Statoil

Alberta Energy Regulator - Directive 054
2015 Annual Performance Presentation

Leismer SAGD Project, Approval No. 10935Q

March 10th, 2016

1. Brief Background
2. Geoscience Overview
3. Drilling and Completions
4. Artificial Lift
5. Instrumentation in Wells
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8. Future Plans

The Leismer Project currently includes a Central Processing Facility (CPF) and six well pads, with 35 well pairs and 9 infill wells in total.

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Geoscience Overview

Subsurface Section 1

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LEGEND

- OSE - Oil Sands Evaluation Wells (211)
- OBS - Observation Wells pre-2015 (65)
- WDW – Granite Wash Disposal (4)
- WDW – McMurray Water Disposal Wells (2)
- WSW – Lower Grand Rapids Source Wells (5)
- SAGD – well pairs in Pads L1-L6 pre-2015 (35)
- SAGD – infill wells in Pad L2 in pre-2015 (2)
- SAGD – infill wells in Pads L1-L2 in 2015 (7)
- Existing Drainage Areas (6)
- Leismer Development Area (LDA)
- Watercourse
- Water bodies
- Central Processing Facility (CPF)

Leismer Development Area (LDA) – Well Count

Geoscience Overview

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1. Gross Bitumen in Place (GBIP)
   - Represents the total package that may be accessible via SAGD
   - Petrophysical criteria:
     - Gamma Ray (GR) <= 75 API
     - Resistivity (RT) >= 40 ohm-m
     - Porosity (DPSS) >= 27%
2. Developable Bitumen In Place (DBIP)
   - A more conservative definition used for planning well pair placement
   - Same petrophysical criteria as GBIP

*GBIP Includes DBIP Section

Bitumen Pay Classification

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Both GBIP and DBIP are restricted by lithofacies encountered in core and image logs:

- DBIP is restricted to higher quality lithofacies:
  - F1: Shale-Clast Breccia (if <5m)
  - F2: Trough Cross-Bedded Sand
  - F3: Current-Ripple Laminated Sand
  - F4A-B: Sand with 5-10% Mud Interbeds
- GBIP includes DBIP lithofacies, and:
  - F4C-D: Sand with 10-30% Mud Interbeds
  - F5A-B: Sand with 30-70% Mud Interbeds
- Non Reservoir lithofacies (F6-F7) are not included if they are greater than **2m** in thickness

*GBIP Includes DBIP Section

Reservoir Property	LDA Average	Pads L1-L4 Average	Pad L5 Average	Pad L6 Average
Depth (m TVD)	424	429	444	410
Depth (m subsea)	-216	-221	-222	-230
GBIP Thickness (m)	16.0	24.9	23.8	27.9
Effective Porosity (%)	31.1	32.0	31.9	32.6
Horizontal Permeability (D)	6	6.5	6	6.5
Oil Saturation (%)	84.0	86.0	84.6	85.6
Original Reservoir Pressure (kPa)	-	2,400 - 2,600		
Original Reservoir Temperature (^{o}C)	-	14		

Leismer Reservoir Properties

Geoscience Overview

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Well Pad (50 m Drainage Boundary)	Area (10^3 m^2)	GBIP Rock Volume (10^3 m^3)	McMurray Fm. GBIP (10^3 m^3)
L1	526	14,359	3,977
L2	498	13,015	3,630
L3	411	11,859	3,380
L4	389	9,124	2,428
L5	708	16,810	4,541
L6	571	16,029	4,468
Total	3,103	81,196	22,424
LDA Total	**24,166**	**522,850**	**136,672**

- GBIP is mapped using a seismic compaction trend which is then conditioned to the GBIP picks at the well locations
- GBIP = GBIP Rock Volume X Effective Porosity X Oil Saturation

Gross Bitumen in Place (GBIP) Volumes

GBIP Thickness Map

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DBIP Thickness Map

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GBIP Top Structure Map

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GBIP Base Structure Map

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Gross Bottom Water Thickness Map

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Top Gas Thickness Map

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Volumetrics

- Sand
- Bitumen
- Residual Water
- Free Water
- VSH Mud (Silt and Shale)
- PHIT Mud (Silt and Shale)

LDA Pad L4 Example – 100/16-28-078-10W4/0

Geoscience Overview

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West to East Petrophysical Log Cross-Section – L1 to L6 Area

Geoscience Overview

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North to South Petrophysical Log Cross-Section – L1 to L6 Area

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Volumetrics

- Sand
- Bitumen
- Residual Water
- Free Water
- VSH Mud (Silt and Shale)
- PHIT Mud (Silt and Shale)

LDA Pad L5 Example – 1AC/05-03-079-10W4/0

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West to East Petrophysical Log Cross-Section – L5 Area

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North to South Petrophysical Log Cross-Section – L5 Area

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Seismic Acquisition Map

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- Interferometric Synthetic Aperture Radar (InSAR) – satellite-based radar technique used for mapping surface changes
- INSAR deformation monitoring commenced in April of 2011
  - 89 corner reflectors (with supplemental natural points) installed for Pads L1 to L4 and primary steam pipelines
  - 5 corner reflectors (with supplemental natural points) installed for Pad L5
- Results on Pads L1-L4 to December 27th, 2014 show minimal surface heave (Maximum = 65 mm, Mean = 28.5 mm)
- No InSAR data collected in 2015

InSAR Cumulative Surface Heave – L1 to L4

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- No new cores were obtained or analyzed in 2015 within the LDA
- No petrographic analyses were conducted in 2015
- No geomechanical analyses were conducted in 2015
- No reservoir fracture pressure and caprock integrity tests were conducted in 2015

LDA Geoscience Analysis

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Drilling and Completions

Subsurface Section 2

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7 new infill wells drilled in 2015 (shown in green)

Well Layout

Drilling and Completions

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Pad	Wells	Spacing (m)
L1	P1-P2	100
	P2-P3	100
	P3-P4	100
	P4-P5	100
	P5-P6	100
L1-L2	L2P6-L1P1	100
L2	P1-P2	100-110
	P2-P3	100
	P3-P4	100
	P4-P5	100
	P5-P6	100
L3	P1-P2	75
	P2-P3	75
	P3-P4	100
	P4-P5	100
	P5-P6	100

Pad	Wells	Spacing (m)
L3-L4	L3P6-L4P1	85-95
L4	P1-P2	110
	P2-P3	100
	P3-P4	110
	P4-P5	85
L5	P1-P2	95
	P2-P3	100
	P3-P4	100
	P4-P5	100
	P5-P6	100
	P6-P7	100
L6	P2-P3	100
	P3-P4	100
	P4-P5	100
	P5-P6	100

Wellpair Spacing

Drilling and Completions

Pad	Year drilled	Number of wells	Injector sand control	Injector Tubing	Producer Sand Control	Flow Control Devices (FCDs)
L1	2009	6 WPs	8-5/8″ slotted	Parallel	7″ or 8-5/8″ slotted or wire-wrap screen	None
L2	2009	6 WPs	8-5/8″ slotted	Parallel	7″ or 8-5/8″ slotted or wire-wrap screen	None
L3	2009	6 WPs	8-5/8″ slotted	Parallel	7″ slotted	None
L4	2009	5 WPs	8-5/8″ slotted	Parallel	7″ or 8-5/8″ slotted or wire-wrap screen	1 injector (on tubing)
L5	2013	7 WPs	7″ slotted	Concentric	6-5/8″ or 7″ wire-wrap screen	2 injectors (on liner) 4 producers (on liner)
L6	2014	5 WPs	7″ slotted	Concentric	6-5/8″ or 7″ wire-wrap screen	3 injectors (on tubing) 3 producers (on liner)
L2	2014	2 infills	n/a	n/a	7″ wire-wrap screen	None
L1, L2	2015	7 infills	n/a	n/a	7″ wire-wrap screen	None

- Earlier Pads L1-4 focused on optimization of sand control and liner size
- Later Pads L5-6 focused on optimization of FCDs and injector tubing configuration

Completions Overview: Tubing & Liner Configuration

- Producer wells are initially completed with parallel tubing for the circulation phase
- Producer wells are re-completed to ESP after circulation
- Injector wells are not re-completed after circulation and remain in their initial parallel or concentric tubing configuration

Producer Well Completion During Start-up Circulation

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- Injectors completed with parallel tubing
- Instrumentation carried inside 1.75″ coiled tubing

Typical Well Completion During Production Phase: Pads L1-4

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- Injectors completed with concentric tubing
- Instrumentation carried inside 1.5" coiled tubing. Coil run inside 2-3/8" guide string.
- 5 of 7 injectors on Pad L5 completed with VIT on long tubing
  - Pad L5 start-up showed 10-15% steam savings with VIT during circulation compared to a concentric completion with no VIT

Typical Well Completion During Production Phase: Pads L5-6

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Artificial Lift

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- 31 ESPs running from 3 vendors
  - 25 month MTTF days since field start-up
  - 15 month average run life
- ESP sizes allow for rates 200-1200 m³/d
- Intake conditions:
  - 180-235°C
  - 2500-3300 kPag
- Downhole scale issues on 2 ESPs in 2015:
  - Scale builds-up on production tubing and is pushed downhole during ESP changes
  - Wells were cleared and replacement ESPs were landed at target depth
  - Scale is predominantly silicate-based
  - Investigating scale treatment options

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Instrumentation

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Pad	Number of wells	Wellbore Instrumentation	Additional Instrumentation
L1	6 WPs	10 thermocouples in horizontal 3 bubble tubes (pump, heel, toe)	L1P3, L1P4, L1P5: DTS fiber on (since failed); L1I3: 5 thermocouples + 2 piezos (failed) + BT
L2	6 WPs	10 thermocouples in horizontal 3 bubble tubes (pump, heel, toe)	L2P2: DTS fiber; L2I3: 6 thermocouples + BT
L3	6 WPs	10 thermocouples in horizontal 3 bubble tubes (pump, heel, toe)	L3P1, L3P2, L3P3: 40 point fiber; L3I3: 6 thermocouples + BT; L3P3: fiber pressure gauge
L4	5 WPs	10 thermocouples in horizontal 3 bubble tubes (pump, heel, toe)	None
L5	7 WPs	10 thermocouples in horizontal 2 bubble tubes (heel, toe)	L5P7, L5I1: fiber pressure gauge (heel); L5I5, L5P5, L5I7, L5P7: 3 T/C's on surface casing
L6	5 WPs	10 thermocouples in horizontal 2 bubble tubes (heel, toe)	L6I2, L6I4, L6I6: DTS fiber
L2	2 infills	40 point fiber 2 fiber pressure gauges (heel, toe)	None

- Instrumentation typically deployed inside coiled tubing
- Recent installations involve pumping down instrumentation inside a guide string
- Measurements from thermocouples and fiber have been comparable

Example observation wellhead

- 30 thermocouples, spaced at 1 m, above, below, and within SAGD pay
- Some wells are equipped with fiber optics (DTS) instead of thermocouples
- 3 to 4 piezometers in bitumen, bottom water, and top lean/gas zone

Observation (Obs) Wells

Instrumentation

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4D Seismic

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- **Q1 2009**: 4.9km^2 baseline survey acquired (pre-steam) over L1- L4
- **Q1 2012**: 8.6km^2 3D survey
  - 1st 4D survey (4.9km^2 of active SAGD pads L1-4)
  - New baseline survey for L5 and L6 (3.7km^2)
- **Q1 2013**: 4.5km^2 3D survey
  - 2nd repeat survey (4.9km^2 of active SAGD pads L1- L4)
- **Q1 2014**: 2.1km^2 4D survey (active SAGD pads L3 and L4)
- **Q1 2015**: 9.0km^2 3D survey
  - 3rd 4D repeat survey (2.2km^2 of active SAGD Pads L1 and L2)
  - Repeat 3D seismic for higher resolution data

Acquisition History

4D Seismic

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- 4D seismic anomalies indicate a high degree of conformance along SAGD well pairs
- Irregularities are mainly attributable to reservoir heterogeneity and, in some cases, to heat transfer below the producer elevation into the basal McMurray Fm. (i.e., bottom water)

Survey Comparison

4D Seismic

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Scheme Performance

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Leismer Project Trend

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Production Increased from 2014 (average production 16,100 bopd) due to:

- Production efficiency
  - High steam reliability
  - Reduced ESP downtime and failures
  - Improved production during planned and unplanned events
- Pads L1-5 optimization
  - Negative reservoir retention
  - Bottom water pressure management
  - Lower subcool targets
- Pad L5 ramp-up
- Pad L2 additional wells
  - 2 infill wells
  - start-up of L2P2

2015 avg production 19,925 bopd

2015 Highlights

Scheme Performance

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Well Pad (50 m Drainage Boundary)	Area (10^3 m^2)	GBIP Rock Volume (10^3 m^3)	McMurray Fm. GBIP (10^3 m^3)	Cumulative Production (10^3 m^3)	GBIP Recovery To Date	Predicted Recovery Factor after 15 years
L1	526	14,359	3,977	1,283	32%	65-75%
L2	498	13,015	3,630	1,030	28%	75-85%
L3	411	11,859	3,380	1,189	35%	50-60%
L4	389	9,124	2,428	772	32%	65-75%
L5	708	16,810	4,541	228	5%	45-55%
L6	571	16,029	4,468	0	0%	60-70%
Total	**3,103**	**81,196**	**22,424**	**4,502**	**20%**	**~70%**
LDA Total	24,166	522,850	136,672			

- GBIP, Cumulative Production, and Recovery Factor (RF) valid as of December 31, 2015
- Predicted GBIP RF based on 2D volumetrics and simulations

Pad Recoveries

Scheme Performance

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Production Performance – Pad L1

Scheme Performance

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- Pad L1 continues to be a strong performing pad

  2015 avg production = 5530 bopd from 6 well pairs

- 4D seismic shows steam chamber has grown vertically and laterally between 2013 and 2015
- Subcool targets were reduced in Q4 2014 and positively impacted production over 2015
  - Wells are controlled off minimum wellbore subcool, as calculated at thermocouple points and using the heel or toe pressure
  - New subcool targets are >3°C for each well. Previously, minimum subcools varied from 10-20°C based on bottom water management strategies used at the time
  - Operations at low subcool show no negative impact on bottom water influx and no liner integrity issues
  - Pump intake subcool remains above 10°C indicating a balance of cooler and warmer fluids entering the well
- Infill wells drilled in 2015 are planned to be started in 2016

Production Performance – Pad L1

Scheme Performance

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102/05-27-078-10W4/0

L1P2T (20.5 m away from L1P2)

● Approximate Injector Location

● Approximate Producer Location

Dec 2015	Aug 2015	Apr 2015	Jan 2014
Nov 2015	Jul 2015	Mar 2015	Jan 2013
Oct 2015	Jun 2015	Feb 2015	Jan 2012
Sep 2015	May 2015	Jan 2015	Jan 2011

Pad L1 Observation Well

Scheme Performance

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A mix of sand control liners were used on Pads L1-4

Sand control type	Number of producer wells	Observations after 5 years of operation
Wire-wrap screen	8	- Less than 200 kPa deltaP between injector-producer - Consistently low deltaP (good performance)
Slotted liner	15	- Typically less than 400 kPa deltaP; exceptions: L3P5 - 900 kPa, L1P1 – 500 kPa, L3P6 - 500 kPa - Overall good performance on slots

No sand production issues with either wire-wrap screen or slotted liners

Pad L1 provides a good comparison with 3 WWS and 3 slotted liner wells (normalized to emulsion rate)

Production Performance - Pad L5

Scheme Performance

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- Pad L5 is in challenging reservoir with varying quality and close proximity to bottom water

2015 average production = 3060 bopd from 7 well pairs

- Higher water cut (85%) due to bottom water influx
  - Supports negative water retention targets for Leismer
- No significant geological barrier between bitumen pay and bottom water
- Nearest pad to Leismer disposal wells

O/W contact located in high quality facies

Production Performance - Pad L5

Scheme Performance

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100/05-03-079-10W4/0

L5P4M (40 m away from L5P4)

● Approximate Injector Location

● Approximate Producer Location

Dec 2015	Aug 2015	Apr 2015	Jan 2014
Nov 2015	Jul 2015	Mar 2015	Jan 2013
Oct 2015	Jun 2015	Feb 2015	Jan 2012
Sep 2015	May 2015	Jan 2015	Jan 2011

Pad L5 Observation Well

Scheme Performance

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- Liner-deployed FCDs installed on 4 producer wells and 2 injector wells
  - 2014 ramp-up was accelerated by operating at zero wellbore subcool
  - In general, bottom water influx has lead to cooling of wellbore fluids
    - Consequently, minimum subcools on Pad L5 are higher compared to other pads
  - FCDs on injector wells have resulted in more uniform subcool conformance in the corresponding producer well

Production Performance – Pad L5

Scheme Performance

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Production Performance – Pad L2

Scheme Performance

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Production Performance – Pad L2

Scheme Performance

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Pad L2 2015 average production = 4770 bopd from 5 well pairs + 2 infills

- L2P2 started in 2015
  - Solvent (diesel) was injected in the injector and producer to accelerate start-up
    - Challenging reservoir with an interval of high quality pay at the heel and IHS dominated mid-to-toe
    - Converted to ESP in under 50 days
    - Pressure applied with nitrogen to squeeze solvent into reservoir
  - L2P2 observation well is indicating formation temperatures less than 20°C

Production Performance – Pad L2

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104/04-27-078-10W4/0

L2P6H (27 m away from L2P6)

- Approximate Injector Location
- Approximate Producer Location

Dec 2015	Aug 2015	Apr 2015	Jan 2014
Nov 2015	Jul 2015	Mar 2015	Jan 2013
Oct 2015	Jun 2015	Feb 2015	Jan 2012
Sep 2015	May 2015	Jan 2015	Jan 2011

Pad L2 Observation Well

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Solvent Co-Injection Pilot (SCIP) at Pad L3

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- Pilot start was delayed from original plan due to construction issues
- Co-injection of condensate was carried out from November 2013 to December 2014
  - Condensate injected at 1-5% by volume at wells: L3P3, L3P4, L3P5
- Facility upset complicated pilot operations
- Recovery of injected solvent was approximately 20% up to Q2 2015
- Upsets to sampling equipment impacted the solvent recovery monitoring in Q3/Q4 2015
- Neighboring control wells, L3P2 and L3P6, also produced solvent. L3P1 and L4P1 were not sampled.
- Technology still being considered for commercial application based on pilot learnings and industry knowledge

Successes

- Reduction in steam usage resulting in increased steam availability for the field
- Operational experience for handling and injecting steam-solvent agents
- Knowledge generation related to solvent-aided processes and solvent recovery monitoring
- Indications of higher hydrocarbon recovery (less residual oil) from pore volume

Challenges

- Performance risks: rate of solvent recovery still uncertain
- Subsurface limitations: chamber coalescence, thief zones, bottom water
- Surface equipment: injection and compositional sampling systems

Solvent Co-Injection Pilot (SCIP) at Pad L3

Scheme Performance

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- Throughout 2015, bottom water pressure continued to rise
- Two significant events occurred:
  1. NCG Injection / high source water / high water disposal
  2. Source water stabilization test

- Bottom water pressure originally 2300 kPa
- Pressure rose rapidly with start-up of initial 4 pads
- Strong pressure communication between pads
- Stabilization test shows potential to manage bottom water pressures by minimizing source water

Bottom Water Pressure

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- The bottom water pressure rise observed throughout 2015 was not uniform across the field
- Bottom water pressures at specific locations are dependent on:
  - Regional geology
  - Local reservoir heterogeneity
  - Local bottom water thickness
  - Local steam injection rates
  - Proximity to disposal wells

Bottom Water Pressure

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- Negative retention achieved Q4 2013
- Disposal and retention are controlled to minimize bottom water pressure variations

Bottom Water Retention

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Steam pressure

- Steam is delivered to pads at about 7,000 – 9,000 kPa
- Steam pressure dropped to 5,000 – 6,000 kPa at the pad

Typical steam quality

- Steam quality decreases during transportation to well pads due to heat losses
  - Estimated at 95% at Pads L1-4
  - Estimated at 90% at Pad L5 due to longer, larger diameter pipe line

Steam quality variations

- Steam quality varies as steam rates are increased/decreased
- Most consistent at Pads L1-4 due to shared trunk line
- Most variable at Pad L5 due to additional 4 km steam line off main trunk line

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Future Plans

Subsurface Section 7

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2016 Subsurface Development Plans

- Continued non-condensable gas co-injection at Pad L4
- Pad L6 start-up and conversion to SAGD (5 well pairs)
  - 3 producer wells with liner-deployed FCDs
  - 3 injector wells with tubing-deployed FCDs
- Pad L1 infill well completions and first steam in Q3/Q4 2016 (7 wells)
  - Metal-to-Metal PCPs on 2 wells
- Pad L5 infill well drilling during Q2 2016 (4 wells)
- Pad L4 sidetrack lateral

Pad abandonments

- No pad abandonments anticipated at Leismer within next five years

- Total steam capacity is 69,000 bbl/d (11,000 m³/d)

Leismer Steam Requirements

Future Plans

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There's never been a better time for good ideas

Presentation: Leismer 2015 Annual Performance Presentation (D054) to Alberta Energy Regulator

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