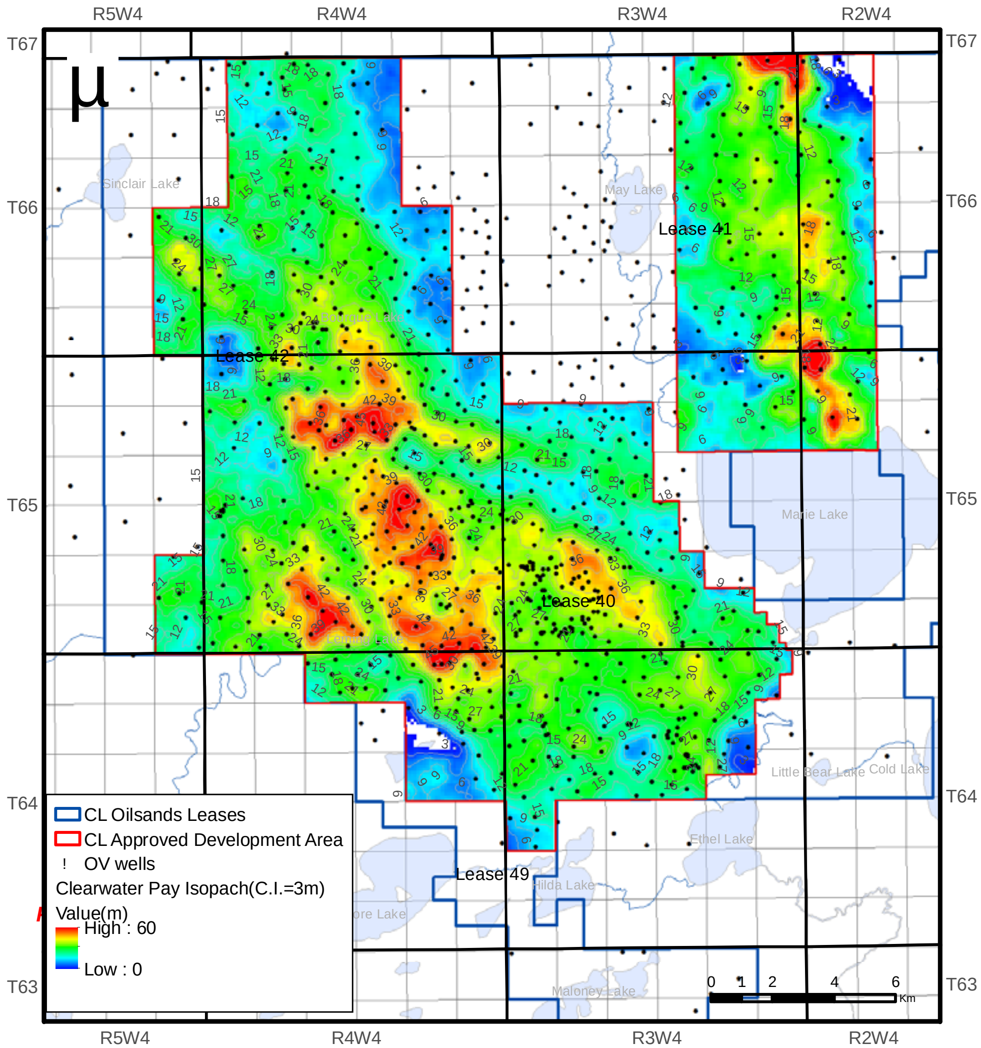
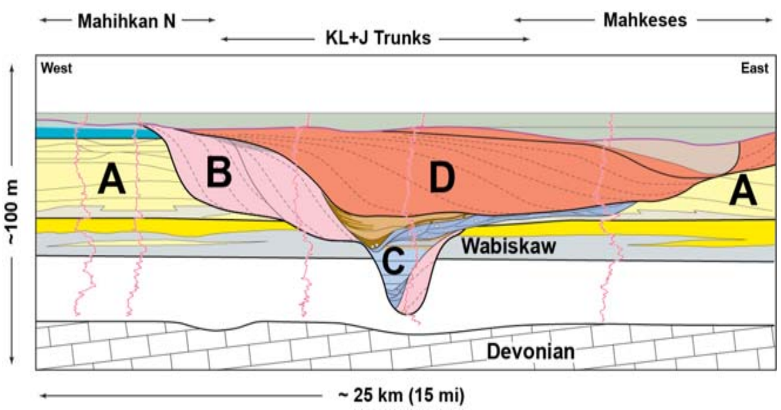
Isopach of Net Bitumen Pay (>8 wt %)



- Map illustrates distribution of pay above 8 wt% saturation cut off
- Thin pay and pay immediately adjacent to water included in isopach calculation
- Thickness trend is consistent with orientation of main valley incision

Clearwater Formation Stratigraphic Framework



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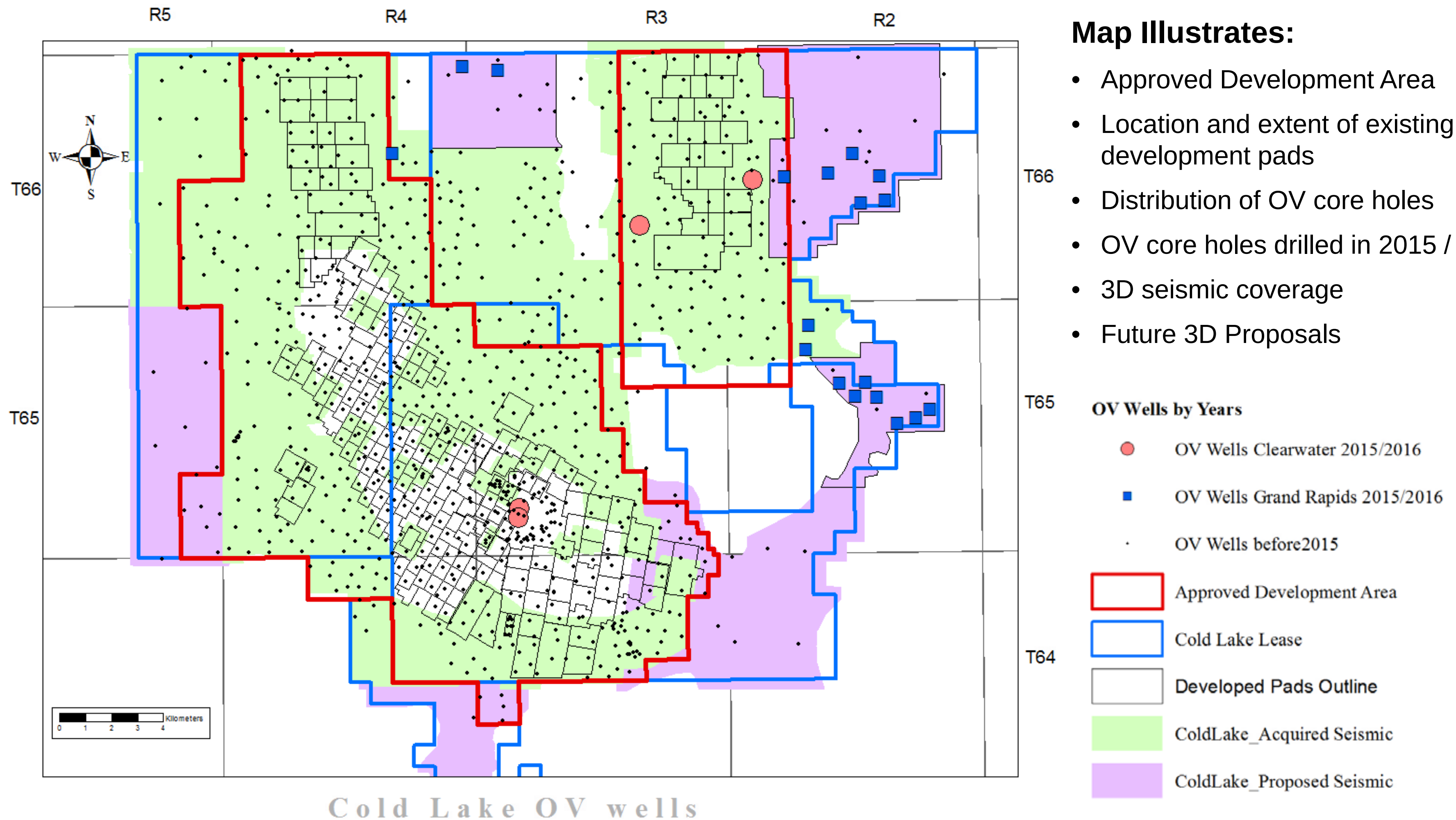
Approved Development Area



Map Illustrates:

- Approved Development Area
- Location and extent of existing development pads
- Distribution of OV core holes
- OV core holes drilled in 2015 / 16
- 3D seismic coverage
- Future 3D Proposals

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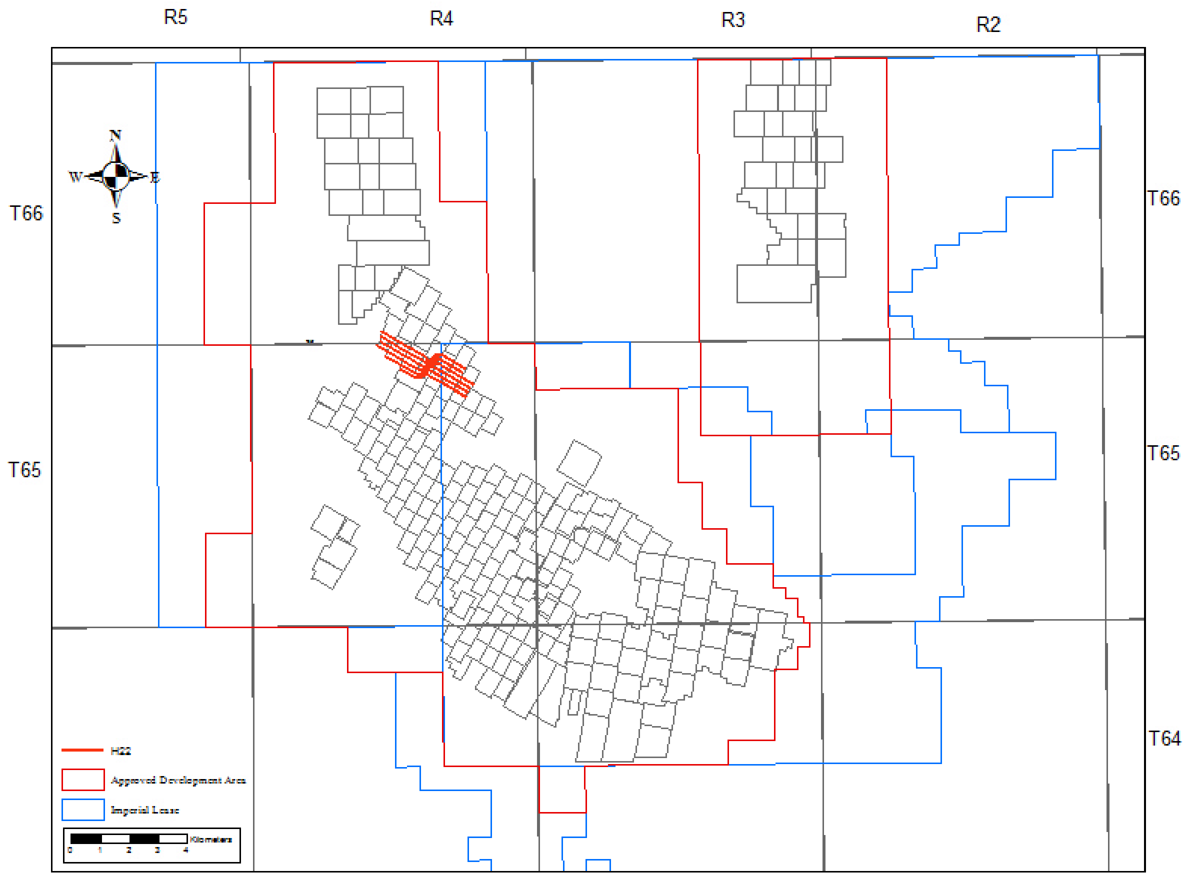
Approved Development Area



Cold Lake Development Wells Drilled by 2015 Year End

Map Illustrates:

- Approved Development Area
- Cold Lake Oilsands Leases
- Location and extent of existing development pads
- Development wells drilled post September 2015
    - H22 laterals

H22

Developed Pads Outline

Approved Development Area

Cold Lake Lease

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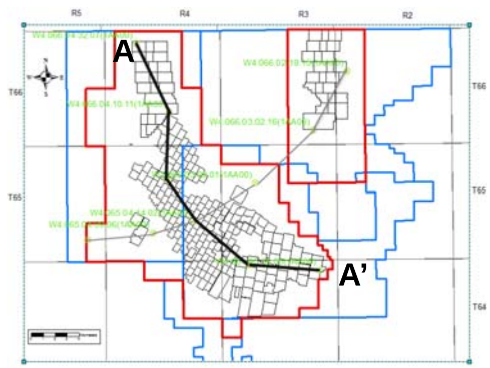
Representative Structural Well Log Cross Section

Cross section represents stratigraphic and structural variability within the Clearwater Formation from northwest to southeast .

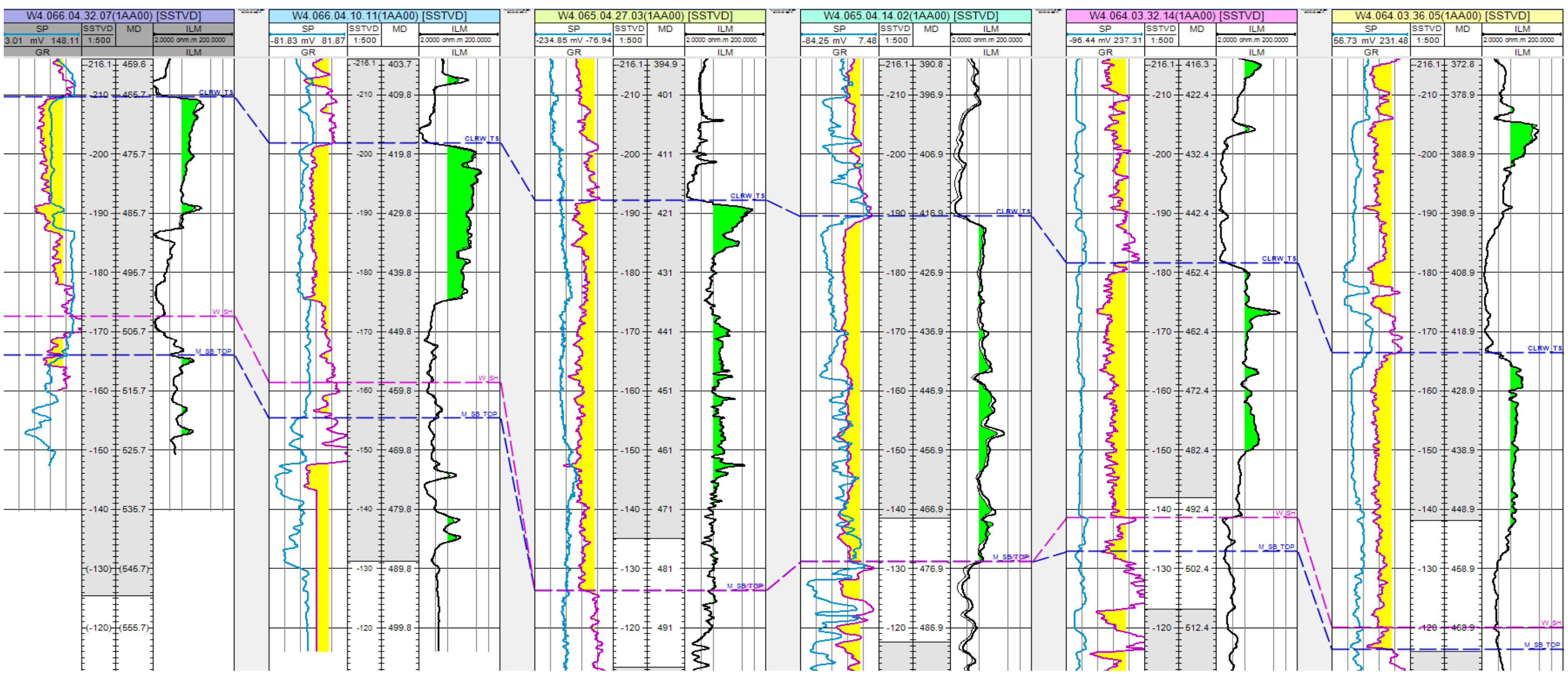


Cold Lake Leases

Approved development boundary

Developed pads

A



A’

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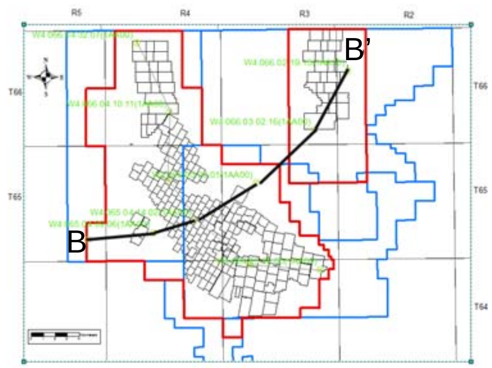
Representative Structural Well Log Cross Section

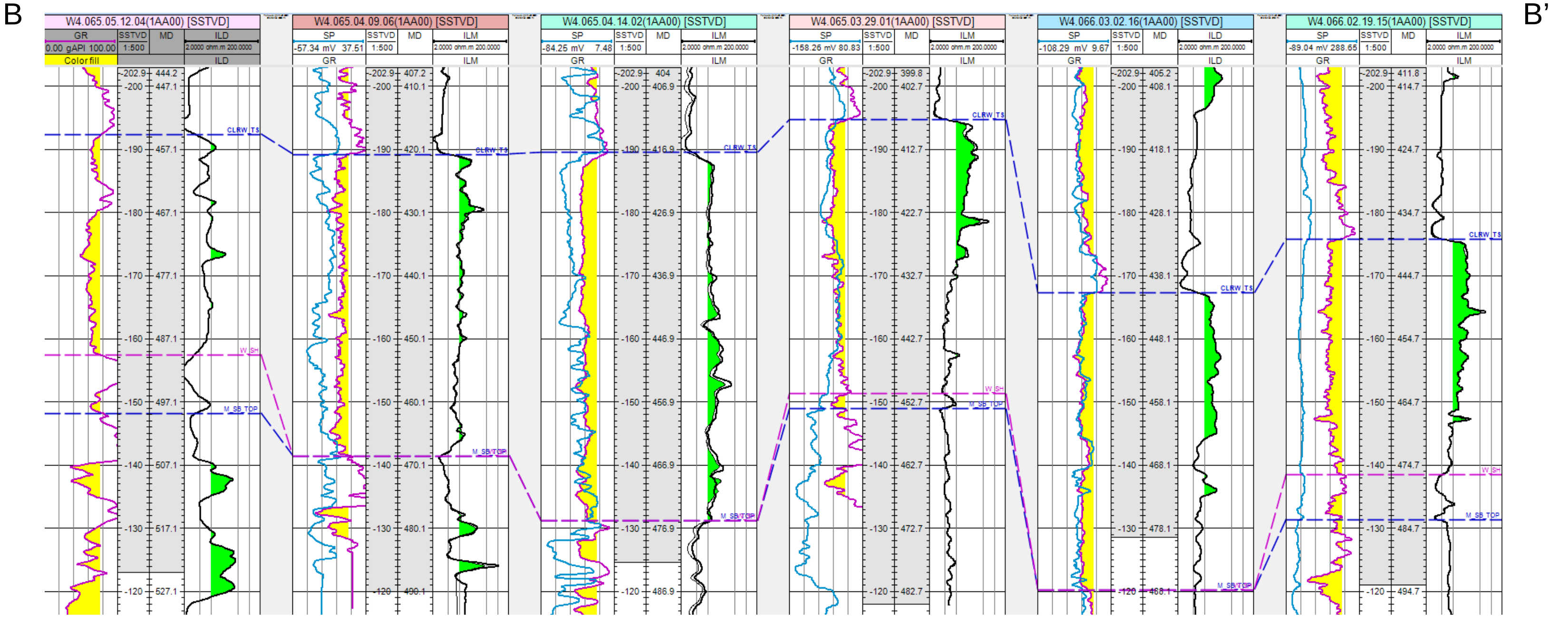
Cross section represents stratigraphic and structural variability within the Clearwater Formation from southwest to northeast.



Cold Lake Leases

Approved development boundary

Developed pads



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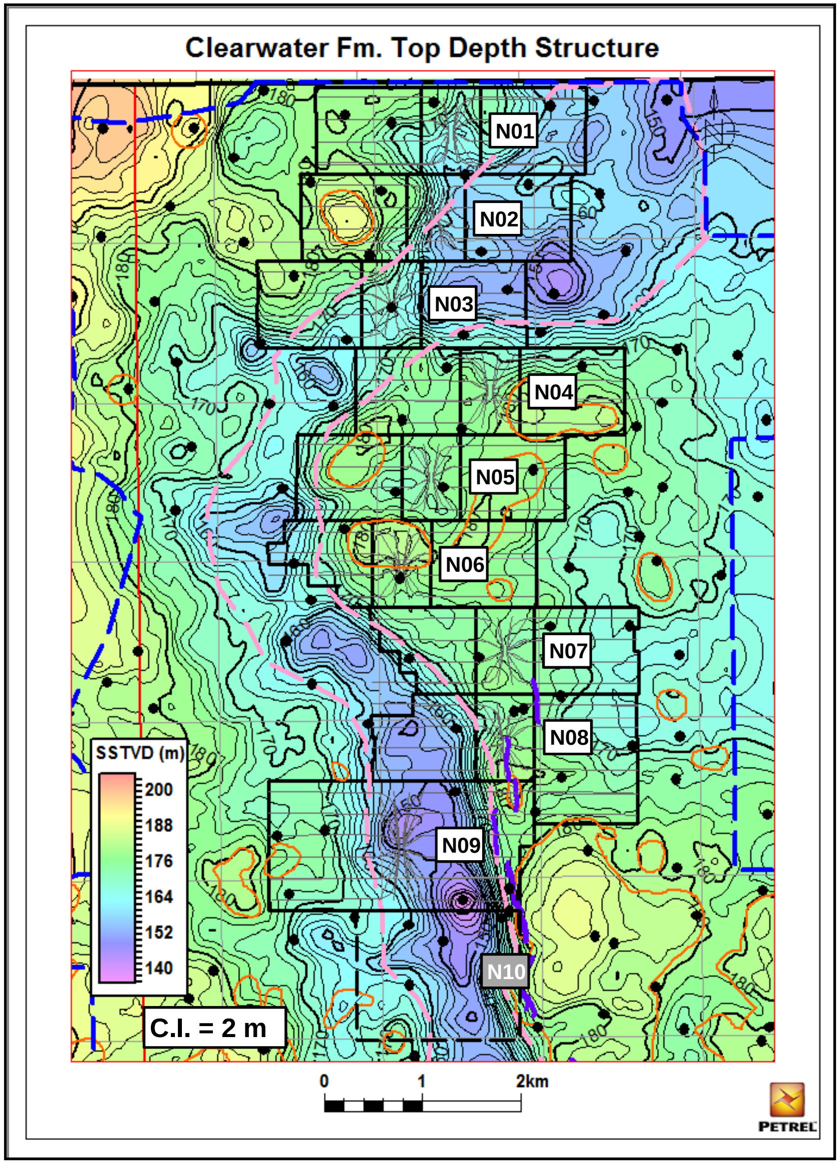
Nabiye Field Geology: Top Clearwater Structure

Map illustrates:

- Depth (Elevation) of the Top Clearwater Formation across the greater Nabiye Development area
  - Clearwater Top structure map integrates 3D seismic surveys and all well data
  - Significant structural change from 200 m asl to 140 m asl due to underlying salt dissolution of Paleozoic evaporites
  - Salt dissolution in the area occurred pre-, syn- and post-deposition of the Mannville Group
  - Structural deformation generated extensional faults within the Clearwater, Grand Rapids, and lower Joli Fou formations along the southeastern edge of the salt-dissolution valley
- Presence of top gas/water areas
- Distribution of the OV wells used in GeoModel
- Current production pads and future development pads

Cored OV Wells used in updated GeoModel
Production Pads: Drilled and Steamed (N01-N08)
Production Pads: Drilled (N09)
Future Development Pads (N10)
Seismic Surveys combined outline (3D)
Top Gas/Water Areas (From Seismic and Wells)
Salt Dissolution
Faults in Clearwater Formation



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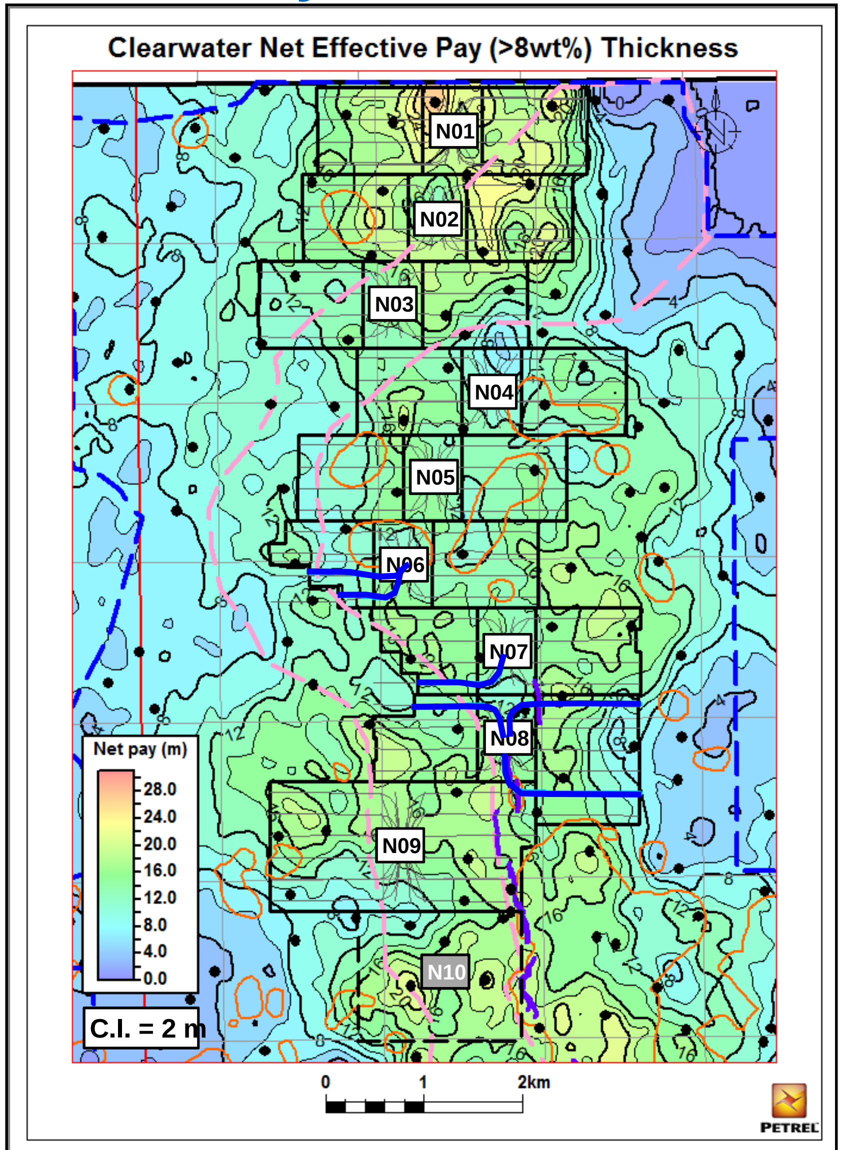
Isopach of Net Effective Bitumen Pay

Map illustrates:

- Distribution of Net Effective Pay Thickness across the greater Nabiye Development area
  - Calculated from well top picks – top and base effective pay which account for top gas/water and bottom water standoff
  - Effective Pay defined as >8 wt% bitumen saturation; thin pay not included
- Blue well paths illustrate where horizontal production wells encountered free water and required re-drill
  - West side of pads N06, N07 and N08 (lateral stand-off); and east side of pad N08 (vertical stand-off)
- Presence of top gas/water areas
- Distribution of the OV wells used in GeoModel

Cored OV Wells used in updated GeoModel
Production Pads: Drilled and Steamed (N01-N08)
Production Pads: Drilled (N09)
Future Development Pads (N10)
Seismic Surveys combined outline (3D)
Wells re-drilled due to encountering free water
Top Gas Areas (From Seismic and Wells)
Salt Dissolution
Faults in Clearwater Formation



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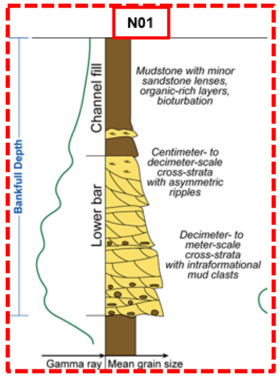
Nabiye: Geoscience Summary & EOD Interpretation

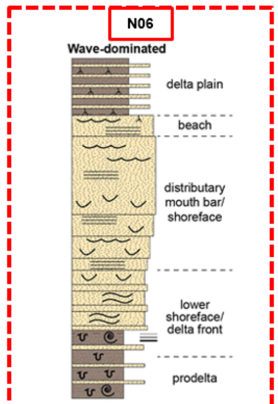
Nabiye genetically related to older deltaic "A" units rather than younger fluvial "D" units

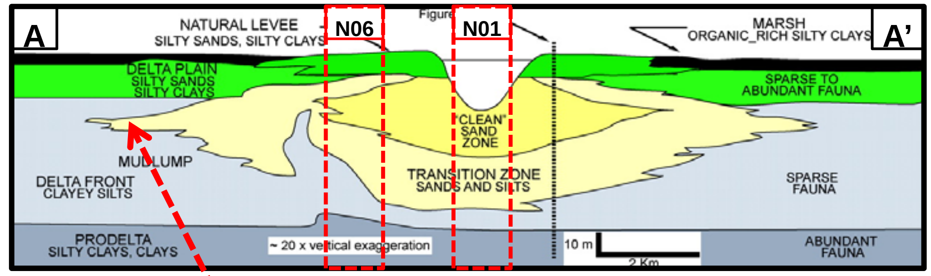
Nabiye subdivided into 3 main Geobodies (*A6a; A6b; Regional Deltaics*):

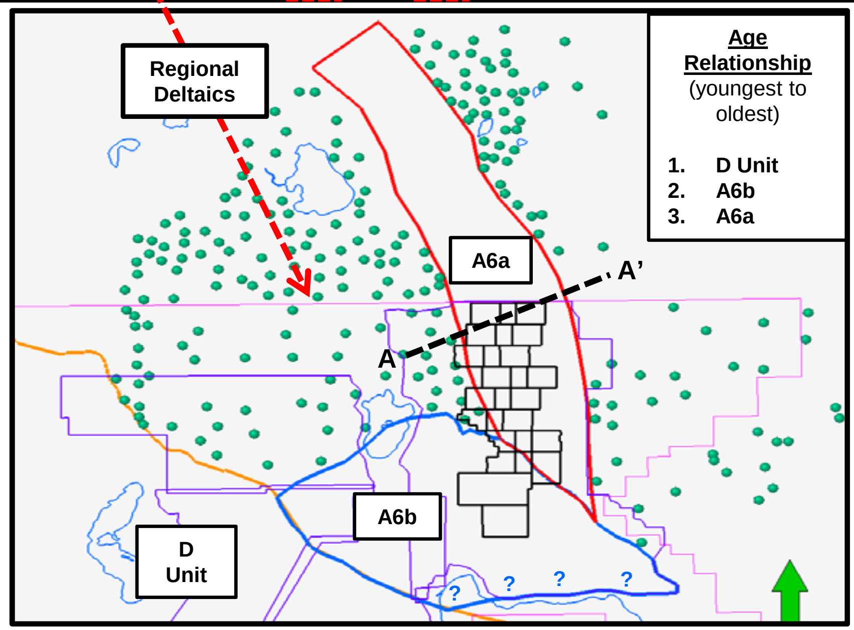
Age-relationships resolved and tied to OSC framework based on cross-cutting relationships

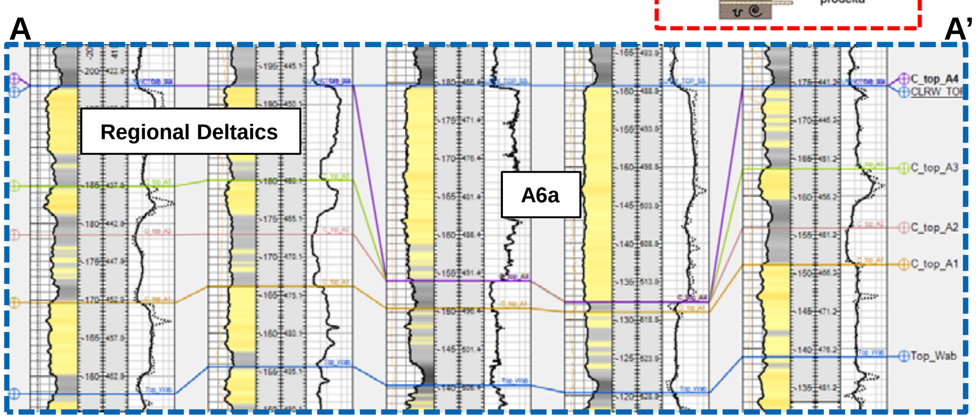
Reservoir differences may represent down-dip and lateral facies changes relative to the main axis of deposition within individual lobes (*e.g. distributary channel vs. terminal distributary channel/mouth-bar vs. proximal and distal delta-front EODs)*









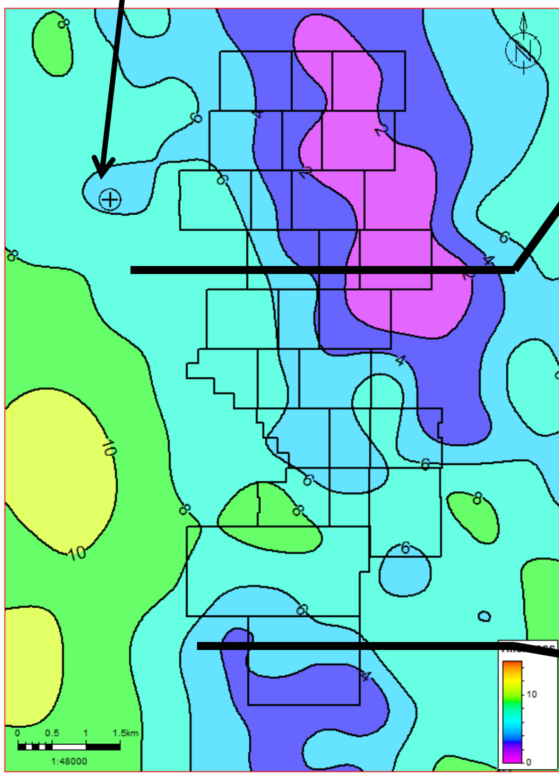


Well log cross section datumed on Top Clearwater surface displaying the internal stratigraphy across Nabiye field (pad N01/N02 area)

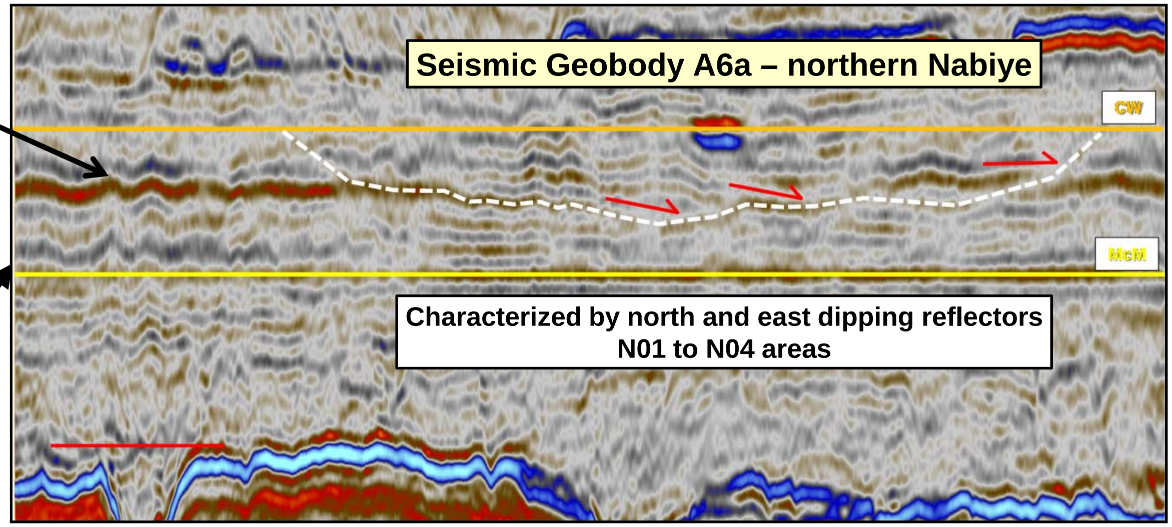
Nabiye Geobodies: Seismic Mapping

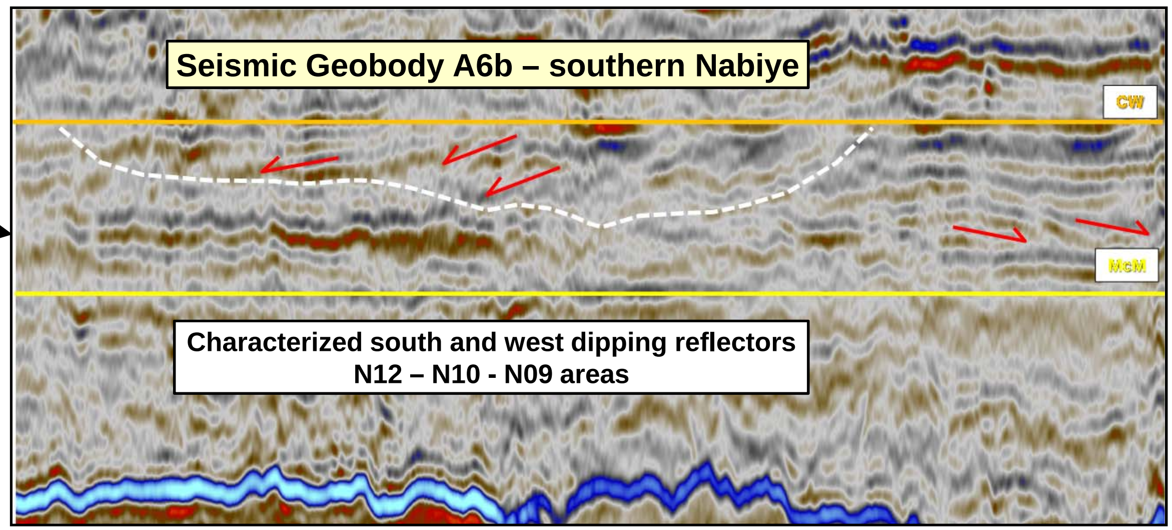
Regional Deltaics

A2 Isopach



Time Seismic Volume Double-flattened on Clearwater and McMurray Tops





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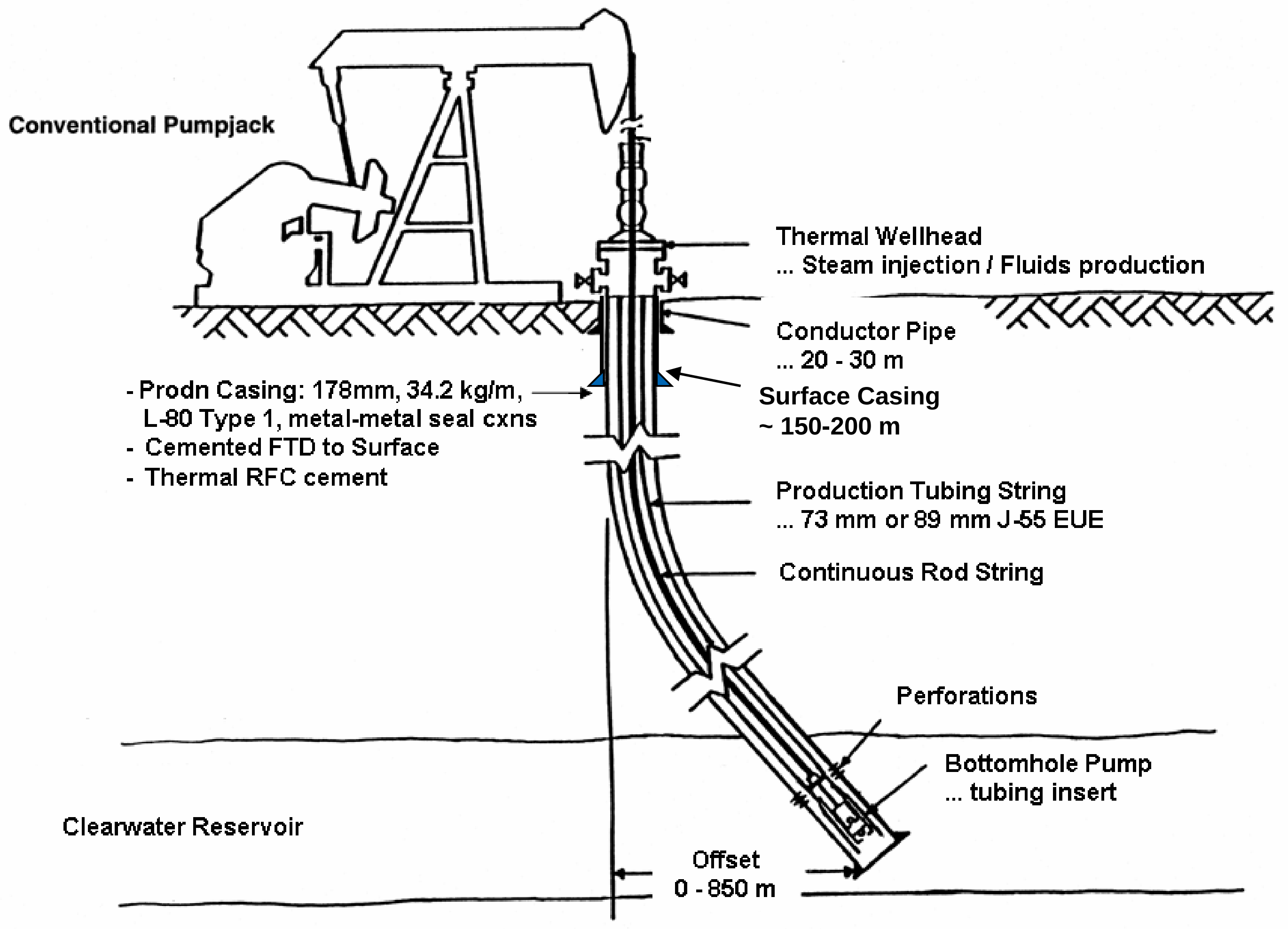
Drilling and Completions

Typical Deviated CSS Well Design



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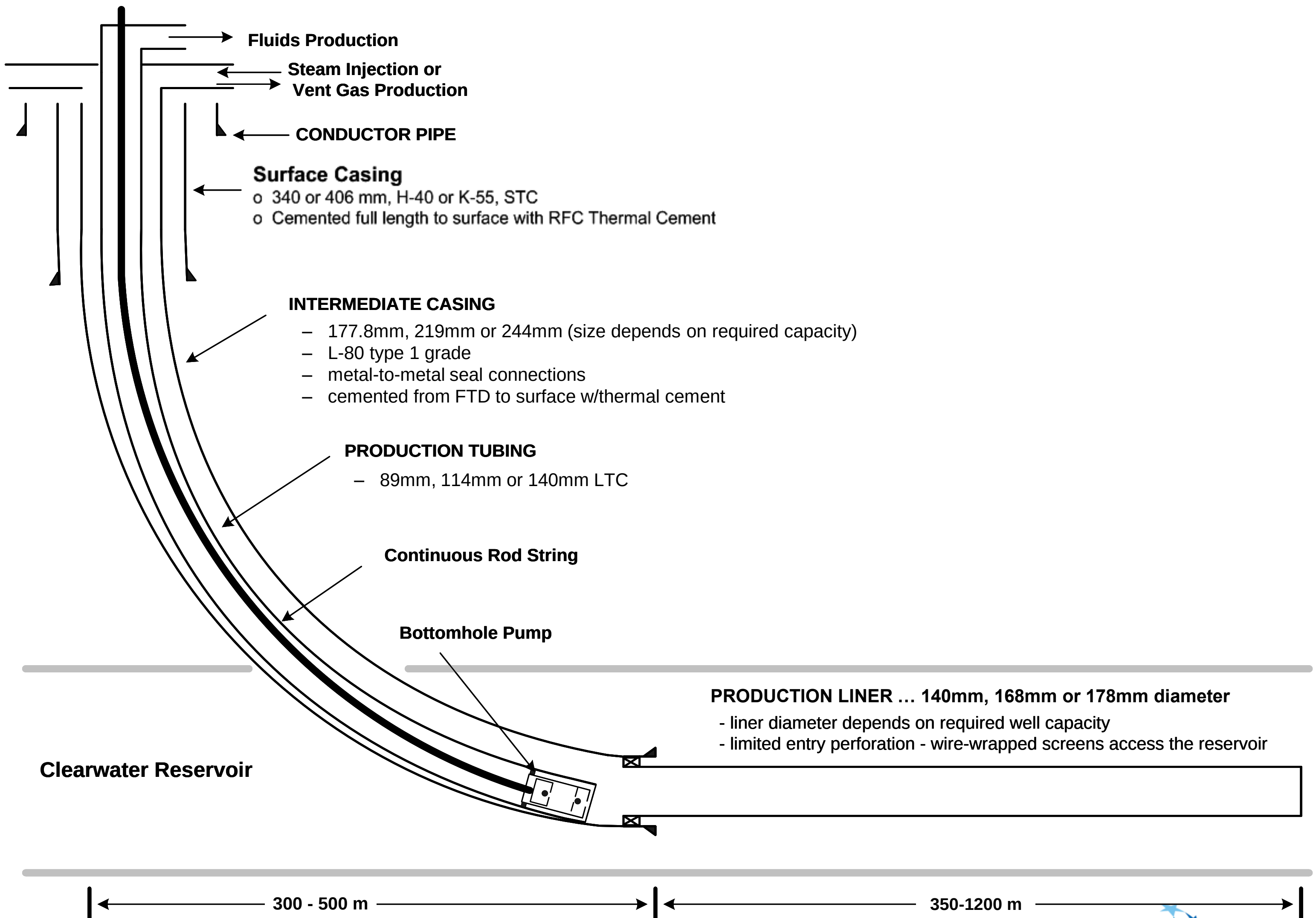
Horizontal CSS or HIP Well Design



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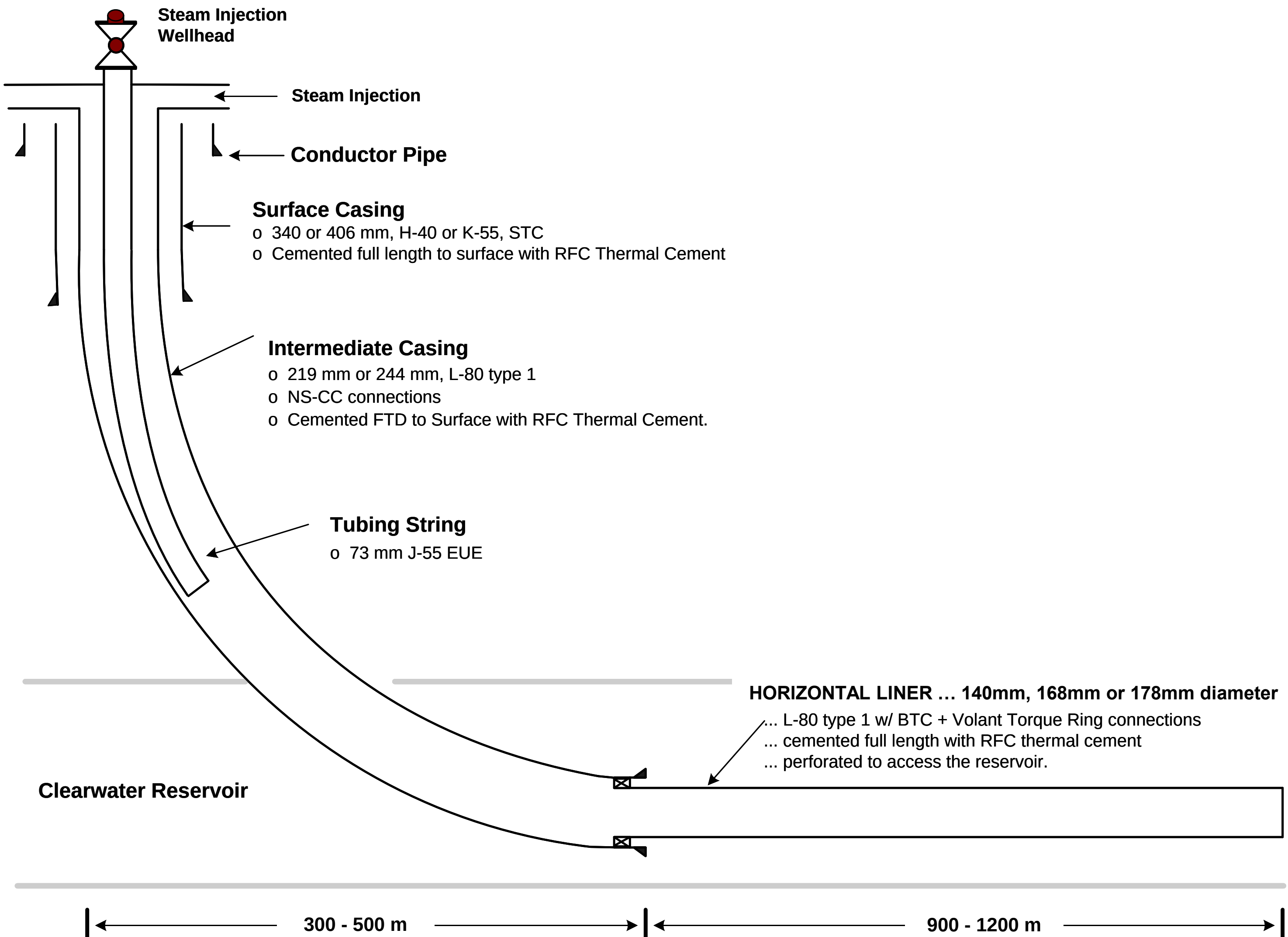
Horizontal Steam Injection Well Design



Artificial Lift

Artificial Lift Performance

Pumpjack	Bottom Hole Pump	Speed	Design Rate
160 - 173 - 86	50.8 mm	7 SPM 11 SPM 16 SPM	38 m3/d 60 m3/d 87 m3/d
228 - 173 - 86 or 320 - 213 - 86	63.5 mm	7 SPM 11 SPM 16 SPM	60 m3/d 93 m3/d 135 m3/d
456 - 213 - 144	63.5 mm (long stroke)	4 SPM 7 SPM 14 SPM	55 m3/d 100 m3/d 200 m3/d
912 - 305 - 192	82.6 mm	4 SPM 7 SPM 11 SPM	130 m3/d 225 m3/d 350 m3/d
1280 - 305 - 240	95.3 mm	4 SPM 7 SPM 10 SPM	210 m3/d 370 m3/d 530 m3/d

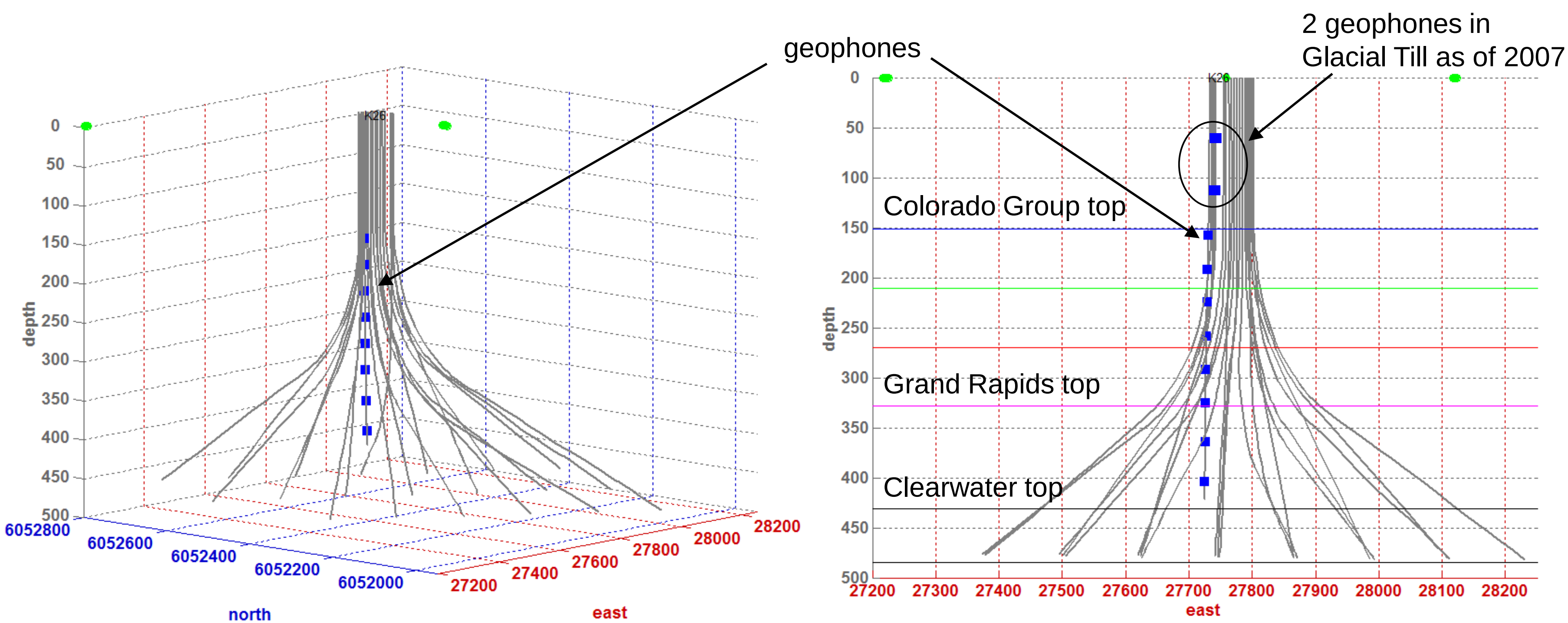
- Insert rod pumps used across field
- Size of lift system depends on:
  - Offset to reservoir target
  - Well deliverability: deviated versus horizontal wells
- Operating Conditions
  - Pumping temperature 75 – 220°C
  - Pump Intake pressure 6 MPa to less than 500 kPa
  - Average run life of rod pumps is between 600-700 days
- Corpac Variable Frequency Drive (VFD) Program ongoing
  - Installing VFD’s on all new producing wells and select retrofits on existing producing wells
  - Using VFD controllers for inferred measurement, speed control, pumping unit shutdown and optimization

Instrumentation in Wells

Instrumentation in Wells

- A passive seismic well with permanent omnidirectional geophones is installed at all new high pressure pads at Cold Lake since 1998
- Seismicity is monitored to detect fluid incursion and casing failures in uphole zones

Typical Passive Seismic Configuration



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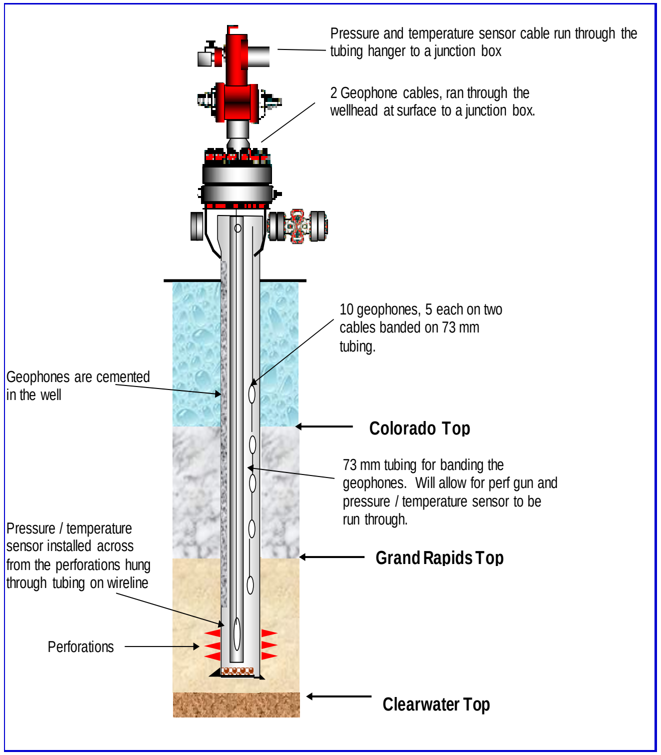
Instrumentation in Wells

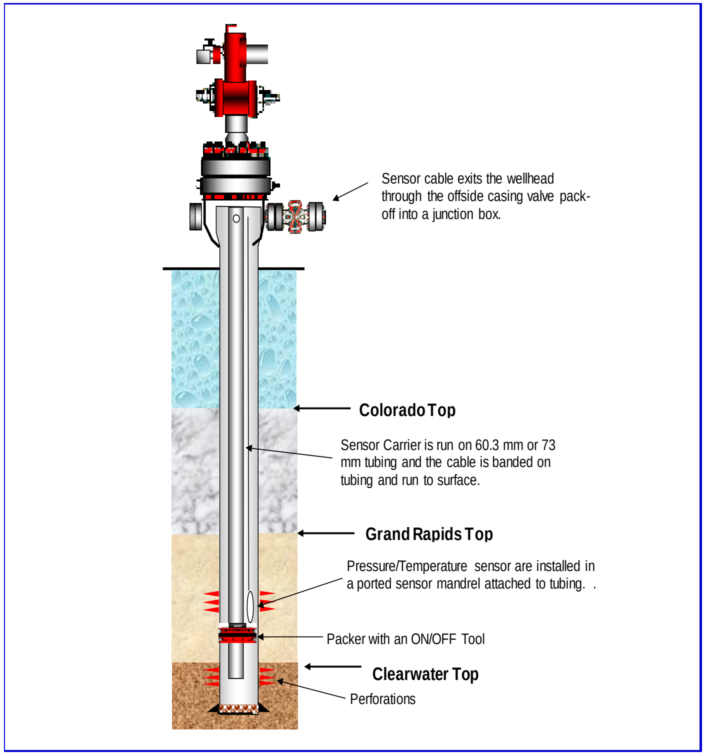
Hybrid Passive Seismic Well

- A hybrid Passive Seismic well design allows pressure monitoring in the Grand Rapids and passive seismic monitoring with cemented geophones in the same well.

Grand Rapids Pressure Monitoring Well

- There are several wells in the field used to monitor Grand Rapids pressure. These wells often monitor more than one interval. The configuration below provides pressure monitoring in one Grand Rapids interval and one Clearwater interval.





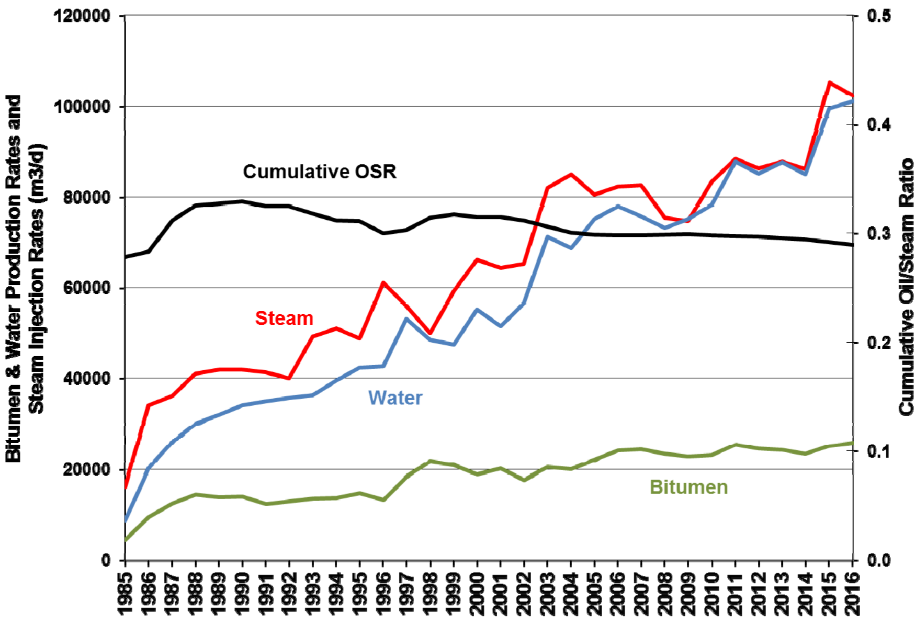
Scheme Performance

Cold Lake Recovery Determination

- Bitumen recovery from the CSS process in the Clearwater zone is a function of effective pay thickness and bitumen saturation
- Effective pay and bitumen saturations are determined from facies based descriptions of logs and cores obtained from the Clearwater zone at an 8 wt% cutoff
    - Shale and clay content are considered in the determination of effective pay
- Recovery predictions are based on performance type curves derived from field performance and reservoir simulation
- Adjustments are made for other factors impacting recovery such as:
    - Bottom water
    - Clearwater gas cap
    - Split pay
    - Adjacent reservoir depletion
    - Well spacing

Cold Lake Production Performance

Cold Lake Approval 8558 Area Production

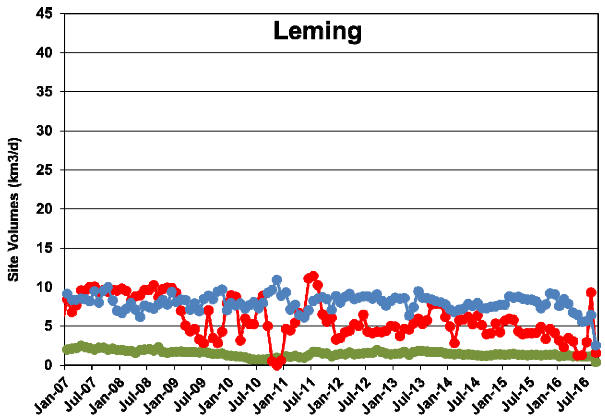


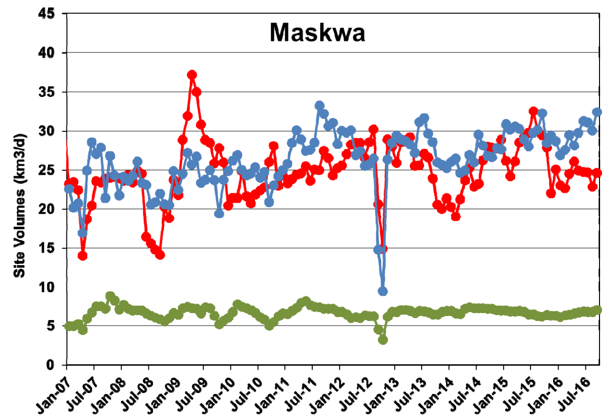
	Bitumen Production 10^3 m^3/d	Steam Injection 10^3 m^3/d	Cumulative OSR	Cumulative SOR
2015	25.2	105.5	0.29	3.4
2016 YTD Sep	25.7	102.5	0.29	3.4

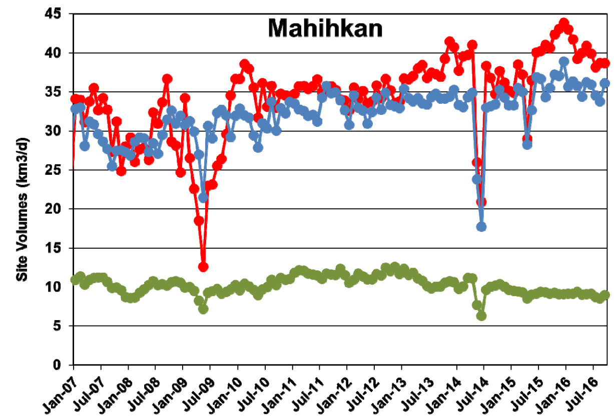
Notes
- Steam volumes prior to Oct 2004 not adjusted for meter correction
- Production data includes CSP and SA-SAGD pilot projects
- SOR on wet steam basis

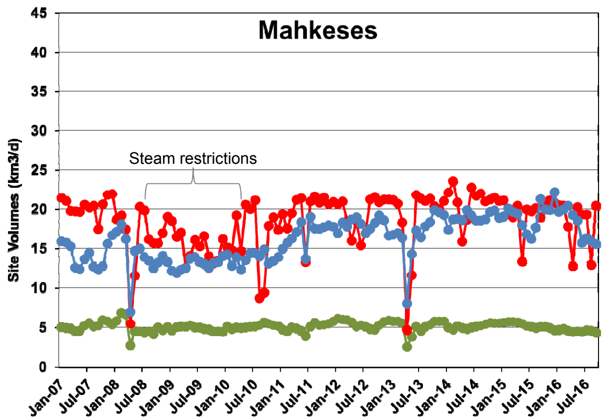
- Maximum daily bitumen production under approval 8558 is 40,000 m^3/d
- Development continues to increase production rates
- Development is driven by many factors including technology and economics

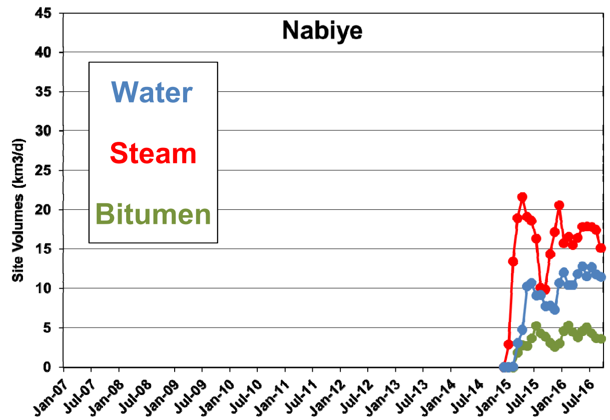
Individual Site Performance











Plant	2016 Average	
	OSR	SOR
Leming	0.34	2.9
Maskwa	0.27	3.6
Mahihkan	0.23	4.4
Mahkeses	0.25	4.0
Nabiye	0.26	3.8

Steam Transfers (10^3 m^3)

Maskwa to Mahihkan:	**1,081**	**D04 Infills (Oct 2015 – Sep 2016), A06 Infills (Oct 2015 – Sep 2016)**
Mahihkan to Maskwa:	**0**	
Leming to Maskwa:	**1,406**	**0FF Infills (Oct 2015 – Sep 2016), 00U Infills (Oct 2015 – Sep 2016)**
Leming to Mahkeses:	**0**	
Mahkeses to Leming:	**447**	**T05 Infills (Mar 2016 – Apr 2016, Jul 2016 – Sep 2016)**

Abandonment Outlook

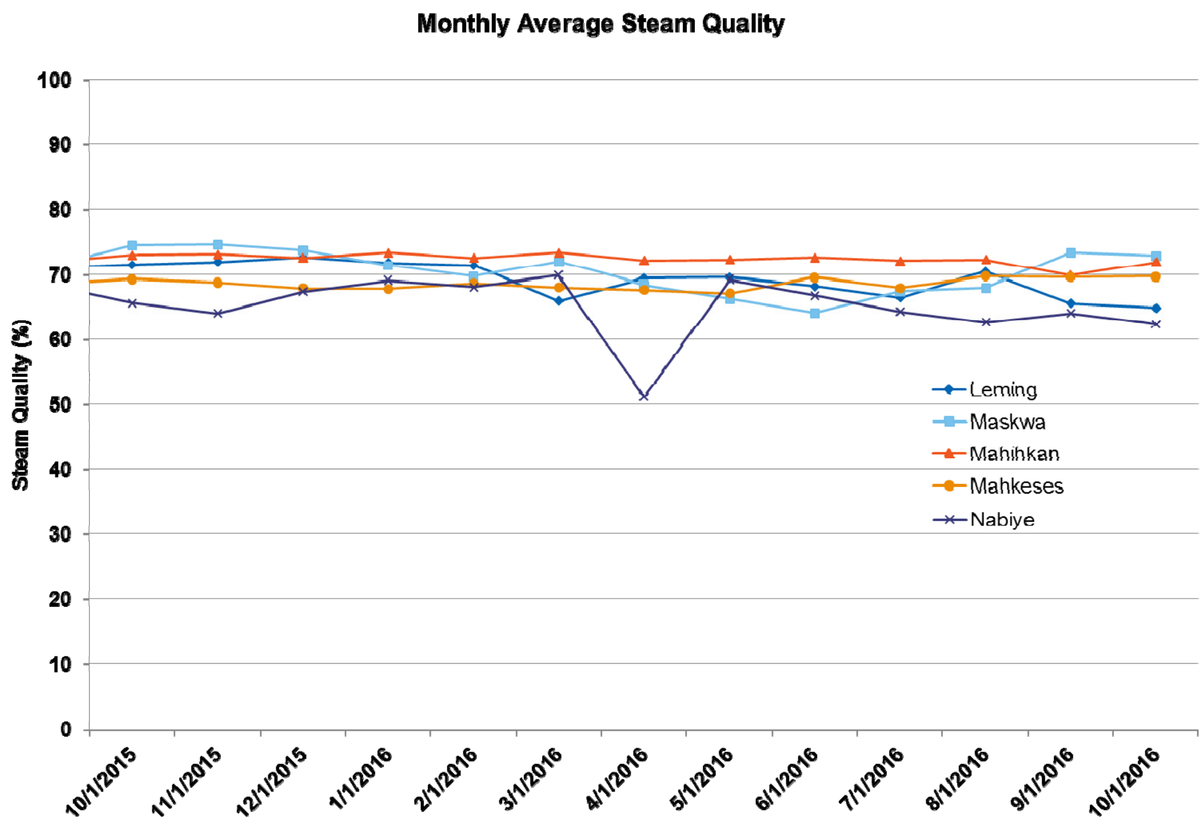
- 5 year outlook for pad abandonment
  - 'Flow Behind Pipe' assessment (inc. E07 pad testing) confirms hydraulic isolation behind casing on Cold Lake wells.
  - Assessment also demonstrates that post-steam cement bond logs do not reflect degree of hydraulic isolation behind casing
  - Aquifer isolation study completed in 2016 confirms that isolation of aquifers at the time of full subsurface abandonment is not necessary
  - E07 pad wells have been fully abandoned except for two wells which have been retained for monitoring of adjacent D29 pad high pressure steaming operations
  - CC/DD/GG pad abandonment progressed; 44 wells fully or partially abandoned, remainder will continue 2016+
  - Q and S pad scheme approval in place, abandonments to follow CC, DD & GG
    - Discontinue monitoring for Q-01 approved by AER in 2016
  - B03 pad abandonment progressed, 16 wells partially abandoned, 2 fully subsurface abandoned, remainder will continue 2017+
  - 20 Shale monitoring wells will be abandoned in low pressure areas as per AER approval
  - Pads with support from adjacent pads will continue operation
- Individual wells that are uneconomic will be zonally abandoned to meet Directive 13:
  - 36 individual wells had appropriate abandonment work completed in 2016

Pads not steamed in prior 48 months

Pad	Plans
00N	Operating as water storage pad
00U	Operating with support from adjacent pads
00V	Operating with support from adjacent pads
00Q	All wells zonally abandoned in the CLW
00S	All wells zonally abandoned in the CLW
0AA	Operating with support from adjacent pads
0CC	Abandonment process started
0BB	Operating with support from adjacent pads
0DD	Abandonment process started
0FF	Operating with support from adjacent pads
0GG	Abandonment process started
0HH	Operating with support from adjacent pads
0LL	Operating with support from adjacent pads
00W	Operating with support from adjacent pads
A01	Operating with support from adjacent pads
A02	Operating with support from adjacent pads
A03	Operating with support from adjacent pads
A05	Operating with support from adjacent pads
B01	Operating with support from adjacent pads
B02	Operating with support from adjacent pads
B03	Abandonment process started
B04	Operating with support from adjacent pads
B05	Operating with support from adjacent pads
B06	Operating with support from adjacent pads
D54	Operating with support from adjacent pads
D55	Operating with support from adjacent pads
C03	Operating with support from adjacent pads
C05	Operating with support from adjacent pads
D26	Operating with support from adjacent pads
D27	Operating with support from adjacent pads
D52	Operating with support from adjacent pads
H24	Operating with support from adjacent pads
H31	Operating with support from adjacent pads
H32	Operating with support from adjacent pads
H33	Operating with support from adjacent pads
H34	Operating with support from adjacent pads
H35	Operating with support from adjacent pads
K24	Operating with support from adjacent pads
P01	Operating with support from adjacent pads
P02	Operating with support from adjacent pads
P03	Operating with support from adjacent pads
M03-M07	Operating with support from adjacent pads
J27	Operating with support from adjacent pads
D57	Abandonment process started, all wells zonally abandoned
D66	Abandonment process started, all wells zonally abandoned

Steam Quality

- Nabiye steam quality low in April 2016 due to reduced power to plant during isolation from power grid for cable line repair



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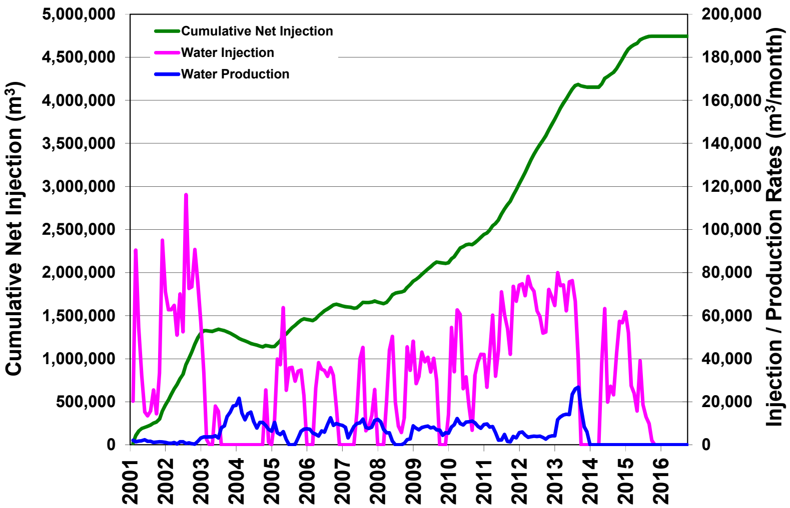
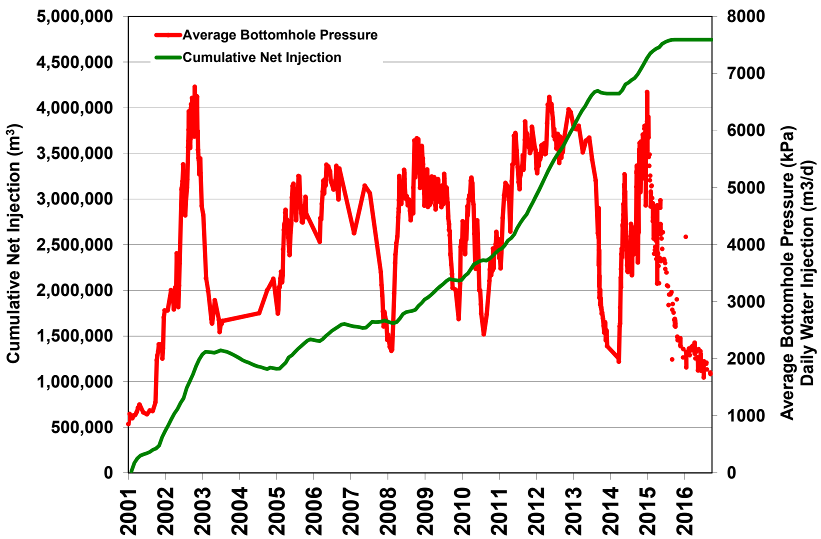
Cold Lake N-Pad – Approval 4510

- Approval 4510 is for utilization of Leming N-pad as a temporary water storage scheme
- Annual N-Pad Report submitted in Nov 2016
- No N-Pad water production since Dec 2013
- No N-Pad water injection since Oct 2015
- Adjacent pad performance indicates connection to N-Pad storage volume
  - Water production from N pad storage will continue through adjacent pad wells
- Plan to continue current operating strategy of no water injection at N pad





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Cold Lake N-Pad – Approval 4510

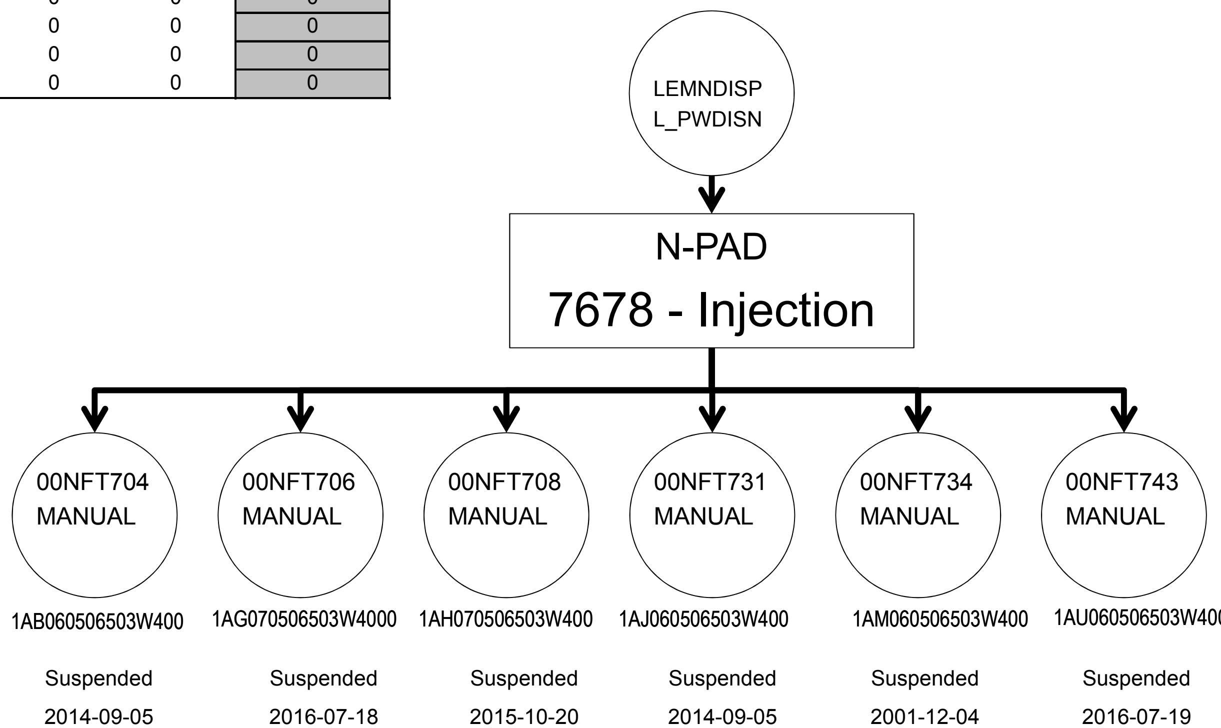
Table 1: N-Pad Water Injection (m3)

Month	N-04	N-06	N-08	N-31	N-34	N-43	Monthly Total
Oct-15	0	0	0	0	0	0	0
Nov-15	0	0	0	0	0	0	0
Dec-15	0	0	0	0	0	0	0
Jan-16	0	0	0	0	0	0	0
Feb-16	0	0	0	0	0	0	0
Mar-16	0	0	0	0	0	0	0
Apr-16	0	0	0	0	0	0	0
May-16	0	0	0	0	0	0	0
Jun-16	0	0	0	0	0	0	0
Jul-16	0	0	0	0	0	0	0
Aug-16	0	0	0	0	0	0	0
Sep-16	0	0	0	0	0	0	0
Oct-16	0	0	0	0	0	0	0

N-Pad Schematic

ERCB injection system #7678

Produced Water From Leming

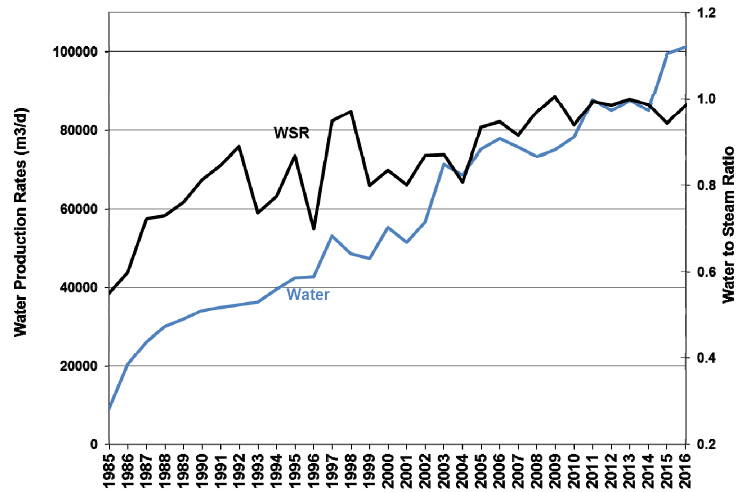


Cold Lake Water Management

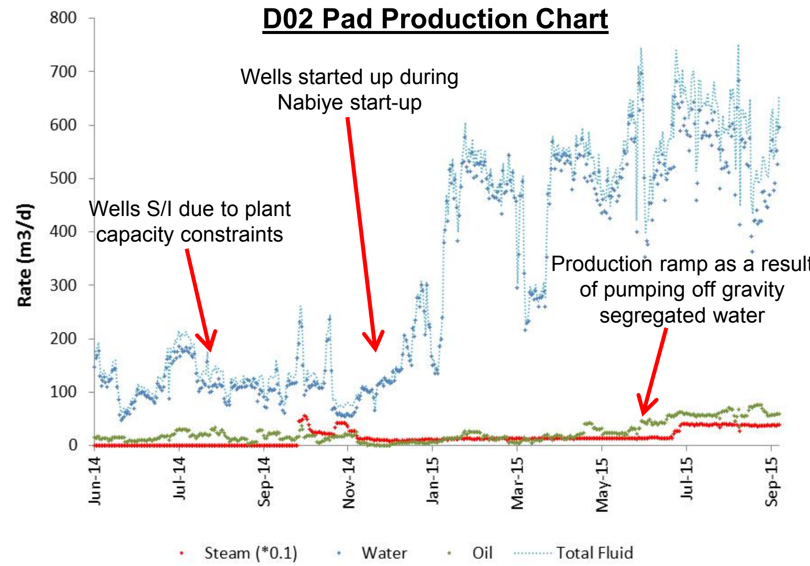
- **Cold Lake Water Production**
  - Increasing water production driven by field development
  - Water to steam ratio has increased as pads move into later cycle production (late life CSS / steamflood)
  - Typically field water deliverability is in excess of facility water handling capacity, requiring production shut-in
  - With Nabiye start-up, water handling capacities increased at existing facilities, allowing wells in the base to increase production

- **Operating Strategies**
  - Production shut-ins prioritized based on water to oil ratio to maximize oil production
  - Maximize steam injection quality
  - Minimize bringing water into the system
    - Freshwater and brackish water
  - Utilize out of zone disposal

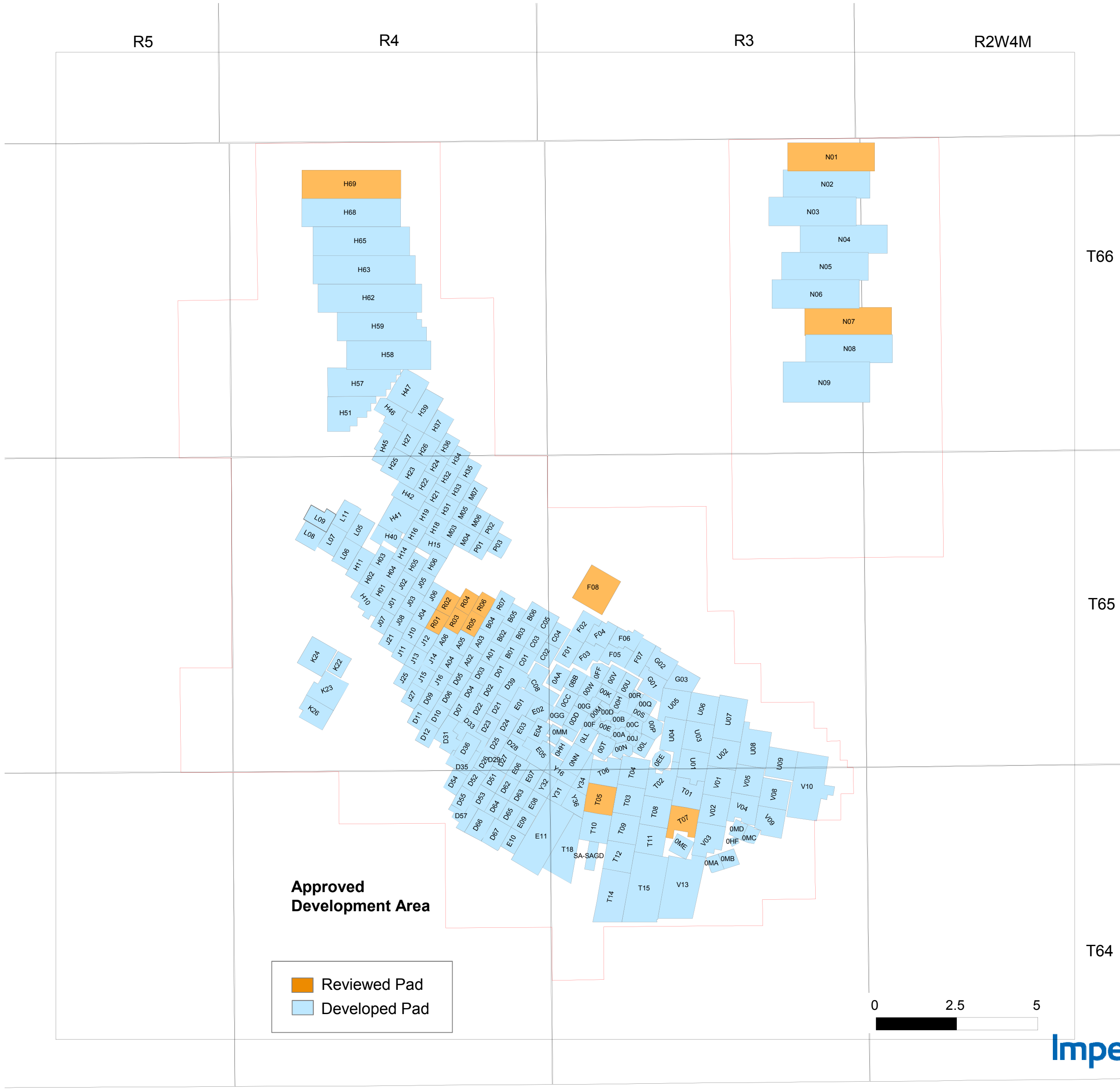
Cold Lake Water Production



D02 Pad Production Chart



Pad Performance Reviews



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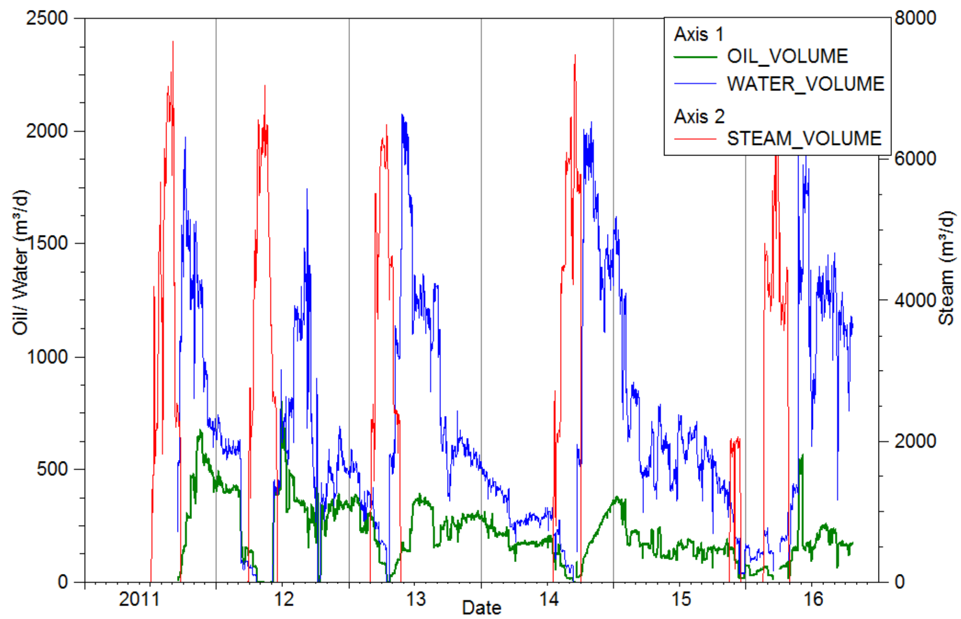
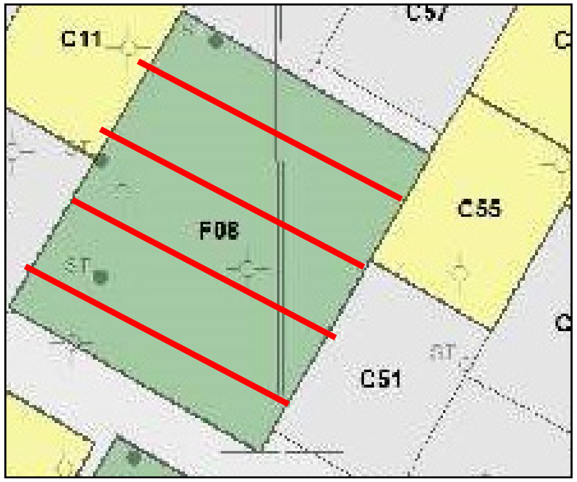
Maskwa F08 Thin Pay Trial

- Maskwa F08 is a 11 acre spacing / 4 horizontal well pad
- Trial uses CSS process
- Currently in Cycle 5, next cycle scheduled for Q1 2018
- Continue to evaluate performance for future thin pay application

F08 Production



F08 Well Layout



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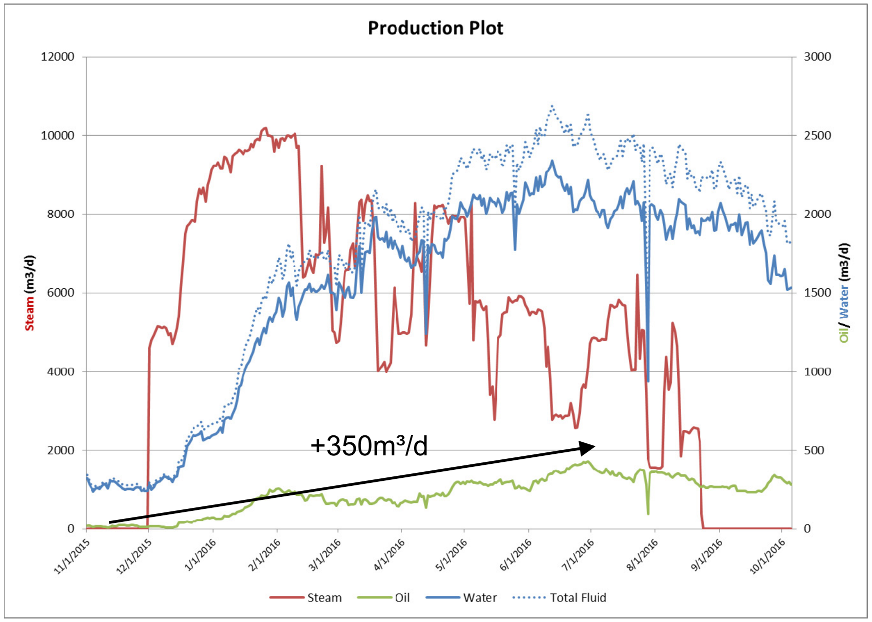
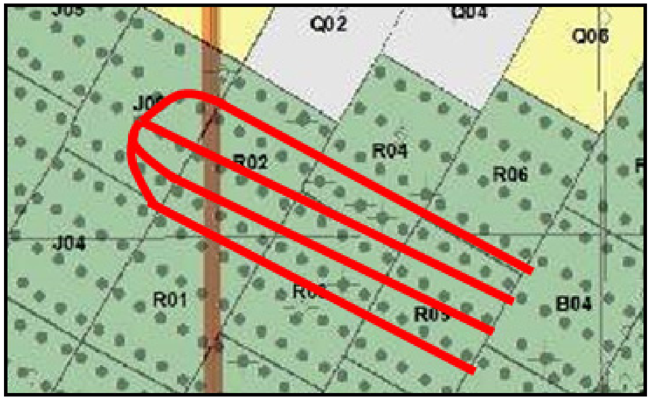
Mahihkan J06 Injector Only Infills

- J06 IOI's are 4 horizontal injector wells infilling R02, R03, R04, R05 pads (75 adjacent bottom hole locations)
- First cycle steam began in late 2015
- Substantial improvement in production rate due to new reservoir drive
- >40 wells were reactivated per Directive 13
- Cycle 2 to begin when production decline is observed and additional reservoir drive is required to sustain production

J06 IOI Area Production



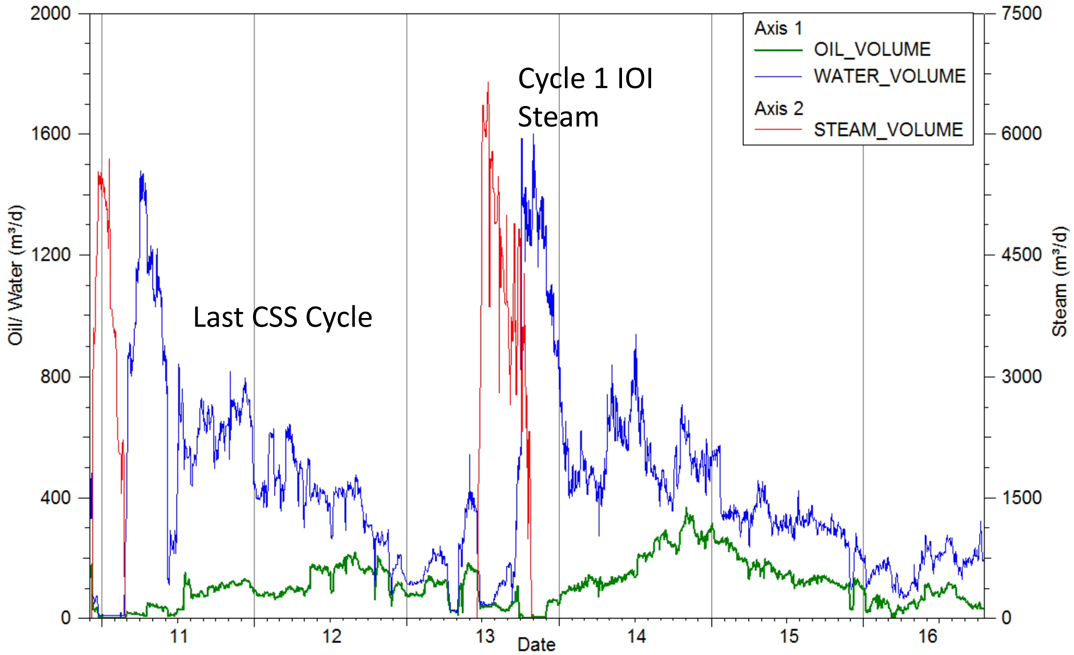
J06 IOI Well Layout



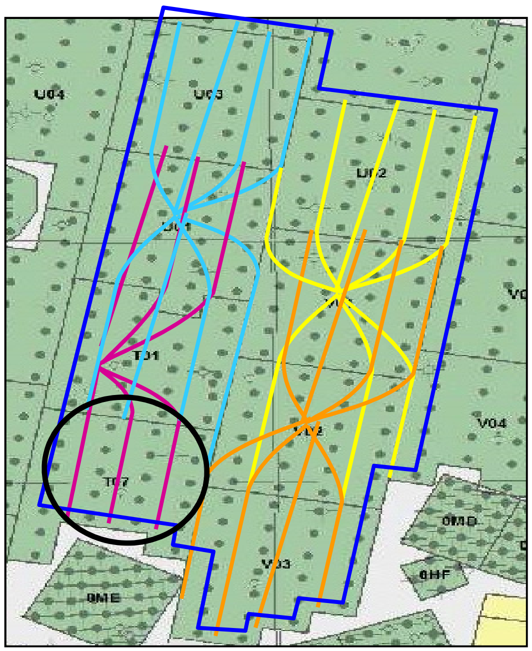
Mahkeses T01 Injector Only Infills

- T07 is an 8 acre 24 well pad infilled by T01 IOIs
- Cycle 1 IOI steamed June– October 2013
- Oil performance to date on track with Cycle 1 IOI expectations
- Cycle 2 steam planned for November 2016 – Cycle steam strategy will re-introduce steam to the IOI's only

T07 Production



T01 IOI Well Layout



= T01 IOI's
= V01 IOI's
= U01 IOI's
= V02 IOI's

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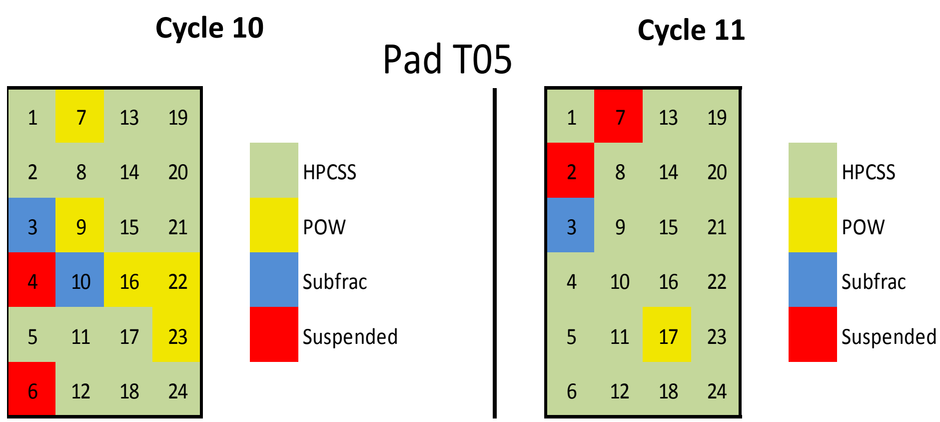
Mahkeses T05 Pad

- T05 is an 8-acre, 24 well pad
- 7 wells were repaired to HPCSS prior to cycle 11 to improve wellbore utility
- Repair campaign allowed for increased steam volumes to be injected in Cycle 11
- To date, T05 pad has shown improved early cycle performance compared to Cycle 10 results

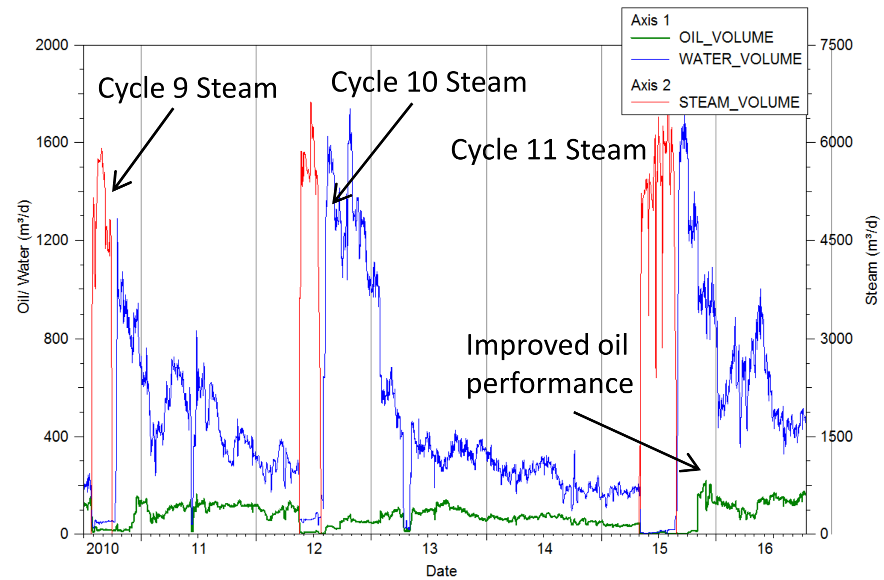
T05 Well Utility



Total Avg VOF:
4,200 m3/BHL
Total Pad Steam:
350,000 m3

Total Avg VOF:
7,700 m3/BHL
Total Pad Steam:
630,000 m3

T05 Production



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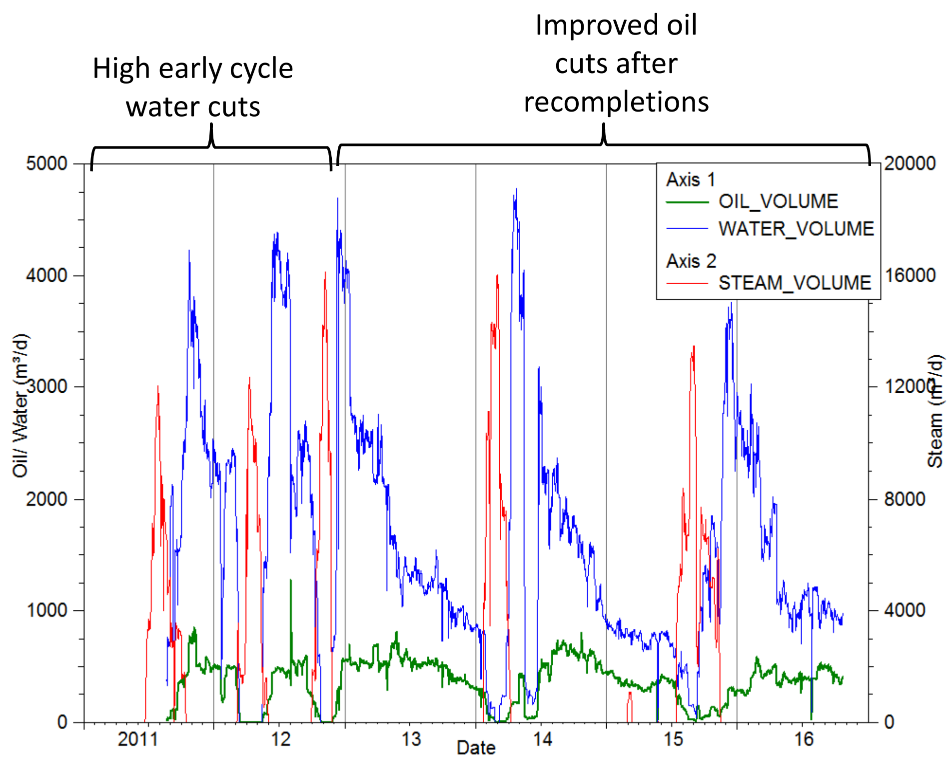
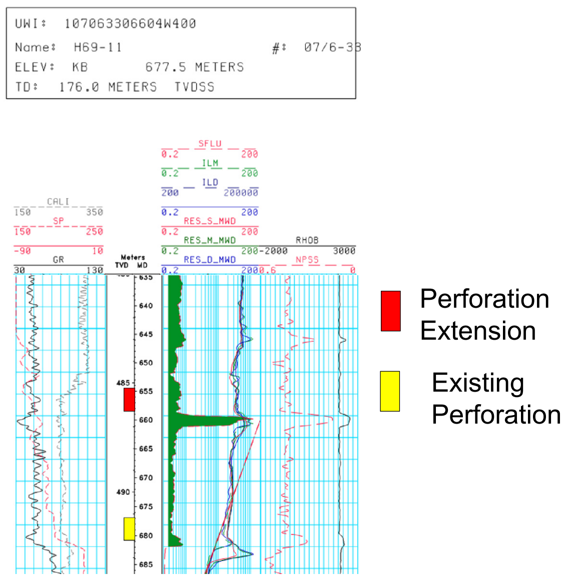
Mahihkan H69 Pad

- Mahihkan H69 is an 8 acre spacing / 24 well (16 vertical, 8 horizontal) pad, currently in cycle 6
- 13 vertical wells recompleted uphole into higher bitumen saturation interval
  - Environment of deposition thought to have influenced early cycle production performance, similar to H68 pad
  - Both perforation extensions and reperforations with plug backs attempted – both were equally successful
  - Recompleted wells were steamed at reduced rates/volumes following recompletion to increase the likelihood of establishing new conformance regions
  - Most recent cycle steamed at typical rates/volumes
  - Improved oil cut performance has continued in most recent cycle but the oil cut is still lower than typical Cold Lake CSS pad
- Cycle 7 steam in scheduled for Q1 2019

H69 Production



H69 Analog Recompletion



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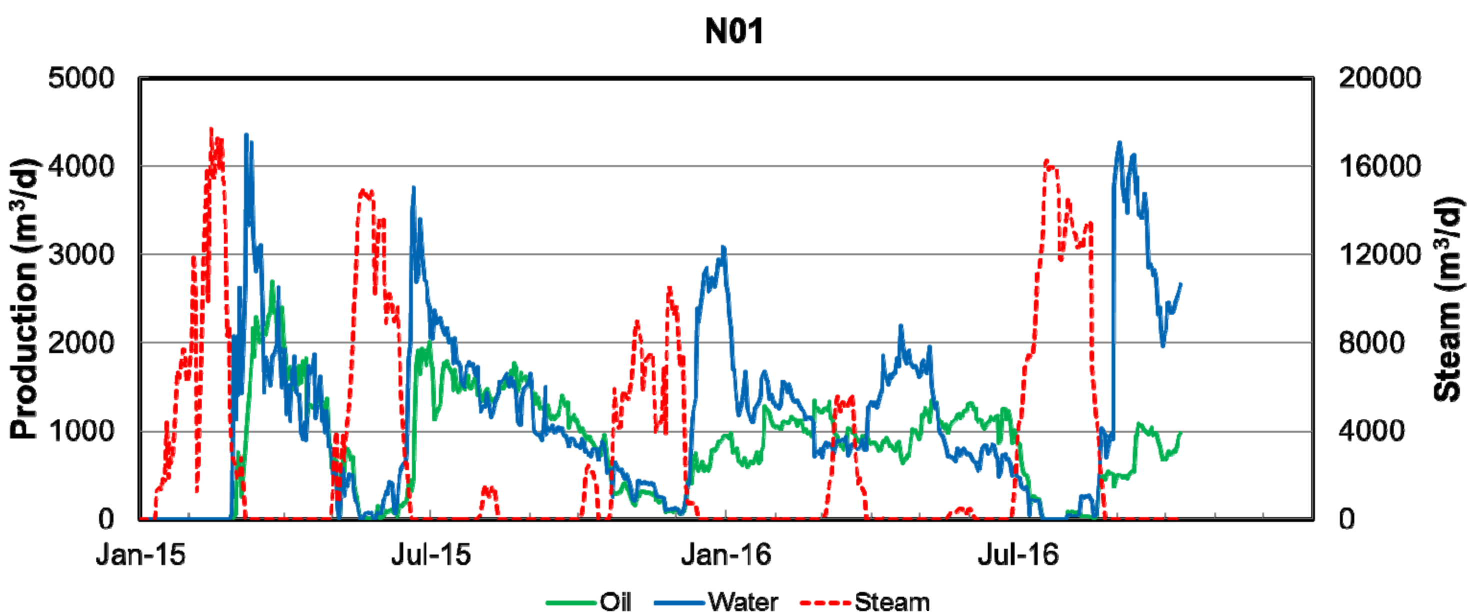
Nabiye N01 Pad

- Nabiye N01 is a 24 well pad (16 deviated, 8 horizontal), accessing 70 bottom-hole locations on 8 acre spacing
- Currently in the production phase of cycle 4
- Steam volumes have been reduced from Cold Lake best practices to manage pressure responses in the Grand Rapids
- Observed oil cut is typical for an early-cycle CSS pad



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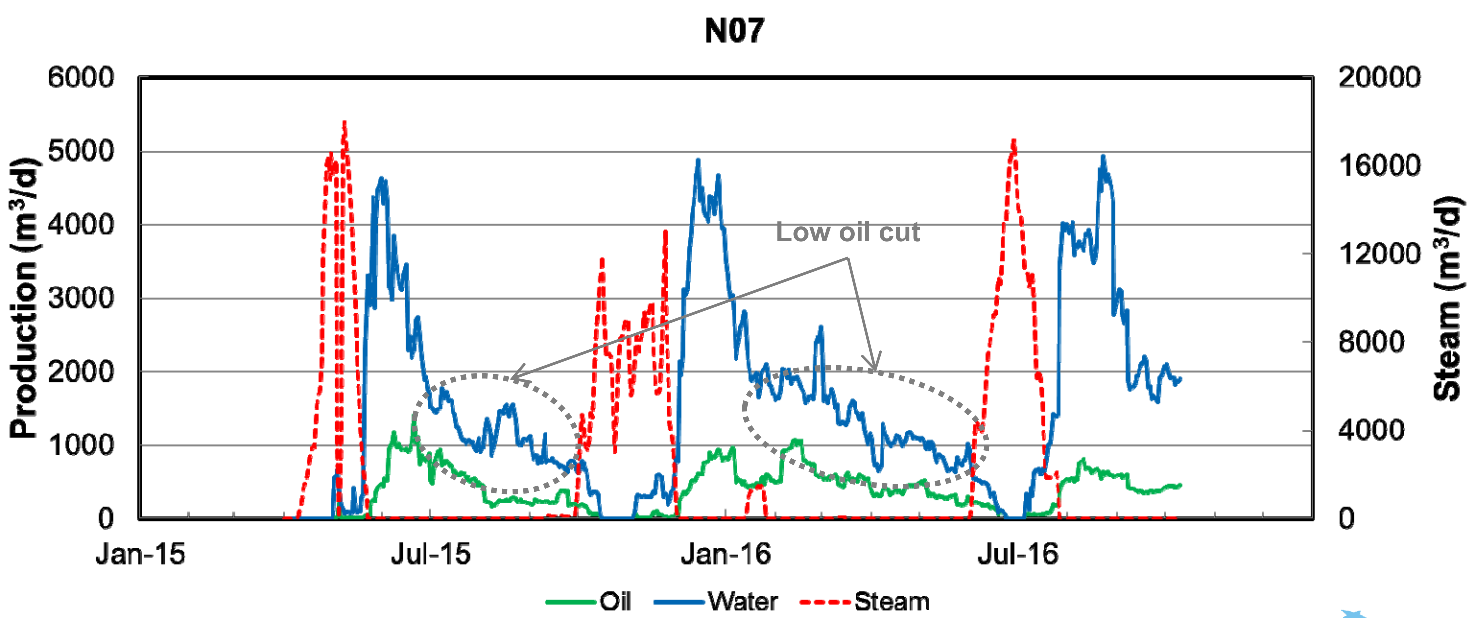
Nabiye N07 Pad

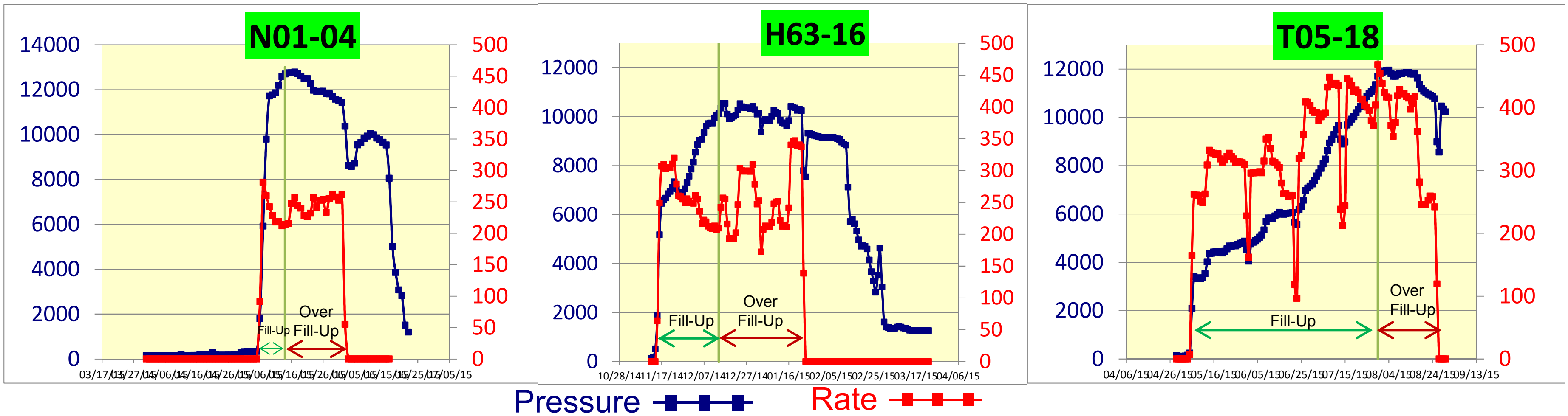
- Nabiye N07 is a 24 well pad (16 deviated, 8 horizontal), accessing 66 bottom-hole locations on 8 acre spacing
- Injection volumes have been reduced from Cold Lake best practices to manage pressure increases in the Grand Rapids
- Observed low oil cuts in the first 2 cycles
- Adjusted cycle 3 steam volumes on a subset of N07 wells to determine if steaming strategy can influence oil cut
- Low oil cut behavior has been observed in some other Nabiye pads. Ongoing study to understand key drivers



Steam Volume Over Fill-up Methodology

Volume Over Fill-up (VOF)

- Steam volume injected into an individual well's above specified fracture pressure is summated as VOF. Specified fracture pressure is estimated using pressure and rate data during the steam cycle. During the steam cycle of the well, pressure will increase until it hits a point of 'roll-over' where it will no longer increase in pressure, staying constant. At the point of roll-over is where VOF starts being counted. All volume injected prior to roll-over, is considered fill-up.



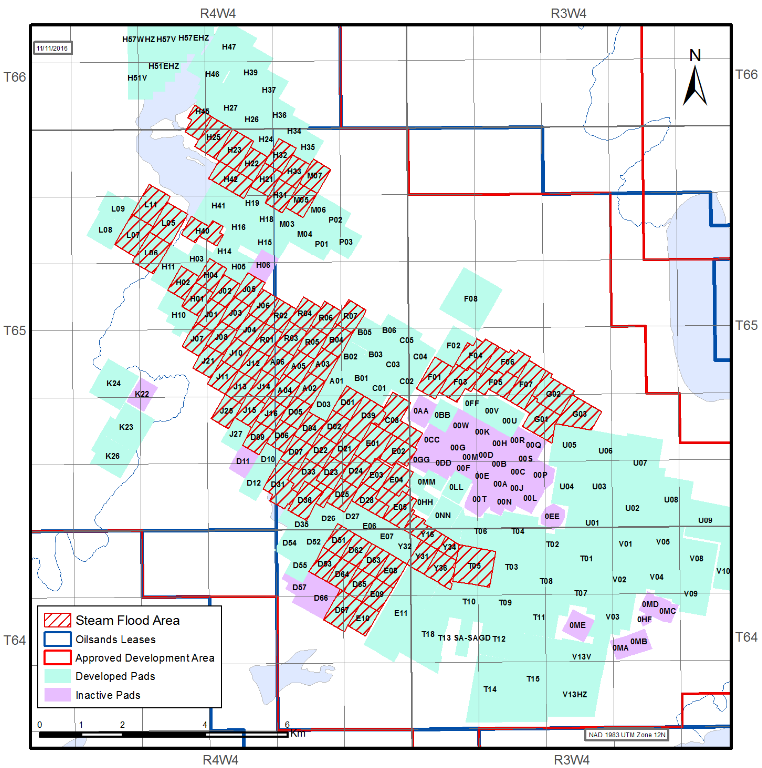
Designation	Well	Cycle	Total Volume (m3)	Volume to Fill-up (m3)	Volume Over Fill-up (m3)
Early Cycle	N01-04	2	6209	1737	4471
Mid Cycle	H63-16	4	17351	7373	9987
Late Cycle	T05-18	11	38066	28085	9981

- Volume over fill-up Best Practices have been implemented to manage reservoir communication and casing integrity.
- All VOF is calculated using wellhead pressure.
- Examples above demonstrate analysis on a per well basis.

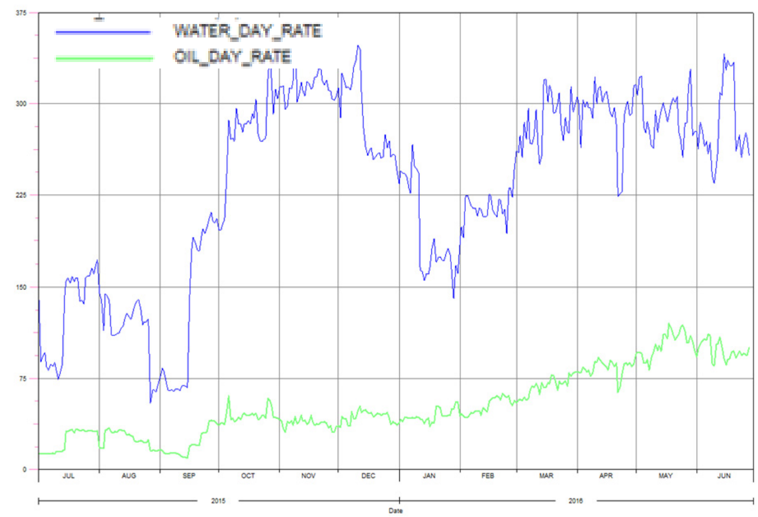
Late Life Steamflood Performance

Late Life Steamflood

- Steamflood Approval received for entire Cold Lake Development Area
- Currently ~125 infills on steamflood into 65 producing pads (~1300 wells)
- Extensive workover program undertaken to reactivate/improve steamflood wells – 22 wells repaired to date
  - Production was increased 100 m3/d and wells continue to improve with IOI support
- Evolving understanding of robustness of steamflood process:
  - Minimal production impact from short periods of non-optimal steaming – area can be over-steamed or under-steamed to satisfy operational constraints without jeopardizing long term production
  - Areas with lower pay quality (clasts/interbeds) demonstrate improved production with cyclic infill steam – however production character more typical of steamflood rather than CSS
  - LEP reconfiguration workovers have been successful at improving steam distribution within the reservoir and increasing production at wells that were previously unsupported



Steamflood Repairs – Production



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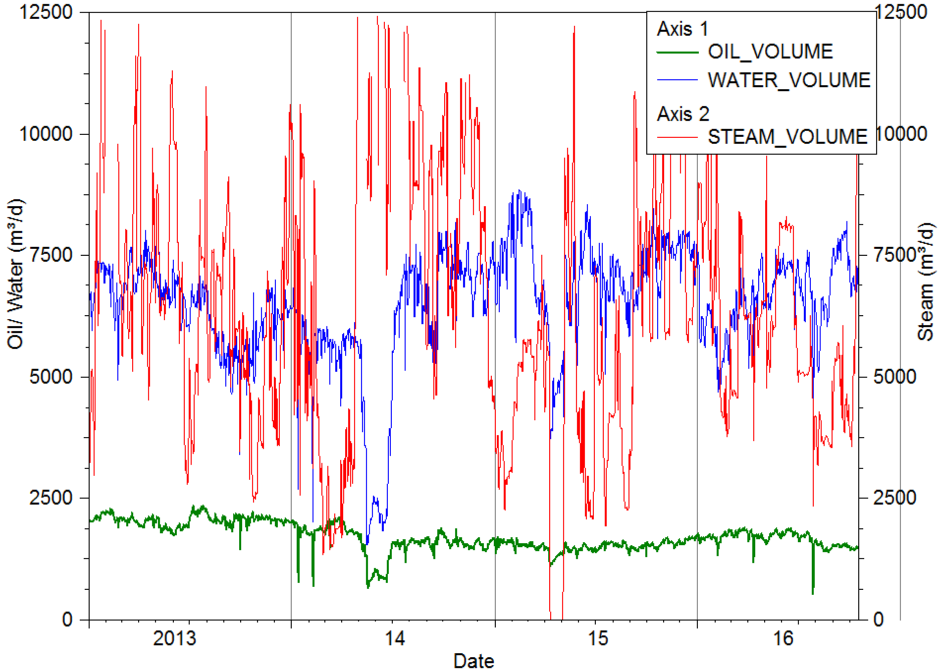
Late Life Steamflood

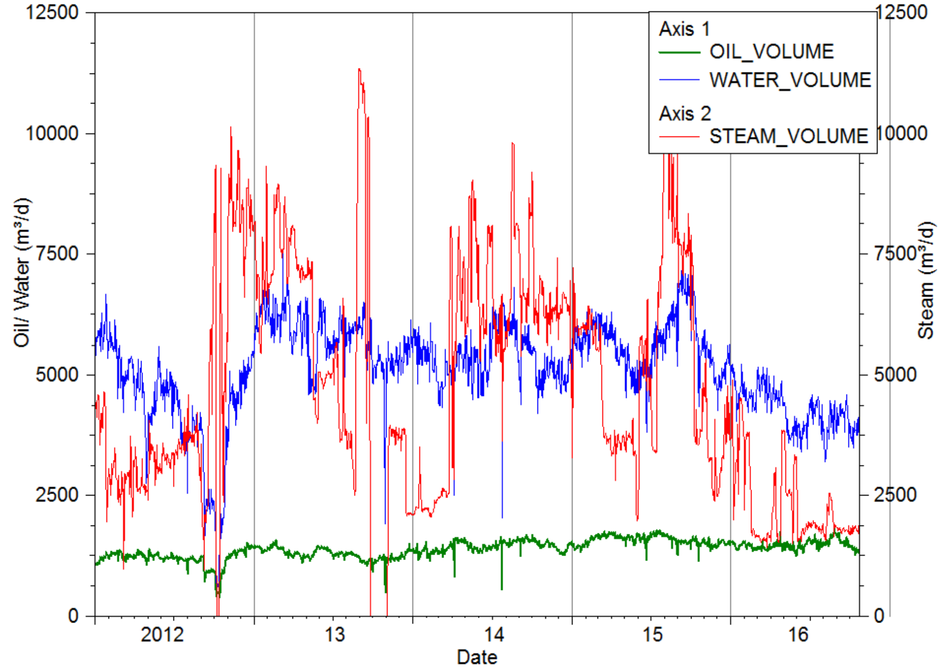
Mahihkan J01/H01/J07/J10/J16 Steamflood Area
16 Pads: A06, H01, H02, H04, J01,
J03, J04, J08, J10-J15, J21, J25

- Steamflood into Mahihkan J trunk. Overall performance to date as expected
- Steamflood injection rates reduced in the last year in these infills
- Recovery factors as high as 70-85% for pads in this area



Maskwa D04/D06/D07 Steamflood Area
10 Pads: A04, D04-D07, D09, D10, D22, D33, J16

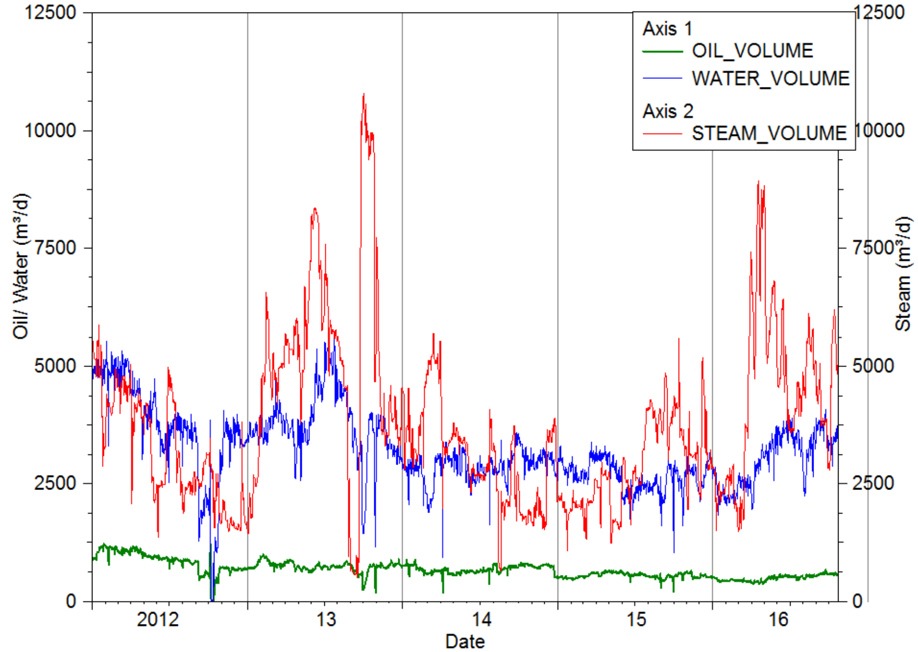
- Steamflood expansion into Maskwa D trunk. Overall performance to date as expected
- Steamflood injection rates have decreased in the last year and oil production has remained fairly steady
- Recovery factors are approaching 70% on some of these pads



Late Life Steamflood

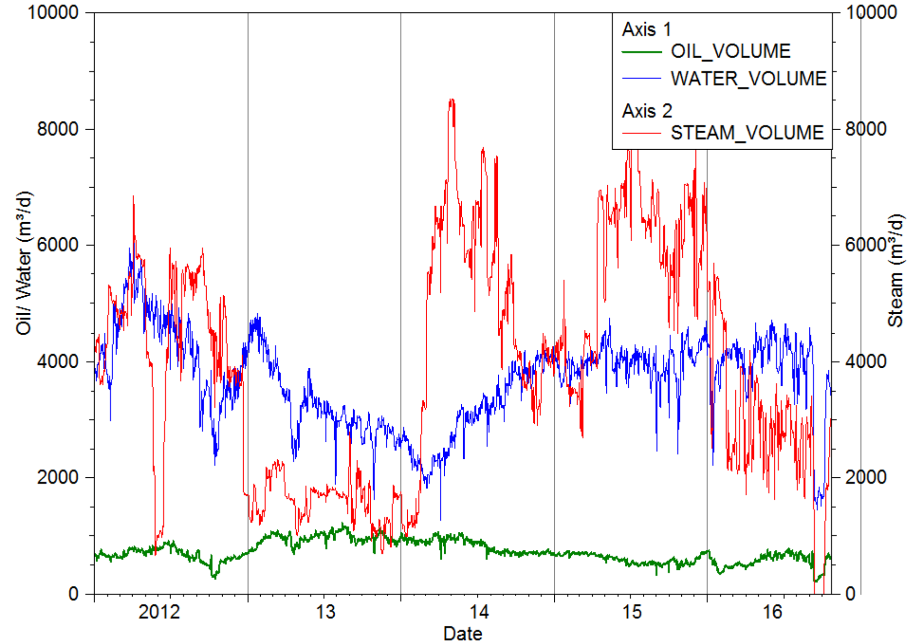
Maskwa F02/F03/FF Steamflood Area
6 Pads: F01, F02, F03, F04, F05, F06

- F-Trunk steamflood is performing as expected
- Steamflood rates have been increased in this area over the last year and total fluids have been increasing
- Recovery for pads in this area ranges from 35-50%



Maskwa 00U and Leming G02 Steamflood Area
4 Pads F07, G01, G02, G03

- Steamflood expansion into the rest of F-Trunk (F07) and Leming G01 and G02 pad via 00U & G02 IOI's started Q4 2011
- Steamflood rates were decreased over the past year, water and oil rates have remained relatively steady
- Recovery of pads range from 40-50% in the area



LASER Recovery Process

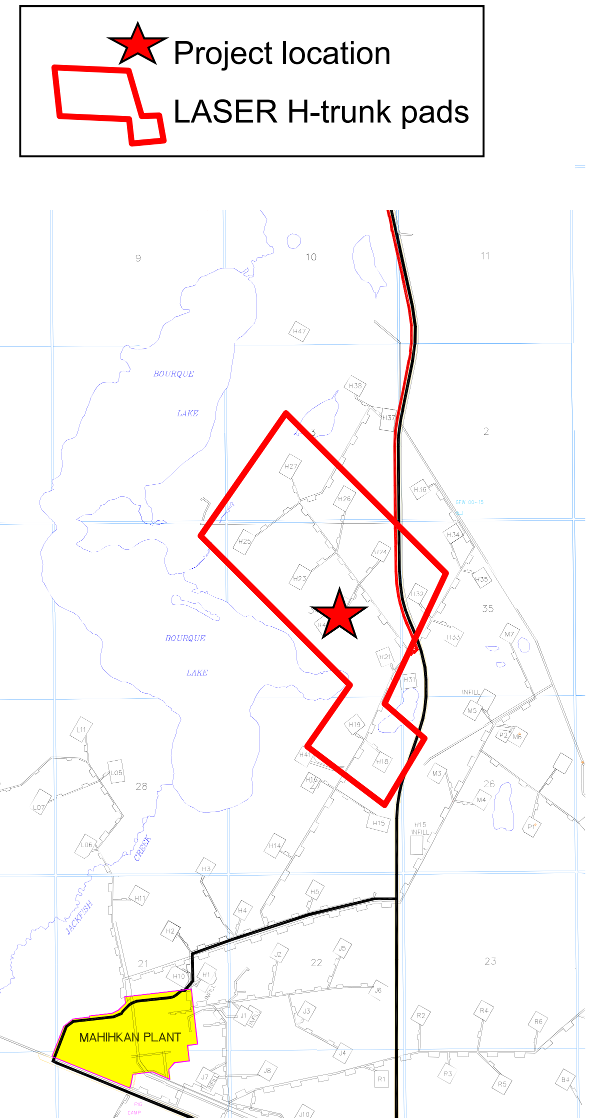
Laser H Trunk Project- Cycle 1 Summary

Background

- 10 pads in Mahihkan H-trunk – diluent injection complete
  - First cycle diluent injection began in Q3 2007 and was completed April 2009
- Diluent management
  - Distributed to pads via dedicated distribution pipeline
  - Produced back to Mahihkan Plant as part of common production stream
    - Produced diluent reduces future blend requirement
- Recovery equipment minimizes burning of flashed diluent in steam generators
  - Started up August 2008

Performance

- Overall first cycle LASER performance is in line with expectations
  - on average a 0.10 OSR uplift was achieved compared to no LASER implementation, due to the 5% v/v diluent injected with the steam in this first LASER cycle. This is approximately a 50% improvement in oil production performance.
  - LASER bitumen production uplift on the 10 H trunk pads ranges from 0.04 to 0.18 OSR uplift
  - 59% of the injected diluent was recovered in LASER cycle 1, in line with expectations
  - LASER diluent production on the 10 H trunk pads ranges from 30% to 90% recovery of the injected diluent
  - there was some fluid migration from the LASER pads, primarily to other pads in the north and east, with the most significant impact being reduced OSR uplift and lower diluent recovery at H26, H27, H24, and H32 pads
  - LASER has been demonstrated to be effective in CSS, IOI, and CSS POW situations
  - implementation of a higher diluent concentration at H23 pad (8.6%) compared to other pads resulted in an increase in incremental bitumen production and OSR uplift for the cycle, but with an apparent lower diluent recovery for LASER. An estimated 0.18 OSR uplift and 49% diluent recovery was achieved at H23 pad, but with uncertainty in the high concentration assessment due to fluid migration between pads.
  - the LASER process has been demonstrated to be successful across a wide range of diluent concentrations at the H trunk project, but identification of an optimal diluent concentration for LASER from the field data is difficult due to the pad-to-pad fluid migration experienced in the cycle
  - the sustainability of the LASER performance uplift has been demonstrated by the third cycle of LASER at H22 pad, with an estimated 0.14 OSR uplift in the cycle



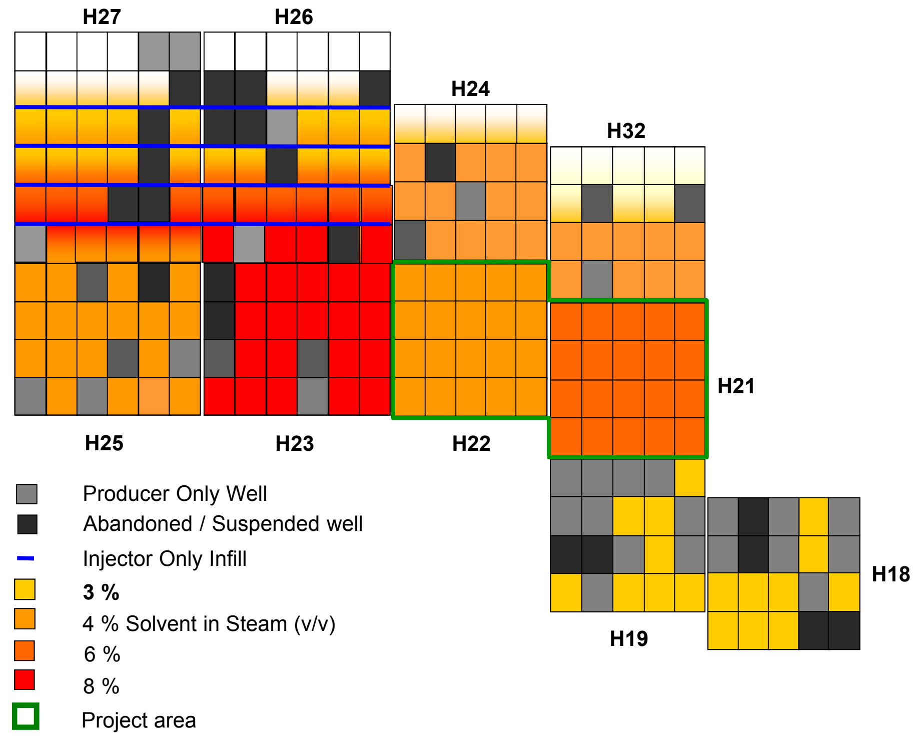
Cycle 1 Laser H Trunk Project- Diluent Injection

Diluent Injection

Complete in all 10 pads

Key Learning Initiative	# of Pads Location	Target (% v/v)	Actual (% v/v)
LASER POW	2		
9 injectors	H18	3%	3.2%
8 injectors	H19	3%	3.0%
LASER CSS	6		
Standard	H21	4%	6.1%
3rd LASER Cycle	H22	4%	4.5%
High Diluent	H23	8%	8.6%
Standard	H25	4%	4.4%
Potential Last Cycle	H24	3.5%	3.9%
Potential Last Cycle	H32	3%	3.9%
LASER IOI	2		
After 1 IOI cycle completed	H26	5%	4.4%
After 1 IOI cycle completed	H27	5%	4.6%

- Original LASER Pilot at H22 pad had 6% v/v of diluent injected in 8 wells (equivalent to ~2.4% v/v across a 20-well pad)
- Based on successful results at H22 Pilot, increased diluent to nominal average of 5% v/v for commercial implementation in 2007
- 8% v/v injected at H23 to test theory of increased benefits with higher concentration
- Remaining pads received diluent concentrations between 3-6% v/v
    - Lower diluent concentrations injected into pads with lower performance expectations



Injection Data for First LASER Cycle (10 pads)

Cumulative (km^3)	to 09/30/2012
Steam Injection	6,246
Diluent Injection	297

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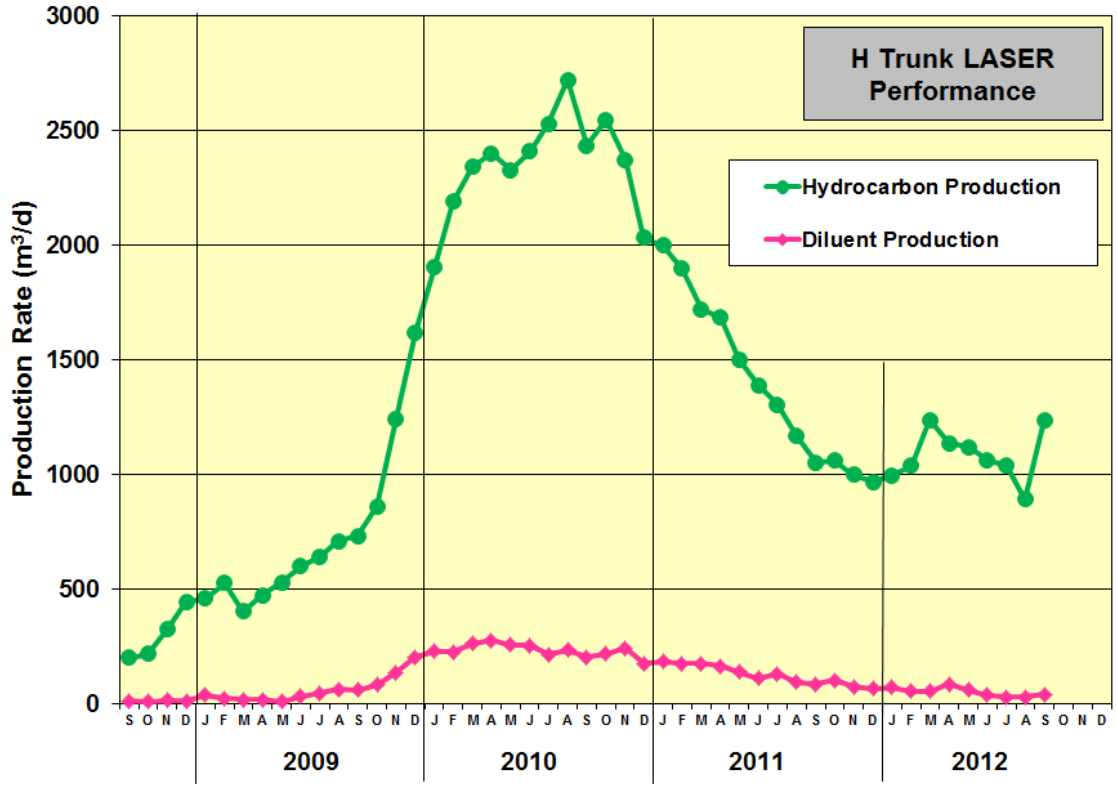
Cycle 1 LASER H Trunk - Production Performance

Production

- Steam injection cycle at the 10 pad H Trunk LASER implementation was completed in early 2009
- Oil production and diluent reproduction increased to peak rates in 2010 as expected
- Production has declined throughout the remainder of the cycle, through 2011 and into 2012
- With the first H Trunk LASER cycle now at an end, the performance is encouraging. The overall incremental oil production and diluent recovery are in line with expectations.

- H18 and H19 began the production cycle in Q2 2008
    - Peak oil production rates were achieved in 2010 and wells on oil decline during 2011 & 2012
- H21, H22, H23, H25 began the production cycle in Q4 2008
    - Peak oil production rates were achieved in 2010 and wells on oil decline during 2011 & 2012
- H24, H26, H27, H32 began the production cycle in Q1 2009
    - Peak oil production rates were achieved in 2010 and wells on oil decline during 2011 & 2012



Production Data for First LASER Cycle (10 pads)

Cumulative (km^3)	to 09/30/2012
Hydrocarbon Production	1,886
Diluent Production	174

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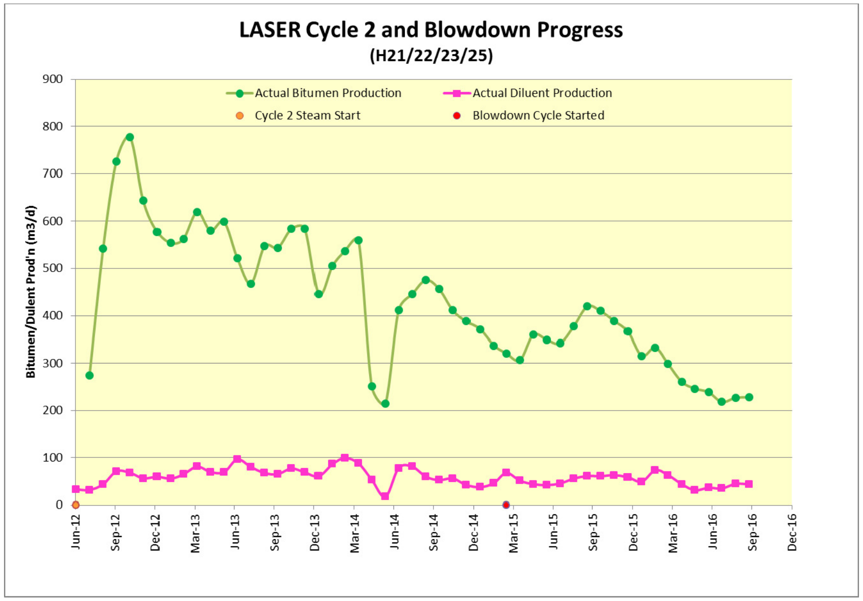
Cycle 2 LASER H Trunk - Production Performance

Background
- H21, H22, H23 and H25 steamed with diluent for cycle 2
- 2nd Cycle injection focus strictly on CSS strategy
- Focus on longer term performance understanding

Injection
- Steamed with diluent from Sept -Dec 2012
- Total steam injection - 1638 km^3
- Total diluent injection – 77 km^3 (4.7% dil. v/v)
- Pressures of ~1.0 - 2.0 MPa achieved
  - Lower reservoir pressures compared to 1st LASER cycle
  - Higher level of depletion and inter-well communication across all pads

Production Performance
- Oil produced in Cycle 2: 534 km^3
- Diluent recovery to date for both cycles: 261 km^3
- Cycle 2 production ended in Mar 2015. At the end of the cycle, the four pads averaged OSR increases of 0.12, exceeding the original expectation.
- Diluent production rates peaked in July 2013 and trended as expected, to a cumulative of 62% by the end of the cycle
- The four pads went into a blowdown cycle in which steam with no diluent was injected. Diluent reproduction continues to be tracked as recovery under blowdown will be a key learning for future LASER projects. The current cumulative recovery for cycle 1 & 2 is 70%.



Production Data to Date:

Updated to 10/01/2016 (km3)	Cycle 1	Cycle 2	Blowdown
Cycle Start	May 2007	Jul 2012	Mar 2015
Diluent Injection	297	77	0
Diluent Production	174	58	29
Cumulative Diluent Recovery	59%	62%	70%

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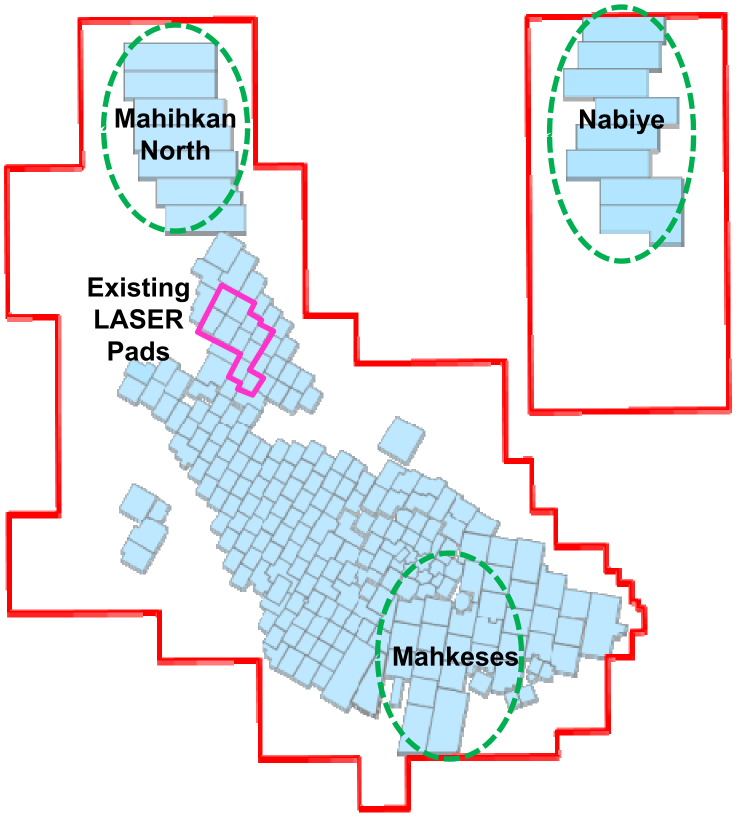
LASER - Potential Future Applications



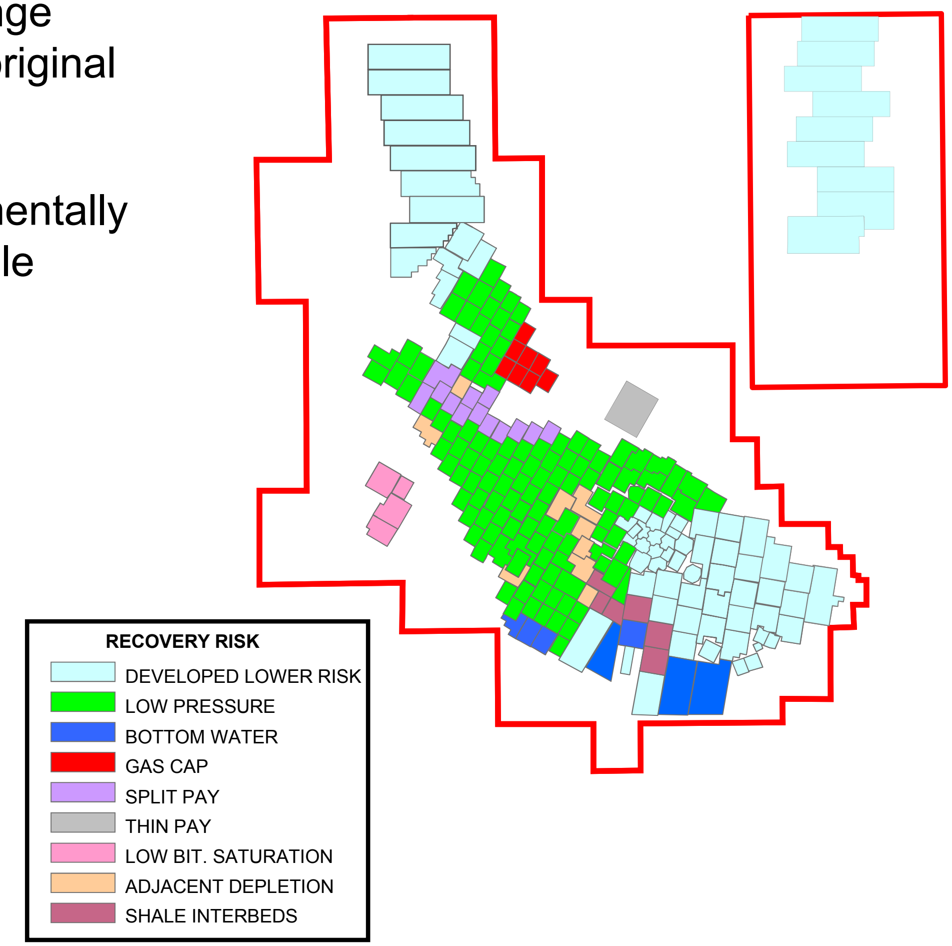
LASER Future Plans

- Following the successes of previous LASER projects, opportunities exist to apply the technology in additional areas of the field
- Potential future applications include:
    - Mahihkan North
    - Nabiye
    - Mahkeses
- Construction on the 9-Pad Mahihkan North LASER Project is underway and solvent injection is targeted to commence in March 2017
- Work is underway to evaluate additional opportunities and plans will be communicated as they become more defined

Factors Impacting Recovery

Factors Impacting Recovery

- Individual pad recovery expectations range from less than 10% to over 60% of the original effective bitumen in place
- The variation in recovery level is fundamentally a function of bitumen saturation and shale structure/distribution
- Additional reservoir challenges include:
  - Bottom water
  - Clearwater gas cap
  - Split pay
  - Adjacent reservoir depletion
  - Well Spacing



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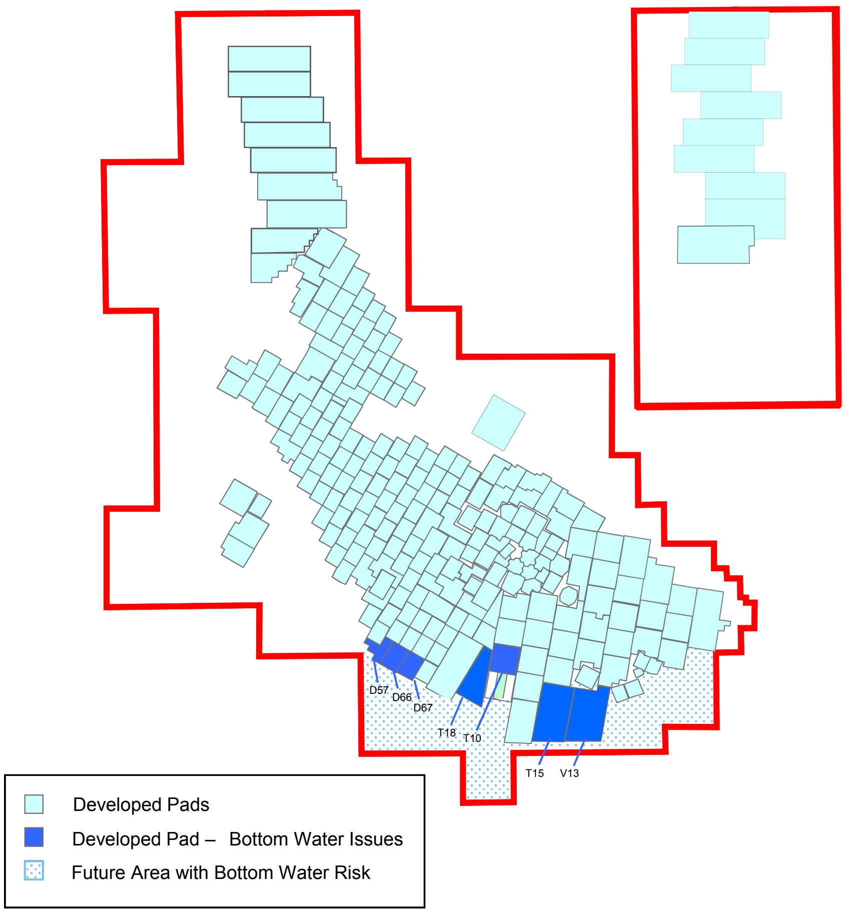
CSS Performance - Bottom Water



- Performance issues:
  - Bottom water is a thief zone for steam injection
  - High mobility water excludes bitumen production
- Mitigation
  - Basal Wabiskaw shale provides seal for much of CLPP 1-13
  - Perforation standoff from transition zone and thin bottom water
  - Additional standoff required for thick bottom water in clean sand
  - Uphole recompletions of wet wells can be effective if sufficient separation is left between old and new perforations

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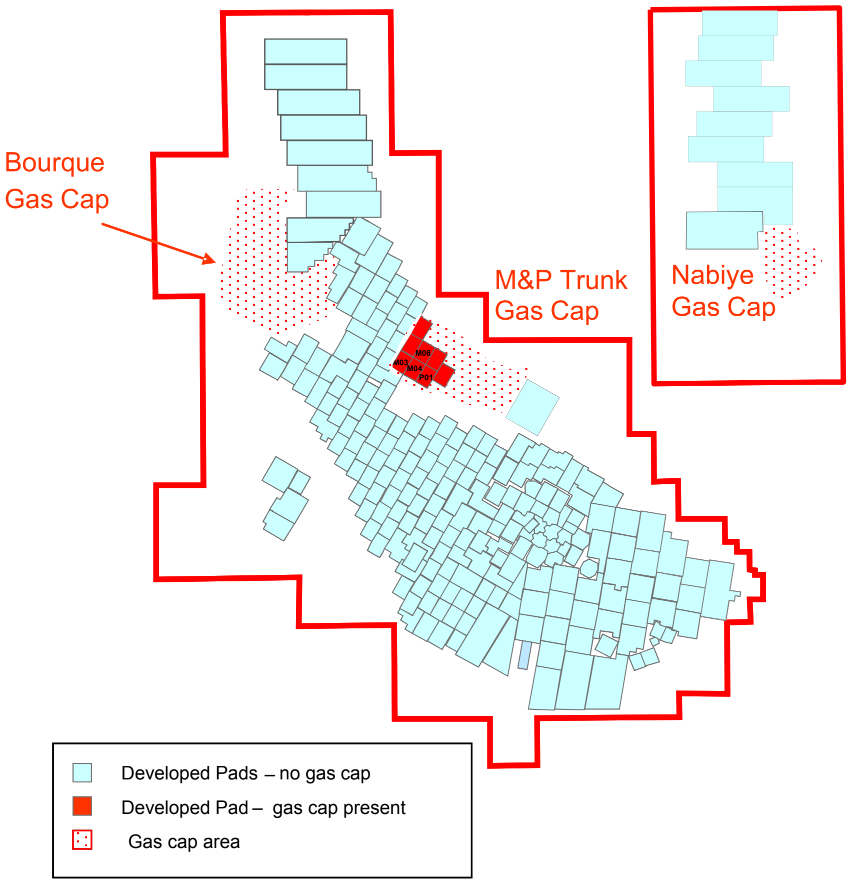
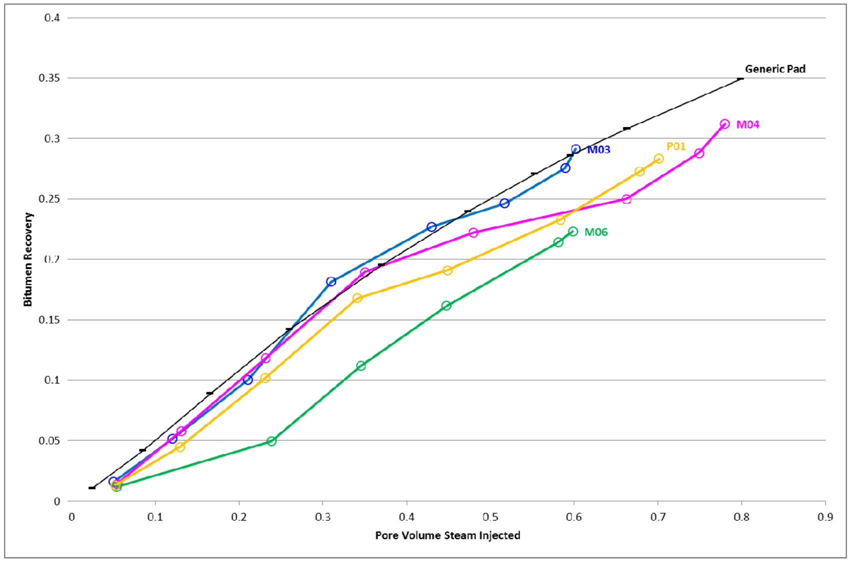
CSS Performance - Gas Cap



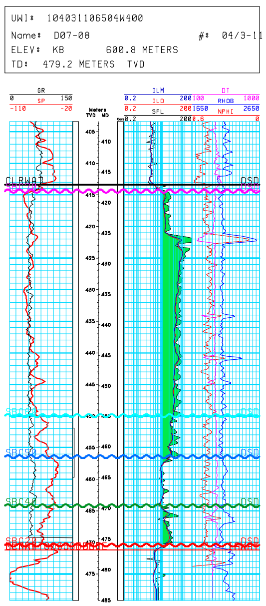
Performance of Gas Cap Pads



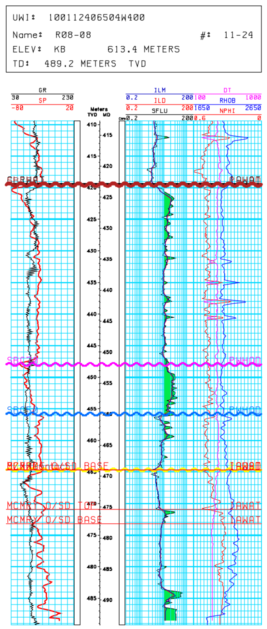
- Three significant Clearwater gas cap areas
  - M&P Trunk – producing
  - Bourque Lake gas cap – undeveloped
  - South Nabiye - undeveloped
- M&P Trunk pads exhibited poorer performance due to pressure losses to the gas cap
- Steaming all pads under a gas cap together reduces steam losses and improves performance
- Recovery expectations at M&P Trunk pads are 30-40% lower due to presence of gas cap

CSS Performance - Split Pay

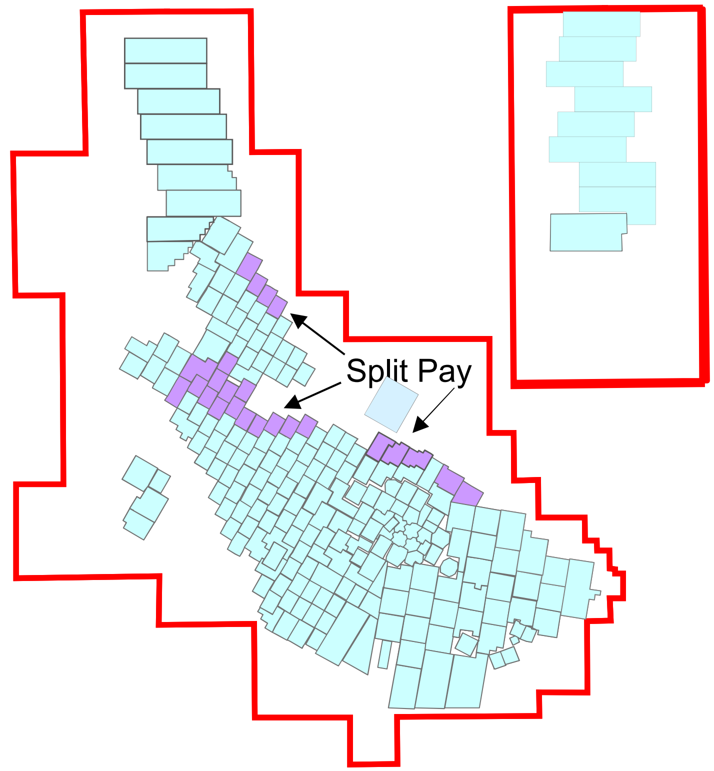
Thick Continuous Pay



Thin Split Pay



Interbedded sequence

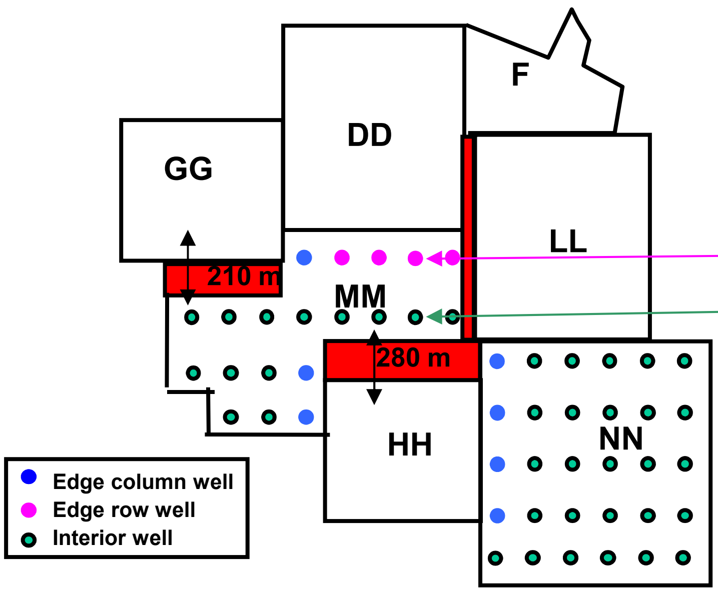


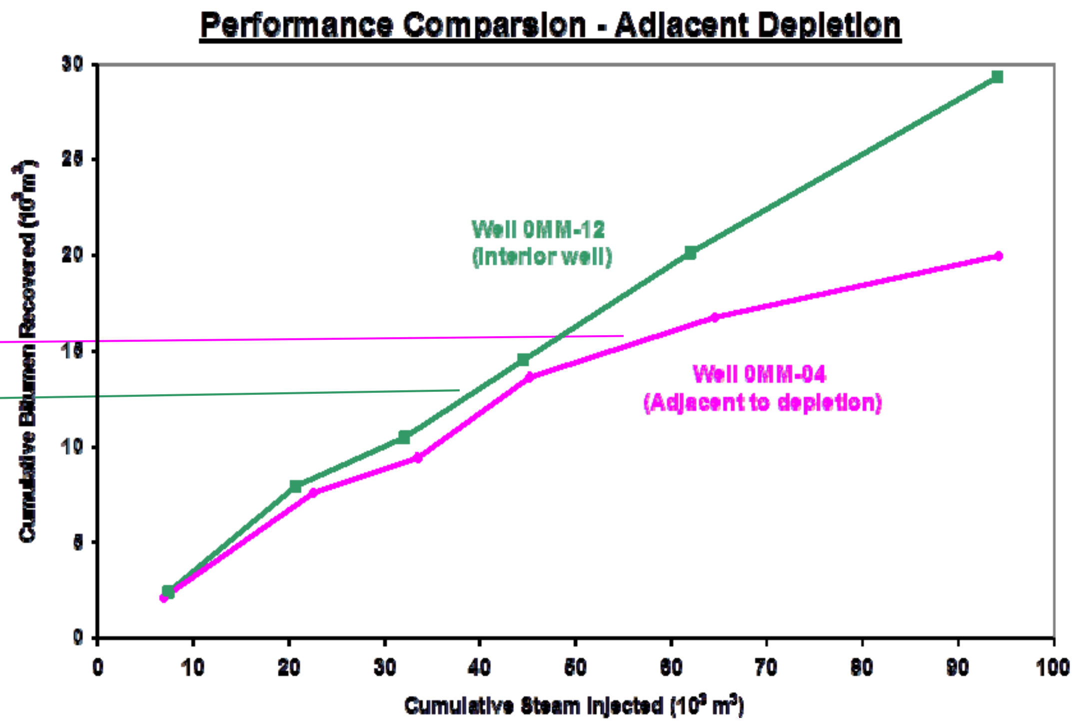
- Split pay occurs where an interbedded sequence has cut through lower reservoir sequences
- Interbedded sands and shales act as vertical permeability barrier between lower reservoir sequences and good quality sand in upper sequence

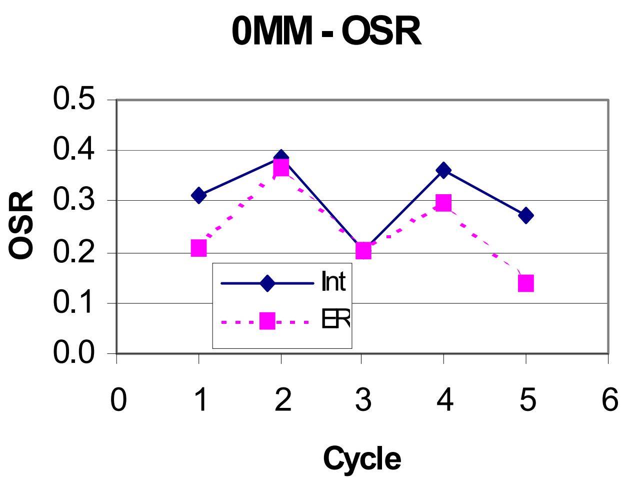
- Upper zone can be accessed through recompletion after lower zone depletion
- Concurrent depletion trials with limited entry perforations resulted in poor inflow performance
- Thin zones have substantially lower recovery due to heat losses to surrounding non-reservoir rock
- Split pay can be used to isolate effects of top fluids

Adjacent to Depletion Example- MM Pad

- MM pad is adjacent to depletion in DD pad which acts as thief zone for steam

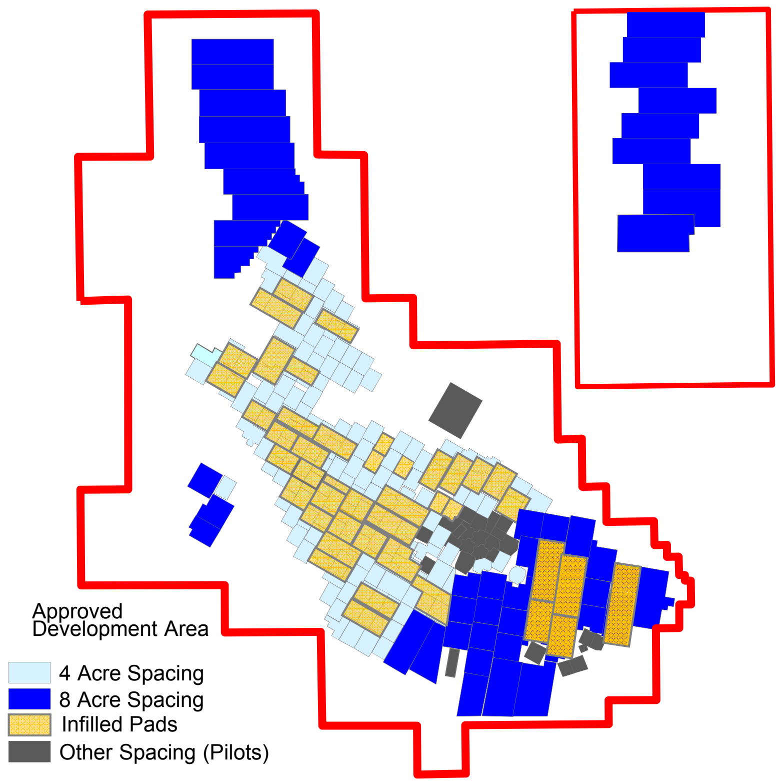






- Difficult to achieve high injection pressure after cycle 2 in edge row wells
- Low fluid production in edge row wells

Well Spacing

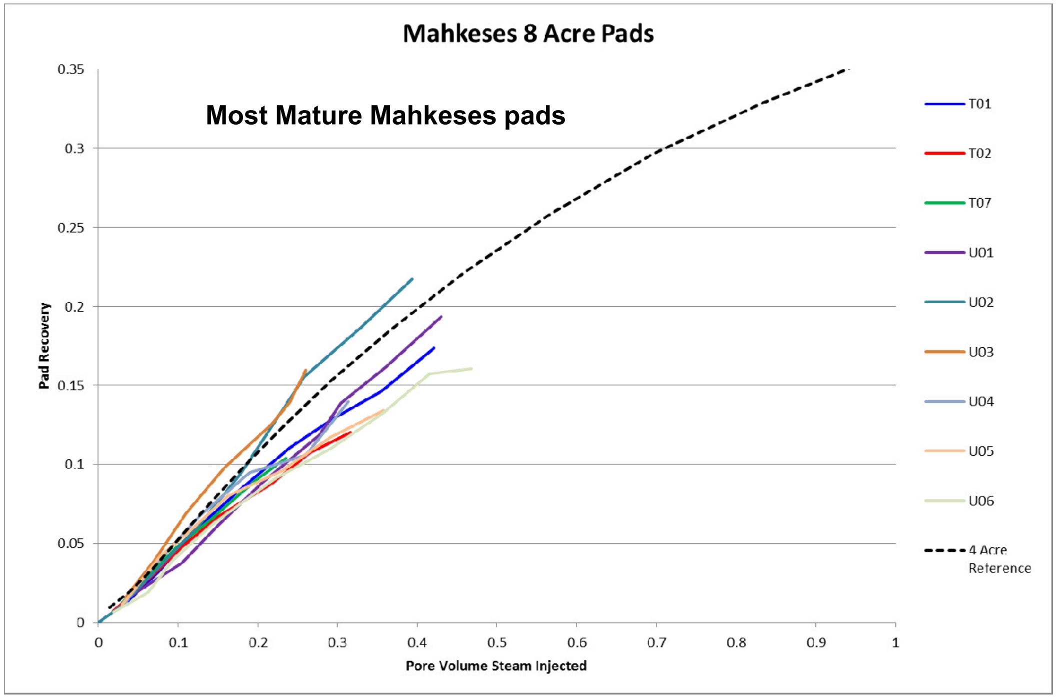


Infill Drilling
- Where economic, horizontal injector-only-infills are drilled between the rows of wells at mature pads
- Infill steam is directed to bypassed bitumen to increase recovery by 15 to 30% relative to CSS
- Infill steam injection volumes per pad are similar to CSS volumes

- Commercial pads are developed on 4 acre, 8 acre or 11 acre well spacing
  - 4 acre spacing in the thicker central area of the field
  - 8 or 11 acre spacing in thinner resource areas
- Cycle steam injection volumes have been derived primarily from field operating experience with the objectives of:
  - Achieving high levels of reservoir conformance to mobilize cold bitumen
  - Managing inter-well communication
  - Limiting casing damage caused by shear stress
- Current steaming practices employ the same early cycle injection volume strategy for both 4 and 8 acre well spacings:[1]
  - > Cycle 1 8,000 m^3
  - > Cycle 2 7,000 m^3
  - > Cycle 3 8,000 m^3
  - Cycle 2 volumes are reduced because injected fluids are typically not fully reproduced in cycle 1
- Subsequent cycle high pressure steam injection volumes range up to 10,000 m^3 (volumes injected at dilation pressure)
  - Actual injection performance from previous cycles is used to develop the steaming strategy for an individual pad
- Wells drilled on 8 acre spacing are expected to operate through more cycles than those on 4 acre spacing
- Expected recovery from 8 acre spacing is approximately 80% of 4 acre recovery based on reservoir simulation
  - Existing 8 acre pads are not sufficiently mature to demonstrate lower recovery

[1] 11 Acre Spacing steam strategy approved by the ERCB in July 2011 allowing for 12,000 m^3 overfillup per cycle.

Impact of Well Spacing on Recovery



- 4 acre performance curve shown for equivalent resource to Mahkeses pads
- Most mature Mahkeses pads not sufficiently depleted to validate recovery expectations

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Pad Recovery

Pad	Effective OBIP (e3m3)	Recovery to Sept 2016 e3m3	Recovery to Sept 2016 % EBIP	Ultimate Recovery (% EBIP)
00A	1184	152	13%	EUR = Recovery to date
00B	1772	126	7%	EUR = Recovery to date
00C	1559	216	14%	EUR = Recovery to date
00D	1236	212	17%	EUR = Recovery to date
00E	1257	150	12%	EUR = Recovery to date
00F	1079	233	22%	EUR = Recovery to date
00G	2097	358	17%	EUR = Recovery to date
00H	2010	291	14%	EUR = Recovery to date
00J	850	249	29%	EUR = Recovery to date
00K	1905	489	26%	EUR = Recovery to date
00L	2019	450	22%	EUR = Recovery to date
00M	982	68	7%	EUR = Recovery to date
00N	1648	490	30%	EUR = Recovery to date
00P	2341	714	30%	EUR = Recovery to date
00Q	1988	342	17%	EUR = Recovery to date
00R	1764	116	7%	EUR = Recovery to date
00S	1174	136	12%	EUR = Recovery to date
00T	2644	846	32%	EUR = Recovery to date
00U	2122	1031	49%	49% - 50%
00V	2301	745	32%	40% - 45%
00W	2103	1341	64%	65% - 70%
0AA	2533	1115	44%	EUR = Recovery to date
0BB	2191	1619	74%	75% - 80%
0CC	2546	941	37%	37% - 40%
0DD	1883	920	49%	49% - 50%
0EE	1854	575	31%	EUR = Recovery to date
0FF	1909	1139	60%	60% - 65%
0GG	1403	511	36%	36% - 40%
0HF	297	102	34%	EUR = Recovery to date
0HH	1210	628	52%	52% - 55%
0LL	1734	732	42%	42% - 45%
0MA	1454	126	9%	EUR = Recovery to date
0MB	1942	452	23%	EUR = Recovery to date
0MC	1087	496	46%	EUR = Recovery to date
0MD	816	496	61%	EUR = Recovery to date
0ME	2276	533	23%	EUR = Recovery to date

- Pad production updated to September 2016
- Pad EBIPs changes are due to a new geological model
- E07 and D29 pad combined as they are now depleted by one set of horizontal wells

Pad Recovery

Pad	Effective OBIP (e3m3)	Recovery to Sept 2016		Ultimate Recovery (% EBIP)
		e3m3	% EBIP	
0MM	1659	662	40%	40% - 45%
0NN	2613	955	37%	40% - 45%
A01	2230	954	43%	43% - 45%
A02	2486	984	40%	45% - 50%
A03	2235	970	43%	43% - 45%
A04	2837	1298	46%	50% - 55%
A05	1980	795	40%	40% - 45%
A06	2554	993	39%	39% - 40%
B01	2058	938	46%	46% - 50%
B02	2045	1023	50%	50% - 55%
B03	2104	876	42%	50% - 55%
B04	2005	981	49%	49% - 55%
B05	1998	1452	73%	73% - 75%
B06	2013	1048	52%	52% - 55%
C01	2150	876	41%	41% - 45%
C02	1984	1104	56%	56% - 60%
C03	2405	1367	57%	65% - 70%
C04	1971	911	46%	50% - 55%
C05	1946	792	41%	41% - 45%
C08	5074	1001	20%	50% - 60%
D01	2199	957	44%	45% - 50%
D02	2233	760	34%	45% - 55%
D03	2818	1154	41%	41% - 50%
D04	3269	1521	47%	50% - 60%
D05	2956	1579	53%	55% - 65%
D06	3980	2677	67%	75% - 80%
D07	3498	2010	57%	60% - 70%
D09	3305	2238	68%	75% - 80%
D10	3307	1871	57%	57% - 65%
D11	2431	80	3%	EUR = Recovery to date
D12	2135	559	26%	26% - 35%
D21	2014	718	36%	45% - 50%
D22	2659	1263	48%	50% - 55%
D23	2934	1311	45%	50% - 60%
D24	2007	859	43%	50% - 55%
D25	2597	1175	45%	45% - 50%

Pad	Effective OBIP (e3m3)	Recovery to Sept 2016		Ultimate Recovery (% EBIP)
		e3m3	% EBIP	
D26	3021	1538	51%	51% - 55%
D27	2562	964	38%	38% - 40%
D28	2430	681	28%	40% - 50%
D31	5743	1991	35%	50% - 65%
D33	4385	1723	39%	55% - 70%
D35	3427	904	26%	50% - 60%
D36	3447	1038	30%	50% - 60%
D39	3867	945	24%	40% - 50%
D51	3019	1117	37%	50% - 70%
D52	2904	789	27%	27% - 30%
D53	2610	1367	52%	55% - 65%
D54	1705	644	38%	38% - 40%
D55	1363	649	48%	48% - 50%
D57	769	97	13%	13% - 15%
D62	2563	1251	49%	55% - 65%
D63	2213	1019	46%	55% - 65%
D64	2499	1356	54%	55% - 65%
D65	2427	1018	42%	50% - 60%
D66	1498	187	12%	EUR = Recovery to date
D67	3180	668	21%	25% - 35%
E01	3179	1044	33%	50% - 60%
E02	2321	857	37%	40% - 50%
E03	2025	798	39%	40% - 50%
E04	2293	768	33%	50% - 65%
E05	3843	1002	26%	50% - 60%
E07	2438	263	11%	20% - 25%
E08	1734	591	34%	40% - 45%
E09	1971	684	35%	35% - 40%
E10	1946	619	32%	35% - 40%
E11	8736	1104	13%	35% - 50%
F01	2770	953	34%	35% - 40%
F02	2174	749	34%	35% - 40%
F03	3166	1310	41%	45% - 55%
F04	2242	992	44%	45% - 55%
F05	2995	1506	50%	55% - 65%

Pad Recovery

Pad	Effective OBIP (e3m3)	Recovery to Sept 2016		Ultimate Recovery (% EBIP)
		e3m3	% EBIP	
F06	2141	911	43%	45% - 50%
F07	3282	1325	40%	50% - 60%
F08	2687	395	15%	15% - 25%
G01	3852	1573	41%	50% - 60%
G02	2585	1003	39%	50% - 55%
G03	1734	1055	61%	61% - 65%
H01	2763	1863	67%	70% - 75%
H02	1949	1149	59%	59% - 65%
H03	1048	447	43%	45% - 50%
H04	1249	511	41%	50% - 55%
H05	1547	339	22%	25% - 30%
H06	2213	147	7%	07% - 10%
H10	2101	585	28%	30% - 35%
H11	2234	1242	56%	60% - 70%
H14	2043	366	18%	20% - 25%
H15	3079	1161	38%	38% - 45%
H16	2366	930	39%	45% - 50%
H18	2718	819	30%	35% - 45%
H19	2074	1064	51%	65% - 70%
H21	2421	1137	47%	60% - 65%
H22	2720	1287	47%	50% - 60%
H23	4105	1968	48%	65% - 70%
H24	2332	723	31%	31% - 35%
H25	3786	1752	46%	60% - 65%
H26	3574	1009	28%	30% - 35%
H27	4048	1369	34%	45% - 50%
H31	2161	834	39%	45% - 50%
H32	2208	657	30%	30% - 40%
H33	1923	556	29%	35% - 40%
H34	1460	323	22%	22% - 25%
H35	1447	326	23%	25% - 35%
H36	1664	353	21%	21% - 25%
H37	1838	511	28%	28% - 30%
H39	3892	519	13%	40% - 50%
H40	2949	787	27%	45% - 55%
H41	4939	1679	34%	60% - 65%

Pad	Effective OBIP (e3m3)	Recovery to Sept 2016		Ultimate Recovery (% EBIP)
		e3m3	% EBIP	
H42	3181	1302	41%	55% - 65%
H45	4343	842	19%	30% - 40%
H46	3557	1350	38%	50% - 65%
H47	4901	1033	21%	50% - 65%
H51	6700	845	13%	35% - 50%
H57	8733	1028	12%	35% - 55%
H58	8726	1944	22%	40% - 50%
H59	9191	1868	20%	30% - 45%
H62	9144	1245	14%	20% - 35%
H63	6798	1046	15%	15% - 35%
H65	7266	1274	18%	18% - 30%
H68	7016	986	14%	20% - 35%
H69	7816	673	9%	20% - 35%
J01	3002	2112	70%	72% - 75%
J02	1926	1280	66%	70% - 80%
J03	2576	1682	65%	70% - 75%
J04	2804	1753	63%	63% - 65%
J05	1515	796	53%	53% - 55%
J06	2451	958	39%	40% - 45%
J07	2147	1734	81%	81% - 83%
J08	3027	2566	85%	85% - 87%
J10	3068	2059	67%	70% - 73%
J11	3136	1284	41%	41% - 45%
J12	2773	1848	67%	67% - 70%
J13	3480	2413	69%	70% - 75%
J14	3692	1635	44%	65% - 70%
J15	3356	2366	71%	71% - 75%
J16	3424	1974	58%	65% - 70%
J21	2584	1361	53%	53% - 60%
J25	2358	796	34%	34% - 40%
J27	2080	395	19%	20% - 25%
K22	1526	516	34%	34% - 35%
K23	2648	677	26%	26% - 30%
K24	1897	507	27%	27% - 30%
K26	1954	288	15%	15% - 20%
L05	2831	1244	44%	50% - 60%

Pad Recovery

Pad	Effective OBIP (e3m3)	Recovery to Sept 2016		Ultimate Recovery (% EBIP)
		e3m3	% EBIP	
L06	2234	1533	69%	70% - 75%
L07	2382	1453	61%	61% - 65%
L08	812	475	58%	60% - 65%
L09	2332	300	13%	25% - 30%
L11	2755	1387	50%	55% - 65%
M03	2807	843	30%	30% - 35%
M04	2599	842	32%	35% - 45%
M05	1998	482	24%	25% - 35%
M06	1977	456	23%	25% - 30%
M07	1454	285	20%	20% - 25%
N01	11101	538	5%	20% - 35%
N02	8621	297	3%	15% - 30%
N03	7777	211	3%	15% - 30%
N04	7589	313	4%	20% - 35%
N05	7828	277	4%	20% - 35%
N06	6383	227	4%	20% - 35%
N07	6878	215	3%	20% - 35%
N08	9307	201	2%	20% - 35%
N09	9179	0	0%	15% - 30%
P01	2730	789	29%	30% - 35%
P02	1894	347	18%	20% - 25%
P03	2255	487	22%	22% - 25%
R01	2410	1093	45%	50% - 55%
R02	2341	793	34%	45% - 55%
R03	2580	755	29%	35% - 40%
R04	2089	489	23%	25% - 30%
R05	1734	613	35%	45% - 50%
R06	1293	466	36%	36% - 40%
R07	1631	651	40%	40% - 40%
T01	4759	983	21%	40% - 50%
T02	5216	768	15%	35% - 45%
T03	3997	726	18%	25% - 35%
T04	3908	657	17%	25% - 35%
T05	5528	705	13%	25% - 35%
T06	4696	712	15%	40% - 50%
T07	5676	888	16%	35% - 45%

Pad	Effective OBIP (e3m3)	Recovery to Sept 2016		Ultimate Recovery (% EBIP)
		e3m3	% EBIP	
T08	5401	755	14%	35% - 45%
T09	5005	530	11%	35% - 45%
T10	5996	583	10%	30% - 40%
T11	4499	637	14%	20% - 30%
T12	4553	653	14%	20% - 30%
T13	1489	191	13%	25% - 35%
T14	6287	719	11%	25% - 40%
T15	9624	834	9%	25% - 40%
T18	5366	369	7%	25% - 40%
U01	4668	1083	23%	40% - 50%
U02	3772	937	25%	45% - 60%
U03	4931	1005	20%	50% - 65%
U04	5162	943	18%	35% - 50%
U05	5912	912	15%	35% - 45%
U06	3840	660	17%	25% - 30%
U07	5617	679	12%	20% - 30%
U08	4523	782	17%	25% - 40%
U09	3822	641	17%	30% - 45%
V01	4915	1003	20%	40% - 50%
V02	5226	868	17%	25% - 35%
V03	4454	697	16%	20% - 30%
V04	4934	1018	21%	40% - 55%
V05	4666	974	21%	40% - 55%
V08	5380	946	18%	40% - 55%
V09	4978	880	18%	40% - 50%
V10	8774	1249	14%	25% - 40%
V13	8516	700	8%	20% - 30%
Y16	2444	802	33%	40% - 50%
Y31	2146	663	31%	40% - 50%
Y32	2539	268	11%	45% - 50%
Y34	2123	670	32%	40% - 45%
Y36	2917	774	27%	40% - 50%

Future Plans

Pad Steaming Priorities

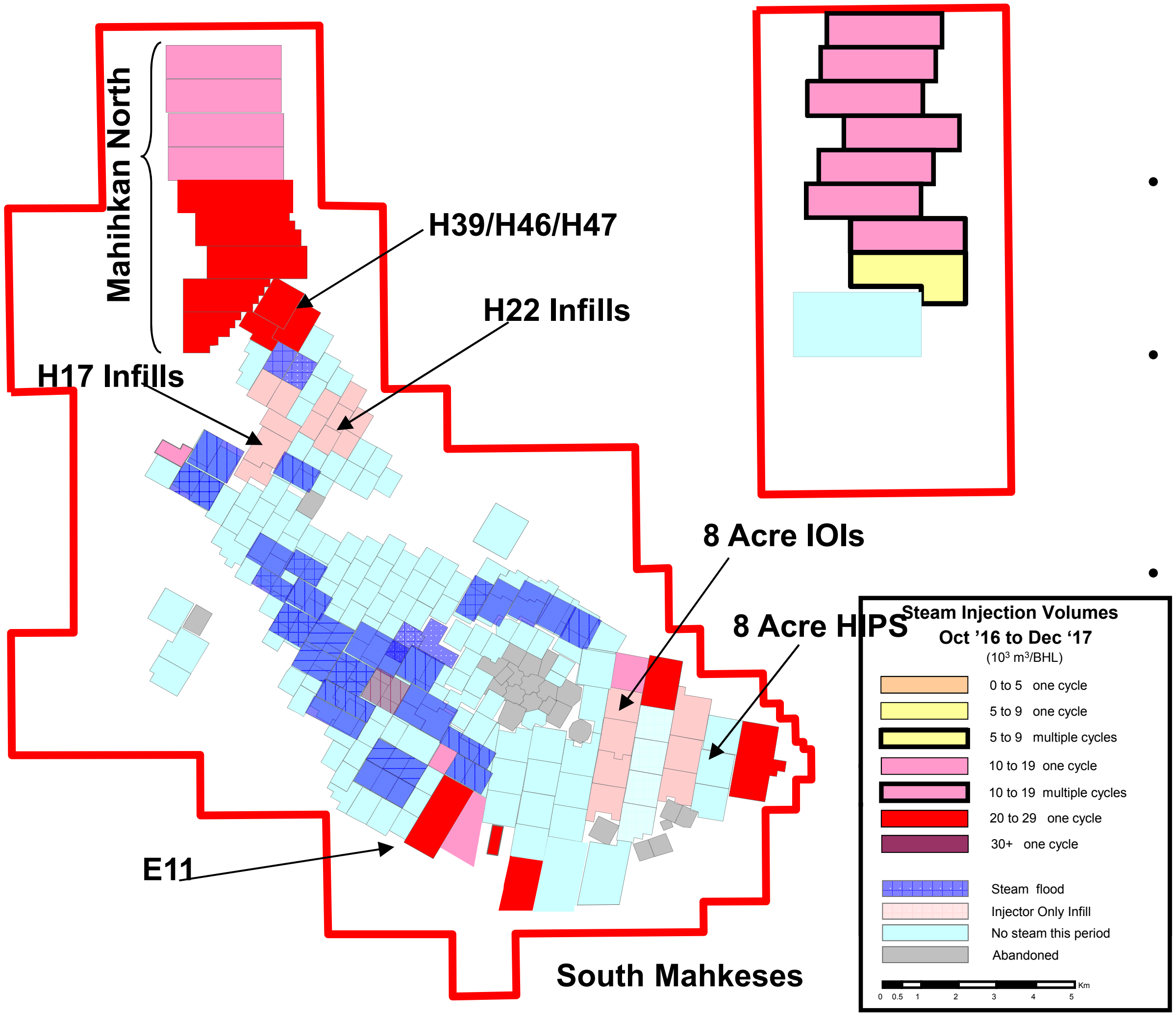
- Long-term steam plans developed annually
  - Targeted cycle timing based on historical performance and optimal cycle length
  - Development plans tied to projected steam demand at each site to fully utilize installed steam capacity

- Earlier cycle pads receive priority during periods of steam demand higher than plant capacity and for scheduling considerations
  - Pads are steamed less frequently as they mature (steam timing is less critical to performance)
  - Individual pad steaming suspended at an economic limit
  - Infill steamflood pads can operate effectively at a range of steaming rates, providing flexibility to steam scheduling

- Steam patterns are developed to balance cycle timing optimization, shear stress management and interwell communication

- Additional factors
  - Setback requirements between drilling and steaming operations

Steam Plans to End 2017



- **Mahkeses**
  - 8 acre IOI sweep(T01/T07/U01/U03)
  - 8 acre HIP Cycle 1 (V09/U09)
  - CSS cycles at T14, T18, V10, U07, U06
  - T13 SA-SAGD
- **Leming**
  - FF/U/G02 and T05 steamfloods
  - Y32
- **Maskwa**
  - D, E and F-Trunk steamfloods
  - Cycle 2 Infills: D01
  - E11 CSS cycle
- **Mahihkan**
  - H, J, and L- and R Trunk steamfloods
  - Mahihkan North sweep (H63, H65, H68, H69 then H51, H57, H58, H59)
  - CSS cycles at H39/H46/H47 and L09
  - Cycle 1 Infills: H17, H22

Nabiye
- N01-N07 cycle 4 and 5 steaming
- N08 cycle 3 and 4 steaming
- N09 productivity maintenance pads

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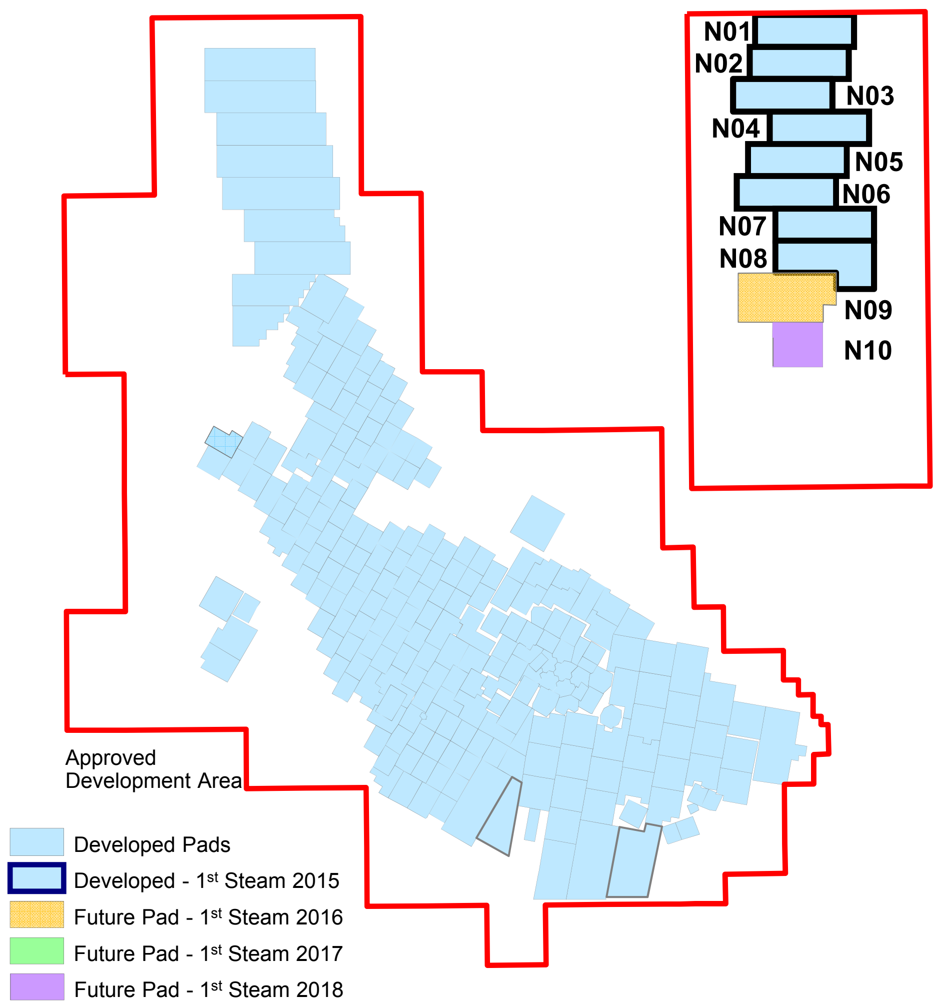
Pad Development Program



Drilling and Steaming Schedule

N01	2012	2015
N02	2012	2015
N03	2012	2015
N04	2012	2015
N05	2013	2015
N06	2013	2015
N07	2013	2015
N08	2013	2015
N09	2014	2016
N10	2017	2018

Extensive well repair program and positive steam flood performance has deferred previously planned pad development program

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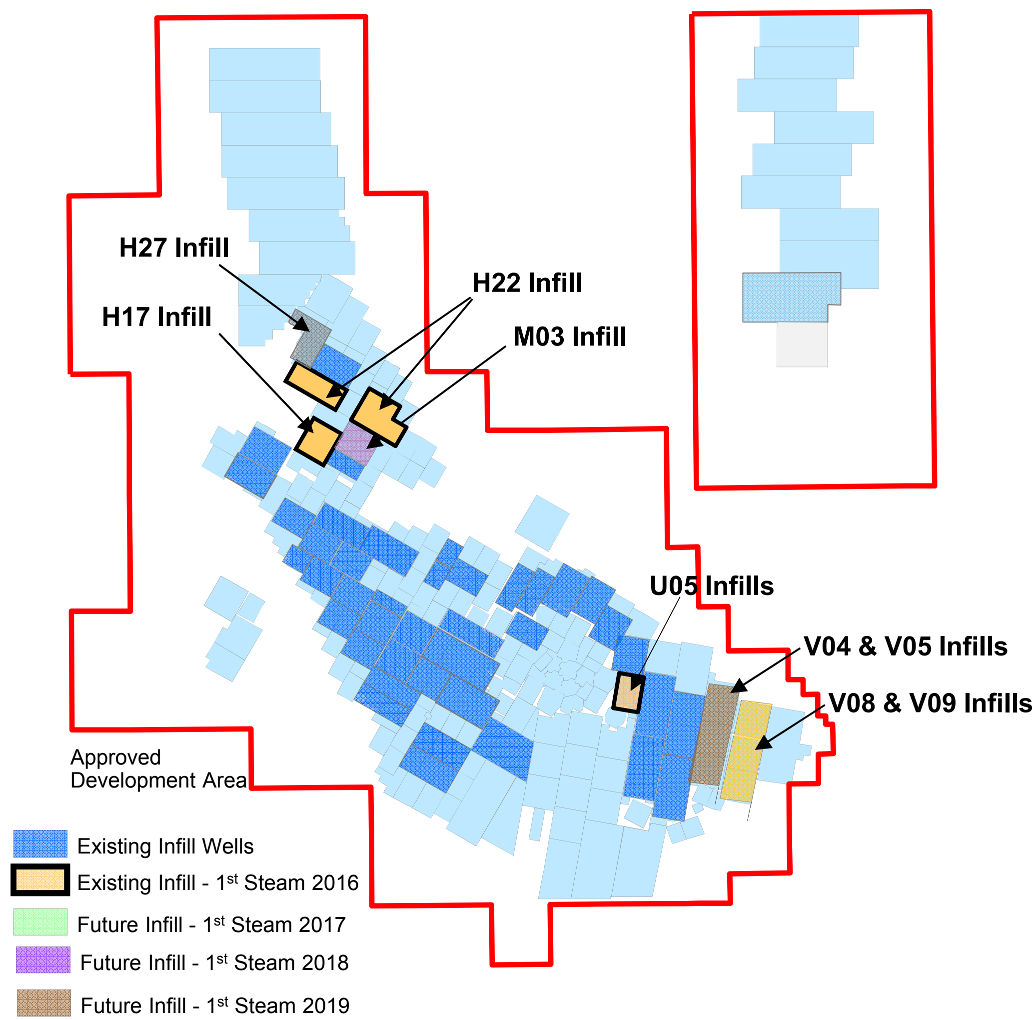
Infill Drilling Program



Drilling and Steaming Schedule

Infill Pad	Year Drilled	1st Steam
V08	2014	2016
V09	2014	2016
H17	2015	2016
H22	2015	2016
U05	2015	2016
M03	2017	2018
V04	2018	2019
V05	2018	2019
H27	2020	2021

T13 SA-SAGD Pilot

Summary

- Solvent Assisted - Steam Assisted Gravity Drainage (SA-SAGD) pilot in Cold Lake

- Pilot includes:
  - — Two horizontal well pairs (four wells)
  - — Six observation wells (OB wells)
  - — Injection and testing facilities

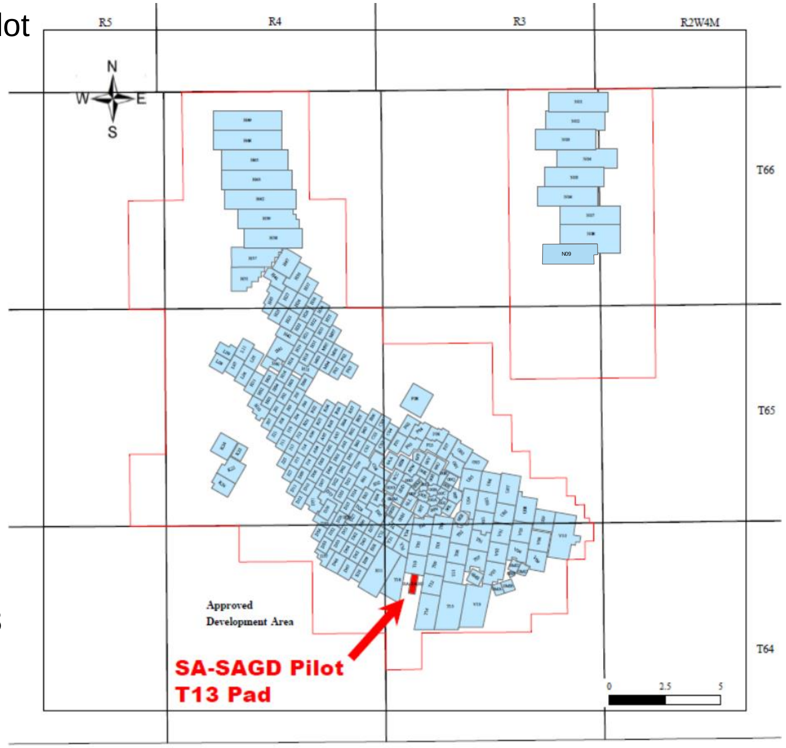
- Pilot utilizes Imperial's existing Mahkeses plant for:
  - — Steam generation
  - — Water treatment, bitumen separation and processing
  - — Steam distribution and production gathering systems

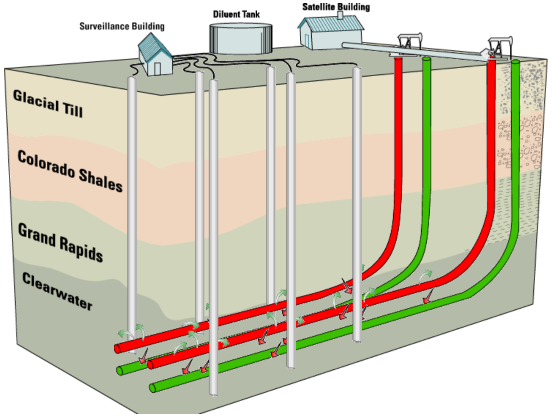
- Pilot Approval 10689D rescinded and transitioned to Approval 8558 on July 14, 2016

- Recovery to date:

	Cumulative Production (km3)	OBIP (km3)	Recovery to Date (%)	Expected Recovery (%)
T13	153	1062	14	40-50

- Future Plans:
  - WP1: optimize solvent concentration & operating parameters
  - WP2: study post steam performance





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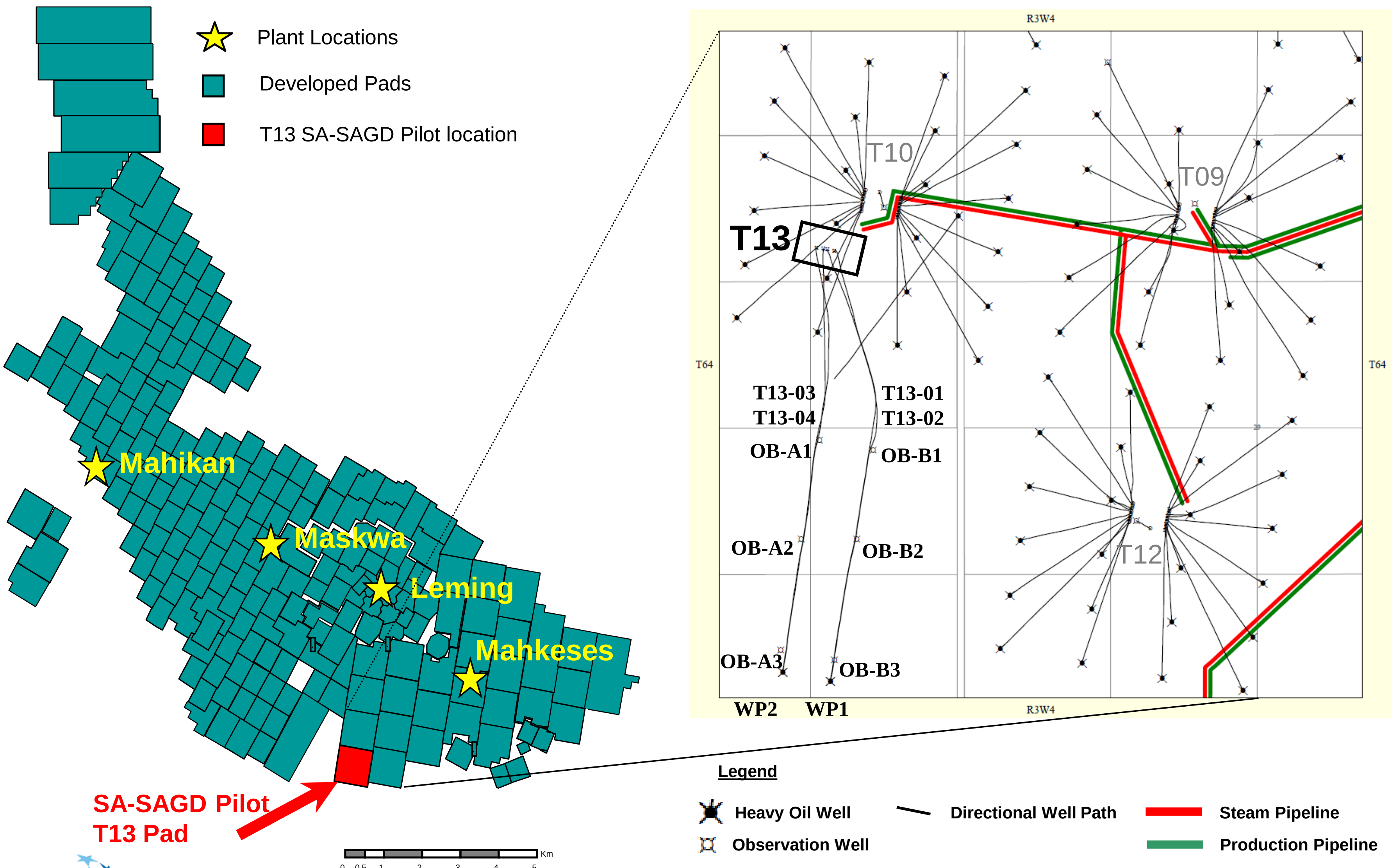
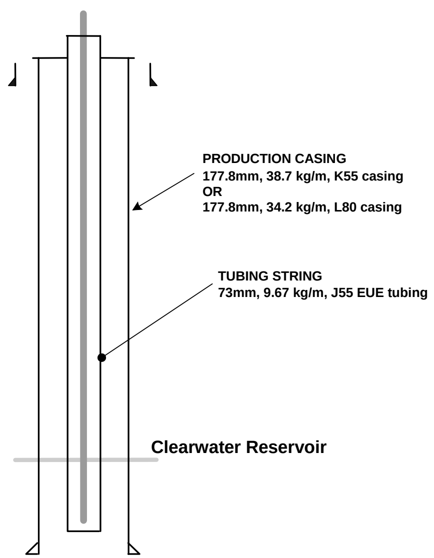
Well Layout

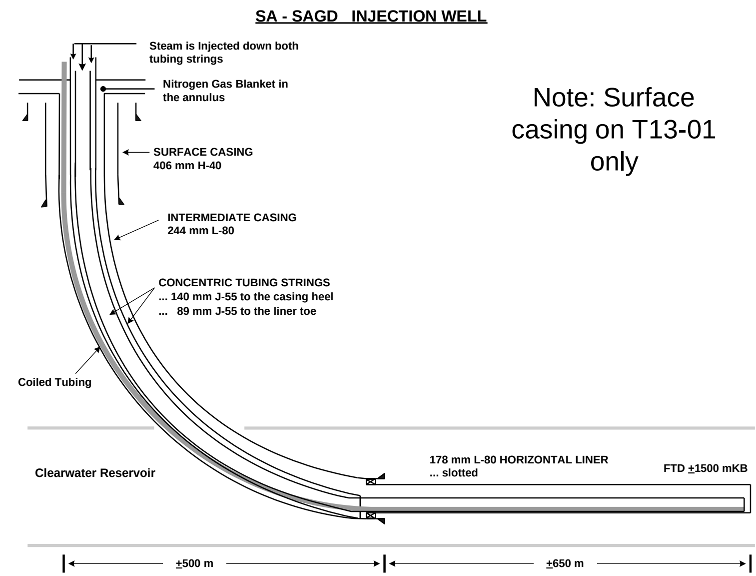


Plant Locations
Developed Pads
T13 SA-SAGD Pilot location
Mahikan
Maskwa
Leming
Mahkeses
SA-SAGD Pilot
T13 Pad
0 0.5 1 2 3 4 5 Km
R3W4
T64
T10
T09
T13
T12
T13-03
T13-04
T13-01
T13-02
OB-A1
OB-B1
OB-A2
OB-B2
OB-A3
OB-B3
WP2
WP1
Legend
Heavy Oil Well
Observation Well
Directional Well Path
Steam Pipeline
Production Pipeline

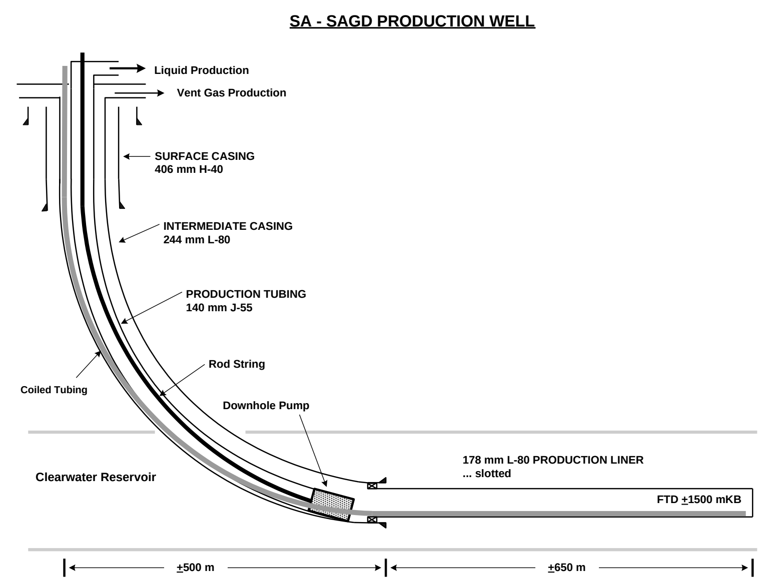
Well Schematics (SAGD / SA-SAGD Mode)

- Injection wells configured with:
  - Horizontal slotted liner
  - Toe / heel tubing string (steam injection)
  - Intermediate casing (filled with N_2)
- Production wells configured with:
  - Horizontal slotted liner
  - Downhole pump at heel of well
  - Production tubing for fluids
  - Intermediate casing for gas production
- Instrumentation in wells include:
  - 3 bubble tubes & 20 thermocouples in producers
  - 12 thermocouples in injectors
  - Between 27 and 34 thermocouples in OB wells





Note: Surface casing on T13-01 only



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T13 Operational History

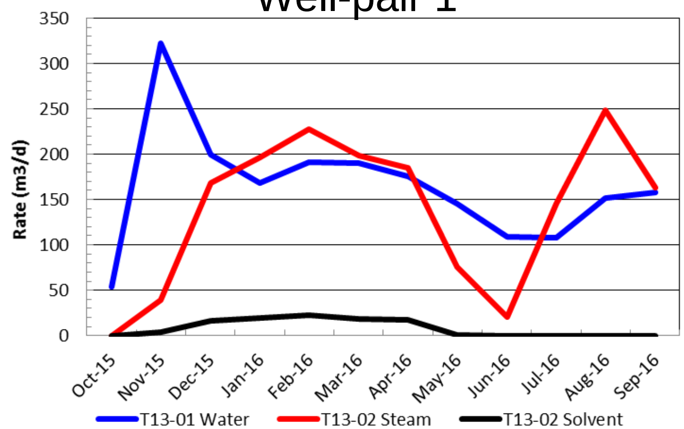
• Jul 20, 2010	SAGD operation commenced on both well-pairs
• Oct 20, 2010	Diluent injection commenced into T13-04, converting well-pair 2 to SA-SAGD mode (well-pair 1 continues in SAGD mode)
• Nov 25 – Dec 22, 2010	Diluent injection shut-in due to surface facility issues (well-pair 2 operated in SAGD mode during this period)
• May 24, 2012	Well-pair 2 was switched from SA-SAGD mode to SAGD mode
• May 29, 2012	Well-pair 1 was switched from SAGD mode to SA-SAGD mode
• Oct 10, 2014	Reduced WP1 diluent injection concentration in steam (v/v) from 20% to 10%
• May 2016	WP2 shut-in, converted WP1 to SAGD operation

2016 Overview

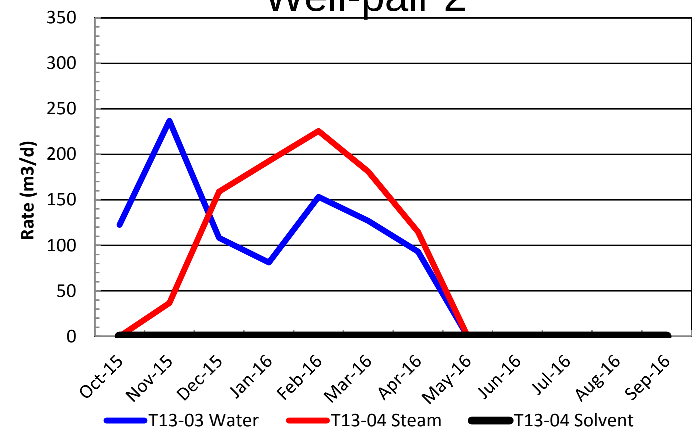
Key Events:

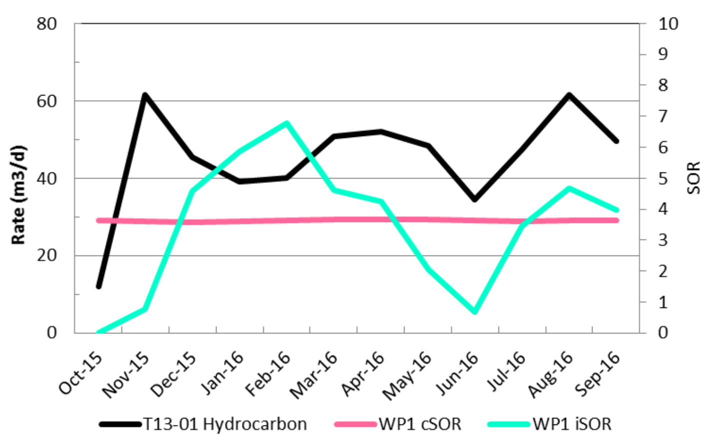
- Steam Outage: Surface reliability issues (Oct-Nov, May-Jun)
- Test Separator Outage: Inferred test system used (Oct – Mar)
- Well Pair 1 (WP1): Perforation job on T13-01 (Oct), converted to SAGD operation (May)
- Well Pair 2 (WP2): Declining production result of skin formation on producer, steam / production shut-in (May)

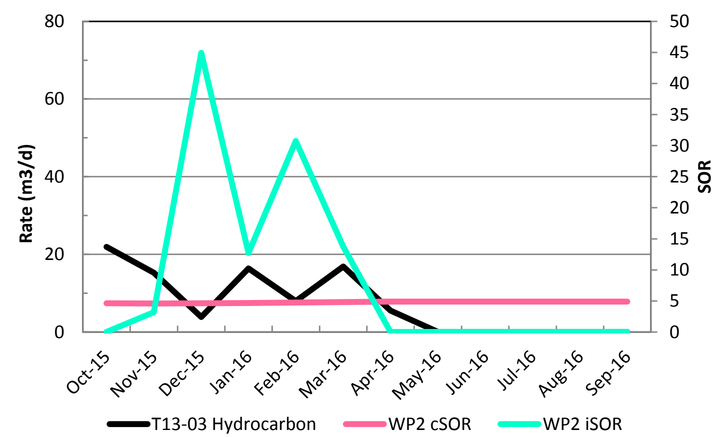
Well-pair 1



Well-pair 2



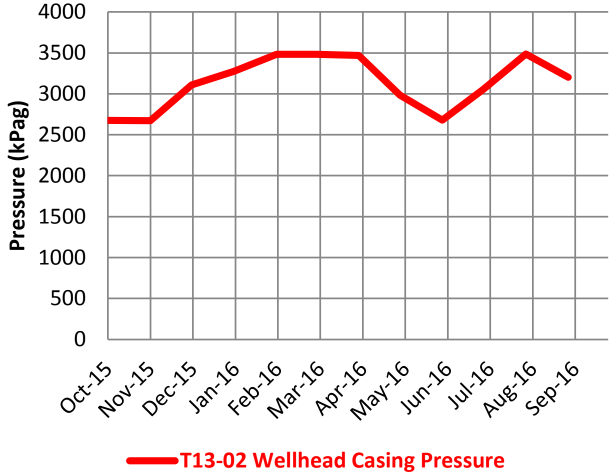


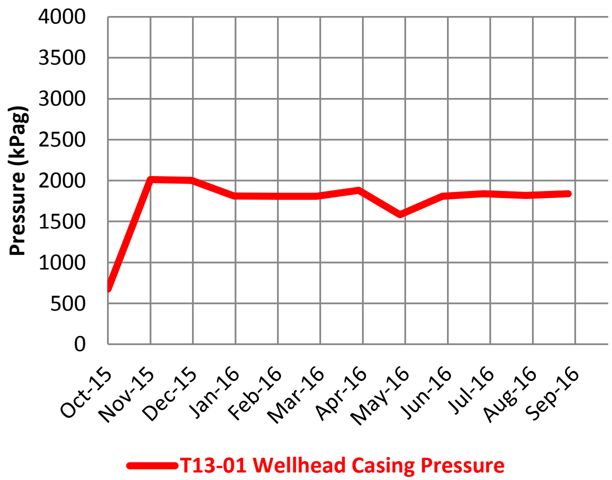


Wellbore Pressure

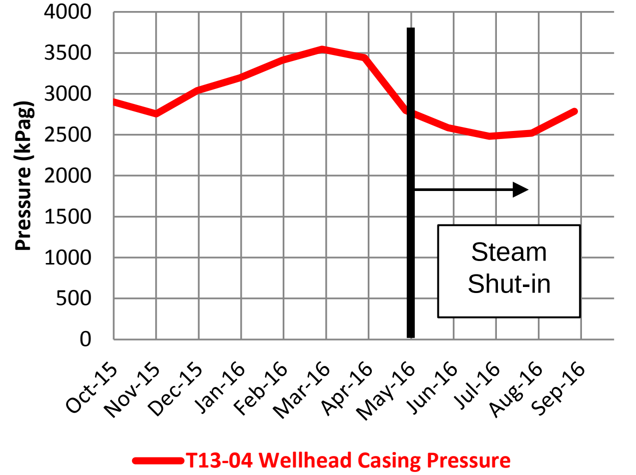
- Well Pair 1: pressure fluctuations result of pad steam reliability issues (Oct-Nov, May-Jun), and producer workover (Oct)
- Well Pair 2: steam/production shut-in in May, both injector and producer N2 purged and show BHP decline
    - Injector re-purged in September resulting in a small pressure increase

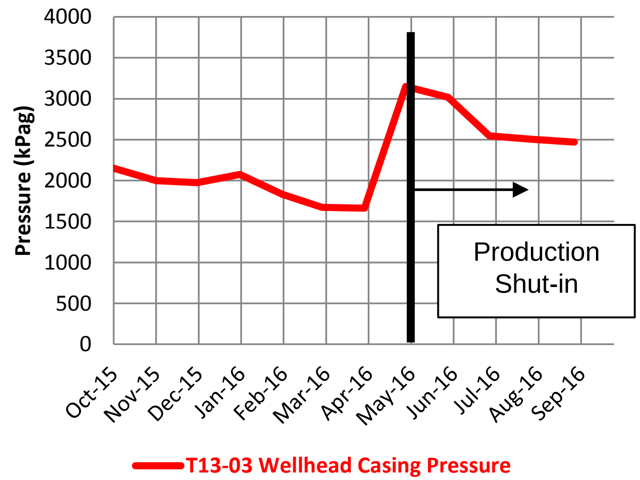
Well-pair 1





Well-pair 2





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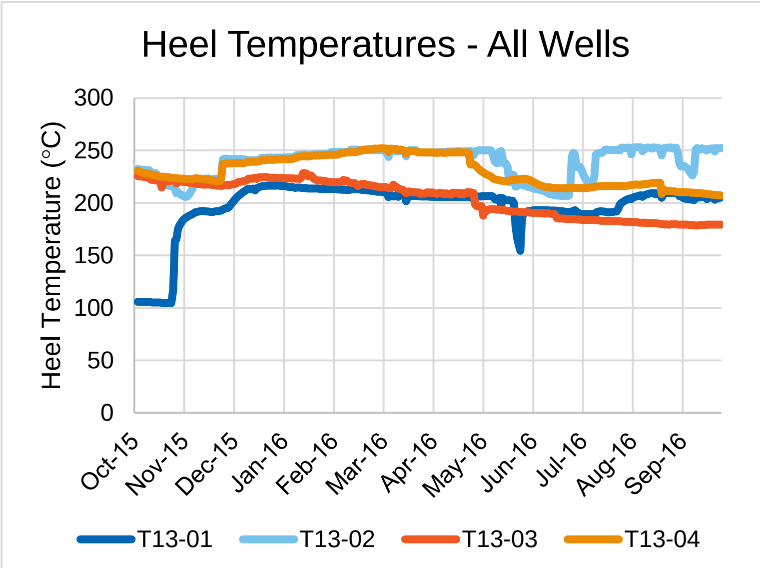
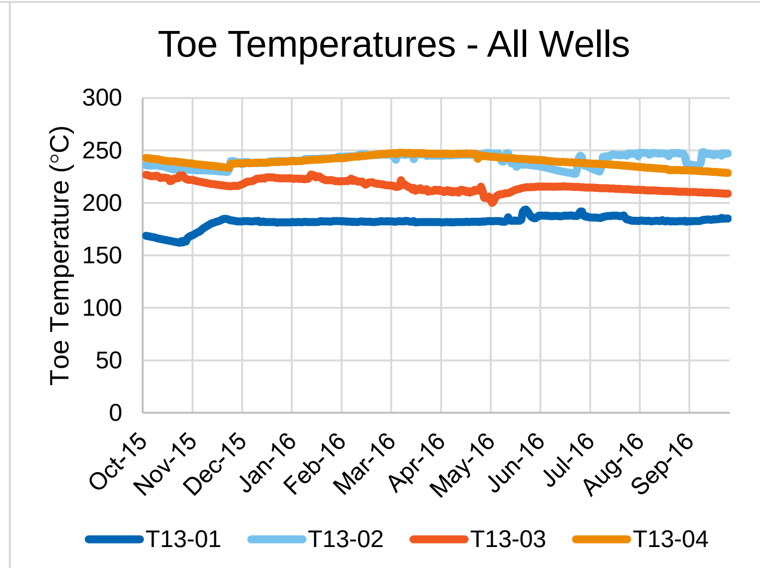
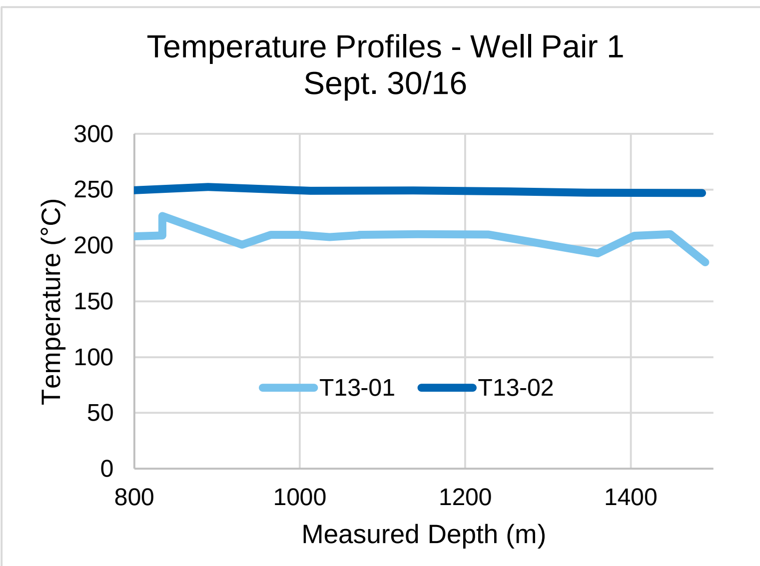
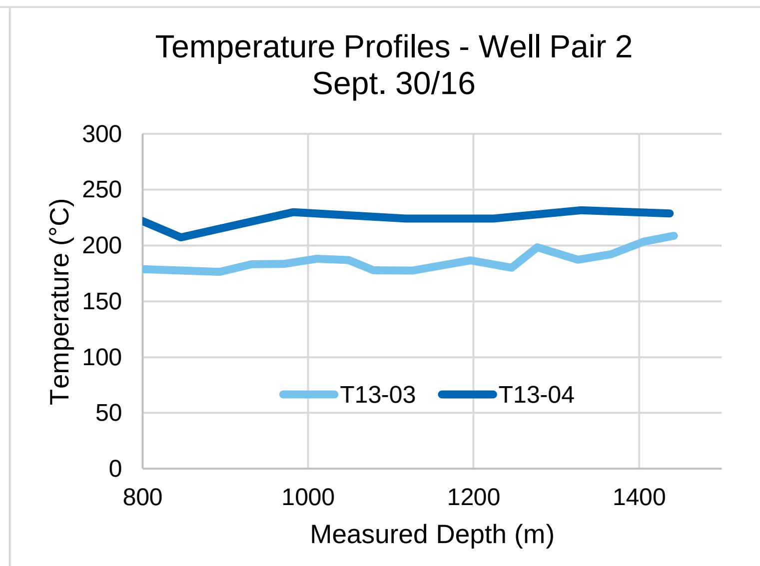
Injector & Producer Temperatures

- Steam injected at saturated steam conditions, with steam quality downhole expected to be 90%+









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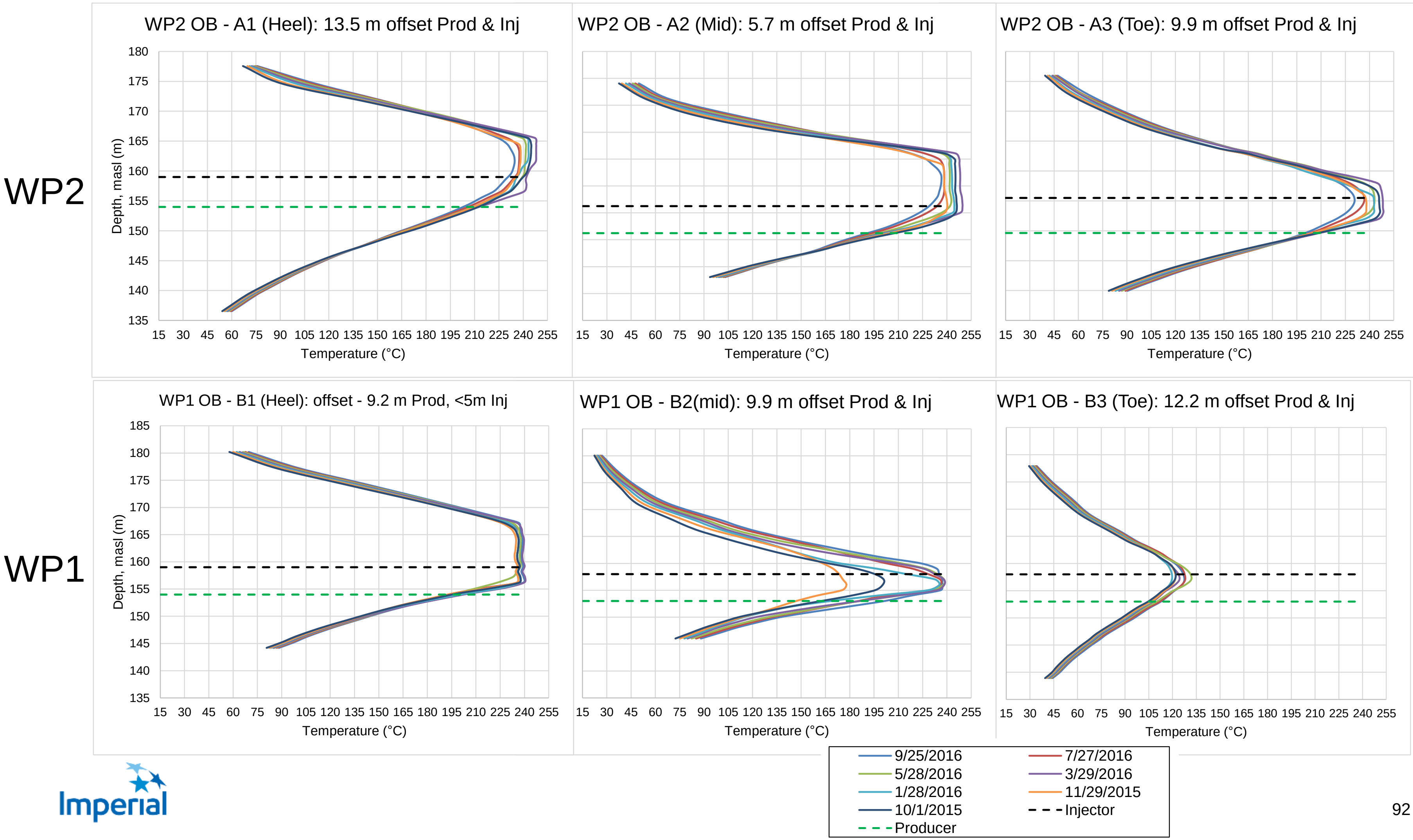
Observation Well Temperatures

- Temperature at observation (OB) wells provides a measure of amount of heat transferred to reservoir
- WP2 OB temperature decline resulting from May steam shut-in
- WP1 OB temperature variance as result of steam outages

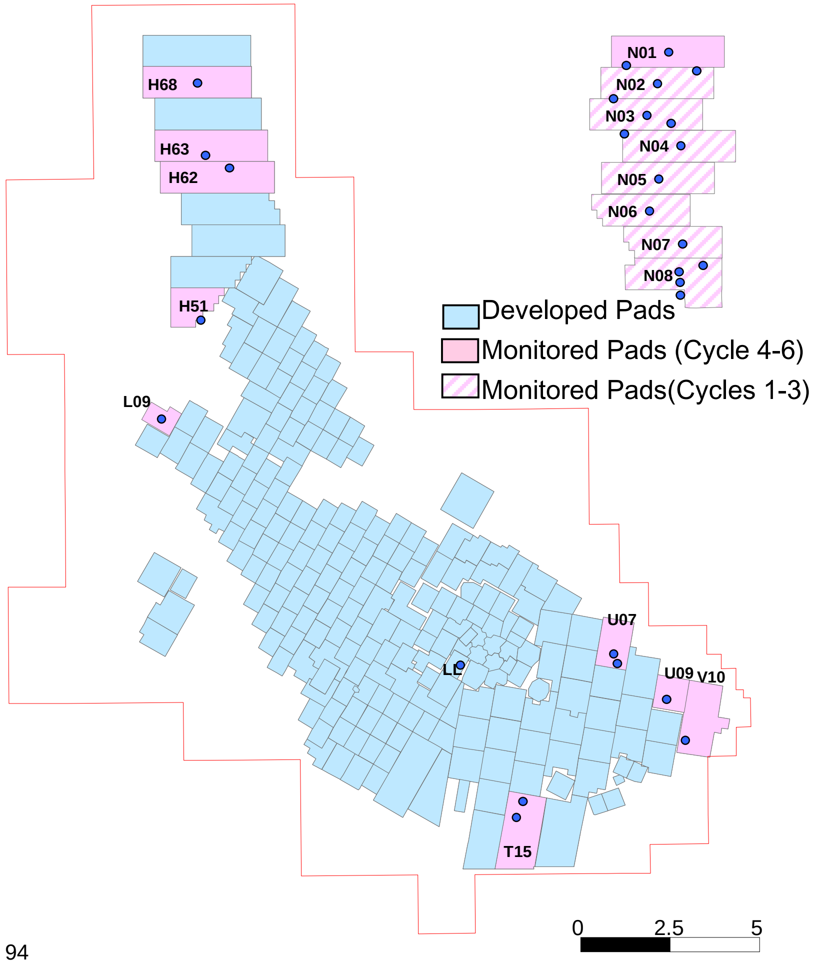


Other Discussion Items

Grand Rapids Monitoring Program

Objective

- Apply risk-based approach and monitor specific pads at Cold Lake for potential fluid excursions into the Grand Rapids formation.
- If excursion occurs, identify sources, determine volumes, notify AER, mitigate, and take steps to limit future fluid excursions.

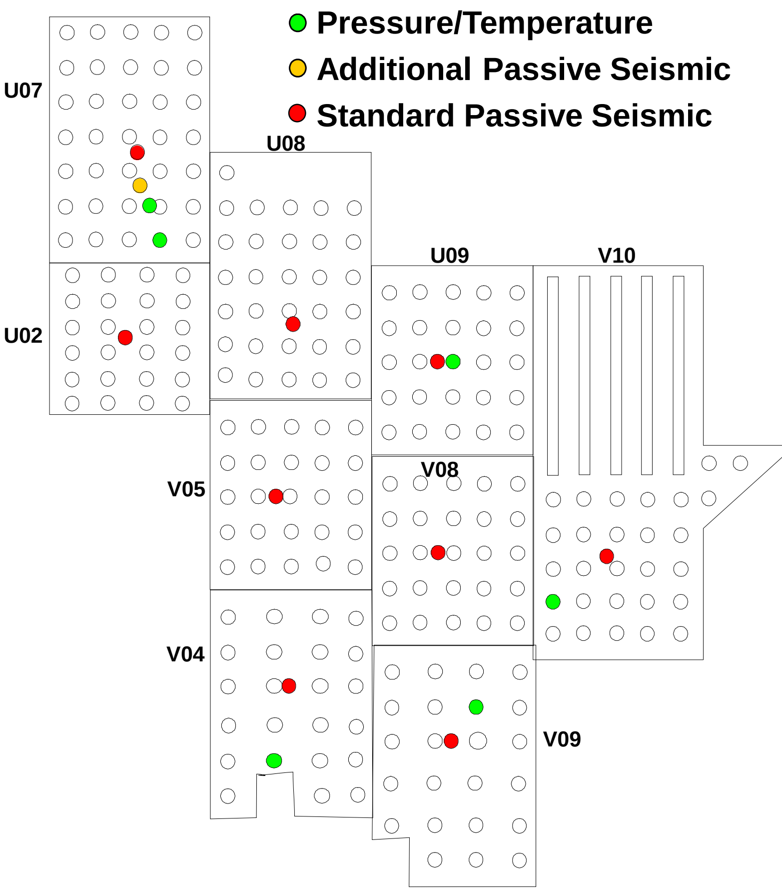


Pad	Basis
U07	Elevated Upper Grand Rapids (UGR) pressure
U09	Elevated Lower Grand Rapids (LGR) pressure
V10	Poor primary cement bond log
T15	Potential cement channels
LL	Unsuccessful abandonment of adjacent OV well
L09	Control pad
H51	Possible ghost hole in the Grand Rapids
H62	Poor primary cement bond log
H63	Poor primary cement bond log
H68	Control pad
Nabiye	Geologic factors and proximity to FTS

U/V Trunk Grand Rapids Monitoring

Grand Rapids Monitoring Program

- All Pads:
  - Standard passive seismic
  - Steam injection rates and pressures
  - Post-steam temperature logs
- U07: One pressure monitoring well in LGR and two wells in UGR, and one additional passive seismic well to monitor the Grand Rapids
- U09: Monitoring discontinued at U09-08 in 2016 and U09-13 recompleted as UGR/LGR pressure monitoring well
- V10: One pressure monitoring well in the LGR and Clearwater



Observations

- Pressure responses in the LGR and UGR observed at U07 in Cycle 2 and 3 were not observed in Cycle 4 when most likely source wells were selectively steamed. Poro-elastic response observed in Cycle 5 and minor fluid excursion observed at well U07-20 in Cycle 6 (2015) under Cold Lake steaming best practices.
- GR pressure responses at V10 diminished with each successive cycle
- Poro-elastic pressure responses at U09-13 during Cycle 8 steam (ongoing)

Conclusions

- Pathways from the Clearwater to Grand Rapids generally healed after early cycles due to either:
  - Plugging or closure of the pathway
  - Stress state changes to favour horizontal fracturing
- High pressures in UGR bitumen zones can be highly localized

Plans

- Steam all pads with high overlap strategy per Cold Lake best practices –including infill wells on U09, V08 and V09
- Continue monitoring the pressure response in the Grand Rapids
- Additional GR monitoring to be added on V09 and V04

Mahihkan North Grand Rapids Monitoring

Grand Rapids Monitoring Program

- H51: 1 LGR pressure monitoring well
- H62: 1 LGR pressure monitoring well
- H63: 1 LGR pressure monitoring well
- H68: 1 Hybrid Passive Seismic Well with LGR pressure monitoring

Observations

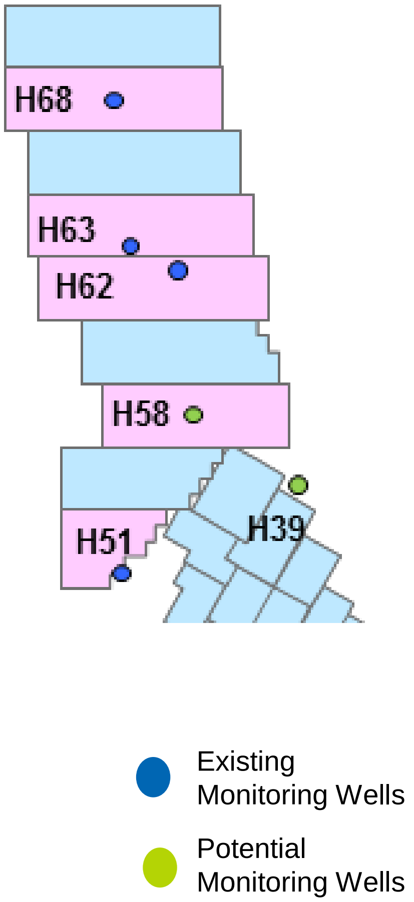
- H51 – Fluid excursion was detected in Cycle 7 (2015)
- H62 – Fluid excursion was detected in Cycle 6 (2016)
- H63 – Only poro-elastic responses observed during steaming
- H68 – Possible excursion identified at H68 in Cycle 3 (2013). Only poro-elastic responses observed during steaming Cycle 5 (2015)

Conclusions

- Cement channels on H62-H63 are not significant pathways for fluid excursions to the Grand Rapids

Plans

- Progress opportunities to add additional GR monitoring at H39 and H58
- Investigate potential pathways for H51 excursion



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Nabiye Grand Rapids Practices

Factors that may impact fluid containment in the Clearwater formation at Nabiye

- Salt dissolution can create fractures in the overlying Clearwater shale
- Thicker overburden increases likelihood of vertical fracturing
- Presence of Mannville faults that intersect the Clearwater shale
- Proximity to CNRL Primrose East flow-to-surface events

Prevention Practices – Designed to prevent out-of-zone fluid excursions

- Reduced steam volume targets for all Nabiye pads compared to Cold Lake Best Practices when necessary
- Well spacing at Nabiye reduces uplift-induced stress changes in the Colorado shale
- Well spacing at Nabiye reduces risk of multi-well excursion event
- Proven drilling and cementing practices
- Nearby abandoned wells thoroughly reviewed and confirmed as being competent
- Extensive casing integrity program

Detection Practices – Designed to identify and locate excursions

- Pressure monitoring network of 19 wells covering 29 zones within the Grand Rapids
- Automated alarm system to detect rapidly changing pressure
- 4-D seismic surveys; first survey acquired across pads N01-N04
- Passive seismic monitoring, well injectivity monitoring and casing integrity verification

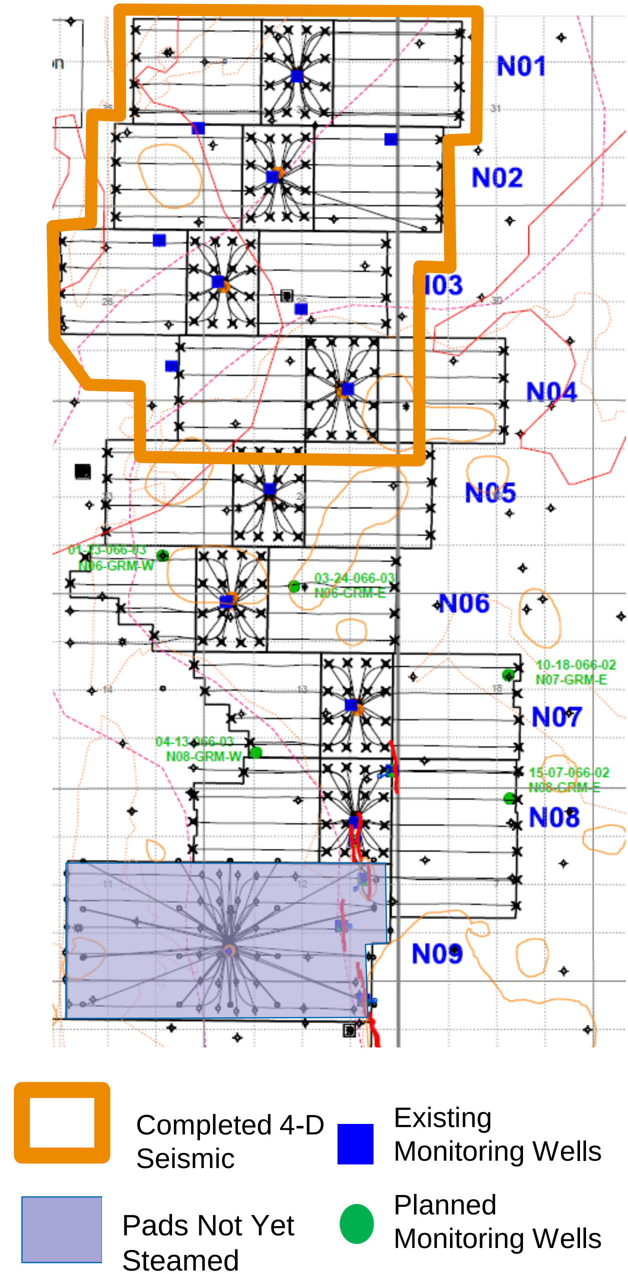
Response Practices – Designed to minimize the volume of excursions

- Identify suspect steaming wells which are then shut-in and may be re-started with lower target volumes
- Reduce steam to field when necessary to manage reduced target well volumes
- Reduce steam rates
- Re-steam suspect wells in the same or subsequent cycles to build horizontal stress to favour horizontal fractures

Nabiye Grand Rapids Monitoring

Pad	Wells (yr installed)	Monitored Zones	Fluid Excursion Confirmed
N01	N01 (2013)	LGR,UGR	All cycles
N02	N02-C (2014), N02-E (2016), N02-W (2016)	LGR,UGR	All cycles
N03	N03-C (2014), N03-E (2016), N03-W (2016)	LGR,UGR	All cycles
N04	N04-C (2014), N04-W (2016)	LGR,UGR	Cycles 1 and 3
N05	N05 (2013)	LGR,UGR	None
N06	N06 (2014)	LGR	Cycle 3
N07	N07-FMW* (2013), N07 (2014)	LGR, PS	All cycles
N08	N08 (2013), N08-FMW* (2014)	LGR, PS	All Cycles
N09	N09 (2014), N09-FMW1 (2015), N09-FMW2 (2015), N09-FMW3 (2015)	LGR, PS	Not yet steamed

*Note: All FMW wells include passive seismic monitoring



Observations

- Fluid excursions to the Grand Rapids have been observed consistently during early cycles
- Post-steam seismic anomalies identified via 4-D seismic on pads N01 and N02

Conclusions

- Combination of geologic factors likely contributing to increased fluid excursions relative to the rest of Cold Lake
- Monitoring and response practices effective at identifying and mitigating fluid excursions

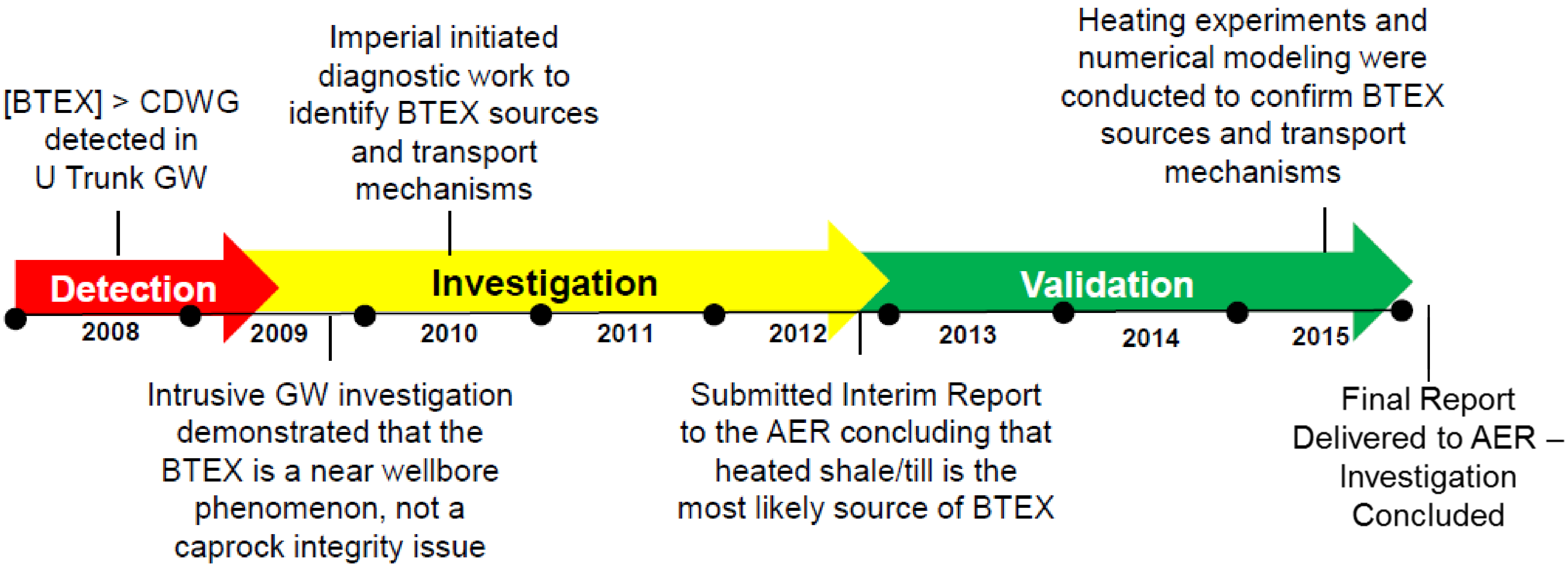
Plans

- Continue to apply the Prevention, Detection and Response Practices developed for Nabiye (see previous page)
- 5 additional Grand Rapids monitoring wells planned over horizontal wells at pads N06-N08

Investigation of BTEX in Deep Groundwater Monitoring Wells

Purpose
- Confirm the sources and transport mechanism of BTEX in groundwater

Background



Conclusions
- Heated Colorado Shales and Glacial Tills are the primary sources of BTEX
- No pathway from the Grand Rapids or Clearwater formations to aquifers
- Flow outside casing in Colorado Shales and Quaternary and direct fluid exchange from the shales or tills are the most likely transport mechanisms for BTEX introduction to the aquifers
- BTEX generation ceases when heating stops and attenuation in the aquifers will reduce BTEX concentration over time

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Facilities

Facility Modifications

OTSG Economizer Replacements

- Continued program to replace economizers reaching end of life
- New economizers are more energy efficient design (~ 2% increase in efficiency)
- 2B-7100 and 1B-7600 economizers replaced in 2016

Electrical Distribution Network Upgrades (Collaborative Effort with ATCO)

- Continued program to upgrade network to improve power reliability across the district and reduce UVL
- Additional lightning arrestors and bird protection devices being installed
- Upgrading old switches and equipment nearing end of life
- Installation of new reclosers has proven to prevent two plant outages in the past year

New Landfill Cell

- Completed construction of new landfill cell C-204L in March 2016
- Due to good focus on waste material management in active cell C-203L, don’t expect to start using new cell until late 2016 or early 2017

Facility Performance

Bitumen Treatment and Vapour Recovery

- Bitumen production remained within AER inlet licence limits over reporting period

AER Inlet Licence	Maskwa	Mahihkan	Leming	Mahkeses	Nabiye
Bitumen Licence (m^3/d)	11,000	15,000	5,000	8,000	8,000
Actual Oct/15 – Sep/16 (m^3/d monthly avg)	6585	9063	1152	4656	3996

- Issues & Limitations
  - None
- Major Downtime
  - Mahkeses GTG/HRSG's inspections - 21 days, Apr-May 2016
  - Nabiye GTG inspections/HRSG upgrades – 11 days, Sep-Oct 2016
  - Leming Turnaround – 23 days, Sept-Oct 2016
- Major Equipment Failures
  - None
- Vapour Recovery Performance - Over 99% produced gas recovery Oct/15 to Sept/16
  - Recent activities to improve venting performance:
    - Continued use of Forward Looking Infra-red (FLIR) camera
    - Optimizing tank PVRV settings and increased surveillance

Facility Performance

Water Treatment

- Water production remained within AER inlet licence limits over reporting period

AER Inlet Licence	Maskwa	Mahihkan	Leming	Mahkeses	Nabiye
Water Licence (m^3/d)	38,000	41,000	13,500	28,000	22,665
Actual Oct/15 – Sep/16 (m^3/d monthly avg)	29510	36097	6948	18,660	10930

- Issues & Limitations
  - Continued focus on improving treated water transfer from Maskwa & Mahkeses to Leming

- Major Downtime
  - Mahkeses Tr1 HLS and GTG/HRSG down: May 2016
  - Leming Shutdown: Sept 2016

- Major Equipment Failures
  - None

Facility Performance

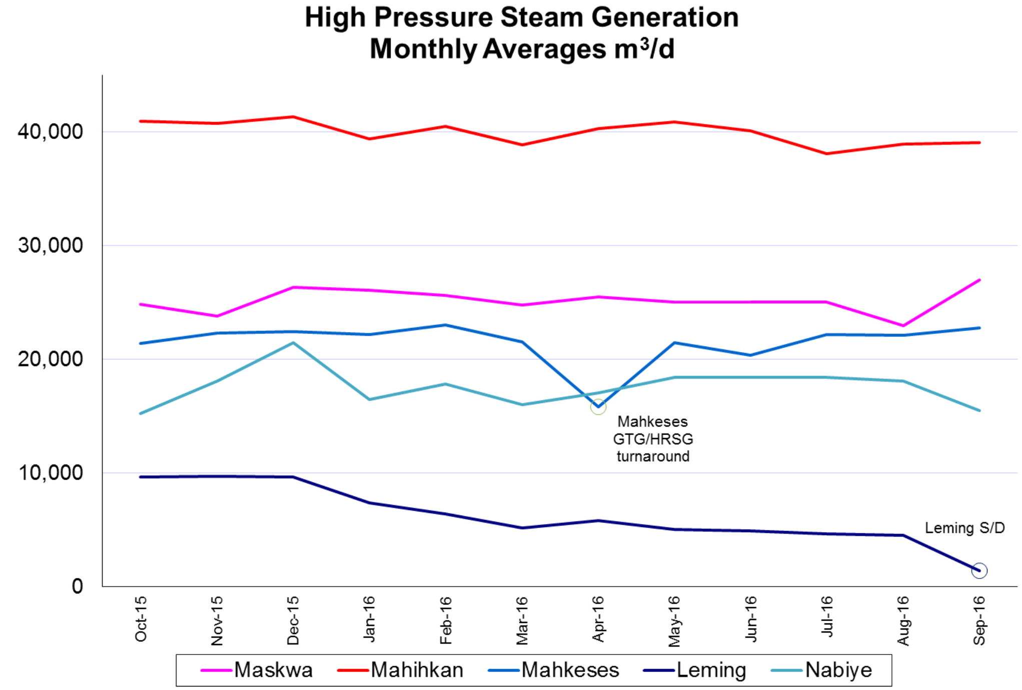
Steam Generation

Cold Lake District HP Steam Generation (m3/d)						
2010	2011	2012	2013	2014	2015	2016 YTD
88,967	92,132	90,386	93,445	90,361	118,144	108,543

- Nabiye steam reduction ↓3500 m3/d
  - Field steam strategy
- Leming steam reduction ↓4100 m3/d
  - Field steam strategy

- Major Downtime
  - Mahkeses GTG/HRSG inspection
    - 21 days: Apr-May 2016
  - Leming turnaround
    - 23 days: Sep–Oct 2016

- Major Equipment Failures
  - None



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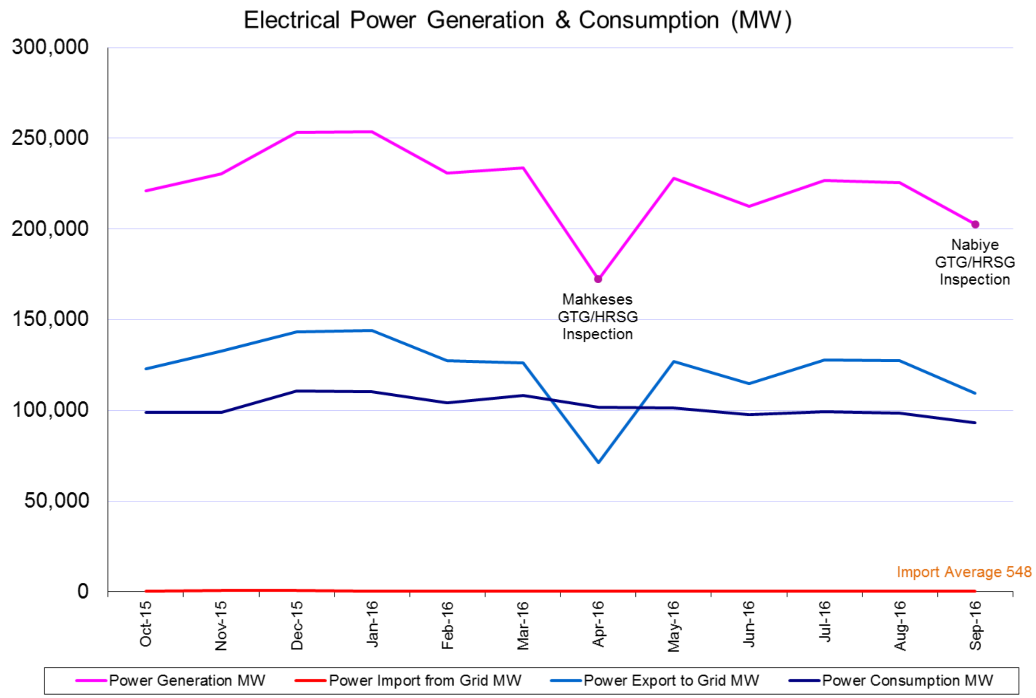
Facility Performance

Electrical Power Generation and Consumption

- Mahkeses & Nabiye Plants each have two gas turbine electrical power generators within a co-generation steam plant that generates power for the district and exports power to the Alberta power grid
- Power in 2016 was imported only to Imperial facilities that are outside the district power grid, from the Alberta power grid
- Issues & Limitations
  - None
- Major Downtime
  - Mahkeses gas turbine generator planned inspections – 21 days, Apr-May 2016
  - Nabiye gas turbine generator planned bore-scope inspection – 11 days Sep 2016
- Major Equipment Failures
  - None



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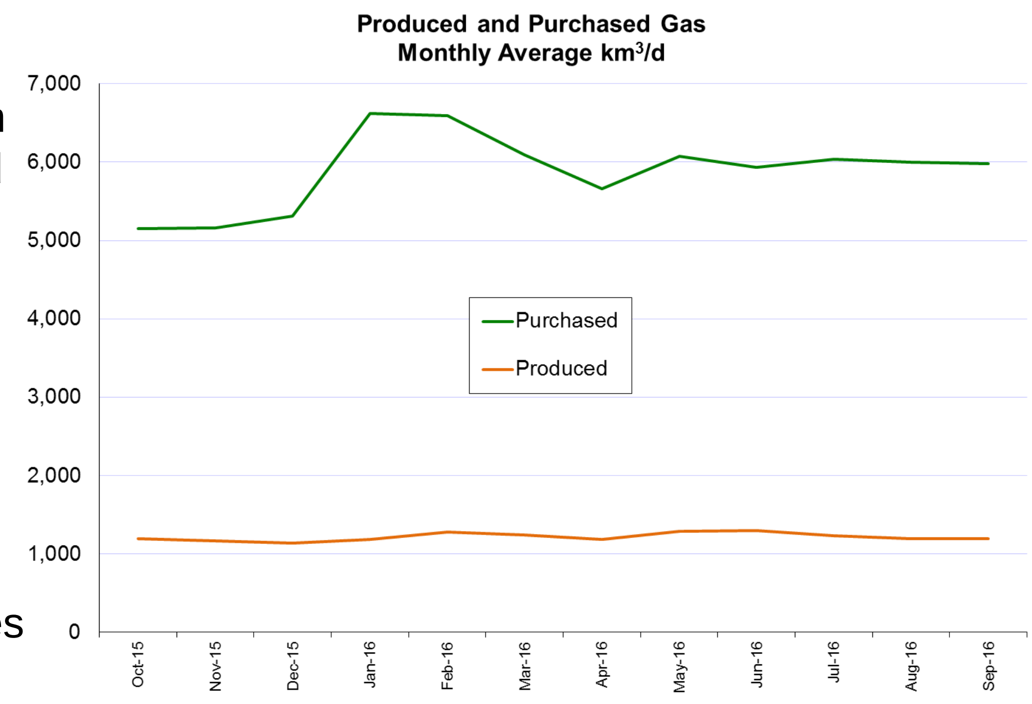
Facility Performance

Produced Gas Management

- All recovered produced gas used as fuel for high pressure steam generation
- Purchased sweet gas is used for steam generation (high and low pressure) and heater operation
- Issues and Limitations
  - None
- Major Downtime
  - As per bitumen and water summaries
- Major Equipment Failures
  - None



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Measurement and Reporting

Measurement & Reporting

- There were zero compliance issues with volume reporting for CLO in Q4 2015 & 2016 YTD
- Collaborated with AER to enable reporting AB EG (gas used to generate electricity) from an injection facility - started May 2016
- Continuing to upgrade plant schematics and allocations for Dir17 compliance and improved fluid balance monitoring
    - Nabiye and Mahkeses complete; Leming in progress with Mahihkan and Maskwa to follow

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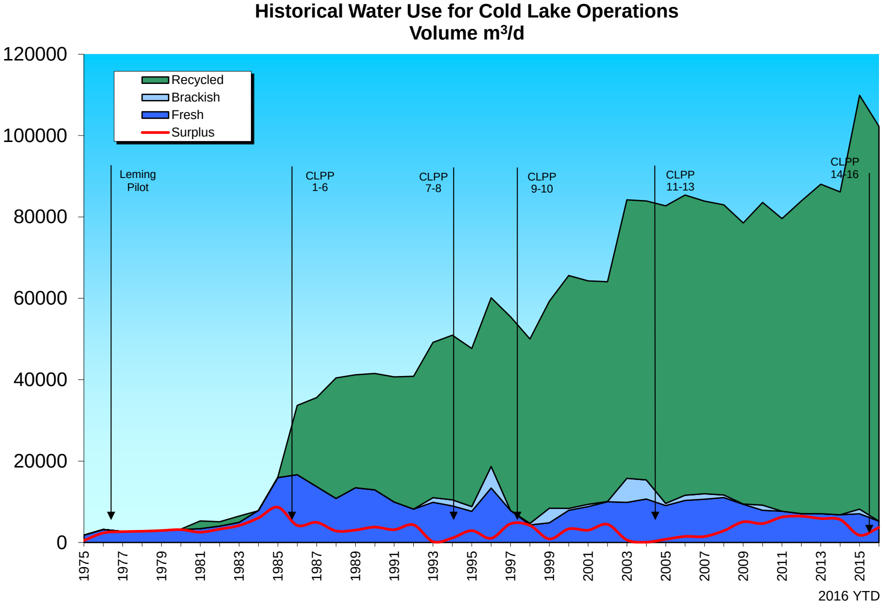
Proration Factors

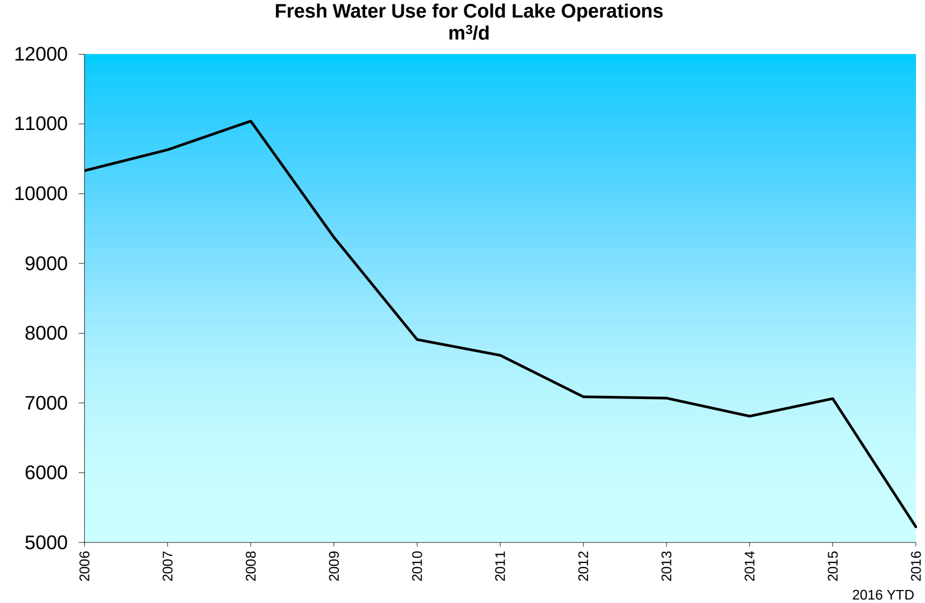
Cold Lake 2015 - 2016 Profac Report															
Profacs which are over Deviation Limit			2015			2016									
Battery Code (1330520)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
LEMING	OIL	0.85-1.15%	1.23	1.15	1.10	1.00	1.01	0.98	0.96	0.97	0.98	1.03	1.12	1.06	1.05
	WATER	0.85-1.15%	1.24	1.27	1.17	1.22	1.19	1.13	1.07	1.01	1.14	1.27	1.25	1.15	1.18
	GAS		0.96	0.81	0.78	0.74	0.90	0.86	0.84	0.87	0.81	0.80	0.78	0.91	0.84
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
Leming Steam Inj IF:0007678	STEAM		1.08	0.92	0.91	0.85	0.93	1.09	1.03	1.00	1.04	1.03	1.06	1.09	1.00
Battery Code (0111783)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
MAHKESES	OIL	0.85-1.15%	0.80	0.81	0.88	0.90	0.92	0.90	0.83	0.80	0.82	0.84	0.81	0.84	0.85
	WATER	0.85-1.15%	1.13	1.24	1.28	1.25	1.31	1.26	1.15	1.25	1.09	1.08	1.04	1.12	1.18
	GAS		0.79	0.83	0.89	0.96	1.01	1.03	0.94	0.94	0.97	0.91	0.86	0.86	0.91
Mahkeses Steam Inj			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
IF:0111784	STEAM		0.91	0.98	0.96	0.99	0.97	0.95	0.95	1.00	0.99	0.96	0.99	1.00	0.97
Battery Code (0051211)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
MASKWA	OIL	0.85-1.15%	1.02	0.99	0.95	0.91	0.97	0.93	0.90	0.98	0.98	1.04	1.02	1.02	0.98
	WATER	0.85-1.15%	1.10	1.15	1.11	1.08	1.10	1.17	1.12	1.13	1.13	1.17	1.09	1.18	1.13
	GAS		0.69	0.70	0.62	0.60	0.63	0.60	0.60	0.67	0.69	0.73	0.72	0.73	0.67
Maskwa Steam Inj			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
IF:0000797	STEAM		0.85	0.89	0.89	0.97	1.02	1.04	1.02	0.96	0.94	0.92	0.96	0.95	0.95
Battery Code (00051212)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
MAHIHKAN	OIL	0.85-1.15%	0.879	0.89	0.92	0.95	0.95	0.96	0.92	0.90	0.93	0.90	0.85	0.87	0.91
	WATER	0.85-1.15%	1.05	1.00	1.01	0.98	0.98	0.99	0.97	0.93	0.96	0.93	0.94	0.99	0.98
	GAS		0.69	0.68	0.69	0.70	0.72	0.75	0.69	0.70	0.71	0.66	0.60	0.67	0.69
Mahihkan Steam Inj			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
IF:0008798	STEAM		1.03	1.04	1.01	1.02	1.06	1.05	1.02	0.99	0.97	0.96	0.97	0.97	1.01
Battery Code (0119087)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
NABIYE	OIL	0.85-1.15%	0.77	0.85	1.00	1.07	0.98	0.93	0.88	0.95	1.02	0.99	0.92	1.02	0.95
	WATER	0.85-1.15%	0.96	0.98	0.99	0.84	0.80	0.99	0.90	0.94	1.00	1.17	1.08	1.04	0.97
	GAS		1.40	1.54	1.85	1.39	1.08	1.03	1.07	1.18	1.34	1.53	1.58	1.66	1.39
Nabiye Steam Inj			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
IF:0119086	STEAM					1.01	1.00	1.00	1.03	1.02	1.01	1.08	1.05	1.10	1.03
Battery Code (0100902)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
SA-SAGD REPORTED	OIL	0.85-1.15%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WATER	0.85-1.15%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GAS		1.00	1.00	1.00	1.00	1.00	0.99	1.01	1.00	1.00	1.00	1.00	1.00	1.00
SA-SAGD Steam Inj			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
IF:0100903	STEAM		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.92
SaltWater Disposal Steam Inj			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AVG
IF:00008036	STEAM		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

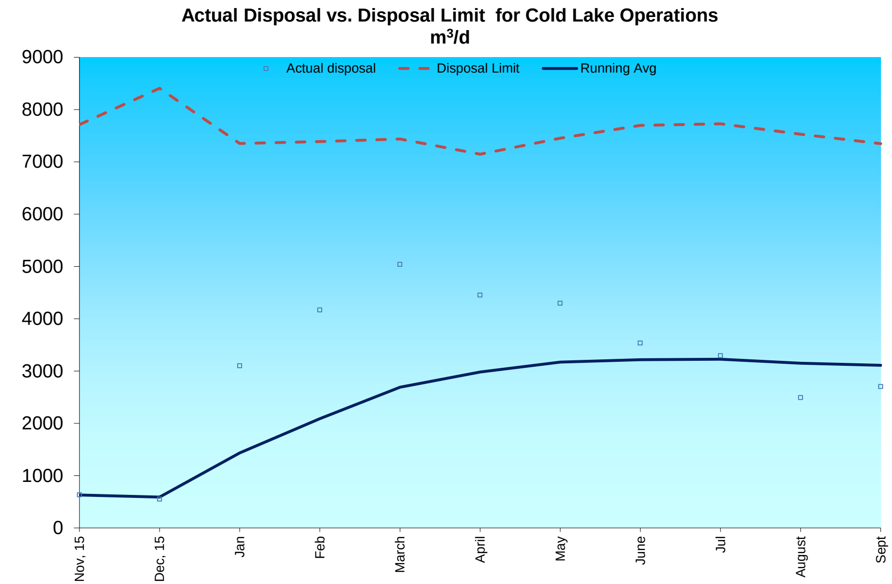
Facility proration factors reviewed daily at production review meetings with Field, Plant, Well Servicing, Maintenance, Management Representatives. Monthly proration factors documented, reviewed & approved with action plans assigned & stewarded for deviations (Gas & Steam Injection proration factors are used for monitoring & stewardship vs compliance)

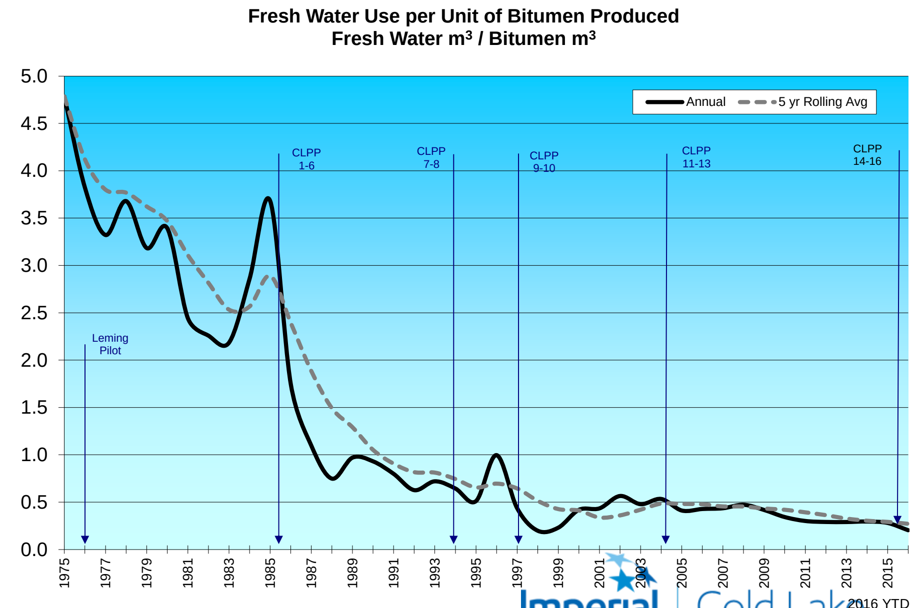
Water Sources and Use

Cold Lake Water Use









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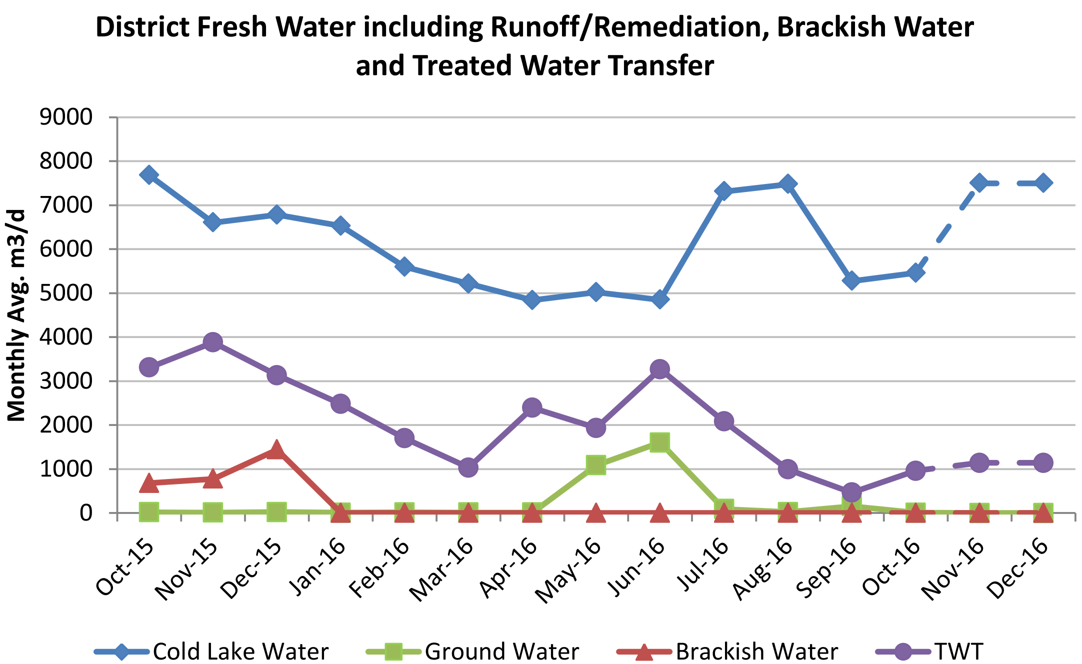
Cold Lake Water Use (cont'd)

Fresh Water Use & Actual Disposal vs. Disposal Limit

- 2015-2016 ground water used only for Cold Lake source water system maintenance
- Decreased FW usage mainly due to Leming steam injection strategy
- Transitioned to disposal limit formula November 2015
  - 2016 YTD Actual Disposal volumes 3507 m3/day vs. disposal limit of 7420 m3/day



	Disposal Limit, m3/d	Actual Disposal , m3/d
January	7351	3099
February	7388	4167
March	7435	5038
April	7148	4451
May	7453	4296
June	7697	3534
July	7727	3292
August	7528	2490
September	7348	2701
October	7123	2045
November*	8956	4352
December*	8881	2803
YE*	7670	3516

***** = forecast

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Freshwater Reduction

- Freshwater reduction continues to be key focus area
- 2016 YTD non-saline water consumption ~5200 m3/d (~32% reduction from 2011), continuing strong performance since 2011
- Technical assessments of alternatives ongoing in freshwater utility boilers, inlet cooling, and improved treated water transfer

Water Disposal and Waste Management

Produced Water Disposal to Cambrian – Approval 4510

Monthly Injection Volumes and Average Wellhead Injection Pressures

		2015						2016																	
WELL IDENTIFIER	Disposal Zone	OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
		(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)	(MPA)	(m^3)
00 01 19 064 03 4 00 (SWDFT701)	Cambrian	0.0	13878.3	0.0	2,796	0.0	853	0.0	31,974	11.8	45,692	12.1	53,169	12.0	47,363	11.9	47,642	12.2	49,307	12.0	48,884	12.1	34,350	12.0	40,908
00 01 32 064 03 4 00 (SWDFT702)	Cambrian	13.4	21405.4	13.4	15,834	13.4	15,107	13.4	62,289	12.3	52,880	12.6	60,697	12.5	51,105	12.3	49,343	12.5	54,114	12.1	51,473	12.1	41,134	12.1	37,664
02 02 03 064 03 4 00 (SWDFT703)	Cambrian	12.2	2.4	12.2	3	12.2	143	12.2	4	12.1	20,575	12.6	41,577	12.4	33,402	12.2	32,944	11.5	703	0.0	0	0.0	0	0.0	0
00 03 04 065 03 4 00 Abandoned	Cambrian																								
00 04 17 065 03 4 00 Abandoned	Cambrian																								
00 08 33 064 03 4 00 Abandoned	Cambrian																								
00 11 07 065 03 4 00 Abandoned	Cambrian																								
00 12 08 065 03 4 00 Abandoned	Cambrian																								
00 07 18 064 03 4 00 (SWDFT705)	Cambrian	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
00 11 22 064 03 4 00 Abandoned	Cambrian																								
TOTAL DISPOSAL (m^3)			**35286**		**18,633**		**16,102**		**94,266**		**119,148**		**155,443**		**131,869**		**129,929**		**104,124**		**100,357**		**75,484**		**78,571**
DAILY AVERAGE(m^3)			**1138**		**621**		**519**		**3,041**		**4,255**		**5,014**		**4,396**		**4,191**		**3,471**		**3,237**		**2,435**		**2,619**

- Water disposal required due to high field produced water levels (high water to steam ratios)
- Efforts to improve water recycle include reduced fresh water usage, improved steam generation and water reuse service factors, and improved water inter-plant transfer capability

Cold Lake Waste Management

<u>On Site Disposal</u>

Class II Non-DOW Landfill Disposal

Lime Sludge – 11,176 m^3

All other Class II Landfilled Waste – 25,480 m^3

Oily Waste Byproduct Storage Facility (Maskwa Ecopit)

Oily Waste Deposited in OWBSF – 11,627 m^3

Recycled Waste Streams

Recycle (Plastic, office paper, news print etc) – 92 tonnes

Cardboard – 615 tonnes

Steel – 1,118 tonnes

Wood (burned onsite) – 655 tonnes

Landfill Leachate Collection and Recycle at Mahkeses Plant – 23,854 m^3

<u>Off Site Disposal</u>

Solid Waste (Rags, soils etc) – 3,819 m^3

Liquid Waste (Glycol, etc) – 2,706 m^3

Environmental Summary

Approval Renewals and Amendments

AER Approvals

- Waste Management 039 license amendment (WM039 K)

Approvals under the Environmental Protection and Enhancement Act (EPEA)

- No change

Approvals under the Water Act

- Renewal Application for Cold Lake Water Act license renewal for surface water diversion submitted in June 2016 (Approval No. 79923-01-00), extended to Jan 31, 2017
- Renewal Application for Water Act license renewal for back-up groundwater wells submitted in June 2016 (Approval No. 148301-01-00), extended to Jan 31, 2017

Monitoring Programs – Wildlife

Cold Lake Operations continues to enhance and restore wildlife habitat.

- In 2010, Imperial Cold Lake Operations received the Wildlife at Work Certification from the Wildlife Habitat Council for the successful implementation of a comprehensive wildlife habitat management program. Imperial achieved recertification in 2015.
  - The Wildlife Habitat Council (WHC) created in 1988, is a nonprofit group of corporations, conservation organizations and individuals dedicated to enhancing and restoring wildlife habitat. WHC helps large landowners, like Imperial, manage their unused lands in an ecologically sensitive manner for the benefit of wildlife.

- Continue implementation of AEP-approved *Wildlife Monitoring and Mitigation Plan* and *Caribou Mitigation and Monitoring Plan*, which list wildlife habitat preservation measures.

- Annual issuance of AEP *Research and Collection License*.

Monitoring Programs – Groundwater

Cold Lake Operations maintains an extensive groundwater monitoring program.

- Monitoring > 400 deep groundwater wells (including 17 domestic) and > 220 shallow wells
- Monitoring includes chemistry & water levels
- Drilling activity in 2015/2016
  - > Deep:
    - N08 GEW 15-2
    - REG 15-1 Nest
    - H11 15-1 well for VIT trial
    - V10 16-1 and 16-2 GEW Nests for Arsenic Monitoring
  - > Shallow:
    - Landfill Wells LNLF 38-8 and LNLF 37-6
    - EcoPit MWPO-22R-5
    - Mahkeses MKPO-10-8
- Abandonment activity in 2015/2016: LNLF-8-X and MWPO-22-5.

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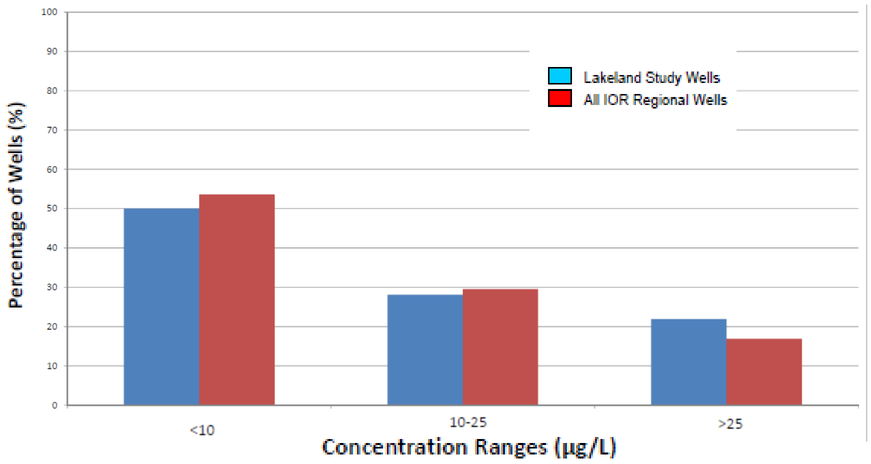
Monitoring Programs – Thermal Mobilization

Based on groundwater monitoring to date, there is no evidence that mobilized arsenic has impacted domestic or livestock groundwater wells. Cold Lake Operations continues its extensive groundwater monitoring program.

Technical Update

- In 2006, Health Canada lowered the maximum acceptable concentration for arsenic in drinking water from 25 µg/L to 10 µg/L.
- Using this standard, 50% of domestic wells in the Lakeland area have naturally high arsenic concentrations above guidelines. (Alberta Health and Wellness Data: Arsenic in Groundwater from Domestic Wells in Three Areas of Northern Alberta, Oct 2000).
- In 2015, Imperial conducted a review of arsenic in its regional groundwater wells and reconfirmed that arsenic concentrations are similar to the AHW (2000) study and do not display increasing trends over time.
- Imperial monitors thermally mobilized arsenic at D55, D57, L08 and V10.
- Field observations confirm that heat convection cells play a significant role in the release and transport of arsenic when the GW velocity is low.
- Laboratory experiments indicate that arsenic released by conductive heating is re-adsorbed when the GW is exposed to unheated sediments.



A comparison of arsenic concentrations in wells tested by Alberta Health and Wellness (Lakeland Study Wells - 2000) and wells in Imperial's Regional Groundwater Monitoring Network (IOR Regional Wells - 2015)

- Field study results indicate that peak arsenic concentrations and arsenic mass at D55 and D57 pads have declined as the arsenic plumes migrate down gradient. The average velocity of the dissolved arsenic is retarded relative to GW flow velocity. These observations indicate that arsenic attenuates as it moves down gradient.
- Additional downgradient monitoring wells are positioned to measure the rate and extent of attenuation. These are key objectives of ongoing work.
- In 2015 and 2016, Imperial shared technical updates with the AER and has an AEPEA requirement to complete a technical update report in 2020.

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Monitoring Programs – Surface Water

Cold Lake Operations maintains an extensive surface water monitoring program.

Comprised of the following components:

- Surface Water Quality Sampling (Regional, Infield, Wetlands)
- Annual Drainage Assessment
- Level Monitoring (Lake, creeks, wetland piezometers)
- Long-term Wetland Monitoring Plots

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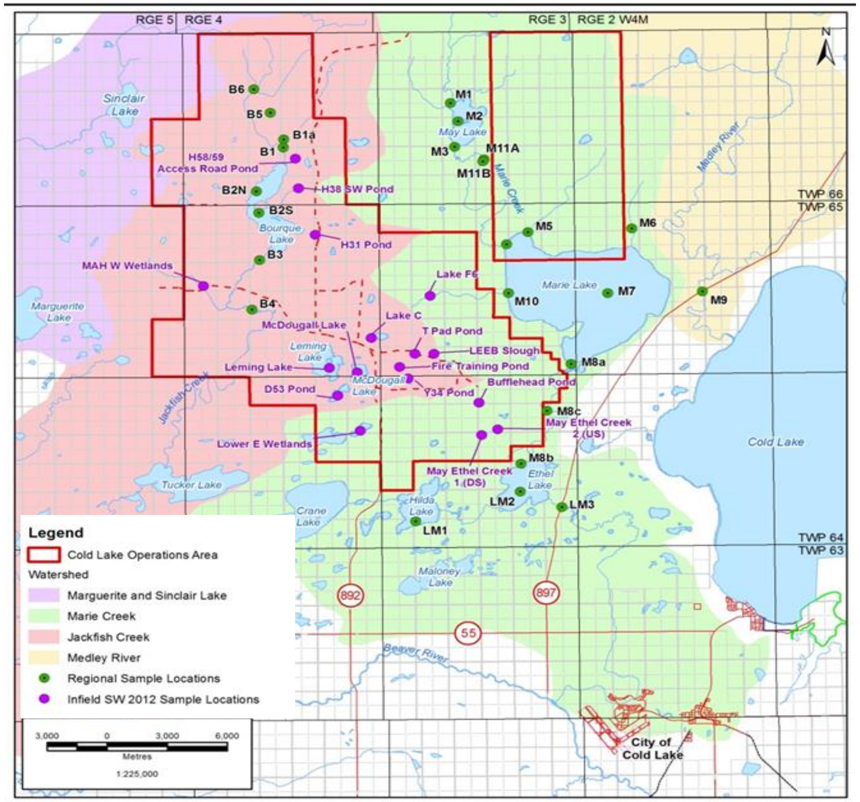
Monitoring Programs – Surface Water



Data and observations support the absence of effects directly or indirectly associated with Cold Lake operations.

Sampling

- Spring and fall sampling of water bodies (routine water quality parameters (pH, alkalinity, hardness, etc), major cations and anions, forms of nitrogen, phosphorous, hydrocarbons, and trace elements)
- Flow measurements at selected creek sites
- Depth composite samples from canoe for both regional and infield lakes where depths are greater than 2 meters

Regional

- Regional program included spring and fall sampling at 25 sites.
- Data from this program is shared with Beaver River Watershed Association (BRWA), Alberta Lake Management Society (ALMS), Marie Lake Air and Watershed Society (MLAWS), as well as some landowners.
- Includes sites within the Jackfish Creek, Marie Creek, & Medley River Watersheds.

Infield

- 18 Sites sampled bi-annually for field and routine parameters, total and dissolved metals, nutrients, and hydrocarbons
- Generally, water parameters did not exceed the water quality guidelines

Monitoring Programs – Surface Water Drainage

Drainage and culvert assessments serve a few objectives, including monitoring health of potentially fish-bearing habitats.

- Completed on an annual basis since 2002
- Drainage Assessment: Includes qualitative examination of drainage impediments, vegetation stress, rutting, erosion and/or sedimentation
- Culvert assessment: Assesses fish passage, culvert integrity and erosion

Monitoring Programs – Surface Water
Wetland Level Monitoring

Shallow groundwater levels at most wetlands have been relatively stable over time with less than 1 m of variation.

Program Status:

- In 2015/2016, piezometers were monitored for levels using transducers.
- 9 Pairs of staff gauges were installed along the Nabiye road in 2014.

Monitoring Programs – Surface Water Long-term Wetland Monitoring Plots

Vegetative stress was not identified the field assessments.

- Established in August 2006, as per EPEA 73534-00-04 Section 4.9.2a
- Purpose: Monitor long-term effects of groundwater withdrawals on wetland health, extent and distribution
  - Establishment of 11 plots
  - Baseline data collection
- Next Monitoring Date:
  - 2020
- 2015 Results
  - Vegetative stress was not identified in any plots in the field level assessment. Analysis of plot data is currently being undertaken.

Monitoring Programs – Vegetation

No impact to species richness have been observed.

Overview:

- In 2006 a long-term vegetation monitoring program was established, per the commitments made in Section 9, Subject 10 of the IOR Nabiye and Mahihkan North EIA
- The monitoring program was revised and improved in 2009
- The extent of the program is expected to increase as monitoring plots are identified and established in the Nabiye Operating Area

Monitoring Results:

- Monitoring consisted of both edge effects and rare plants monitoring in 2015
- Consultant (AMEC) Conclusion:
  - Edge effects at the transects have been variable.
  - Overall, no significant difference between baseline and species richness values during the Rare Plant survey.

Pitcher Plant (Sarracenia purpurea)

Next Monitoring Date:

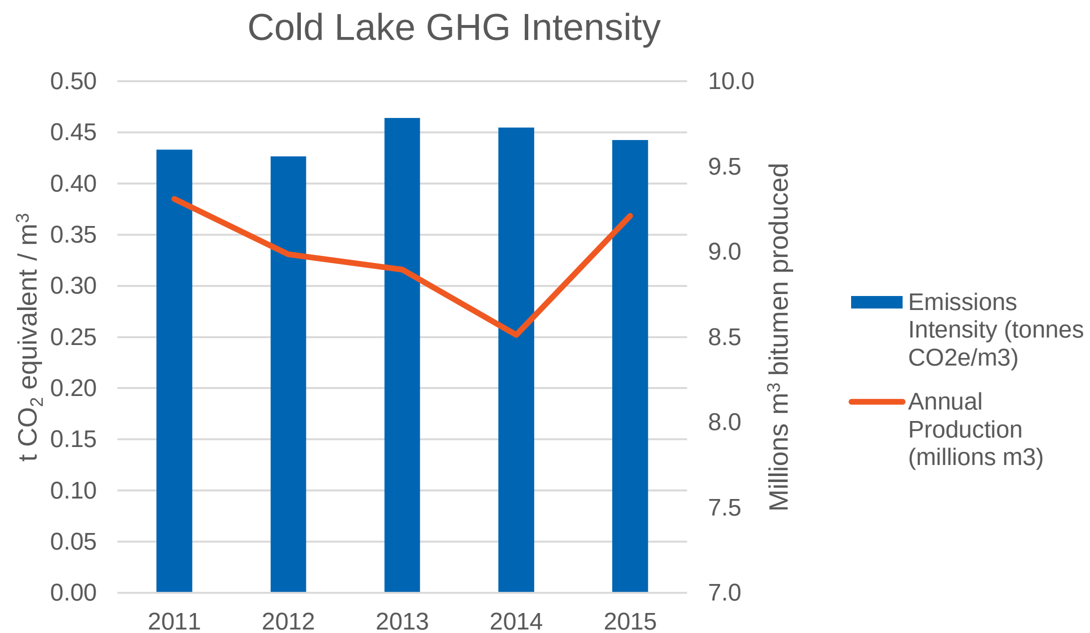
- 2018

Monitoring Programs – Air GHG Emissions

Cold Lake's greenhouse gas (GHG) emission intensity has been stable. Next-generation technologies are being tested to reduce greenhouse gas emissions.

Examples include:

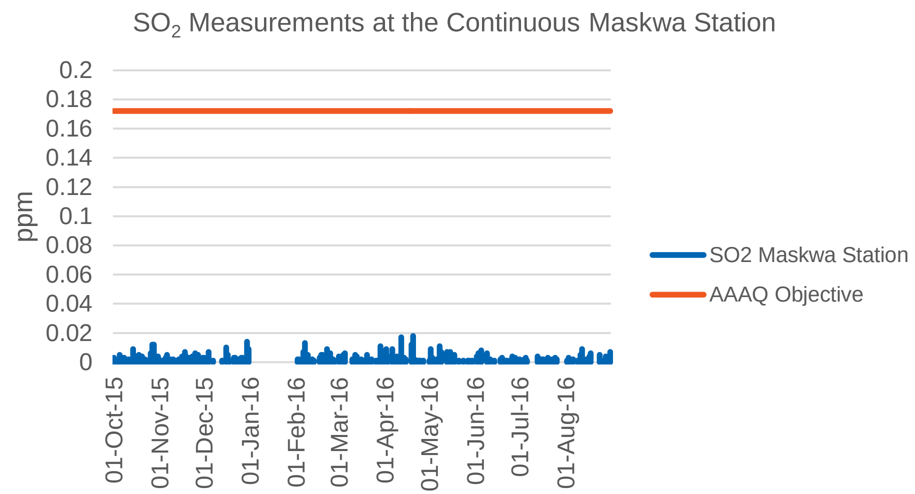
- **Liquid Addition to Steam for Enhancing Recovery** (LASER) is a solvent-assisted process that increases bitumen recovery rates for the same steam injection.
- **Cyclic Solvent Process** (CSP) is a non-thermal process that injects solvent instead of steam to recover bitumen. In 2014, a $100-million pilot facility was initiated. Direct GHG emissions would be reduced by more than 90 %.
- **Solvent-Assisted Steam-Assisted Gravity Drainage** - (SA-SAGD) is a recovery process enhanced by the addition of solvent injection with the steam. Cold Lake has operated a $50M field pilot since 2010. A 25 % reduction in GHG intensity compared to SAGD is expected.



As reported to Alberta Environment under the Specified Gas Emitters Regulation

Monitoring Programs – Air

Air quality has been meeting provincial objectives. Data is shared with communities.

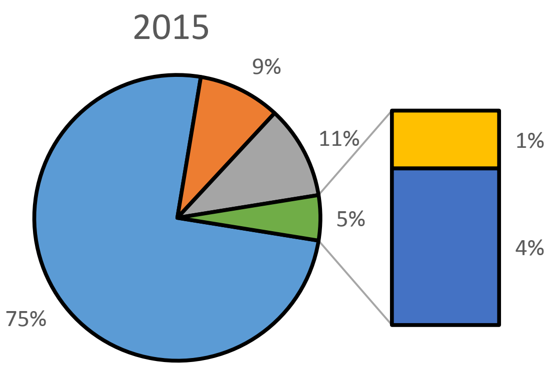


- The Maskwa station is maintained and operated by LICA (Lakeland Industry and Community Association).
  - Alberta Ambient Air Quality Objectives (AAAQO) includes target concentrations for certain compounds. Hourly averages measurements are below the AAQO targets.
  - Maskwa station performs continuous monitoring of SO_2, H_2S, NO_x, Particulate Matters, Total Hydrocarbons, Total Reduced Sulphur, Meteorology
  - Passive monitoring is performed for SO_2, H_2S, NO_2, Ozone.
  - Example of air emissions measurements taken by the station are shown on the graph.
- Fugitives emissions detection program
  - Fugitives emissions are minor; represent less than 0.5% of Cold Lake Operations green house gas (GHG) emissions
  - Leak Detection and Repair (LDAR) program is implemented to detect unintentional hydrocarbon emissions (seals, valves, flanges, etc.).
  - Area sampled at a 3-year frequency: Mahkeses and Leming (plant and field) and Nabiye (field) sampled in fall 2015.

Monitoring – Reclamation

Reclamation is integral to Cold Lake Operations' activities.

Since 1999, Imperial's Cold Lake operation has planted over 1.7 million tree and shrub seedlings. In 2016, 75,240 trees and 24,230 shrubs seedlings were planted.



2015 – Cold Lake Operations Mineral Surface Lease = 14181.6 ha

- 75% Undisturbed / Disturbed by Others (Surface water, lands, forest and distrubed by others)
- 9% Disturbed for Operations (Areas cleared and disturbed by operations)
- 11% Temporary Reclaimed (Areas that are reclaimed and have the potential to be re-disturbed in the future)
- 1% Undergoing Remediation and Reclamation (Remediation, recontouring, soils placed, revegetation or wetland reclamation trial)
- 4% Reclaimed (Areas reforested, natural reclamation, created habitat and reclaimed weltands)

Year	Total Area Disturbed (ha)	% Undergoing Temporary Reclamation, Remediation and Reclamation	% Reclaimed	Total % Undergoing Reclamation Activity
2012	3,455	43%	14%	57%
2013	3,482	47%	14%	61%
2014	3482	47%	15%	62%
2015	3534	48%	15%	63%

Monitoring – Reclamation (cont'd)

Soil and Terrain

- Site stability - annual observations for the first 5 years
- Soil sampling first year following reclamation to demonstrate replacement of soils to an appropriate depth
  - > 2016 results - sites have adequate topsoil replaced

Revegetation

- Has been deferred until the approved Project –Level Conservation, Reclamation and Closure Plan (PLCRCP) implementation

Vegetation Stress Monitoring

- Conducted at 5 year intervals
- Vegetation Monitoring completed in 2016 – monitoring results pending

Environmental and Community Initiatives

CLO continues to support environmental initiatives through both financial contributions and participation in regional committees.

- Cold Lake Operations makes financial contributions to JOSM (Joint Oil Sands Monitoring) to support regional monitoring programs.

- Imperial continues to be involved with COSIA (Canada's Oil Sands Innovation Alliance).

- Imperial continues to be involved with LICA (Lakeland Industry and Community Association) as an industry member.
  - Industry Designate on LICA Board of Directors
  - Industry Alternate on LICA Airshed
  - Industry Alternate on the LICA Education & Information Committee
  - Industry Alternate on Beaver River Watershed Alliance (BRWA)

- Imperial holds the annual "Neighbor Night" that allows the community to learn and enquire about Cold Lake Operations.

- Imperial engages with Marie Lake Air and Watershed Society (MLAWS) and domestic well owners.

Sulphur

Sulphur Removal

Mahihkan Site – Plant Sulphur Removal

- Sustained reliability achieved over reporting period:
  - Achieved greater than 69.7% recovery in all quarters of 4Q15, 1/2/3Q16 and was continuously below emissions limit
- Achieved 100% uptime in 4Q15, 1/2/3Q16

Mahkeses Site – Plant Sulphur Removal

- Sustained reliability achieved over reporting period:
  - Achieved greater than 69.7% recovery in all quarters of 4Q15, 1/2/3Q16 and was continuously below emissions limit
- Achieved 100% uptime in 4Q15, 1/2/3Q16

Leming Site – No Plant Sulphur Removal

- Leming SO_2 emissions were below limits in all quarters of 4Q15, 1/2/3/Q16 and was continuously below daily emissions limit

Maskwa Site – No Plant Sulphur Removal

- Maskwa SO_2 emissions were below limits in all quarters of 4Q15, 1/2/3/Q16 and was continuously below daily emissions limit

Nabiye Site – Plant Sulphur Removal

- Nabiye SO_2 emissions were below limits in all quarters of 4Q15, 1/2/3/Q16 and was continuously below daily emissions limit
- In 4Q15 and 1Q16 Nabiye sulphur production was below all limits without having an SRU in operation
- In June 2016 (2Q16) the SRU was started up to due to increased sulphur production and Nabiye achieved greater than 70.0% recovery in 2/3Q16 (post SRU start up)

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Sulphur Removal, SO_2 Emissions

- Compliant with D56, EPEA, and ID2001-3 over the review period

Calendar Quarter Average Sulphur Emissions By Plant (tonnes/day)

Calendar Quarter	Leming Plant		Maskwa Plants		Mahihkan Plants			Mahkeses Plant			Nabiye Plant			District	
	Sulphur	SO_2	Sulphur	SO_2	Sulphur	SO_2	Removal	Sulphur	SO_2	Removal	Sulphur	SO_2	Removal	Sulphur	SO_2
Q4 2015	0.33	0.66	0.99	1.98	0.37	0.75	74.77%	0.41	0.83	70.51%	0.31	0.62	-	2.42	4.83
Q1 2016	0.19	0.37	0.99	1.99	0.47	0.95	71.90%	0.53	1.06	71.90%	0.45	0.91	-	2.64	5.27
Q2 2016	0.27	0.54	0.88	1.77	0.43	0.87	70.64%	0.50	1.01	70.11%	0.52	1.04	95.02%	2.61	5.22
Q3 2016	0.24	0.49	0.96	1.91	0.36	0.73	70.33%	0.39	0.78	70.78%	0.18	0.36	70.16%	2.14	4.27
Limit	≤1.0 t/d Sulphur		≤1.0 t/d Sulphur		≤1.80 t/d SO_2		≥69.70%	≤1.08 t/d SO_2		≥69.70%	≤1.08 t/d SO_2		≥69.70%	-	

Calendar Quarter Peak Day Sulphur Emissions By Plant (tonnes/day)

Calendar Quarter	Leming Plant		Maskwa Plants		Mahihkan Plants		Mahkeses Plant		Nabiye Plant		District	
	Sulphur	SO_2	Sulphur	SO_2	Sulphur	SO_2	Sulphur	SO_2	Sulphur	SO_2	Sulphur	SO_2
Q4 2015	0.54	1.08	1.15	2.30	0.95	1.90	0.53	1.06	0.83	1.66	3.46	6.91
Q1 2016	0.26	0.51	1.25	2.49	1.04	2.08	0.53	1.07	0.80	1.61	3.21	6.43
Q2 2016	0.47	0.94	1.11	2.21	0.77	1.54	0.53	1.07	0.98	1.96	3.51	7.02
Q3 2016	0.46	0.92	1.30	2.61	0.63	1.25	1.25	2.49	0.34	0.68	3.28	6.56
Limit	≤1.05 t/d Sulphur		≤2.0 t/d Sulphur		≤3.0 t/d Sulphur		≤2.0 t/d Sulphur		≤0.99 t/d Sulphur		≤13.15 t/d SO_2	

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Compliance

AER Compliance

Cold Lake Operations activities pursued without adverse impact on the environment.

Incident Investigations

- Facilities failure investigations: none
- Pipeline failure investigations:
  - **AER Incident 20162708** (September 15th, 2016) – Open
    0.01 m^3 bitumen released from loosened flange located on Mineral Surface Lease (MSL). Response under review.
  - **AER Incident 20161467** (June 1st, 2016) - Open
    0.18 m^3 produced water released within MSL. Integrity documentation provided. Response under review by AER.

Inspections and Compliance

- 12 satisfactory inspections
- 2 satisfactory audits
- 1 voluntary self-disclosure
- 11 non-compliance
  - 5 relate to records retention
- Violation AEP Weeds Act
- Contravention EPEA Approval
  - Uncontrolled release from Leming run-off pond due to heavy rainfalls. No off-lease impacts.
- Contravention Waste Facility Management 039
  - Leachate levels not maintained below maximum level. No environmental adverse impacts.

Future Plans

Future Plans

- Continue to pursue freshwater reduction opportunities

- Mahihkan North LASER Project
  - Liquid Addition to Steam for Enhanced Recovery (LASER) – inject diluent with the steam
  - Construction is underway; first LASER injection cycle planned for Q2 2017
  - Currently upgrading production measurement systems on Mahihkan North pads

- Continue industry sharing and participation

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AER Approvals 8558 and 4510

- Imperial is in compliance with all conditions of Approval 8558
- Imperial is in compliance with all conditions of Amendment F to Approval 4510 (details are enclosed in Attachment 2)

Attachments

Attachment 1

Approval 8558HH

Compliance Conditions

AER Approval 8558

Clause	Requirement Summary -	Responsibility	2016 Status/Comments
2	The Operator shall notify the AER of any proposed alteration or modification of the scheme or to any equipment proposed for use therein, prior to effecting the alteration or modification.	Matt Dawe (CLRE), Hsao-Hsien Chio (CLOT)	8558GG – T13 SAGD & SA-SAGD approval 8558HH – temporary sulphur recovery variance approval
3	Where, in the opinion of the AER, any alteration or modification of any equipment proposed for use therein a) is not of a minor nature, b) is not compatible with the scheme approved herein, or c) may not result in an improved or more efficient scheme or operation, the alteration or modification shall not be proceeded with or effected without the further authorization of the AER.	Matt Dawe (CLRE), Hsao-Hsien Chio (CLOT)	See above
4	Unless otherwise stipulated by the AER, the production from the project area outlined in Appendix A shall not exceed 40 000 cubic metres per day (m3/d) on annual average basis.	Darlene Gates/ G. Armbruster (CLO)	No plan to exceed 40,000 m3
5	The Operator shall conduct all operations to the satisfaction of the AER and in a manner that, under normal operating conditions, will permit a) the recovery of the practical maximum amount of crude bitumen, b) the conservation of the practical maximum volume of produced gas at the well pads and central facilities, c) the practical minimum use of off-site gas for project fuel, d) the practical minimum use of fresh make-up water subject to the Water Act and the practical minimum disposal of water, e) the practical maximum reuse of produced water, with the minimum recycle rate being 95 per cent on an annual basis, unless otherwise stipulated by the AER, and f) the efficient transportation of crude bitumen to market.	Darlene Gates/G. Armbruster (CLO)	In compliance with all requirements. PW recycle rate has been replaced with annual disposal limits. Disposal limits are within the requirements of D81. 2016 YTD actual disposal (3674m3/d) is well below the allowable limit (7452m3/d)
6.1	The Operator shall measure and record, to the satisfaction of the AER, the volumes and other pertinent characteristics of all fluids injected and produced and other streams as may be required by the AER.	Matt Fuller/Dawn Herle(CLO)	There were zero compliance issues with volume reporting for CLO in Q4 2015 & 2016 YTD Began reporting AB GE in May 2016 Currently updating schematics and allocations for MARP
6.2	The measurements referred to in paragraph (1) shall be made with sufficient frequency and accuracy as to allow calculation, to the satisfaction of the AER, of mass balances, energy balances and recovery efficiencies for the production processes.	Gord Armbruster (CLO)	Mahkeses and Leming water balance issues have been resolved. Mahkeses oil profac out of tolerance since April 2016. Installed Coriolis meters in test loops on 9 CLIP pads to improve testing. Working through commissioning issues. No other issues for 2016.

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Clause	Requirement Summary -	Responsibility	2016 Status/Comments
7.1	The Operator shall log all wells from total depth to surface by means of a spontaneous potential - resistivity or gamma ray-resistivity log and such other logs as may be required to ensure sufficient depth and directional control.	Mark Wood (CLOTG)	One or more wells per pad and all OV wells were logged by LWD, wireline or pipe conveyed methods. Exceptions received for some Passive Seismic wells and the horizontal sections of Injection-Only-Infill wells. AER logging waivers obtained for any wells unable to achieve TD due to mechanical issues.
7.2	The Operator, unless otherwise authorized by the AER, shall take full diameter cores of the entire bitumen bearing section of the Clearwater Formation from not less than four vertical evenly-spaced wells per section, and take fill diameter cores of the remaining bitumen bearing sections of the Mannville Group from at least one vertical well per section, and at the AER's request a) analyze portions of such cores, and b) provide suitable photographs of the clean-cut surface of each core slabbed.	Mark Wood (CLOTG)	All OV wells cored through the Clearwater Formation. On average four wells per section drilled prior to development. On average, one well per section cored in Grand Rapids in hydrocarbon zones >8m not encumbered by gas. Core and analysis from cored wells in the 2015 / 16 winter program submitted to AER May - August
7.3	Each of the wells referred to in paragraph 2 and one other well per pad shall be logged over the entire Mannville Group by means of a gamma ray-neutron density log.	Mark Wood (CLOTG)	All OV wells and one well per pad were logged using wireline or pipe conveyed Gamma Ray - Neutron-Density tools. Wireline data from 2015 / 16 winter program submitted to AER February
8	The Operator shall conduct all drilling operations using a water-based mud and not introduce any toxic or potentially toxic additives to any muds or fluids used directly in the drilling of wells associated with the scheme.	Keith Dares (D&C)	Only non-toxic water-based mud systems were used in all drilling activities conducted in 2016
9.1	Prior to the commencement of steam injection operations at all newly-drilled wells, the Operator shall comply with the hydraulic logging requirements of the AER *Directive 051: Injection and Disposal Wells – Well Classifications, Completions, Logging, and Testing Requirements.*	Kelly Wiebe (CLSSE)	Directive 051 approvals received for all newly-drilled wells prior to commencement of steam.
9.2	The Operator shall submit an annual summary report on casing integrity and remedial efforts to the AER by March 31 the following year.	Kelly Wiebe (CLSSE)	Annual casing integrity report submitted March 31, 2016, followed by review on May 18, 2016. No follow-ups.

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Clause	Requirement Summary -	Responsibility	2016 Status/Comments
10	The Operator shall take such steps and effect such measures as may be necessary in the completing and operation of wells to prevent production-casing failures.	Darlene Gates/G. Armbruster (CLO)	Well construction and casing failure prevention/ detection practices discussed with AER through quarterly drilling/ cementing reviews and annual casing integrity submission.
11.1	The Operator shall conduct additional sampling, testing, and studies to help assess formation integrity and to provide baseline geological and geotechnical information and further knowledge on properties that can influence groundwater flow, water quality, and corrosion of casing and degradation of cement.	Mark Ruschkowski (CLO)	Ongoing data collection and analysis in multiple areas: groundwater, passive seismic, gas composition, purge compliance, casing shroud installations, bentonite top ups.
11.2	The Operator shall design and implement monitoring programs to specifically address the potential that its operations may have on liberating or introducing arsenic into the groundwater.	Kal Virk (SHE)	Current monitoring is focused on measuring the rate and extent of natural attenuation of arsenic in long term field tests. Field tests have demonstrated that both peak concentrations and mass are declining as the plume migrates downgradient. A technical update was submitted in March 2015. Imperial conducts reviews of arsenic every 2 years to confirm that arsenic concentrations are not increasing over time. This was confirmed in 2015 based on 2014 data. The next analysis will be conducted in 2017 for 2016 data.
12	The Operator shall install surface casing, in a manner satisfactory to the AER, through the glacial drift on all disposal wells.	Keith Dares (D&C)	With the exception of wells that have had an AER approved surface casing depth reduction waiver, surface casing has been installed on all wells consistent with AER Directive 008: Surface Casing Depth Requirements.
13	The Operator, unless given the express written consent of the AER to do otherwise, shall maintain between the location of steamed wells and wells being drilled, a separation adequate to ensure that zones pressured by injected steam are not encountered by wells being drilled.	Nathan Toone (CLRS)	In full compliance. Drilling program coordinated with steaming schedule to ensure adequate separation.
14	The Operator shall conduct pressure surveys prior to the commencement of steaming and thereafter in any Grand Rapids gas wells that it operates within the expansion area.	Matt Dawe (CLRE)	IOR submitted the annual pressure survey to the AER on July 27, 2016
15	The Operator, subject to such terms and conditions as may be described by the AER upon considering an application therefore, shall undertake extensive field investigations of an alternate or follow-up recovery method that the Operator believes may have potential application in the Clearwater Formation.	Cheryl Trudell (OSDR)	Multiple field investigations underway: infills, LASER, steamflood, HIPs, SAGD, SA-SAGD, and CSP.

AER Approval 8558

Clause	Requirement Summary -	Responsibility	2016 Status/Comments
16	The Operator shall conduct recovery tests, satisfactory to the AER, in the McMurray and Grand Rapids Formations in the project area to determine the practicality of recovering bitumen from these formations and provide the results of such tests to the AER.	Matt Dawe (CLRE)	Submitted Cold Lake Expansion project application in Mar 2016 for bitumen recovery from the Grand Rapids formation using the SA-SAGD process.
17.1	Unless otherwise permitted by the AER, cyclic steam stimulation (CSS) operations, having commenced at a well pad, shall continue until the well pad has produced a minimum of 20 per cent of the in-place volume of crude bitumen assigned to that well pad by the AER.	Matt Dawe (CLRE)	Nothing new to report
17.2	Where the Operator proposes to cease CSS operations at a well pad that has produced less than 20 per cent of the in-place volume of crude bitumen, and the AER's consent therefore is sought, the Operator shall advise the AER as to the following: a) the reason for proposing to cease CSS operations, b) details of individual well workovers and recompletions attempted, c) details of any infill drilling attempted, d) the effect of ceasing CSS operations on the bitumen recovery ultimately achievable from that part of the reservoir associated with the pad and immediately offsetting pads, e) detailed economics of continuing operations, and f) future plans for the well pad with reference to possible follow-up recovery techniques that could be applied and other zones that could be exploited.	Matt Dawe (CLRE)	Nothing new to report
18	The Operator is permitted to implement late life performance optimization using continuous steam injection (steam flooding) in wells at pads A02, A03, A04, A05, A06, B04, D04, D06, D07, D21, D23, D24, D25, D51, D53, D62, D63, D64, D65, D67, E08, E09, E10, F02, F03, F07, G01, G02, G03, H01, H02, H31, H34, H35, H36, J01, J07, J10, J16, M03, M04, M05, M06, M07, 0FF, P01, P02, P03, R01, R02, R03, R04, R05, R06, and R07. Steam injection will be targeted at low rates (150 m3/day/well to 750 m3/day/well) and pressures (700 kPa to 2000 kPa); the Operator is permitted to steam these wells at rates above or below the targeted ranges in order to accommodate steam schedule flexibility as required, but will not exceed peak reservoir pressures of 6 MPa.	Nathan Toone (CLRS)	The Operator is permitted to implement late life performance optimization using continuous steam injection (steam flooding) throughout the approved Cold Lake development area. Steam injection will be targeted at low rates (150 m3/day/well to 750 m3/day/well) and pressures (700 kPa to 3000 kPa); the Operator is permitted to steam these wells at rates above or below the targeted ranges in order to accommodate steam schedule flexibility as required, but will not exceed peak reservoir pressures of 6 MPa.

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Clause	Requirement Summary -	Responsibility	2016 Status/Comments
19.1	A well shall not be abandoned without prior written AER approval.	Kelly Wiebe (CLSSE)	Well specific non-routine approvals sought prior to abandonment.
19.2	Where the Operator proposes to abandon a well and the AER's consent therefore is sought, the Operator shall advise the AER as to the following: a) the reason for the proposed abandonment, b) the effect of abandoning the well on the bitumen recovery ultimately achievable from that part of the reservoir associated with the well, c) plans for recovering any portion of the remaining bitumen in place, and d) plans for recovering bitumen from other zones penetrated by the well.	Kelly Wiebe (CLSSE)	Pad abandonment approvals are sought prior to commencement of well abandonment on the pad, in accordance with the requirements.
20.1	The Operator shall implement an enhanced regional monitoring network at its existing operation and in the expansion area to monitor groundwater flow directions and groundwater chemistry.	Kal Virk (SSHE)	Over 125 regional wells and 17 domestic wells sampled in regional groundwater monitoring network. Monitoring is ongoing as required by Schedule VI of ESRD Approval No. 73534-01-01 and Water Diversion License 148301-01-00, as amended.
20.2	The Operator shall set up an enhanced groundwater-monitoring network within its existing operation and in the expansion area to provide information on any water level responses to steam injection.	Kal Virk (SSHE)	Except for poroelastic response, steam injection has not been observed to cause water level changes.
21	The Operator shall implement a monitoring program for the Grand Rapids Formation in the Nabiye area, as per Application No. 1703441. This will include, but is not limited to, passive seismic monitoring wells located on each pad, a dual completed Grand Rapids pressure monitoring well on Pad N01 and Pad N05, a hybrid passive seismic and Upper Grand Rapids monitoring well on Pad N07 near the fault.	Matt Dawe (CLRE)	Continuous monitoring of the Grand Rapids Formation has been incorporated into our base operational practices.

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Clause	Requirement Summary -	Responsibility	2016 Status/Comments
22	Describe the Operator participation in regional multistakeholders initiatives. Discuss recommendations that have been generated from these regional initiatives and how these recommendations have been incorporated into the project.	Darlene Gates/G. Armbruster (CLO)	Imperial continues to support and participate in regional monitoring programs and initiatives such as the Lakeland Industry and Community Association (LICA). Currently, Imperial holds the following roles as a participant in LICA: industry designate on the LICA Board of Directors, industry alternate on the LICA Airshed, industry alternate on the Education and Information committee and observer on the Beaver River Watershed Alliance BRWA). The BRWA assists and/ or supports regional water monitoring in the Beaver River watershed (surface water, groundwater, wetlands, and aquatic ecosystem health). Recommendations are incorporated into the regional monitoring programs and/ or carried out by LICA/BRWA. Imperial participates in the monitoring programs as dictated by JOSM. JOSM conducts biodiversity monitoring and data collected is provided to management agencies to help support decision-making with scientific knowledge about provincial biodiversity. Imperial continues to be involved with Canada's Oil Sands Innovation Alliance (COSIA). Cold Lake Operations periodically hosts ~~a~~ tours with an environmental focus for community or industry members.
23.1	The Operator shall ensure that sulphur recovery will be operational at the Leming, Maskwa, Mahihkan, Mahkeses, and Nabiye sites before total sulphur emissions from flaring and combustion of gas containing hydrogen sulphide (H2S) reach one tonne/day per site on a calendar quarter-year average basis, unless otherwise stipulated by the AER. The calendar quarter-year sulphur recovery shall not be less than set out in Table 1 of AER *Interim Directive (ID) 2001-03: Sulphur Recovery Guidelines for the Province of Alberta* on the basis of the calendar quarter-year daily average sulphur content of produced gas streams flared and used as fuel at each central processing facility.	Darlene Gates/G. Armbruster (CLO)	Sulfur recovery units are installed and operational at Nabiye, Mahihkan and Mahkeses Plants. Maskwa and Leming manage sulfur limits below the 1 T/day threshold.
23.2	The Operator is required to meet the minimum sulphur recovery requirements as set out in Table 1 of AER *Interim Directive (ID) 2001-03: Sulphur Recovery Guidelines for the Province of Alberta* based on the number of days in the quarter that the non-regenerative sulphur recovery unit is operational. The Operator must maintain a minimum of 95% uptime for the non-regenerative sulphur recovery units. This clause will expire on December 31, 2017[1] (1) Application No. 1863213	Darlene Gates/G. Armbruster (CLO)	All of the sulfur recovery guidelines were met during the period of Q4 2015 to Q3 2016.
24	The bottomhole location of a scheme well shall not be closer than 100 metres to the offset owner's oil sands lease boundary unless, upon application by the Operator, the drilling and operation of such a closer well is approved by the AER.	Matt Dawe (CLRE)	No scheme wells have been drilled within 100m of a lease boundary
25.1	Steam injection into the D29 pad wells must not commence until all E07 pad wells have been properly abandoned. Cement bond logs must be run over the entire intermediate casing interval in all E07 pad wells to confirm hydraulic isolation and determine the need for remediation. A non-routine well abandonment plan must be submitted for all E07 pad wells to the Well Operations Section of the AER's Technical Operations Group for review and approval in accordance with Section 2 of Directive 020: Well Abandonment. The non-routine well abandonment plan must include the interpreted cement bond logs and plans to ensure hydraulic isolation of all primary formation interfaces and across all non-saline aquifers.	Kelly Wiebe (CLSSE)	All E07 wells were initially abandoned to 15 meters above the depth of the oil-in-shale anomaly, allowing D29 to steam. The 'Flow Behind Pipe' assessment was completed, confirming hydraulic isolation behind casing on Cold Lake wells. Final review Sept 17/12. Final E07 non-routine abandonment application submitted Dec 3/13 and approved Jan 31/14 by AER to complete full subsurface abandonment of the E07 wells, excluding E07-14 which remains as an observation well. This abandonment work was completed in Dec/14. This item is complete.

AER Approval 8558

Clause	Requirement Summary -	Responsibility	2016 Status/Comments
25.2	Any E07 pad wells that are already zonally abandoned only require review below the cement top if the AER identifies issues of concern on those wells not yet zonally abandoned. The Operator must, for any wells zonally abandoned across the Clearwater Formation where plugs have not been placed at the correct depth, drill out the existing plug and abandon the well properly as per *Directive 020*.	Kelly Wiebe (CLSSE)	Wells already zonally abandoned were properly addressed in the applications noted in item 25.1, with abandonments executed as per the non-routine abandonment approval. This work is complete.
26	The Operator is permitted to abandon the Q and S Pads as described in Application No. 1684454. For the abandonment of wells on these pads a non-routine well abandonment plan must be submitted for each well to the Well Operations Section of the AER's Technical Operations Group for review and approval in accordance with Section 2 of *Directive 020: Well Abandonment*. The AER notes many wells on the Q and S Pads have been zonally abandoned; any wells which were previously zonally abandoned across the Clearwater Formation that do not have plugs set at the appropriate depth must be drilled out and reabandoned as per *Directive 020*. Additionally, cement bond logs must be run over the entire intermediate casing interval, to the depth of the zonal abandonment plug in all wells where present, to confirm hydraulic isolation and determine the need for remediation. The non-routine well abandonment plan must include the interpreted cement bond logs and discussion on how hydraulic isolation of all primary formation interfaces and across all non-saline aquifers will be maintained.	Kelly Wiebe (CLSSE)	Bond logging on Q and S pads complete. Next steps include development and submission of Q and S well specific non-routine abandonment plans for approval.
27	The Operator is permitted to abandon the 0CC, 0DD and 0GG Pads as described in Application No. 1797105. For abandonment of wells on these pads a non-routine well abandonment plan must be submitted for each well to the AER's Operational Authorization Group for review and approval in accordance with Section 2 of *Directive 020: Well Abandonment*.	Kelly Wiebe (CLSSE)	Full or partial abandonment completed on 44 wellbores. Remainder will continue in 2017+. All wells remain D013 compliant.
28	The Operator is permitted to use Steam-Assisted Gravity Drainage (SAGD), utilizing steam as the injection fluid, or Solvent Assisted-Steam Assisted Gravity Drainage (SA-SAGD), utilizing solvents and steam as the injection fluids, as the recovery process at the following Pad T13 wells: AA/01-30-064-03W4/0 (observation well) AB/01-30-064-03W4/0 (producer) AC/01-30-064-03W4/0 (injector) AA/02-30-064-03W4/0 (observation well) AB/02-30-064-03W4/0 (producer) AC/02-30-064-03W4/0 (injector) AA/07-30-064-03W4/0 (observation well) AA/08-30-064-03W4/0 (observation well) AB/08-30-064-03W4/0 (observation well) AD/08-30-064-03W4/0 (observation well)	Matt Dawe (CLRE)	T-13 SAGD and SA-SAGD operations ongoing.

Attachment 2

Approval 4510

Compliance Conditions

AER Approval 4510

Clause	Requirement Summary	Responsibility	2016 Status/Comments
4510_2	The disposal of fluids...in the wells...which have satisfied Guide 51 requirements, may commence or continue.	Kelly Wiebe (CLSSE)	Injection follows the conditions of the Directive 051 approvals.
4510_3	The reservoir pressure at the observation wells must be monitored on a minimum of an annual basis.	Scott Cooper/Lyle Robins (CLO)	In compliance. All N Pad injection has ceased as of November 2015 . Injection line to N-pad has been discontinued and no longer able to injected.
4510_4	If the reservoir pressure increases to 7500 kPa (ga), all of the following disposal wells must be re-logged to ensure there is no migration of the disposal fluid out of the zone via micro-annuli: AB/06-05-065-03W4/0 AU/06-05-065-03W4/0 AJ/06-05-065-03W4/0 AG/07-05-065-03W4/0 AM/06-05-065-03W4/0 AH/07-05-065-03W4/0	Scott Cooper/Lyle Robins (CLO)	In compliance. All N Pad injection has ceased as of November 2015. Injection line to N-pad has been discontinued and no longer able to injected.
4510	Submit an annual report for Approval 4510 Nov. 2016	Nathan Toone (CLRS)	2016 Report to be submitted Nov. 2016

Attachment 3

Water Disposal and Storage

Water Disposal and Storage

PW Disposal & Storage
District Summary – Volumes in m^3

	2015		2016								
	Nov	**Dec**	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**Jul**	**August**	**Sept**
Disposal Volumes, m3	18,926	17,057	96,075	120,840	156,191	133,531	133,167	106,023	102,065	77,176	81,017
NPAD Storage, m3	0	0	0	0	0	0	0	0	0	0	0
Disposal Limit, m3	231,337	260,625	227,890	214,265	230,498	214,429	231,046	230,914	239,552	233,359	220,440
Actual Disposal (%)	0.6%	0.5%	2.8%	3.8%	4.6%	4.2%	3.9%	3.1%	2.9%	2.2%	2.5%
Disposal Limit (%)	7.0%	7.1%	6.8%	6.8%	6.8%	6.8%	6.8%	6.8%	6.7%	6.7%	6.8%

- N pad storage no longer used for disposal

Attachment 4

Facility Performance by Plant

Cold Lake Facility Performance

	1/1/2015	2/1/2015	3/1/2015	4/1/2015	5/1/2015	6/1/2015	7/1/2015	8/1/2015	9/1/2015	10/1/2015	11/1/2015	12/1/2015	1/1/2016	2/1/2016	3/1/2016	4/1/2016	5/1/2016	6/1/2016	7/1/2016	8/1/2016	9/1/2016
Maskwa Plant																					
Bitumen Production m^3	216201.5	198860.87	212692.2	206959	211393.9	195877	202558.7	193427.6	184892.3	198192.8	189240.5	194662.6	189917.9	184446.6	200516.3	198084.1	209064.9	205472	210593.7	210747.1	212747.9
Produced Water m^3	956774.5	873851.1	948256.4	907527.9	896586.2	840656.4	922525.3	933958.2	968298.2	882628.7	882674.9	888919.2	834159.8	800097.9	912888.2	843535.9	921446.1	937413.6	963496	931048.1	972895
HP Steam Generation m^3	780139.1	690670.11	776831.9	780091.6	838491.2	779796.9	772180	816230.5	750426.2	771588.8	713946.9	816479.2	809401.8	718334.3	767780.1	765740.5	776578.5	752634.3	776201.8	713006.8	810508.3
HP Steam Injection m^3	723319.2	637027.98	717114.8	722583.2	791523.1	748090.5	845339.3	781344.2	724639.5	783210.9	653615.4	751038.5	755028.8	672584.9	712687.6	710169.3	717320.2	694225.5	726647	669947.1	766081.7
Steam Quality %	67.4	67.0	69.0	67.9	68.7	69.5	70.5	70.4	73.9	74.9	74.1	72.9	69.9	70.6	71.4	66.1	64.7	66.8	67.1	72.1	74.7
Produced Gas km^3	10022.4	8953.9571	9531.7	8880.3	8791	9207.7	9238.5	8868.1	8671.9	9385.7	9267.2	8831.6	8729.3	8321.2	8908.5	9018.2	9880	10063.9	10173.1	10278	10443
Purchased Gas km^3	38662.4	34579.6	39400	39343.4	42629.6	39248.8	39073.7	41366.3	39634.8	39734	36120.6	40879.3	40365.8	35560.3	37716.4	36578.7	35112.5	34629.4	38021.8	35441.3	42443.6
Mahihkan Plant																					
Bitumen Production m^3	294988	272155.37	288374.9	254891.7	278871	274206.6	289746.7	288879	274038.8	286775	271817	281878.3	283374	264177.7	290565.6	271010.5	281982.4	273708.3	269436.8	264102.7	269163.8
Produced Water m^3	1030276.3	1030054.7	1085209.2	846781.1	1012331.6	1106876.7	1136620.3	1063595.7	1064691.1	1153913.2	1112227.1	1206403.1	1105934.2	1054211.2	1108296.4	1031683.7	1123358	1078545	1070678.5	1047218.6	1083026
HP Steam Generation m^3	1149078.5	1171293.6	1221874.2	907347.6	1175909.3	1229572	1263125.1	1277509.4	1236156.5	1269098.1	1222992.2	1281175.4	1221377.4	1134806.8	1206023.4	1209050.7	1267879	1202637	1181914	1206798.9	1172633.9
HP Steam Injection m^3	1056950.8	1080076.4	1153809.9	865918.1	1167458.3	1332900.2	1358217	1341859.8	1307910.8	1352664.1	1151334.4	1218805.8	1165756.9	1084433.4	1145523.6	1141368.1	1215419	1142153	1125155	1146900.8	1110621
Steam Quality %	68.0	68.9	69.6	67.7	66.0	69.3	71.7	71.8	73.0	73.2	72.6	73.1	72.7	73.9	72.6	71.9	73.0	72.3	72.5	70.1	72.2
Produced Gas km^3	13556.2	11501.089	12788.5	11792.6	13264	13732.6	13349.3	13182.3	12265	13266.9	12423.7	12559.6	12537.2	12093.7	13779.3	12209.3	13267.9	12747.2	11877.2	11203.6	12471.1
Purchased Gas km^3	50964.6	53968.896	56133.5	38912.8	51947	56054.1	58095.2	59766	58657	58513.7	56467.7	58983.9	56346.3	51874.8	54738.1	55807	57940.6	54633.8	54394.8	55240.8	53604.2
Mahkeses Plant																					
Bitumen Production m^3	174859.8	167541.7	179182.4	171029.3	170162.1	156412.4	158279.6	152190.9	152551.7	158588.6	148508	143976.3	146176.5	139083	142752.6	132321.1	139589.5	132842.2	144183.5	142004	129265.8
Produced Water m^3	591864.6	581792.9	608646.2	583172.0	557960.8	504795.7	501937.1	549243.1	639236.1	618822.2	595414.8	687677.9	608308.9	578347.6	632368.4	576649.6	574738.6	470822	507271.2	493563.3	466975.5
HP Steam Generation m^3	706673.4	606275.35	629666.1	659255.7	482571.2	664357.2	668202.6	688183.6	646778.2	664078.9	670520.5	695432	689042.3	645120.2	668467.5	475662.5	667051.4	612434.4	689198.2	686526.5	684186.3
HP Steam Injection m^3	749925.7	673643.07	693939.5	646140.7	413261.5	598972.2	610071.4	624868.4	610744.1	630642.3	633272.6	645198.5	636256.5	592391.7	619976.9	437639.2	626823.8	578425.1	651564.4	643998.6	639636.3
Steam Quality %	60.5	60.3	60.1	66.2	64.0	67.3	67.9	68.2	69.4	68.7	68.7	67.7	68.7	68.1	68.0	67.4	68.6	68.2	69.5	69.7	69.6
Produced Gas km^3	9442.7	8839.4071	9392.7	8558	8480.7	8473.1	8645.8	8150.5	8285.9	8658.3	8577.5	8233.4	9060.1	8846.9	9478.4	8557.7	9456.1	8988.3	9068.3	8821.1	7750.2
Purchased Gas km^3	49330.5	43741.943	42756.3	44982.3	29474.8	44074.8	45518.4	46332.2	44788.4	45992.6	46838.6	48975.8	49369.7	45436.7	46674.1	30274.6	43955.6	40372.1	46063.8	45928.4	46904.9
Leming Plant																					
Bitumen Production m^3	40926.3	40369.036	44014.8	40429.2	42069.8	38672.3	41545.8	41864.5	39019.4	41768.6	40565.5	42827.5	35560.4	35730.4	38761.6	34877.5	36621	32868.7	33513.2	35457	11964.9
Produced Water m^3	239202.2	254374.2	267530.9	262401.8	263719.3	252203.3	260476.6	252566.4	219035.0	241364.1	274922.9	281983.7	233936.5	244796.5	242621.8	202419.3	199465	166602.3	174778.8	198616.9	74470.2
HP Steam Generation m^3	297009.2	280590.74	299000.3	285403	256283.2	289833.5	327737	330937.1	306962.7	299071.4	292009.1	299560.1	228580.1	179927.3	161061.9	176227.7	157214.1	147266.6	144304.1	141639.4	43649
HP Steam Injection m^3	193121.6	159794.97	186609.4	243663.6	251802.2	286071.5	322110.1	324151.7	299602	294410.7	287576.3	294953.4	223776.6	173617.2	154766.6	169001.8	144996.4	139840.3	134174	135335.5	42404.6
Steam Quality %	72.3	72.6	73.2	73.5	71.4	71.1	70.3	68.5	71.4	72.4	72.2	72.1	71.6	69.6	67.8	69.7	68.0	66.5	70.9	69.6	63.4
Produced Gas km^3	2606.8	2375.825	2321.3	2218.8	2334.2	2112.4	2673.6	2778.6	2412	2287.5	1977	2123.1	1835.9	2241.8	2387.2	2135.2	2331.9	1941.4	1865.5	1755.5	719.9
Purchased Gas km^3	16413.2	15570.721	16530.7	15762.6	13536.4	15629.7	17401	16841.4	16264.4	15486.6	15349.6	15946.4	11551.5	7726.5	6976.1	8492.1	6920.6	6176.4	6346	6502.4	1725.9
Nabiye																					
Bitumen Production m^3	0	92.592857	56908.5	82423.9	81842.6	109409.9	162476.4	132751.4	115153	94639.9	75795.9	92925	143268.9	154009.3	136593.6	112254.9	143309.3	151255.3	131959.7	114245.4	108293.1
Produced Water m^3	0	2197.2679	94426.6	142437.2	317539.6	320429.3	281439.3	282540	232497.9	242076.7	219880.3	331043.1	372184.3	301871.2	322358.9	355923.2	396605.7	344760.9	392607.7	365672	344333.8
HP Steam Generation m^3	168980.9	783067.84	1188366.7	1309678.9	1201726.5	582779.3	529166	322120.4	315885.4	472726.6	542805.2	666898.5	511234.8	499594.2	496852.8	511485.4	571213.1	553899	570784.8	561515.5	464754.4
HP Steam Injection m^3	111273.1	495835.27	718770.6	706073.3	654388.5	608401.3	588061.5	353557.8	295914.1	484138.8	515090.9	637515.7	487804.6	478922.9	480579.2	492847.9	552423.2	535136.7	552086.8	539707.8	452403.6
Steam Quality %			64.5	69.1	63.7	65.1	64.9	67.9	68.1	63.6	66.4	68.4	67.6	70.0	62.6	58.3	66.7	67.9	61.0	63.0	65.7
Produced Gas km^3	0	2.6928571	1648.6	2369.1	3816.2	5914.2	5038.8	3931.5	3928.9	3450.5	2753.5	3436	4497	4328.7	4062.9	3710.2	4918.5	5322.1	5246	5018.4	4631.1
Purchased Gas km^3	9888.5	32214.857	46950.6	52284.6	42971.1	39099	38868.4	23342.2	24505.7	38672.3	46976.5	55090.7	47495	44025.5	42745.6	38619.3	44424	42112.9	42437.2	42768.9	34642.1
SA-SAGD																					
Bitumen Production m^3	2464.4	2248.6393	2892.4	2743.4	2662.1	1917.9	1802.1	1851.4	1122.3	881.6	1737.6	1692.7	1607.4	1222.1	1653.1	1597.4	1351.5	983.1	1269.5	1786.5	1412
Produced Water m^3	9529.7	8624.7036	9203.5	6060.9	7071.2	7974.2	7824.8	7384.4	5590.4	4624.9	14329.4	8745.5	6459.3	8886	9908.6	8061.7	4507.3	3259.9	3132.2	4684.8	4791.6
HP Steam Injection m^3	10671.9	9871.8071	7160.4	264.2	14457.6	13177.4	8075.7	10164.1	5765.1	0	2284.4	10136.8	12068.2	13177.5	11753.4	8997.5	2346	624.6	4531.8	7781.1	5119.4
Produced Gas km^3	23.3	23.303571	29.7	34.1	20.5	8.7	14.5	29	24	21.5	48.8	50.3	31.1	23.6	17.1	8.5	10	5.1	5.8	9.7	11.3
District																					
Fresh Water m^3	240764.2	173572.77	191761.7	185656.2	188639.3	239538.1	266711.5	239101.8	241091.5	219960.9	186277.7	193344	182116.2	151311.3	143910.9	129314.4	116598.7	118625	210549.3	164379.7	118088.8
Brackish Water m^3	0	30203.396	55630.9	90196.2	27030.7	98473	15635	3426.2	0	20968.5	23593.4	50589.5	0	4.2	0	0	0	0	0	0	0
Ground Water m^3	588.8	2131.6036	421.3	46.9	353.6	1042	718.8	4094.6	303.1	537.1	342.2	636.8	244.6	373.5	320.5	324.3	33692	48037.2	2732.9	681.1	4584.7
Disposal Water m^3	196901.7	42679.2	23743.7	15718.2	39092.4	18491.6	13012.0	101925.9	125542.5	35432.3	18926.4	17056.8	96075.4	120840.2	156190.7	133530.9	133166.6	106023.2	102064.6	77175.9	81017.3
PW Recycle %	90.8%	99.1%	101.6%	102.4%	96.1%	99.5%	98.3%	96.7%	89.9%	96.5%	97.5%	97.0%	96.8%	92.3%	89.6%	91.0%	94.8%	89.2%	89.8%	90.5%	92.8%
Power Generation MW	124755	192358	218953	231944	172421	204374	215005	173252	176585.551	221021.71	230606.64	253,089	253532	230965	233609	172399	227978	212413	226611	225472	202602.16
Power Import from Grid MW	1129	679	595	690	564	660	878	927	781	595.005	828.019	734.23	582	582	541	563	428	265	515	516	429
Power Export to Grid MW	39241.731	93482.035	119516.95	131573.46	77032.453	109783.25	117351.33	79746.533	87828.191	122844.71	132700.61	143290.32	143939.49	127263.24	126041.78	71146.998	127211.5	114867.7	127723.31	127490.64	109642.27
Power Consumption MW	86642	99555	100031	101061	95953	95251	98532	94433	89539	98772	98734	110533	110174	104284	108109	101815	101195	97810	99402	98498	93389
Produced Gas km^3	35651.4	31696.275	35712.5	33861.7	36714	39449.7	39026.4	36952.4	35616.7	37141.9	35062.7	35241.8	36690.7	35898.7	38657	35824.2	39985	39115.8	38380.8	37194	36069
Flare Gas km^3	88.1	328.83929	395.8	273.4	394.7	225.6	334.7	251.4	80.5	72.1	426.4	76.1	123.7	85.7	214.8	198.3	68.2	77.2	94.6	140.2	77
Vent Gas km^3	68.8	69.496429	17.9	15.5	39.3	33.9	29.4	65	27	21.6	17.4	11.5	16.5	14.7	29.8	28.4	26.4	21.3	10.2	6.6	7.3
Produced Gas Recovery %	99.6	98.7	98.8	99.1	98.8	99.3	99.1	99.1	99.7	99.7	98.7	99.8	99.6	99.7	99.4	99.4	99.8	99.7	99.7	99.6	99.8

Imperial | Cold Lake

Attachment 5

Sulphur Balances by Plant

Cold Lake Plant Sulphur Balances

As per AER approval 8558 clause 24.2, Imperial is required to report monthly sulphur and comply on a calendar quarter year average basis for each plant.

Tonnes/Day	Month	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
District	Sulphur Inlet	132.27	126.97	155.90	171.41	147.56	154.08	147.46	163.01	141.31	129.59	129.10	142.91
	Sulphur Removed	58.04	57.85	77.06	86.07	73.58	73.54	67.70	74.05	72.59	68.03	64.37	72.73
	Sulphur Emissions	74.23	69.12	78.84	85.34	73.98	80.54	79.76	88.96	68.72	61.56	64.73	70.18
	SO_2 Emissions	148.47	138.24	157.67	170.68	147.97	161.08	159.52	177.91	137.43	123.12	129.46	140.37
	Sulphur Recovery	43.88%	45.56%	49.43%	50.21%	49.86%	47.73%	45.91%	45.43%	51.37%	52.50%	49.86%	50.89%
Leming	Sulphur Inlet	14.45	9.93	5.82	4.96	5.63	6.47	6.35	8.42	9.74	11.26	8.26	2.99
	Sulphur Removed	0	0	0	0	0	0	0	0	0	0	0	0
	Sulphur Emissions	14.45	9.93	5.82	4.96	5.63	6.47	6.35	8.42	9.74	11.26	8.26	2.99
	SO_2 Emissions	28.89	19.85	11.64	9.92	11.25	12.93	12.70	16.84	19.47	22.52	16.52	5.99
	Sulphur Recovery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Maskwa	Sulphur Inlet	32.83	29.13	29.09	32.84	27.72	29.80	28.10	28.22	24.11	24.80	29.65	33.62
	Sulphur Removed	0	0	0	0	0	0	0	0	0	0	0	0
	Sulphur Emissions	32.83	29.13	29.09	32.84	27.72	29.80	28.10	28.22	24.11	24.80	29.65	33.62
	SO_2 Emissions	65.65	58.27	58.17	65.67	55.45	59.61	56.19	56.44	48.22	49.60	59.30	67.23
	Sulphur Recovery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mahihkan	Sulphur Inlet	43.54	40.17	52.59	53.23	50.11	49.71	41.59	51.22	41.32	35.91	35.68	41.34
	Sulphur Removed	33.51	29.44	38.95	39.43	34.82	35.78	30.44	37.65	26.67	23.95	26.37	29.10
	Sulphur Emissions	10.02	10.72	13.64	13.80	15.28	13.93	11.16	13.58	14.65	11.96	9.31	12.24
	SO_2 Emissions	20.05	21.44	27.27	27.60	30.57	27.86	22.31	27.15	29.30	23.91	18.62	24.48
	Sulphur Recovery	76.97%	73.31%	74.07%	74.08%	69.50%	71.98%	73.18%	73.50%	64.55%	66.71%	73.91%	70.39%
Mahkeses	Sulphur Inlet	34.99	40.52	53.63	63.08	54.17	54.05	52.56	52.01	48.77	37.33	42.17	42.68
	Sulphur Removed	24.53	28.41	38.11	46.64	38.75	37.76	37.26	36.41	33.84	26.19	30.50	29.79
	Sulphur Emissions	10.46	12.11	15.52	16.43	15.41	16.29	15.30	15.60	14.94	11.14	11.68	12.89
	SO_2 Emissions	20.92	24.23	31.03	32.87	30.83	32.57	30.61	31.20	29.87	22.28	23.35	25.78
	Sulphur Recovery	70.11%	70.11%	71.07%	73.95%	71.54%	69.87%	70.89%	70.00%	69.38%	70.15%	72.32%	69.80%
Nabiye	Sulphur Inlet	6.48	7.22	14.78	17.31	9.94	14.06	18.86	23.14	17.37	20.29	13.34	22.28
	Sulphur Removed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.09	17.89	7.50	13.84
	Sulphur Emissions	6.48	7.22	14.78	17.31	9.94	14.06	18.86	23.14	5.29	2.40	5.84	8.44
	SO_2 Emissions	12.96	14.45	29.55	34.63	19.88	28.11	37.71	46.28	10.57	4.80	11.68	16.89
	Sulphur Recovery	0%	0%	0%	0%	0%	0%	0%	0%	69.57%	88.16%	56.24%	62.11%

Sulphur Measurement & Reporting

Sulphur (H_2S) Sampling Process

- Manual gas samples taken to monitor H_2S concentration
- Additional gas samples may be taken if increased frequency is desired (e.g. approaching licence limits and/or increased variability in samples expected or performance control improvements)

	Gas sample locations	Sampling Frequency
Maskwa Plant	Inlet gas P1 & P3	Weekly
Mahihkan Plant	Inlet gas P2 & P4, P4 SRU inlet and outlet	Weekly (P2) | MWF (P4)
Leming Plant	Inlet gas	Weekly
Mahkeses Plant	Inlet gas, SRU inlet and outlet, combined gas	TTh
Nabiye Plant	Inlet gas	TTh

- Sulphur measurement process accuracy is within the requirements of ID 2001-03 for reporting (+/- 0.1 tonnes S and +/- 0.1 km^3 gas)
- Sulphur emissions are documented on a daily basis and monitored against the quarterly limits for each plant

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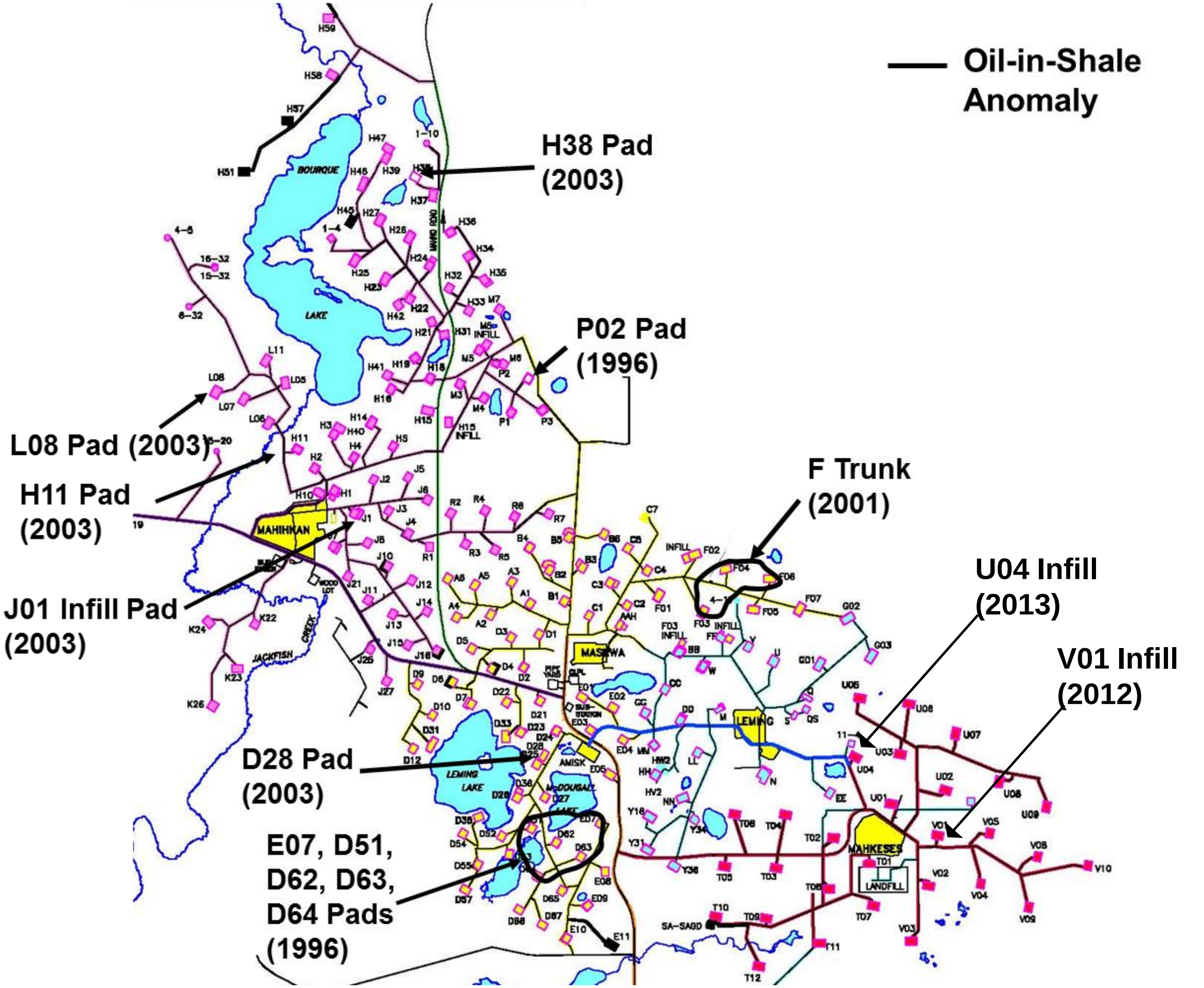
Attachment 6

2016 Bitumen in Shale Report

Oil in Shale Summary



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Oil In Shale Summary

No new oil in shale events to report

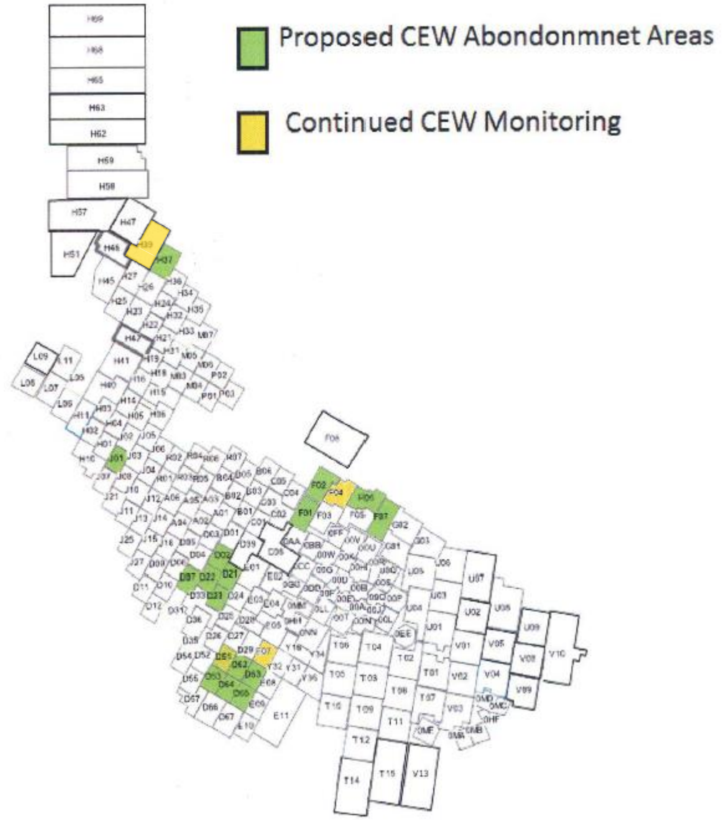
Location	Issue	Date of Discovery	Current Restriction?	Comments/ Commitments/ Results	Next Scheduled Steam Date
E07	Oil in Shale found during drilling at E07 pad	1997	No	E07 wells abandoned. Resource accessed via D29 horizontal wells. Shale pressure monitored while steaming.	Q3 2017 resource steamed via D29
F trunk	Oil in Shale found during re-drill at F03-16A	2001	No	Steaming restrictions lifted Sept 10, 2003. Anomaly area steamed 2006, including new infill wells. Shale pressure monitored and steam pattern adjusted to minimize shear stresses. One GEW shows <1 ppb benzene and below Canadian drinking water quality guidelines (CDWQG), consistent with thermally mobilized BTEX.	Steam Flood Ongoing (via infills)
L08	Oil reported during drilling of L08-01 and PS well on pad.	2003	No	Steaming restriction lifted June 13, 2003. Steamed 8 cycles with no abnormal pressures in CEW. Closest GEW well has shown BTEX levels over CDWQG in the past but are now below detection limits.	Q2 2018
H38/H39	Oil reported during drilling of H38-12 and H38-22.	2003	No	Steaming restriction lifted Nov 25, 2004. Shale pressure and ground water monitoring wells monitored through 7 cycles. No abnormal pressures observed. In Feb 2011 groundwater had benzene concentrations above CDWQG on H39. Since April 2013, chemistry has been below CDWQG.	Q3 2017
H11	Oil reported during drilling of H11-02 and H11-05	2003	No	No abnormal pressures at CEW during 8 steam cycles. Benzene observed in 2004 and 2005 but was subsequently below detection limit. Benzene was seen in GEW 11-7 in 2012, but has since been below CDWQG.	No steam plan

Oil In Shale Summary

Location	Issue	Date of Discovery	Current Restriction?	Comments/ Commitments/ Results	Next Scheduled Steam Date
J01 Infills	Oil reported during drilling of J01-H1	2003	No	No abnormal pressures at CEW during infill well steaming cycles. Groundwater shows no abnormal hydrocarbons.	Steam Flood Operations Ongoing
D28	Oil reported during drilling of D28-07 and D28-09.	2003	No	Steaming area via infill wells since 2012 with no anomalous pressure response at the CEW. Groundwater shows no abnormal hydrocarbons.	Steam Flood Ongoing (via infills)
V01	Oil in Shale found during drilling of V01-H28 infill	Nov 2012	No	Deep groundwater monitoring well installed – no impacts were observed	Q4 2016 (via infills)
U04	Oil in Shale found during drilling of U04-H26	Feb 2013	No	No groundwater monitoring drilled as there is no deep continuous aquifer to monitor	Q3 2017 (via infills)

Colorado Shale Monitoring Wells

- AER has approved Imperial's application to discontinue monitoring at 28 Colorado Shale monitoring wells in areas which have converted to low pressure steaming operations
- Of the 28 wells, 20 will be abandoned and eight will be returned to low pressure operation
- In a few areas with either high pressure steaming plans, or high pressure in the Colorado Shale, four monitoring wells will be maintained
- A list of these wells is on the next page



Colorado Shale Monitoring Wells

H38-CEW-24 moved from abandonment list (Table 2) to keep list (Table 3) in Q4, 2015

Table 1 – Monitoring wells proposed for conversion to low-pressure producers

Well	UWI	License #	Comments
D51-05 (Colorado)	102/13-36-64-4W4/0	127833	Retain D51-10 as the pad monitoring well
D51-17 (Colorado)	100/09-35-64-4W4/0	127845	Retain D51-10 as the pad monitoring well
D02-02 (Colorado)	102/09-11-65-4W4/0	114515	
D21-12 (Colorado)	102/01-11-65-4W4/0	114815	
D21-15 (Colorado)	106/04-12-65-4W4/0	114818	
D22-14 (Colorado)	105/02-11-65-4W4/0	115055	
D23-13 (Lloydminster and Colony)	109/16-2-65-4W4/0	116121	
D65-11 (Colony)	105/04-36-64-4W4/0	188547	Run temperature log and take manual pressure reading before conversion

Table 3 – Wells proposed for continued monitoring

Well	UWI	License #	Comments
D51-10	100/16-35-64-4W4/0	127838	Retain D51-10 as the pad monitoring well
E07-PM1	112/15-36-64-4W4/0	218719	Retain E07-PM1 –continued HP steaming from D29 –failed sensor recently repaired
E07-14	108/15-36-64-4W4/0	189068	Retain E07-14 –continued HP steaming from D29
F04 CEW-7	114/09-18-65-3W4/0	265997	Retain F04 CEW-7 to monitor anomaly
H38-CEW-24	106/16-3-66-4W4/0	297208	

Table 2 – Colorado Evaluation Wells (CEWs) proposed for abandonment

Well	UWI	License #	Comments
D62-OB2	1AB/11-36-64-4W4/0	194968	Run temperature log and take manual pressure reading before abandonment
D63-OB2	112/11-36-64-4W4/0	199930	Run temperature log and take manual pressure reading before abandonment
D64-OB2	1AA/05-36-64-4W4/0	196036	Run temperature log and take manual pressure reading before abandonment
D07-CEW-5	112/03-11-65-4W4/0	265162	Run temperature log and take manual pressure reading before abandonment
F01 CEW-8	110/06-18-65-3W4/0	267431	
F02 CEW-6	112/10-18-65-3W4/0	265998	
F03 CEW-1	115/02-18-65-3W4/0	263666	Previously suspended
F03 CEW-2	111/08-18-65-3W4/0	263374	
F03 CEW-3	112/04-17-65-3W4/0	263493	Previously suspended
F03-16A	110/08-18-65-3W4/0	260559	
F04 CEW-9	103/13-17-65-3W4/0	265997	Previously suspended
F06 CEW-10	112/06-17-65-3W4/0	267585	
F07 CEW-13	112/02-17-65-3W4/0	267537	
14-17 CEW-12	102/14-17-65-3W4/0	268171	Previously suspended
FF CEW4	100/16-7-65-3W4/0	268445	Previously suspended
H37-CEW-18	111/09-3-66-4W4/0	284934	
H38-CEW-26	103/16-3-66-4W4/0	275128	
H38-CEW-27	107/15-3-66-4W4/0	277163	
J01-CEW-21	112/04-22-65-4W4/0	289972	No plans for this pad

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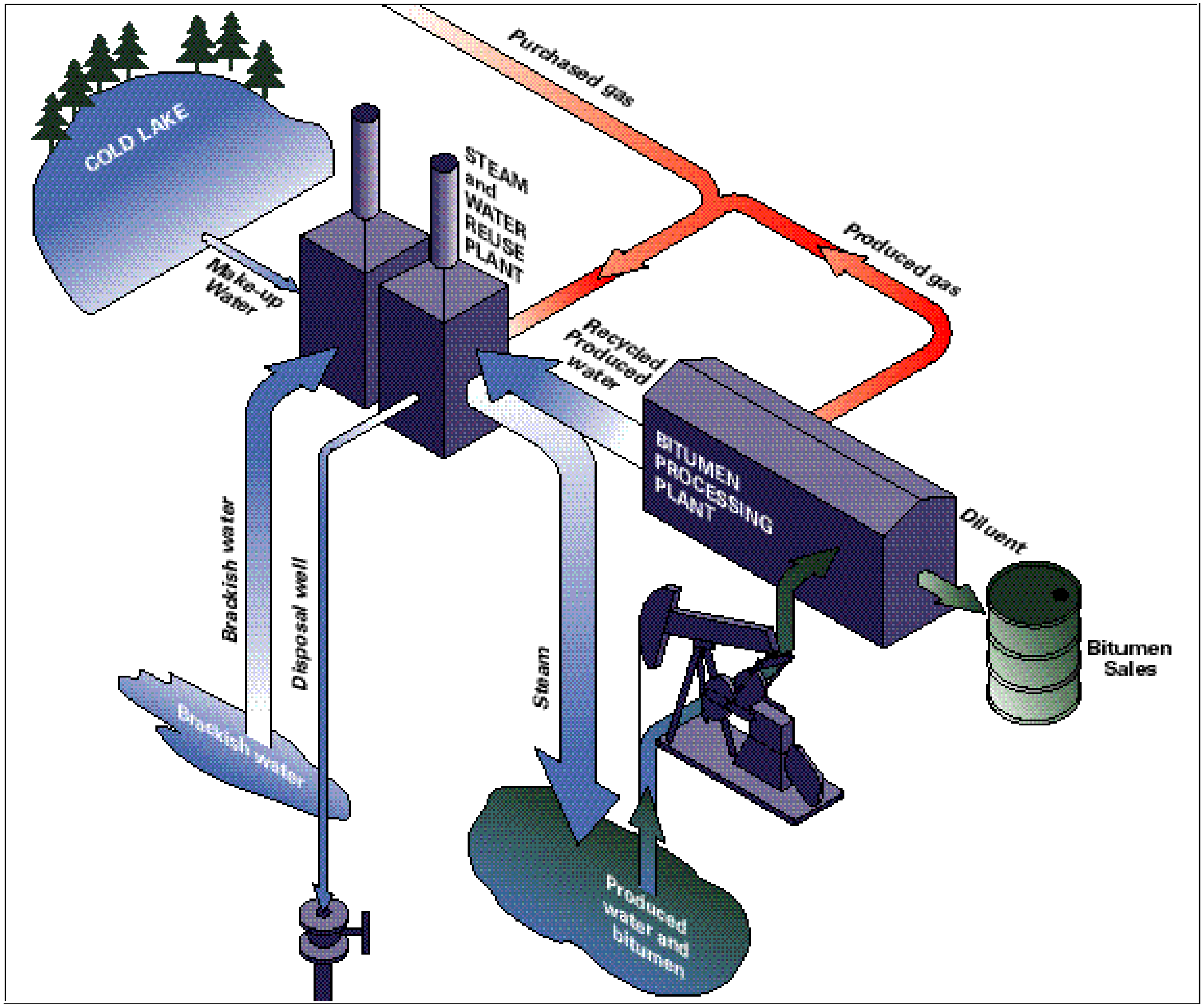
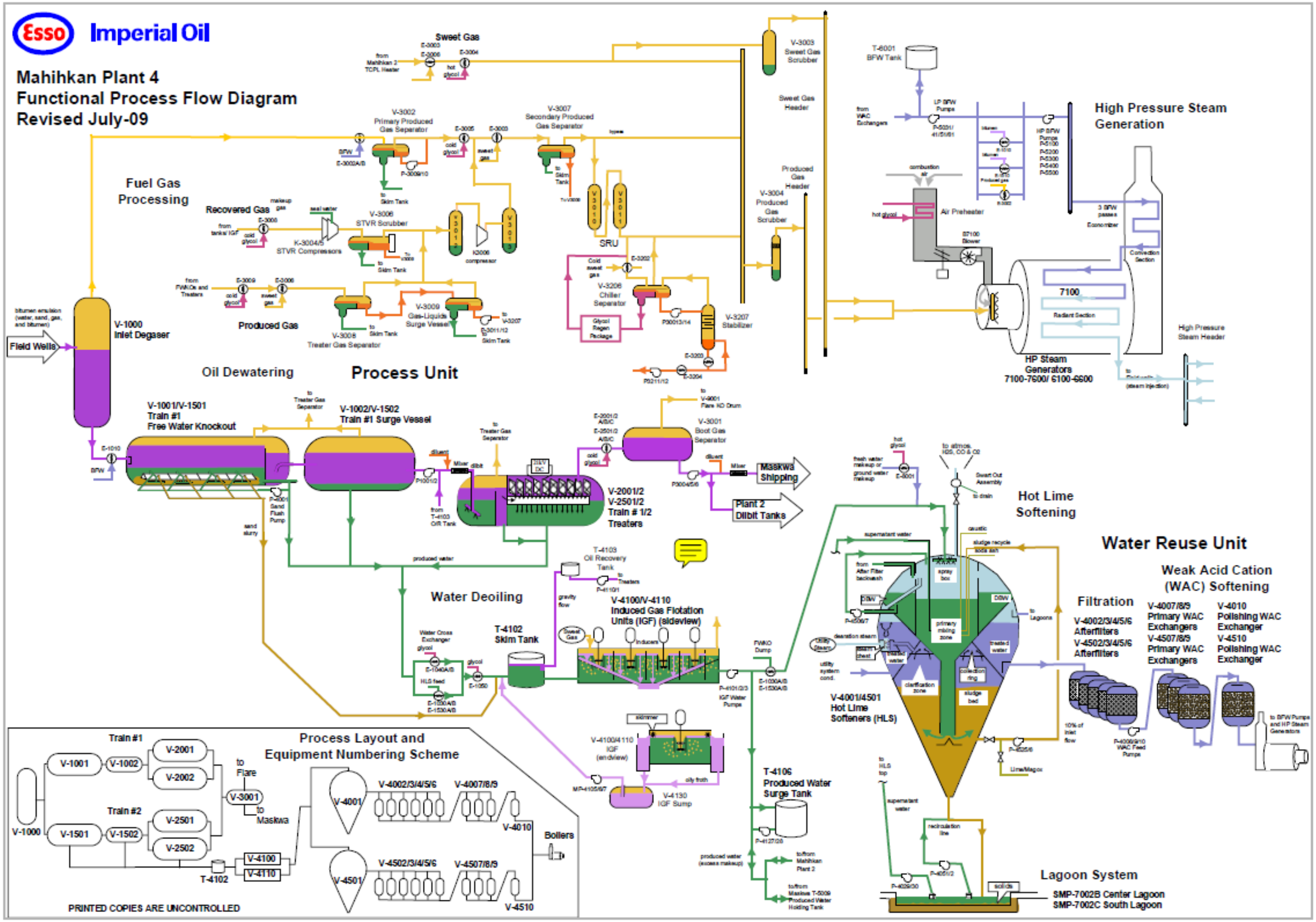
Attachment 7

Process Flow Schematics

Cold Lake Operations Process Overview



Process Flow Schematics



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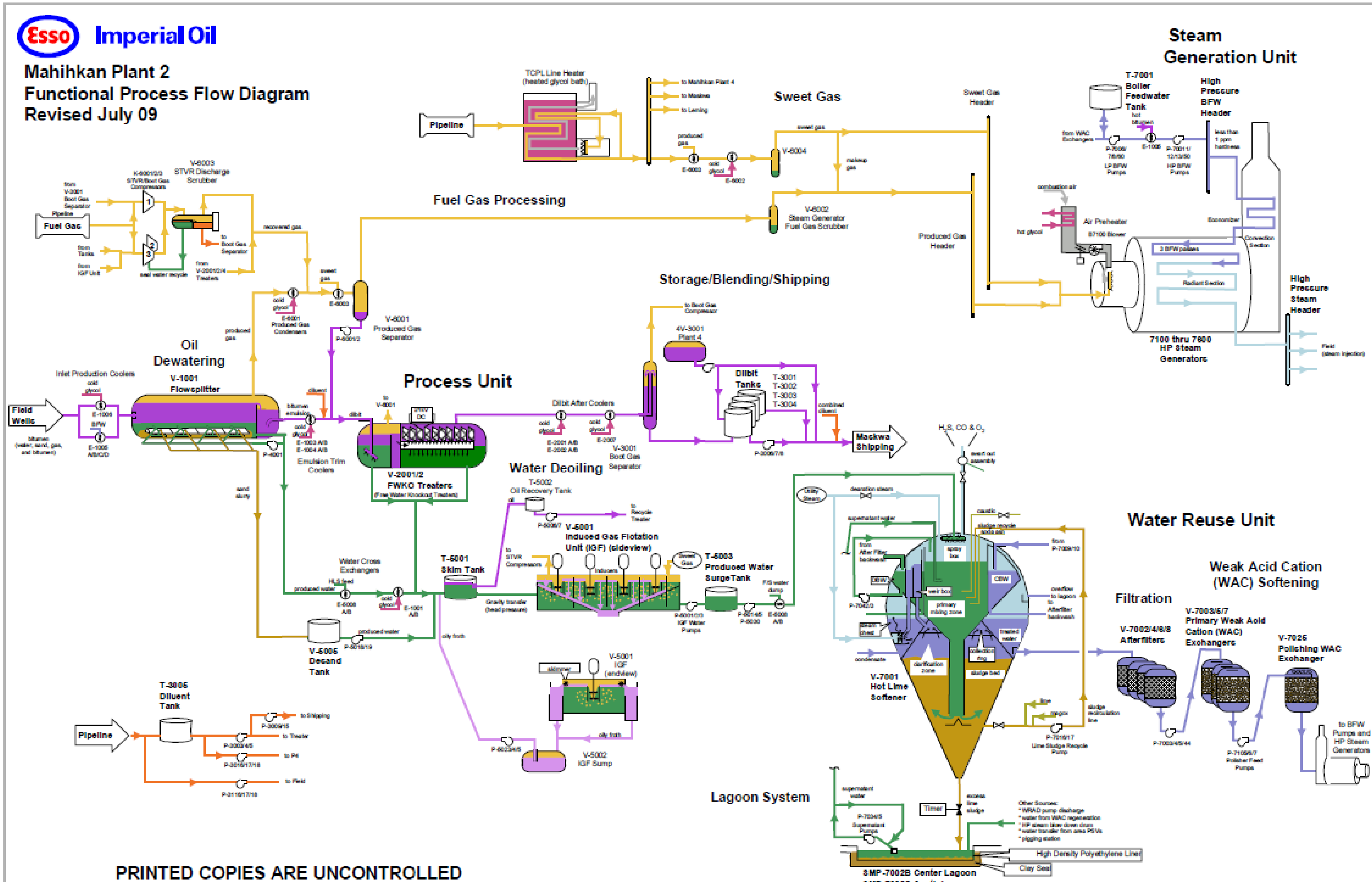
Process Flow Schematics



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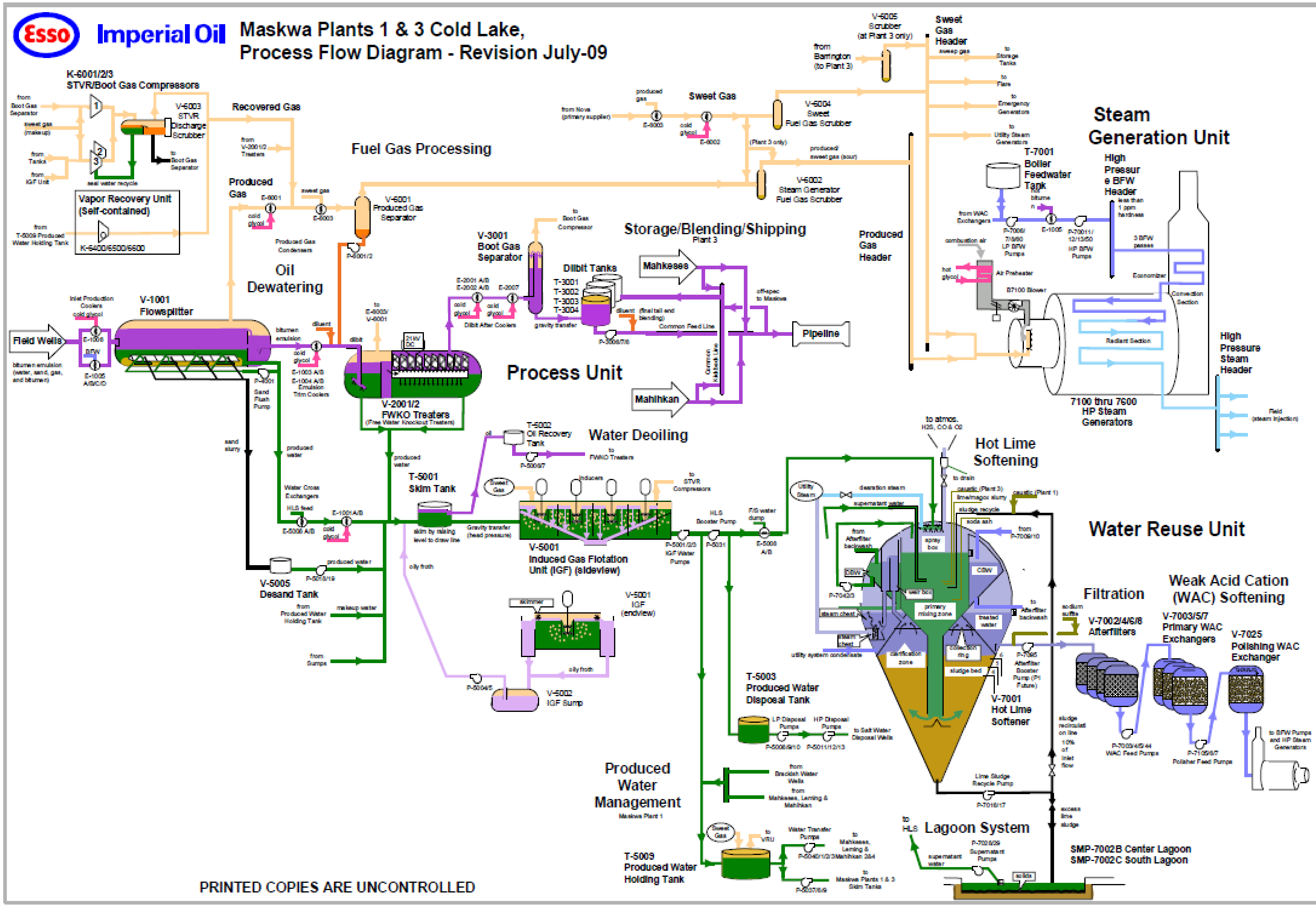
Process Flow Schematics



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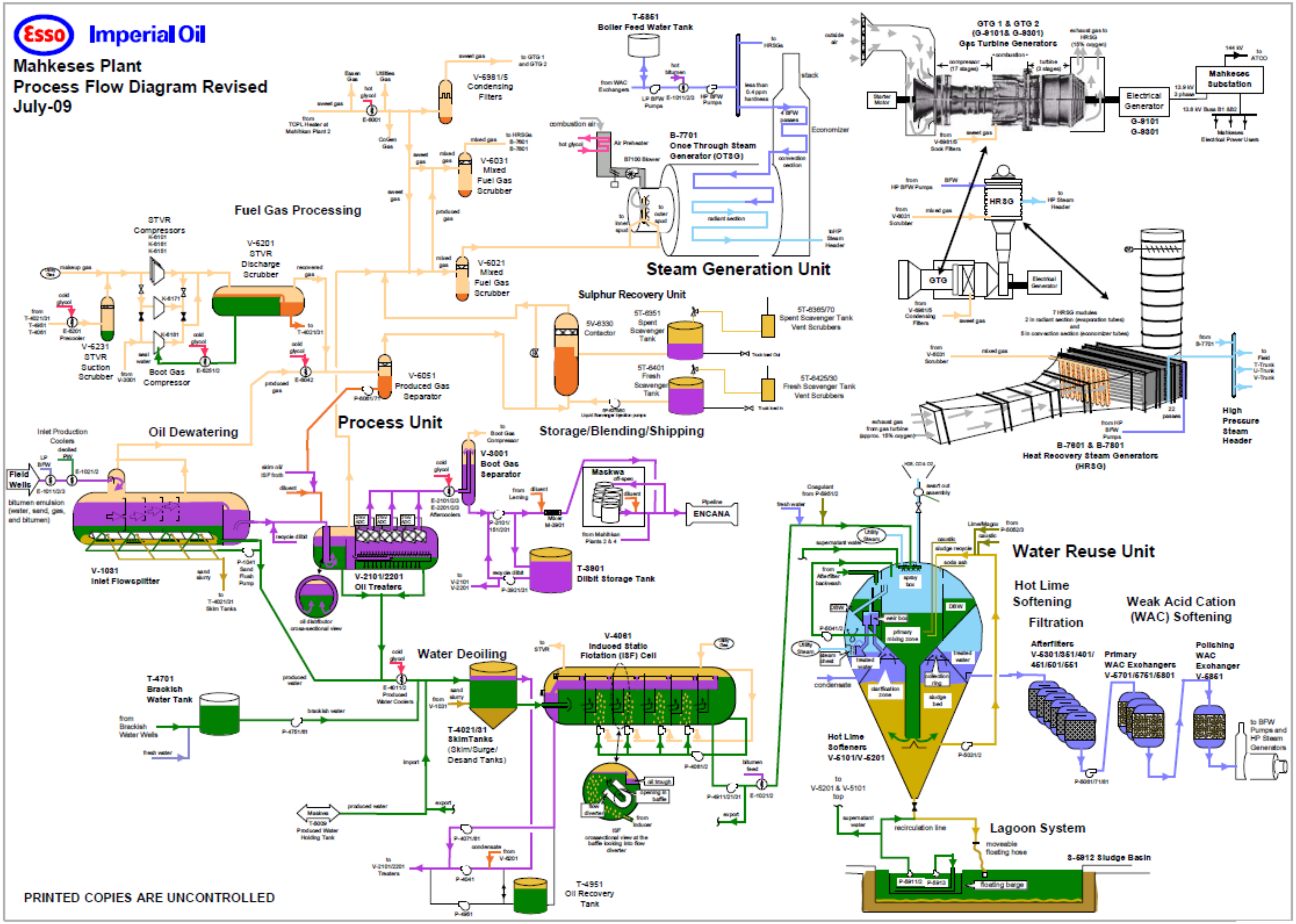
Process Flow Schematics



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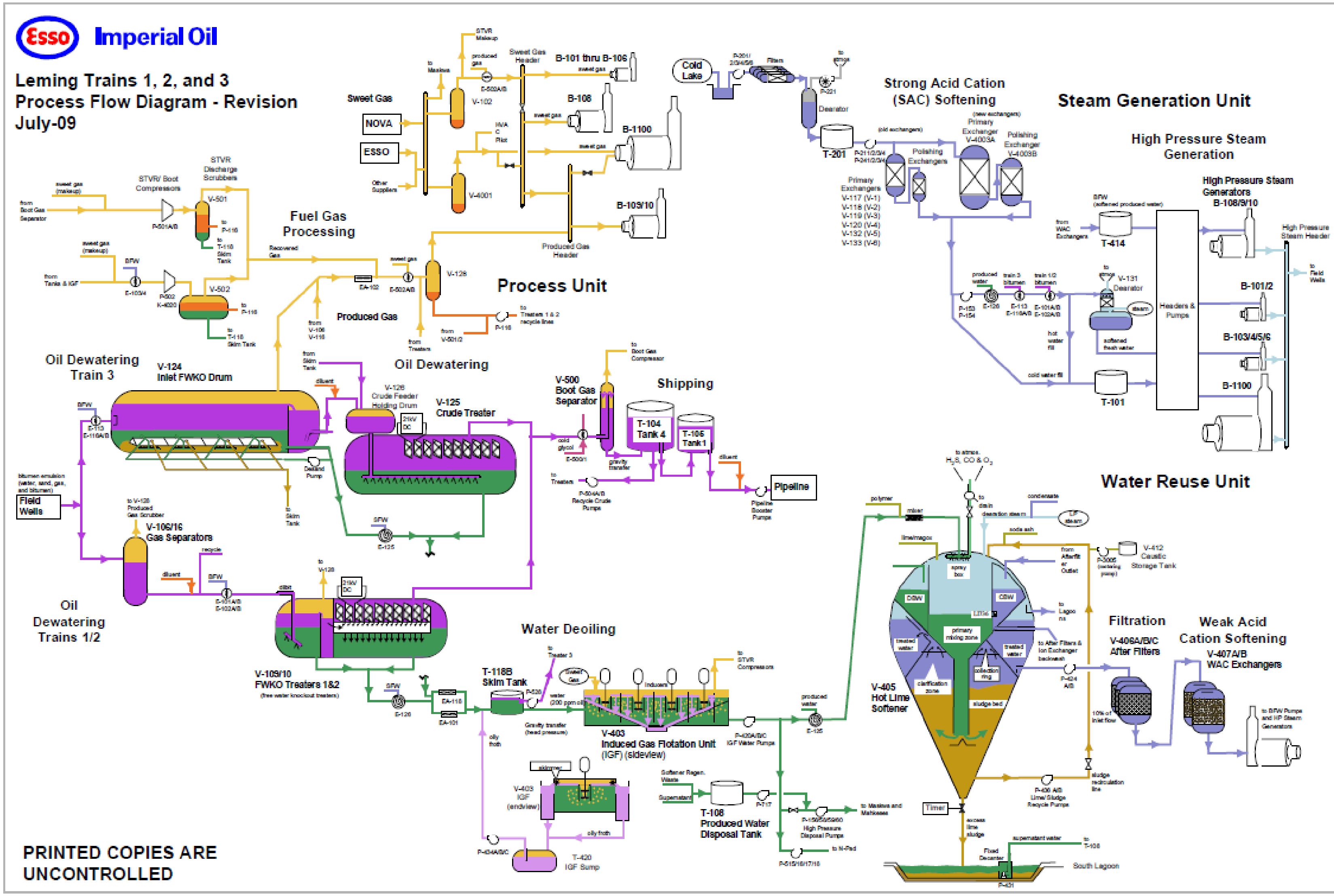
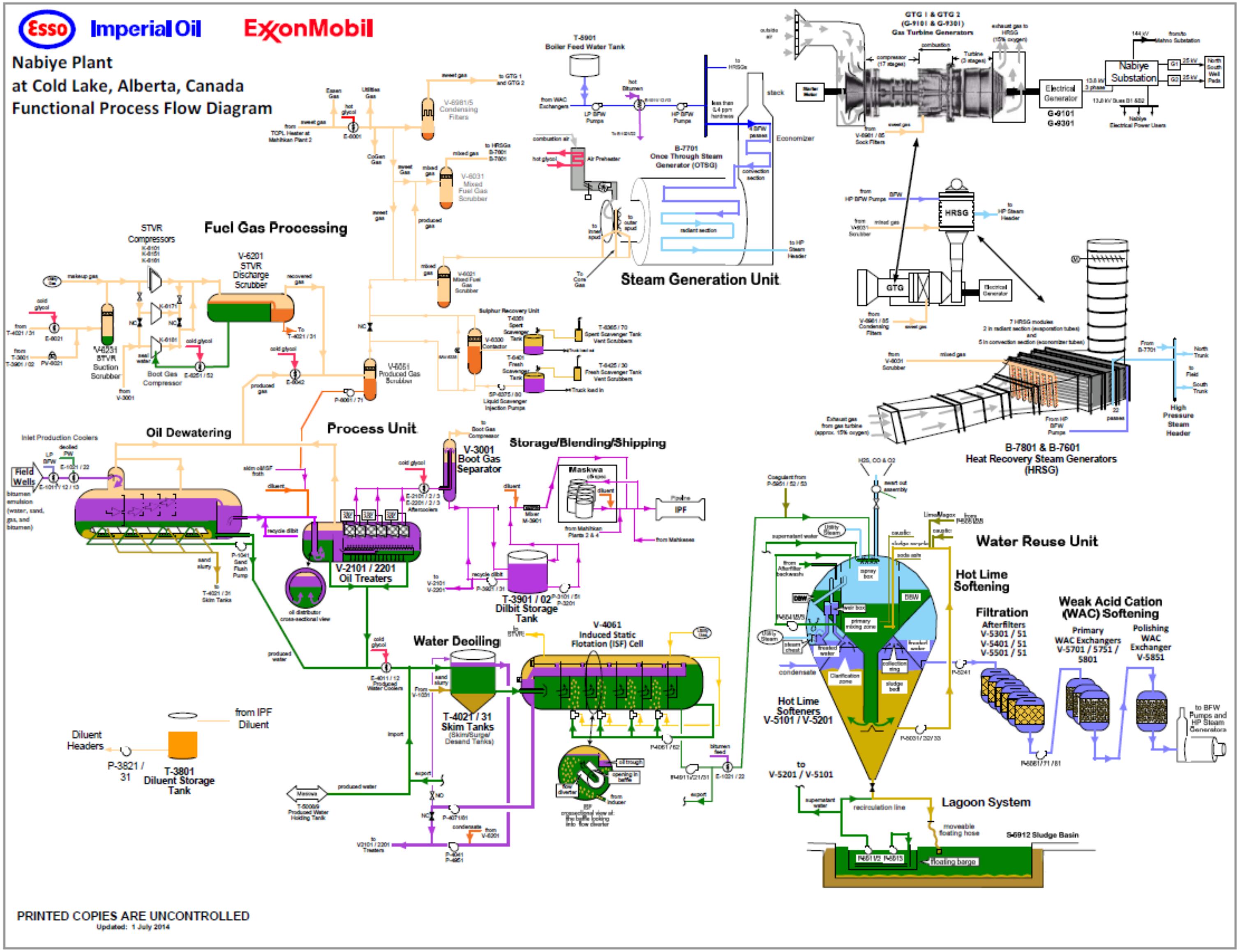
Process Flow Schematics



Process Flow Schematics



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Attachment 8

Cold Lake Water Use

Cold Lake Water Use (cont'd)

Cold Lake Operations Water Management Strategy

- Maximize produced water recycling
- Minimize the need for non-saline water
- Use the non-saline groundwater withdrawal licence for Cold Lake water system maintenance or as a contingency source in the event of lower water levels in Cold Lake

Cold Lake Fresh Water Uses:

- Leming production inlet cooling and HP steam boiler feed water makeup
- Domestic use, safety showers/eyewashes
- Utility boiler feed water for low-pressure steam
- Utility water; sample cooling, seal flush water for pump seals and compressors
- Field wellhead and rig work activities
- Emergency firewater supply

Water Conservation & Improvements

- Early 90's developed capability to utilize brackish water to supplement produced water
- Inter-site produced water transfer systems reduce make-up water requirements and limit disposal of produced water
- Mahkeses & Nabiye freshwater consumption significantly lower than other plants (<100 m3/d)
- Treated water transferred from Maskwa & Mahkeses to Leming reduces freshwater usage
- Brackish water deliverability not an issue to date
- Inter-site steam transfer provide additional water use flexibility
- Completed fresh water reduction initiatives which will reduce freshwater consumption on site by 30% by 2014 (reduction based on average consumption, 2006-2008)

Cold Lake Water Use (cont'd)

- Produced water and Brackish water both contain TDS (Total Dissolved Solids)
- Produced water contains silica (requires MgO treatment)
- Natural waters do not contain silica, tannin and are higher in magnesium
- Produced water contains tannin (helps mitigate Caustic Stress Corrosion Cracking)
- Produced water pH is a function of dissolved CO_2

Brackish and Fresh water well summary:

Well ID	*UWI*	*Regulatory Name*
Brackish water (1-05-65-02-W4M)		
BRAK1CLD	*1F1010506502W 400*	*BRAKISH WATER WELL #1*
BRAK2CLD	*1F2010506502W 400*	*BRAKISH WATER WELL #2*
BRAK3CLD	*1F3010506502W 400*	*IMP MARIE 3 COLDLK 1-5-65-2*
Groundwater (5-22-65-04-W4M) – Licence 00148301-00-00		
FW1-1 CLD	*1F1052206504W 400*	*ESSO FW E1-1 COLD LAKE WW 5-22-65-4*
FW1-2 CLD	*1F3052206504W 400*	*ESSO FW E1-2 COLD LAKE WW 5-22-65-4*
Cold Lake water (14-02-65-02-W4M) – Licence 00079923-00-00		
LEMFWCLD	*1L1140206502W 400*	*COLD LAKE FRESH WATER SOURCE*

Water properties summary:

Parameter	Produced Water	Brackish Water	Cold Lake Water	Ground Water	Disposal Water
pH	~6 to 7.5	~7.5	~7.5	~8	~6 to 7.5
Ca as CaCO3	150 - 300 ppm	85 ppm	90 ppm	200 ppm	150 - 400 ppm
Mg as CaCO3	5–25 ppm	95 ppm	40 ppm	150 ppm	5–100 ppm
Total Hardness as CaCO3	155–325 ppm	180 ppm	130 ppm	350 ppm	155–500 ppm
Alkalinity "M" Alkalinity "TIC"	450 ppm 300 ppm	1000 ppm 1000 ppm	150 ppm 150 ppm	550 ppm 550 ppm	450 ppm 300 ppm
Silica	150–350 ppm	< 10 ppm	< 5 ppm	< 15 ppm	50–350 ppm
Chloride	5000–8000 ppm	4000 ppm	< 5 ppm	< 20 ppm	2000–10000 ppm
TDS	~12000 ppm	~7000 ppm	~300 ppm	~800 ppm	5000-12000 ppm
Tannin	100–200 ppm	0 ppm	0 ppm	0 ppm	50–200 ppm
Dissolved Gases	CH4, CO2, H2S	CH4, CO2	Dissolved Oxygen	CO2	CH4, CO2, H2S

Attachment 9

Plant Licence Limits

Plant Licence Limits

Cold Lake Operations – Operating Plant Licence Limits

Agency	Maximum Daily Inlet Limits	Units	Maskwa	Mahihkan	Mahkeses	Leming	Nabiye	District
AER	Bitumen Inlet	m^3/d	11,000	15,000	8,000	5,000	8,000	40,000
AER	Gas Inlet	km^3/d	600	600	400	250	280	--
AER	Water Inlet	m^3/d	38,000	50,000	28,000	13,500	22,665	--
AER	H_2S Inlet Composition	mol/kmol	9.99	10.00	9.99	9.99	9.99	--
AER	Sulphur Inlet	t/d	8.13	3.00	4.43	3.39	3.76	--
Agency	**Maximum Daily Emission Limits**	**Units**	**Maskwa**	**Mahihkan**	**Mahkeses**	**Leming**	**Nabiye**	**District**
AER	Sulphur	t/d	2.00	3.00	2.00	1.05	0.99	--
AER	NOx	kg/hr	196.66	167.3	135.00	80.24	135.75	--
AER	CO_2	t/d	4,532.00	4,500.00	4,917.00	1,596.40	4323.00	--
AER	Continuous Flaring	km^3/d	0	0	0	0	0	--
AER	Continuous Venting	km^3/d	0	0	0.02	0	0.16	--
AENV	Sulphur Dioxide (SO_2)	t/d	4.00	--	--	2.10	--	13.15
AENV	NOx	kg/hr	--	--	126.00	--	135.75	--
Agency	**Calendar Quarter-Year Daily AVERAGE Emission Limits**	**Units**	**Maskwa**	**Mahihkan**	**Mahkeses**	**Leming**	**Nabiye**	**District**
AER	Sulphur	t/d	1.00	--	--	1.00	--	--
AER	Inlet Produced Gas Sulphur Recovery	%	--	69.7%	69.7%	--	70.0%	--
AENV	Sulphur Dioxide (SO_2)	t/d	--	1.80	1.08	--	1.08	--

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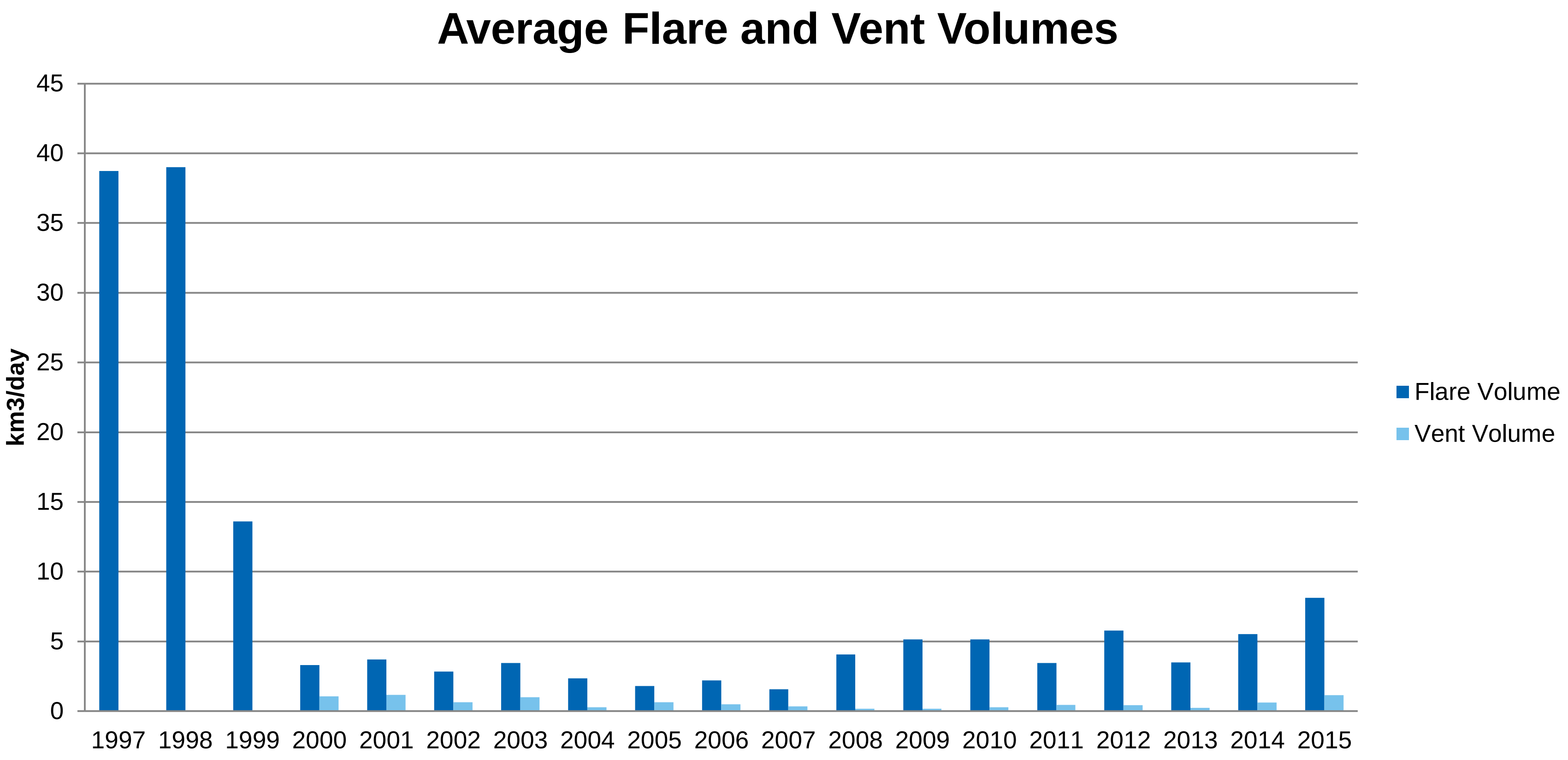
Attachment 10

Monitoring Programs

Flare and Vent

Monitoring Programs – Air Flare and Vent

Flare and vent volumes remain minimal.
Slight increase in flaring volumes attributable to the Nabiye plant start-up.



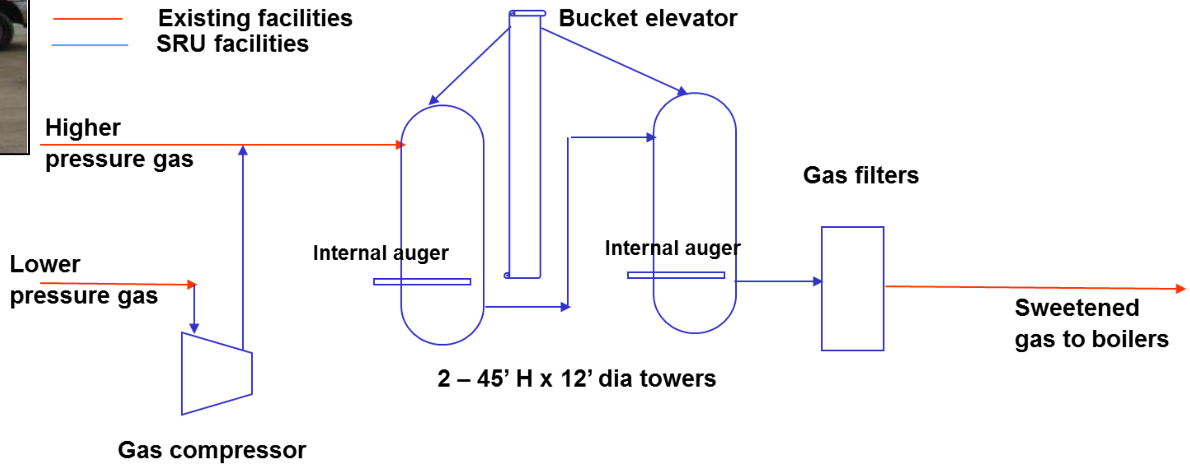
Attachment 11

SRU Description

Mahihkan and Mahkeses

Mahihkan SRU Description

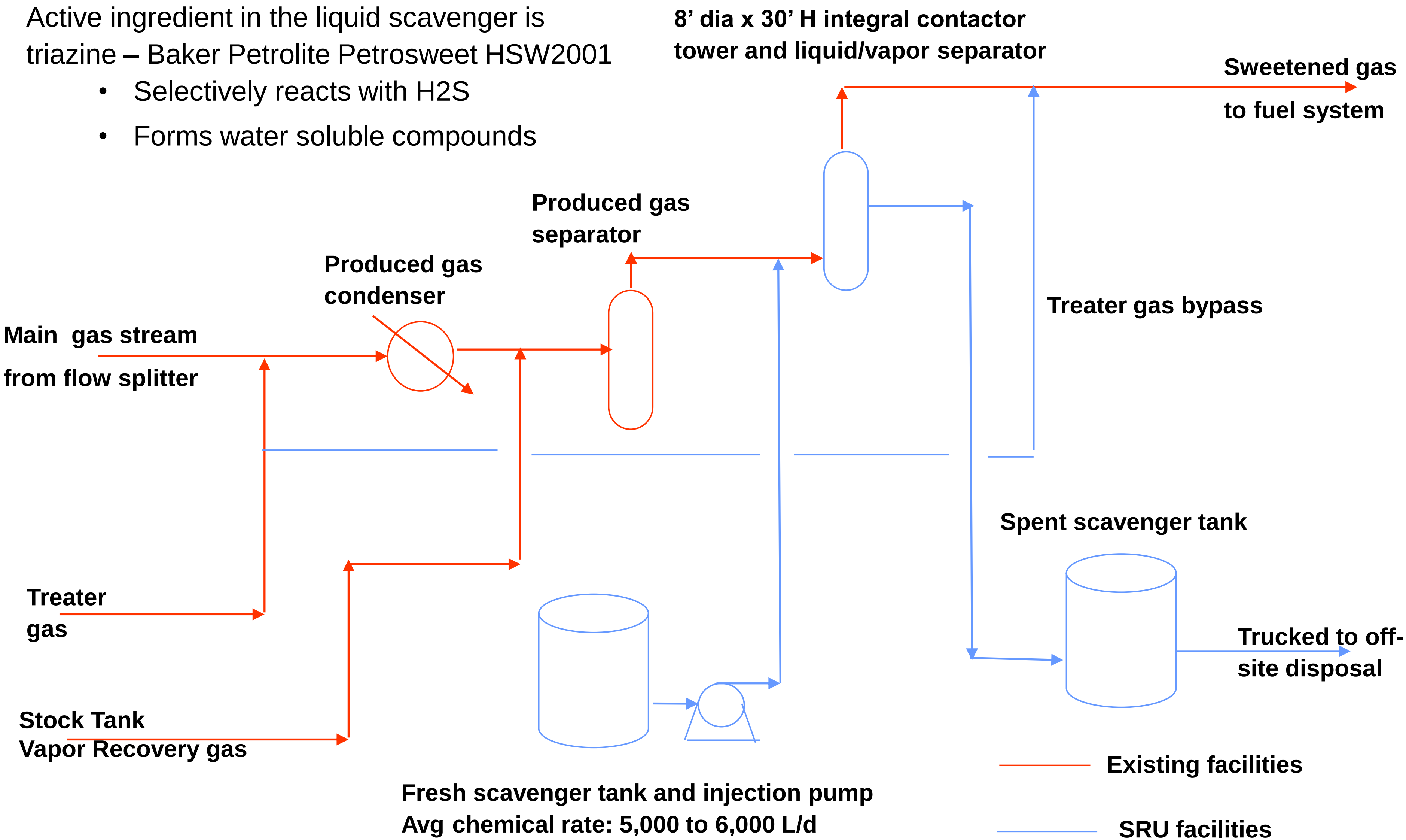
- 2 identical towers for batch operation: 12 ft Diameter by 45 ft Height
- Solid media H_2S scavenger Sulphatreat XLP ®
- Piping and switching valves to allow parallel or series (lead/lag) operation. Bypass included for control of gas rate (pressure drop)
- Screw compressor skid to boost low pressure gas streams to SRU
- Media sock filters at outlet of SRU
- External portable auger and bucket elevator for media loading at top of contactor
- Internal auger for tower unloading



Mahkeses SRU Description

Active ingredient in the liquid scavenger is triazine – Baker Petrolite Petrosweet HSW2001

- Selectively reacts with H2S
- Forms water soluble compounds



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