Premium Value.
Defined Growth.
Independent.
Canadian Natural

JACKFISH IN SITU PROJECT DIRECTIVE 54 ANNUAL PERFORMANCE PRESENTATION

Commercial Scheme Approval 10097 (as amended)

November 2019

Outline – Subsurface

Outline – Surface

Canadian Natural

Subsurface Operations

Canadian Natural

Project Background
3.1.1-1

Brief Background of Scheme

Jackfish

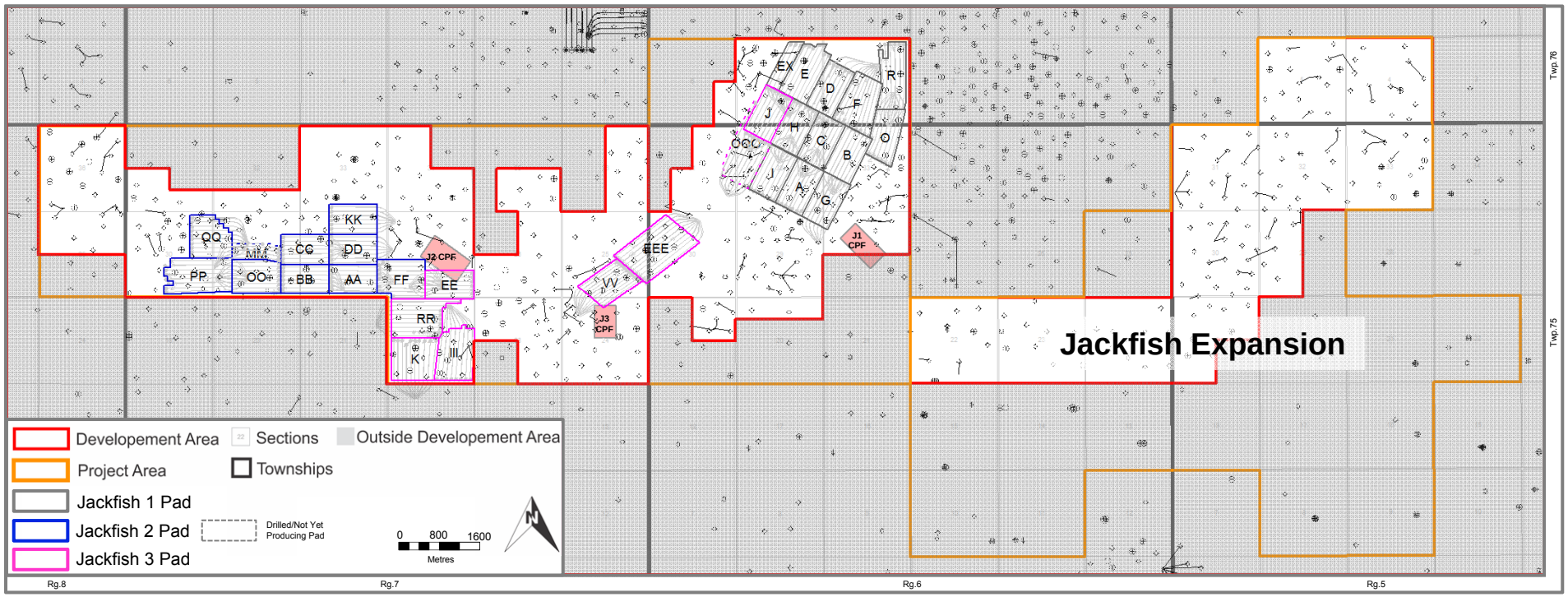
3.1.1-1

- Jackfish 1, 2, and 3 utilize steam-assisted gravity drainage (SAGD) to recover bitumen from the McMurray formation
- Located 150 km south of Fort McMurray
- Jackfish 1 scheme approval granted August 2006; first steam August 2007
- Jackfish 2 scheme approval granted August 2008; first steam May 2011
- Amalgamation of Jackfish approvals (including Jackfish 3) November 2011; first steam July 2014
- Jackfish Expansion approval granted in August 2019

Brief Background of Scheme

Jackfish

3.1.1-1



Brief Background of Scheme

Jackfish

3.1.1-1

Asset	Number of Operating Pads	Number of Operating Well Pairs	Upcoming Pads
Jackfish 1	11	78	-
Jackfish 2	8	60	-
Jackfish 3	7	51	-
TOTAL	**26**	**189**	**-**

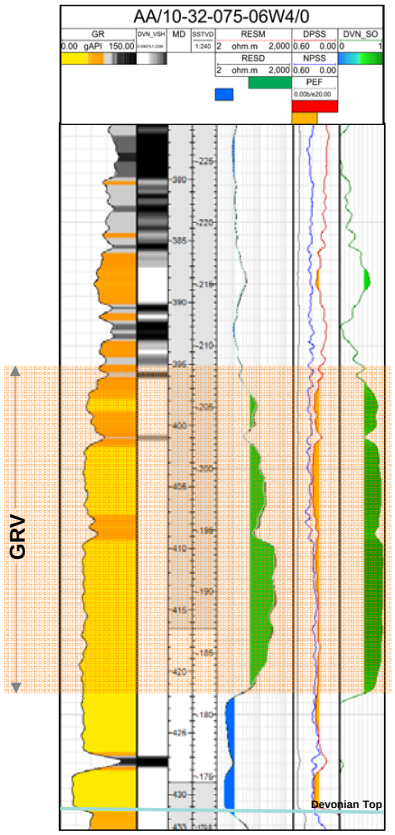
Canadian Natural

Geology, Seismic
3.1.1-2, 3.1.1-6

Geology

Jackfish Gross Rock Volume Pay Definition

3.1.1-2a



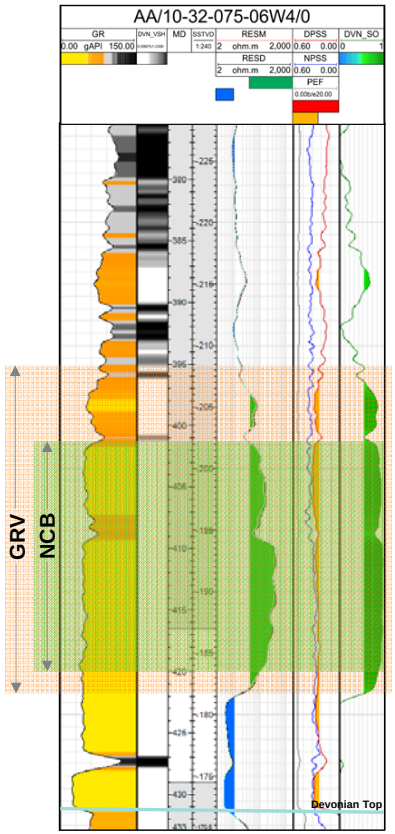
Gross Rock Volume (GRV)

- Characterizes the complete package accessible through SAGD
- Defined by:
  - S_o > 50%
  - V_{sh} < 40%
  - encompasses all brecciated intervals
- V_{sh} and S_o are standard petrophysical curves calculated from gamma ray, resistivity, and porosity logs, and correlated to image logs and core data

Geology

Jackfish Net Continuous Pay Definition

3.1.1-2a



Net Continuous Bitumen (NCB)

- More conservative definition used to define continuous bitumen pay, used for pad and well pair planning
- Defined by:
  - V_{sh} < 40%
  - can contain up to 1m continuous non-reservoir
  - excludes breccias that do not meet V_{sh} cutoff
  - base defined by producer (actual or estimated) elevation
- V_{sh} and S_o are standard petrophysical curves calculated from gamma ray, resistivity, and porosity logs, and correlated to image logs and core data

Geology

Jackfish Volumetrics and Average Reservoir Properties

3.1.1-2a,b

	Area (Ha)	OBIP(10^6m^3)	Avg. GRV thickness (m)	Avg. Oil Saturation (So)	Avg. Porosity (%)
Project Area	**13,802**	**633.95**	**19.06**	**71.7**	**33.6**
Development Area	**8,161**	**506.88**	**25.4**	**72.5**	**33.7**

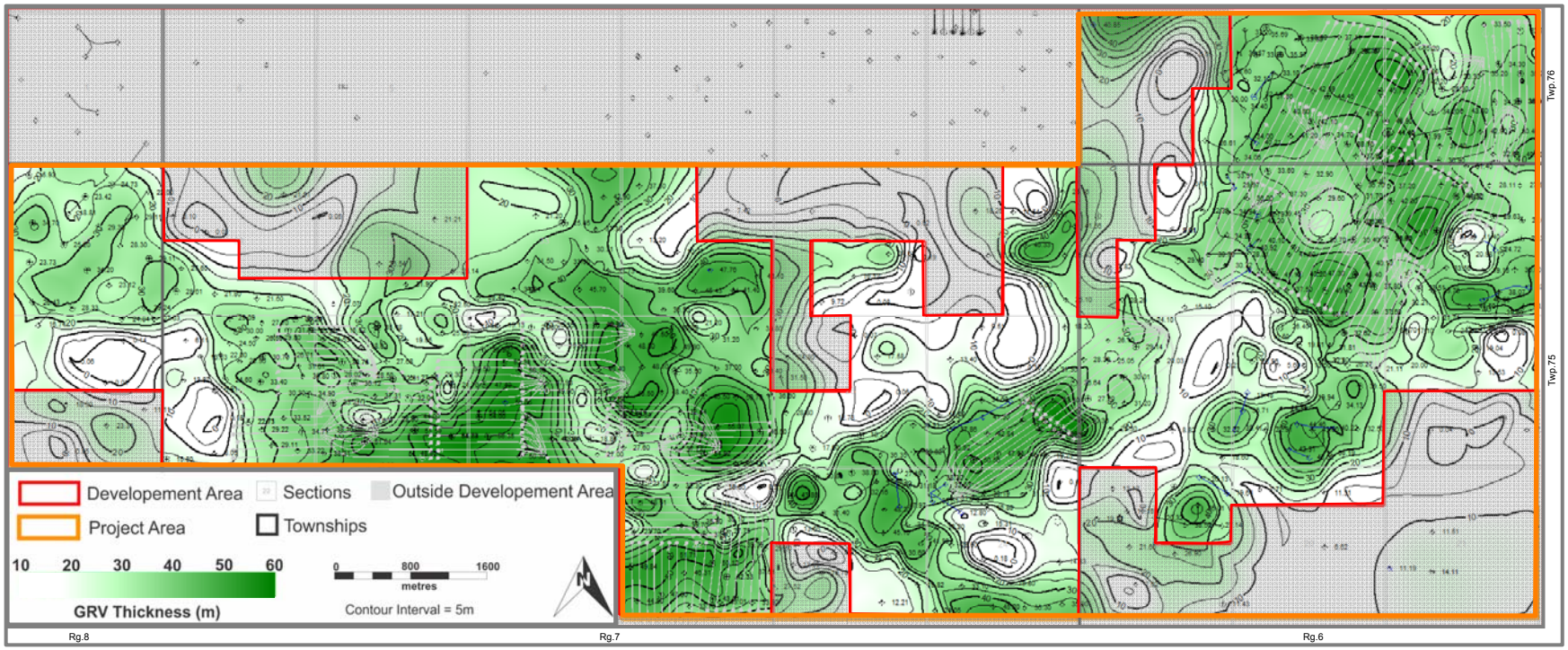
Property	**Jackfish 1**	**Jackfish 2**	**Jackfish 3**
OBIP *(10^6m^3)**	75.3	81.3	67.5
Avg. Reservoir Depth (*mTVD)* Avg. Reservoir Depth (*mASL)*	400 202	459 202	428 202
Avg. Original Reservoir Pressure *(kPa)*	2,700 @ scheme startup	2,700 @ scheme startup	2,700 @ scheme startup
Avg. Reservoir Temp. (*ºC)*	12	12	12
Avg. Kh *(md)*	5,000	3,000	4,000
Avg. Kv *(md)*	2,000	1,200	1,500
Avg. Phi *(%)*	33	33	33
Avg. Bitumen Viscosity *(Cp)*	1,000,000+	1,000,000+	1,000,000+
Original Bottom Water Pressure *(kPa)*	2,300	2,300	2,300

*Total for all producing, drilled, and planned pads

Geology

Jackfish Gross Rock Volume Pay Thickness

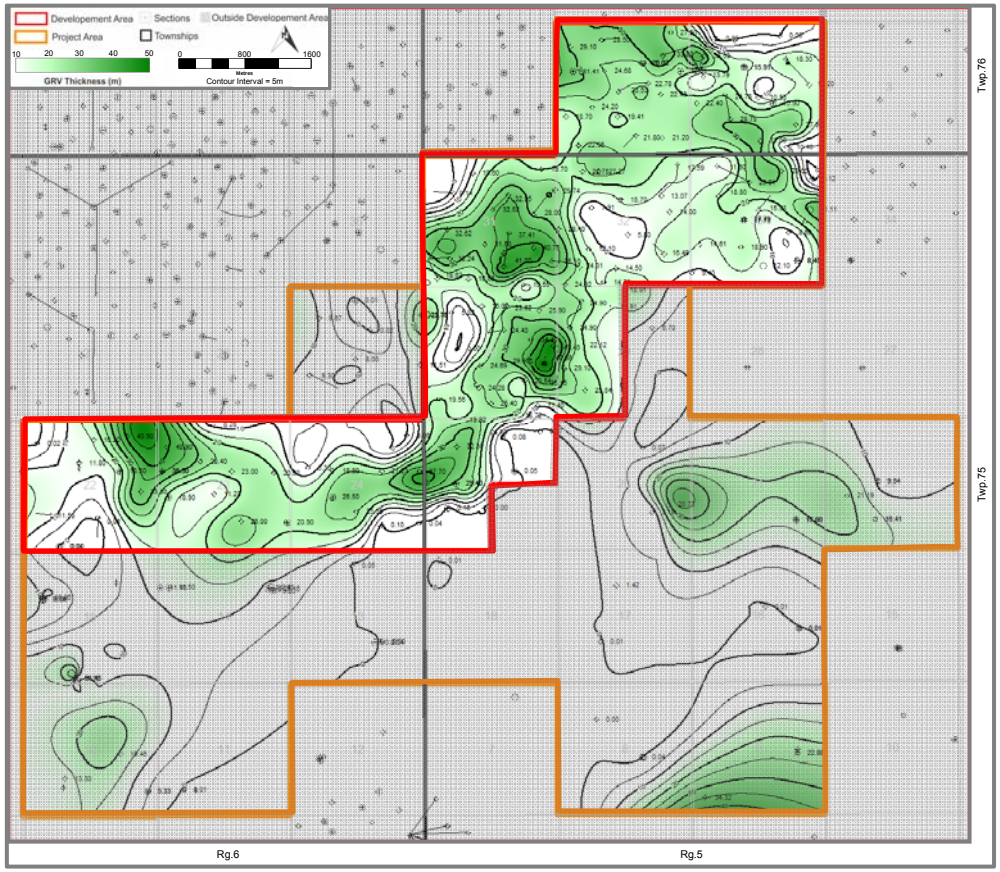
3.1.1-2c



Geology

Jackfish Expansion Gross Rock Volume Pay Thickness

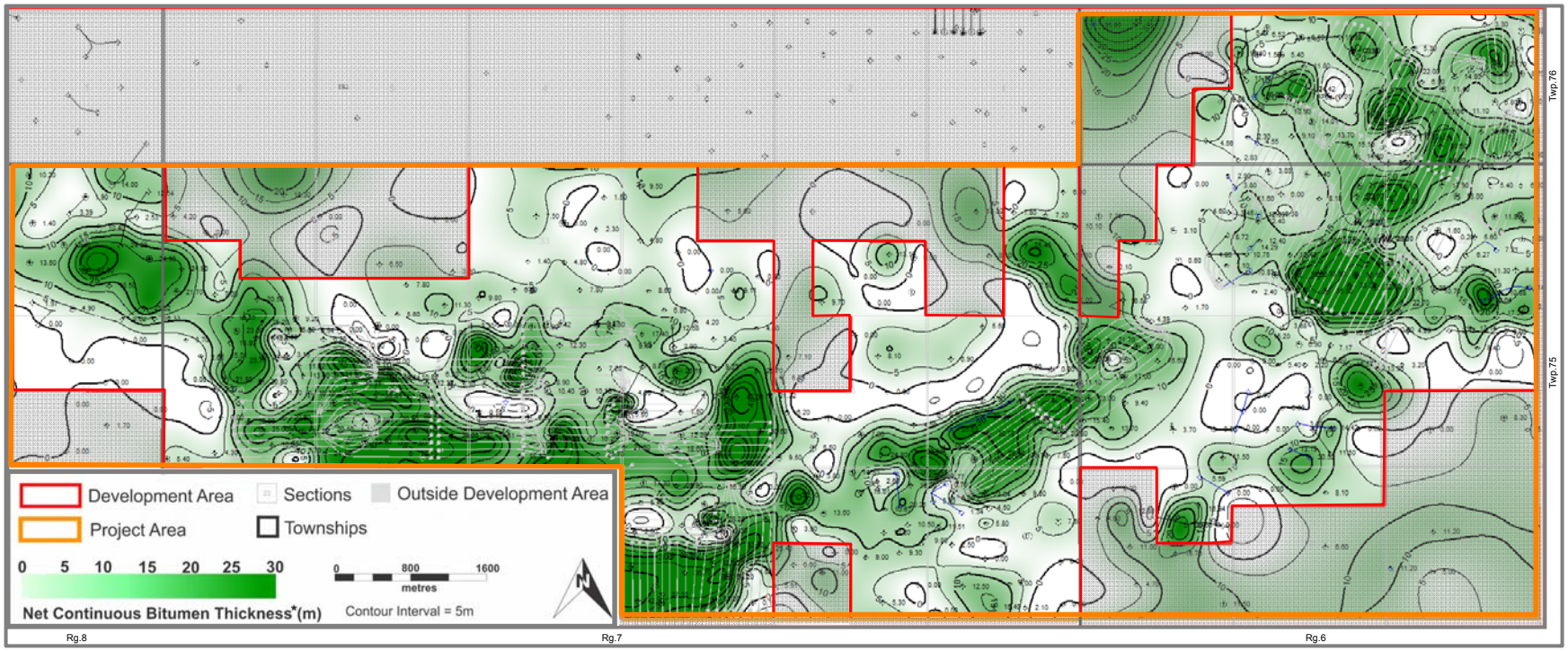
3.1.1-2c



Geology

Jackfish Net Continuous Bitumen Isopach

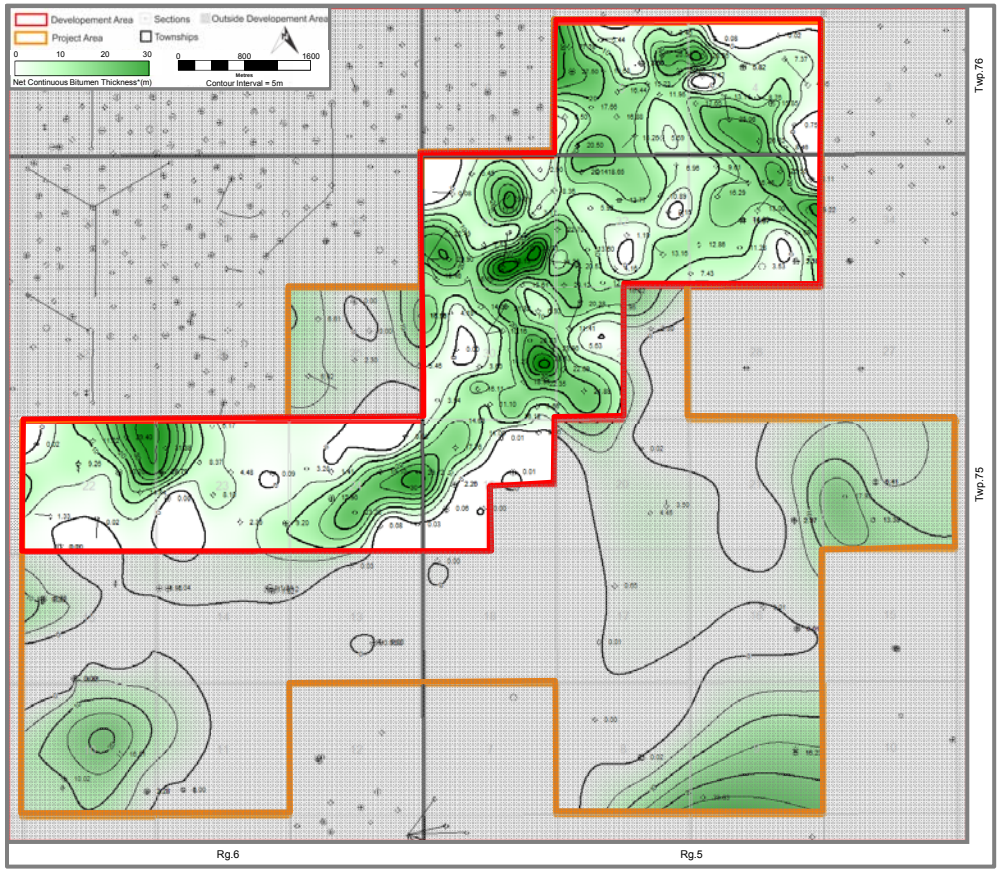
3.1.1-2c



Geology

Jackfish Expansion Net Continuous Bitumen Isopach

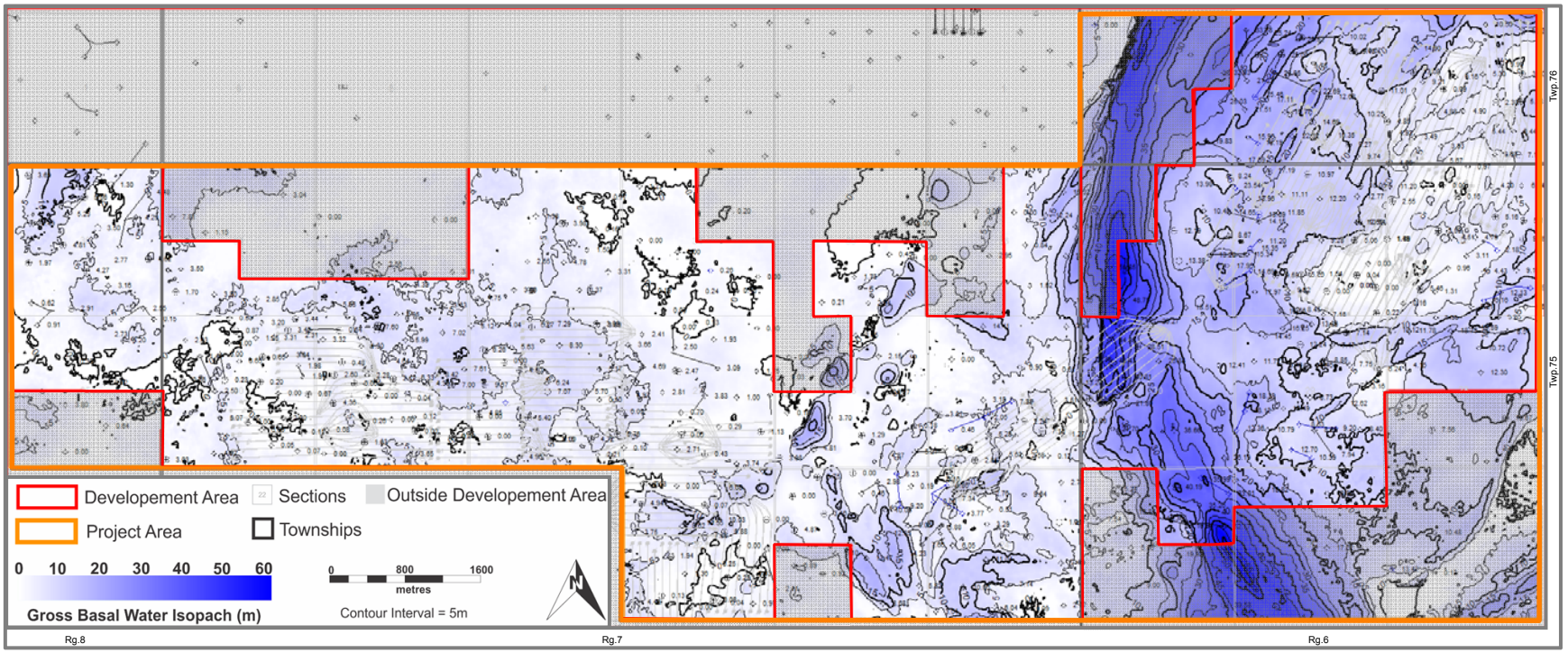
3.1.1-2c



Geology

Jackfish McMurray Water Contact to Paleozoic Isopach

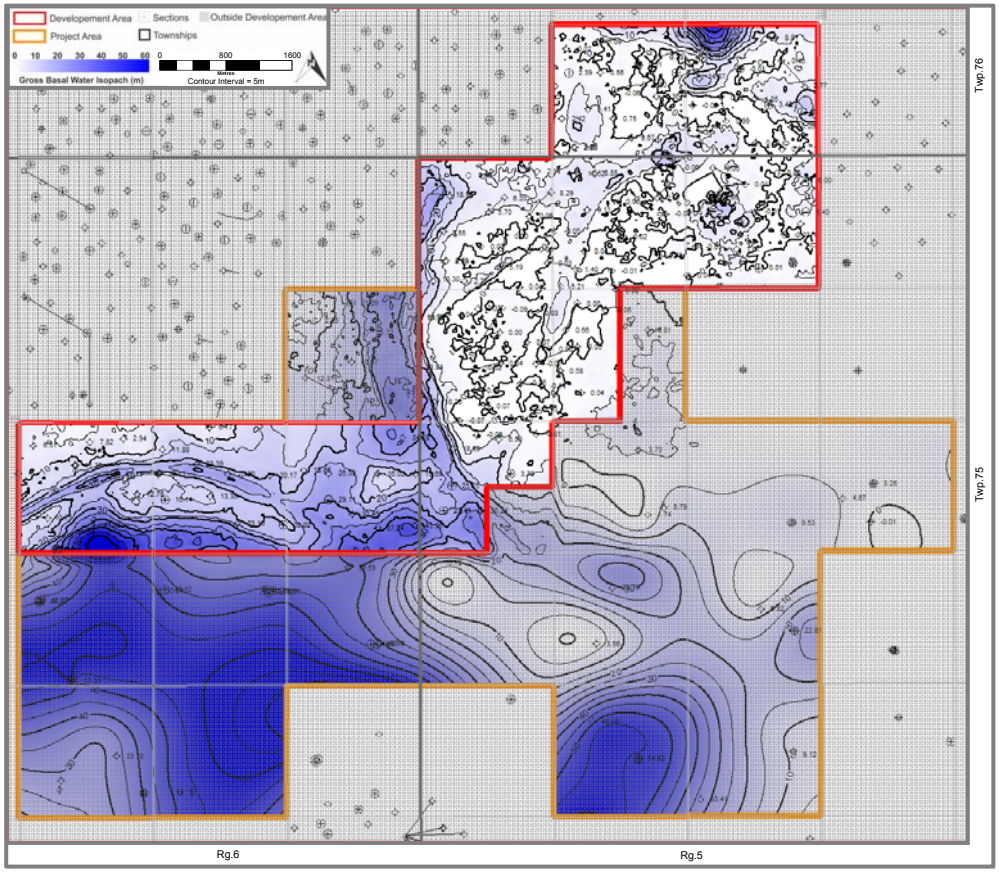
3.1.1-2c



Geology

Jackfish Expansion McMurray Water Contact to Paleozoic Isopach

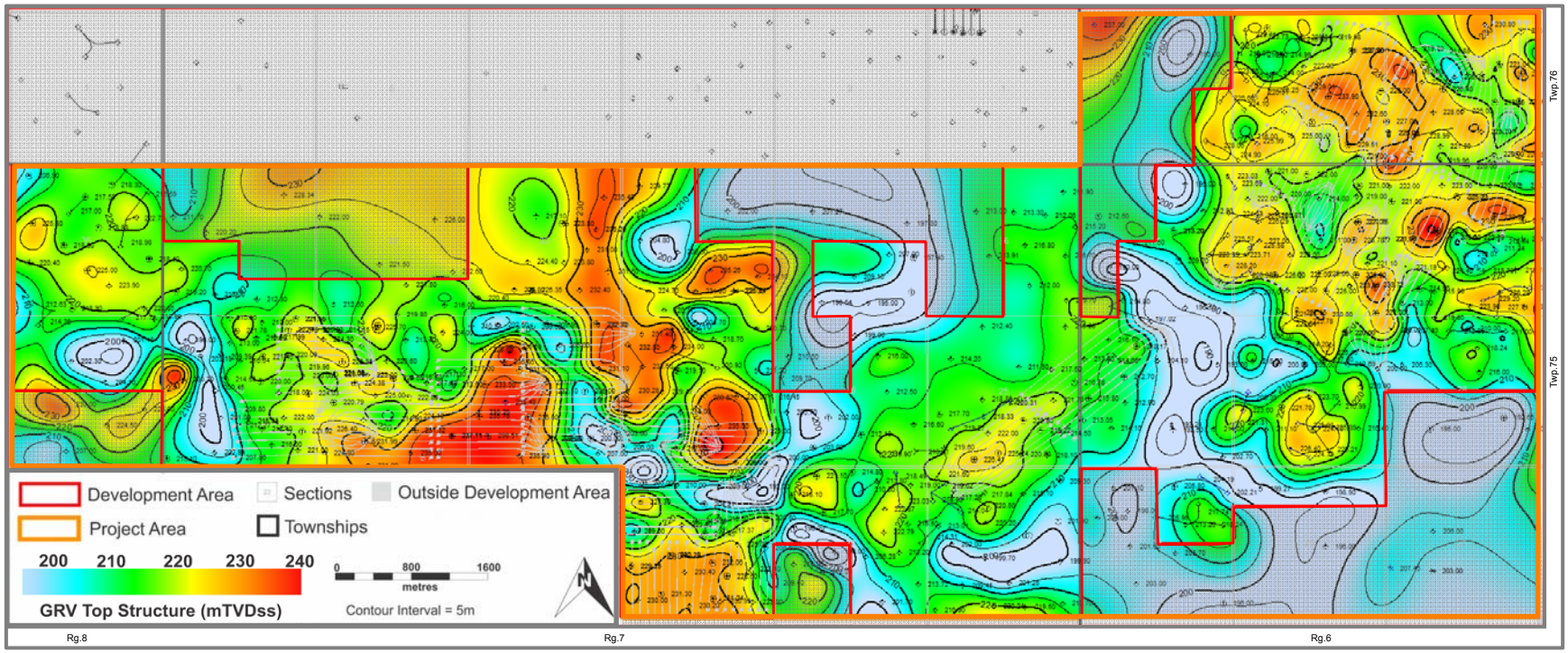
3.1.1-2c



Geology

Jackfish Top Structure of Gross Rock Volume

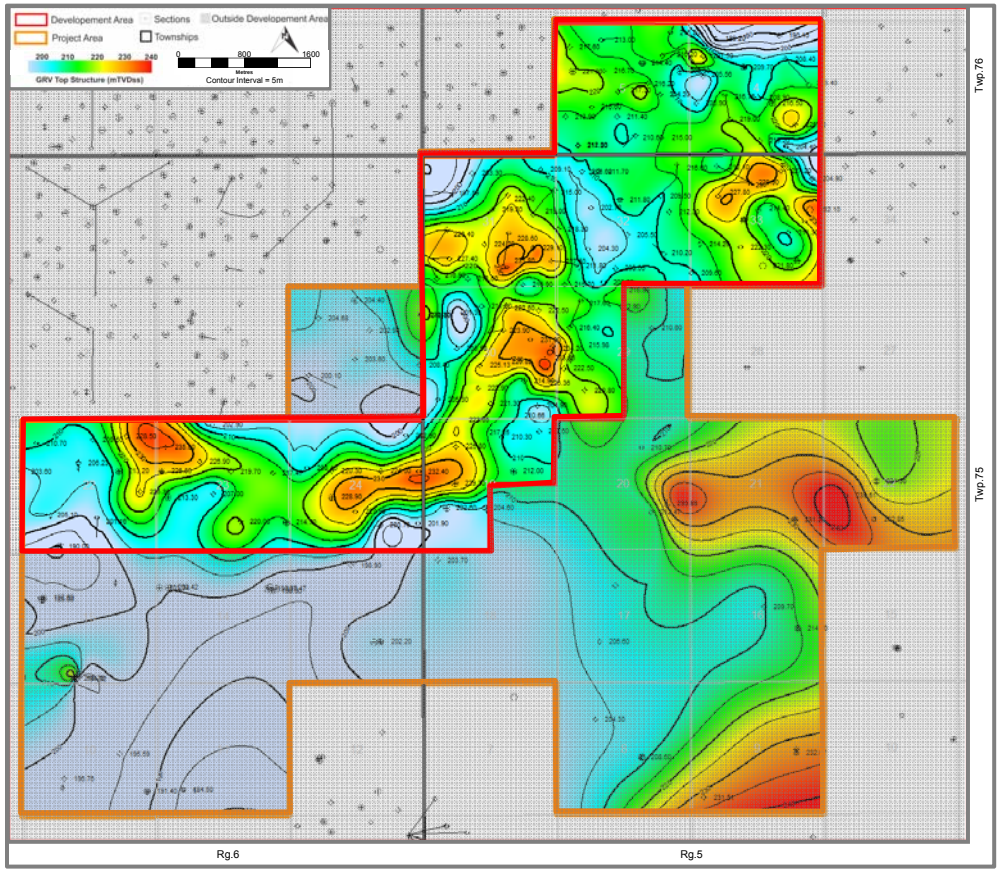
3.1.1-2d



Geology

Jackfish Expansion Top Structure of Gross Rock Volume

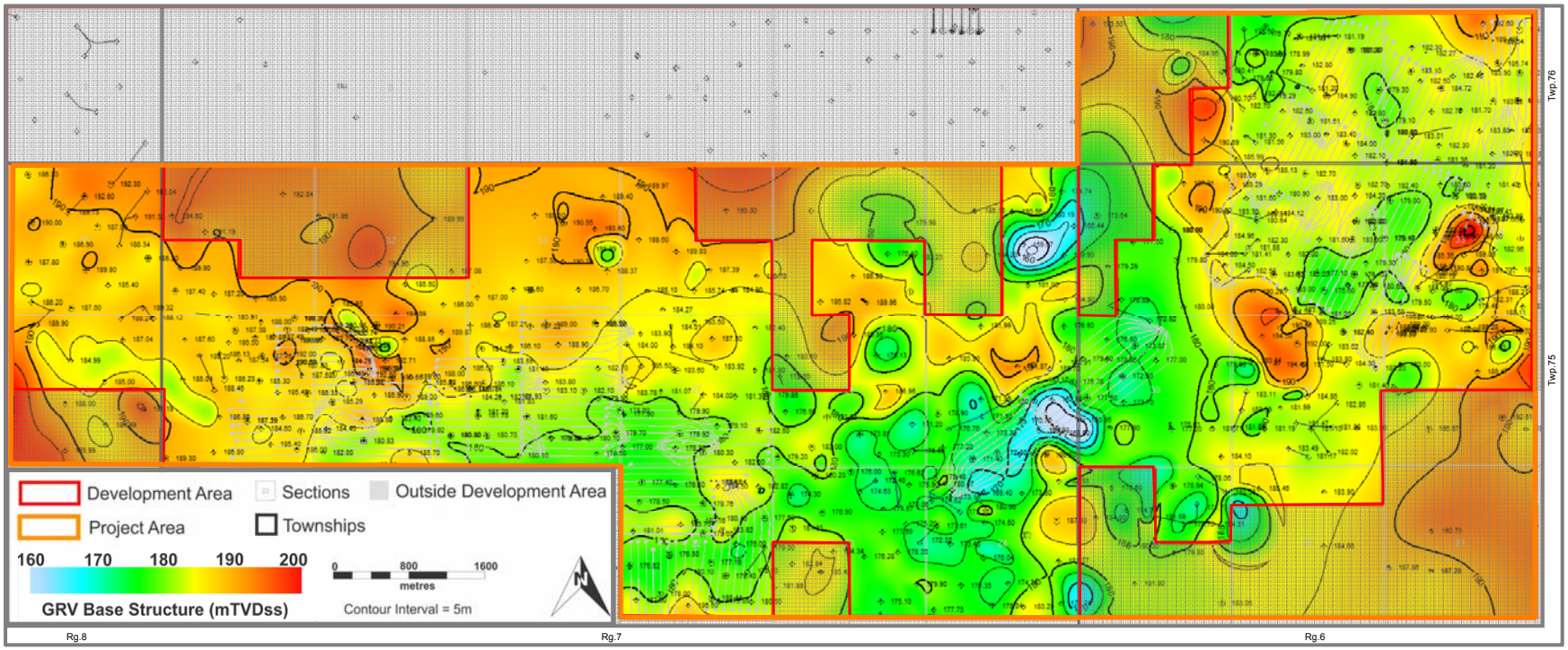
3.1.1-2d



Geology

Jackfish Base Structure of Gross Rock Volume

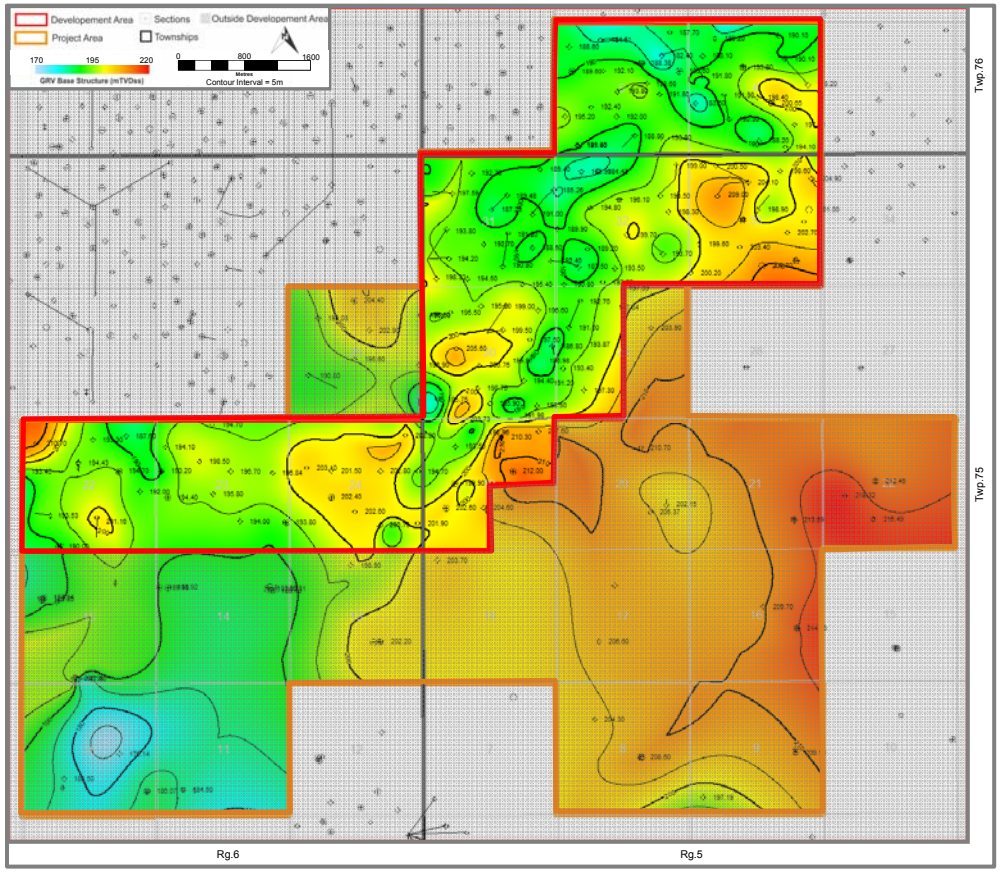
3.1.1-2d



Geology

Jackfish Expansion Base Structure of Gross Rock Volume

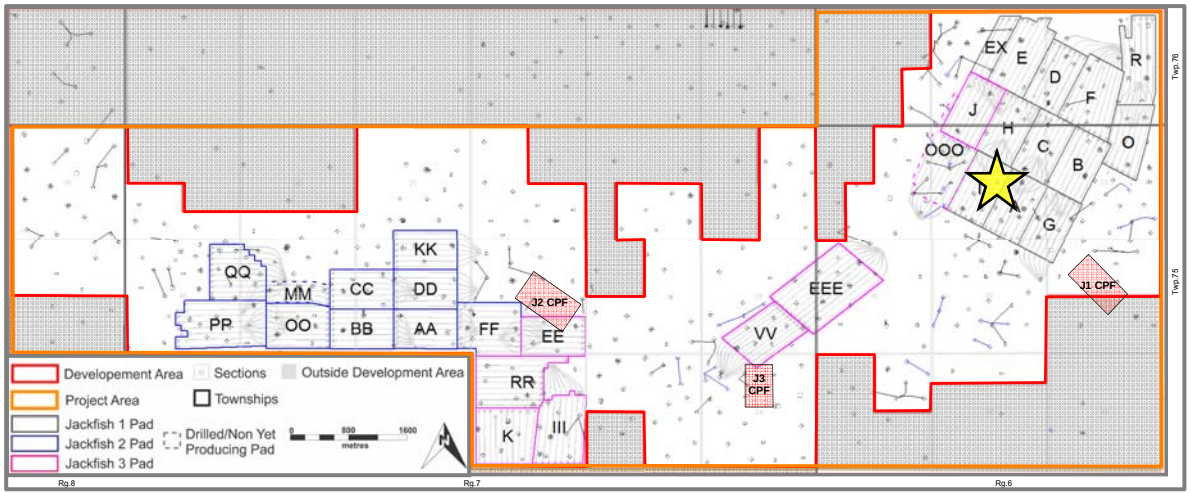
3.1.1-2d

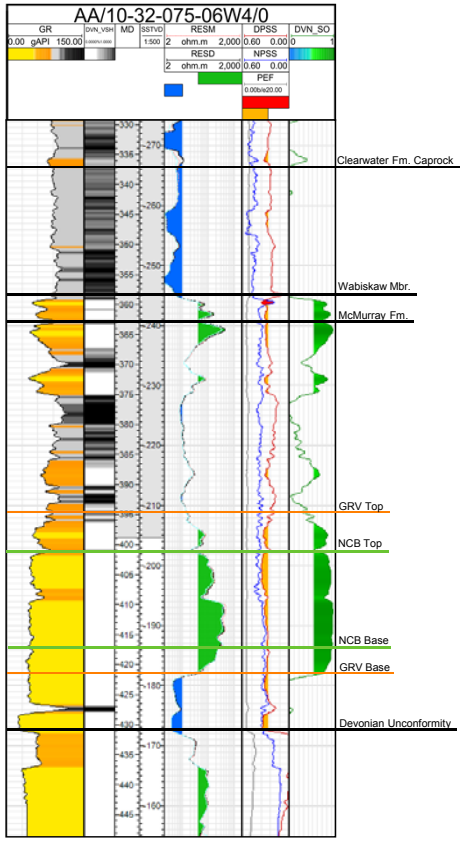


Geology

Jackfish 1 Representative Well Log

3.1.1-2e

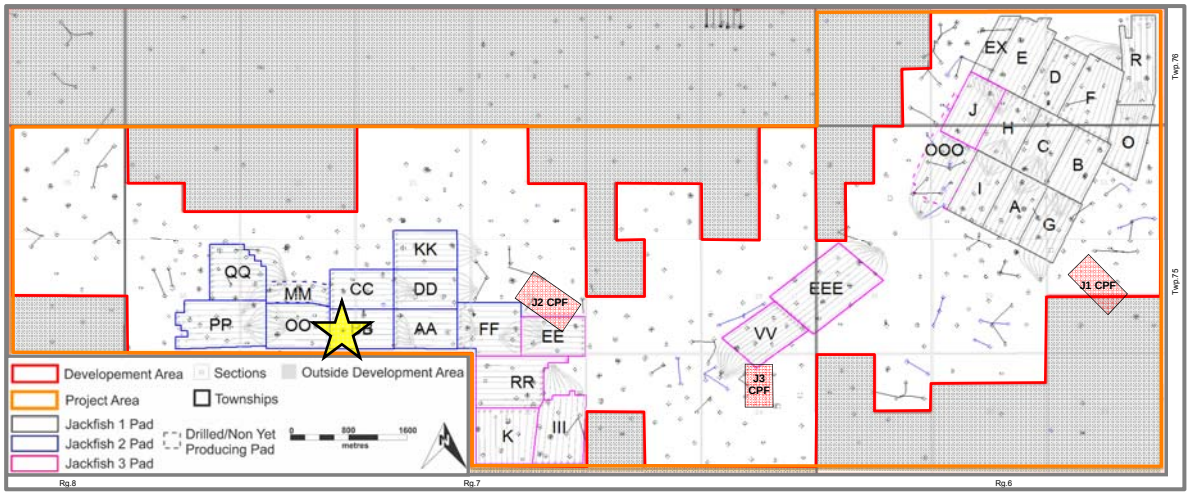


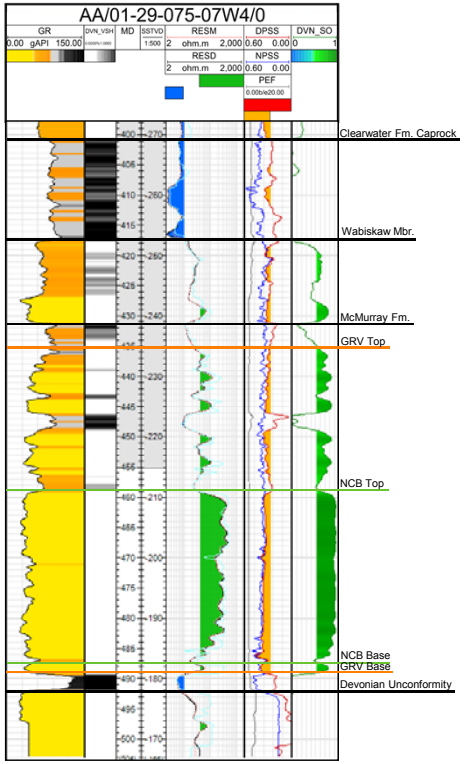


Geology

Jackfish 2 Representative Well Log

3.1.1-2e

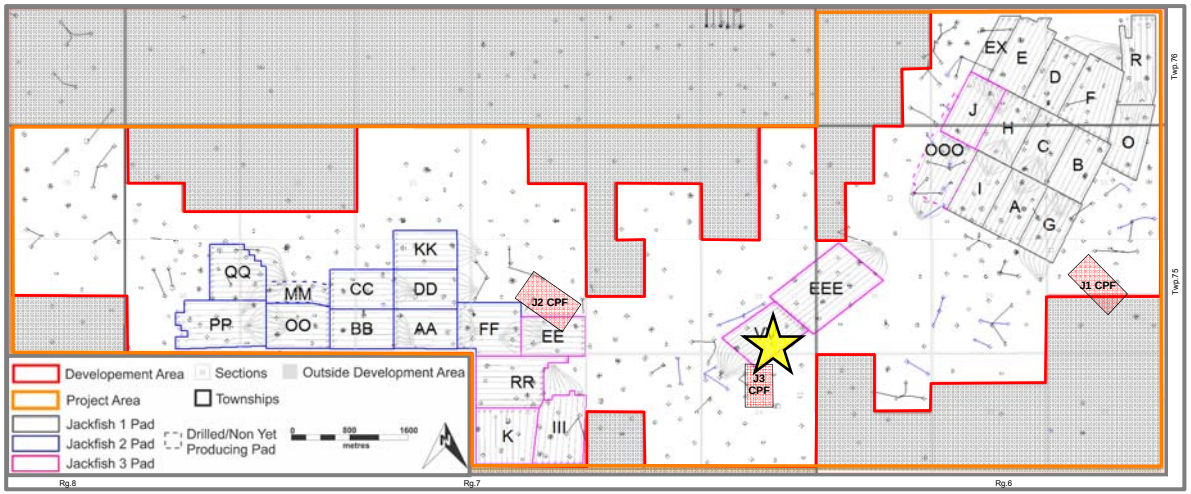


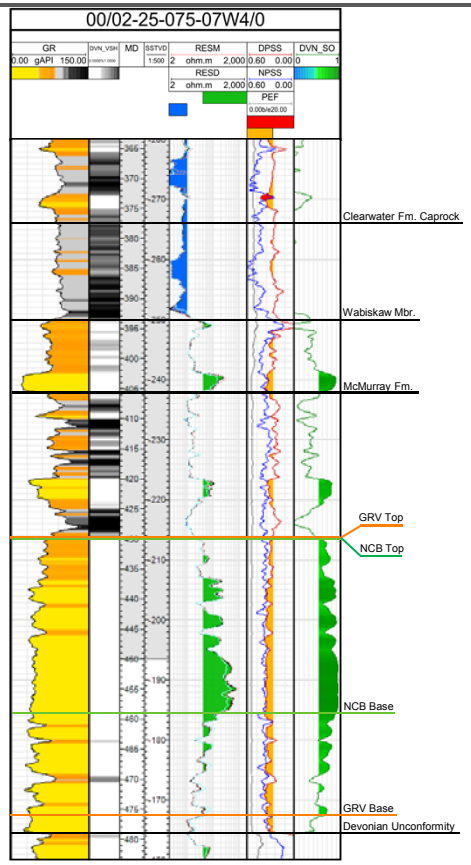


Geology

Jackfish 3 Representative Well Log

3.1.1-2e

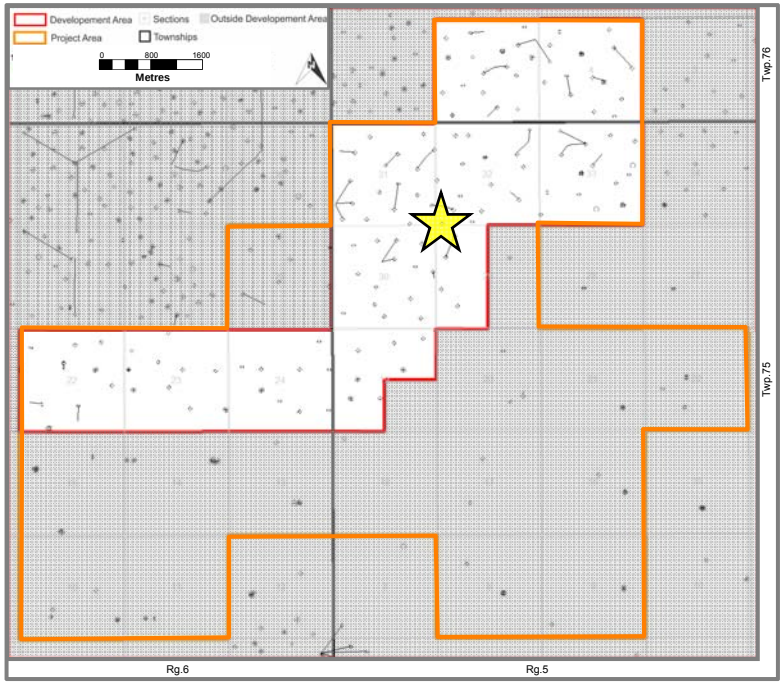


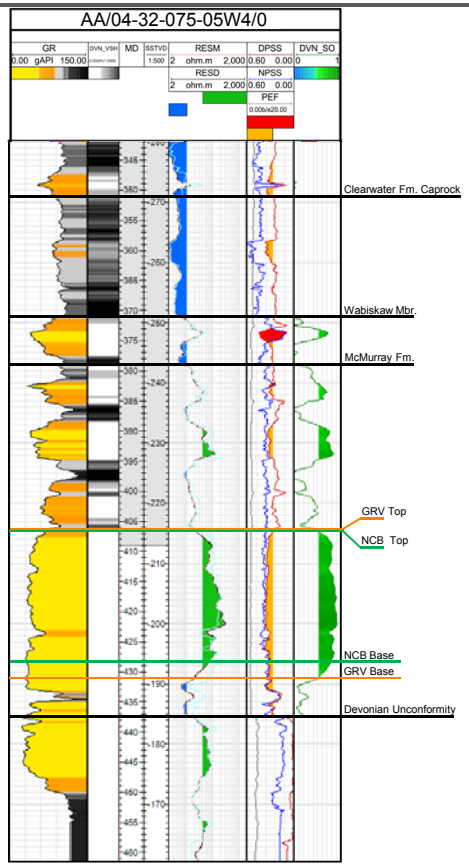


Geology

Jackfish Expansion Representative Well Log

3.1.1-2e

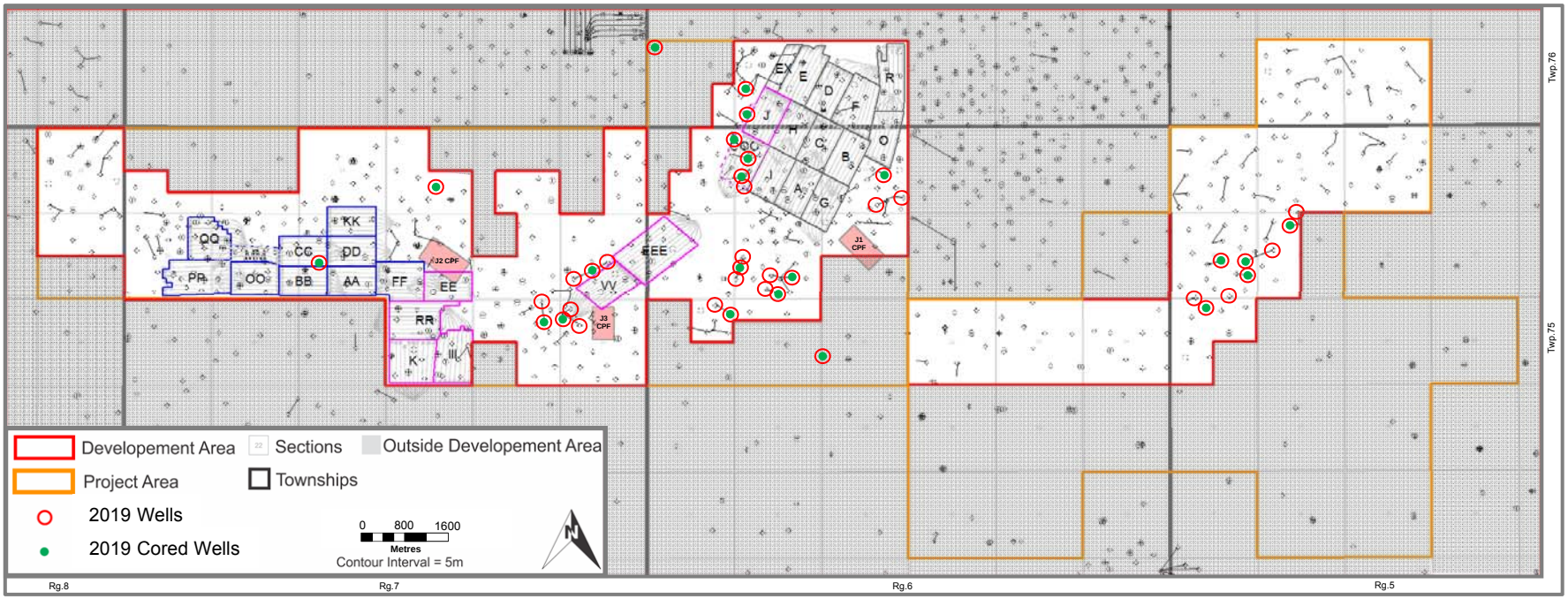




Geology

Jackfish 2019 Drilling Program and Cored Wells

3.1.1-2f



Project Area	
2018-2019 Wells: 39	Total Well Count: 732
2018-2019 Core: 22	Total Core: 304

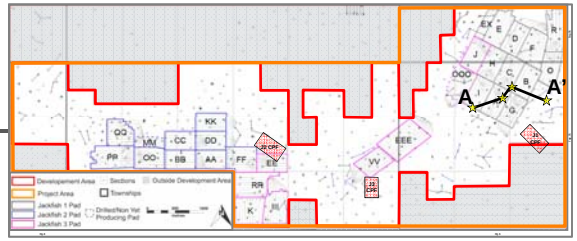
Special Core Analysis

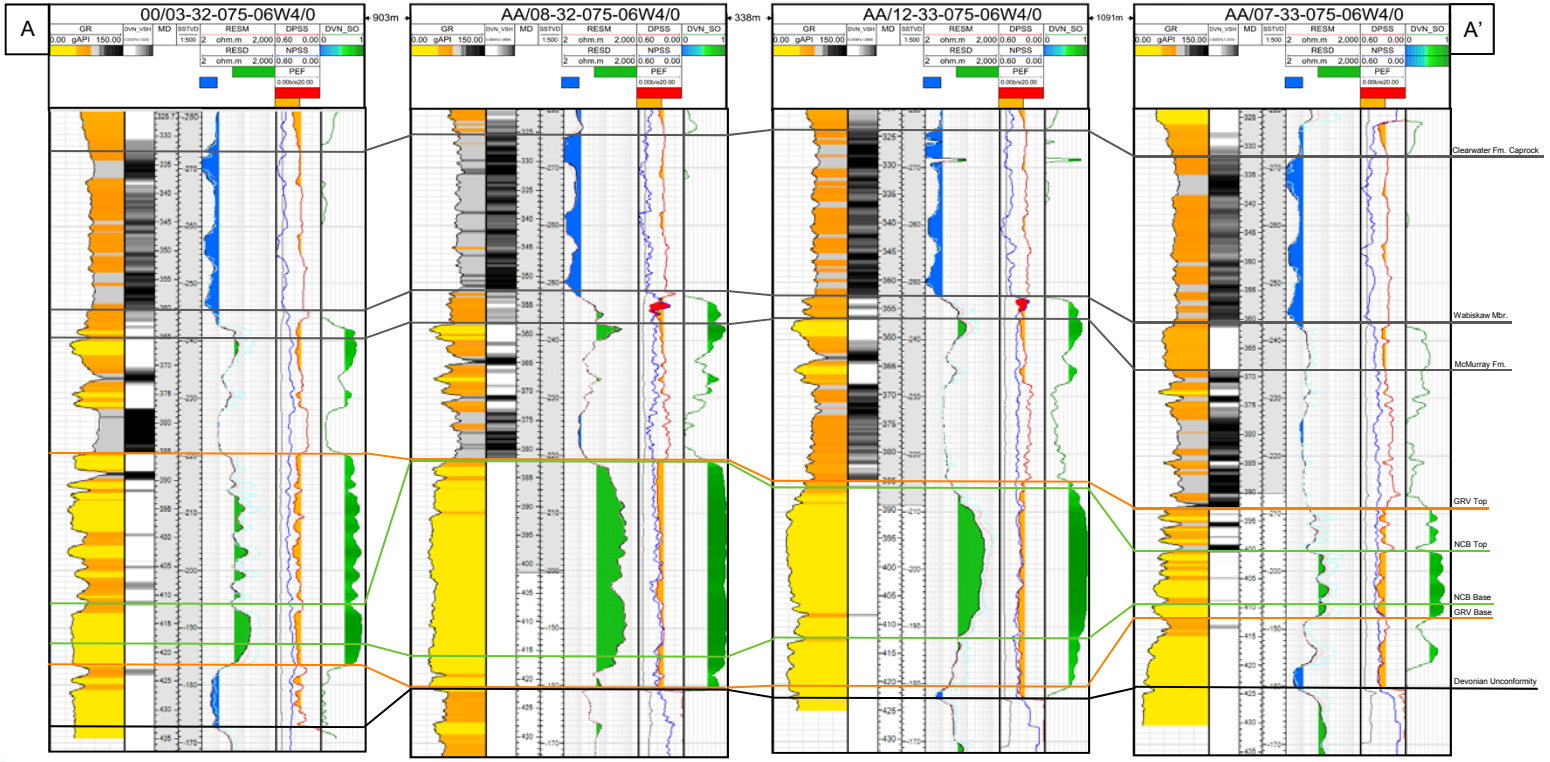
No special core analysis conducted on core from the 2019 drilling program.

Geology

Jackfish 1 Representative Structural Cross-section

3.1.1-2i

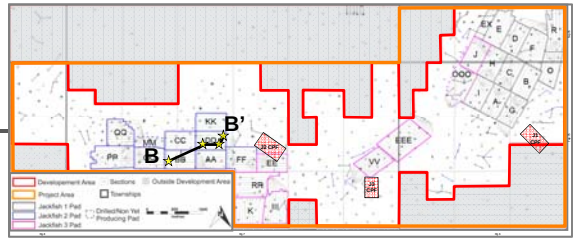


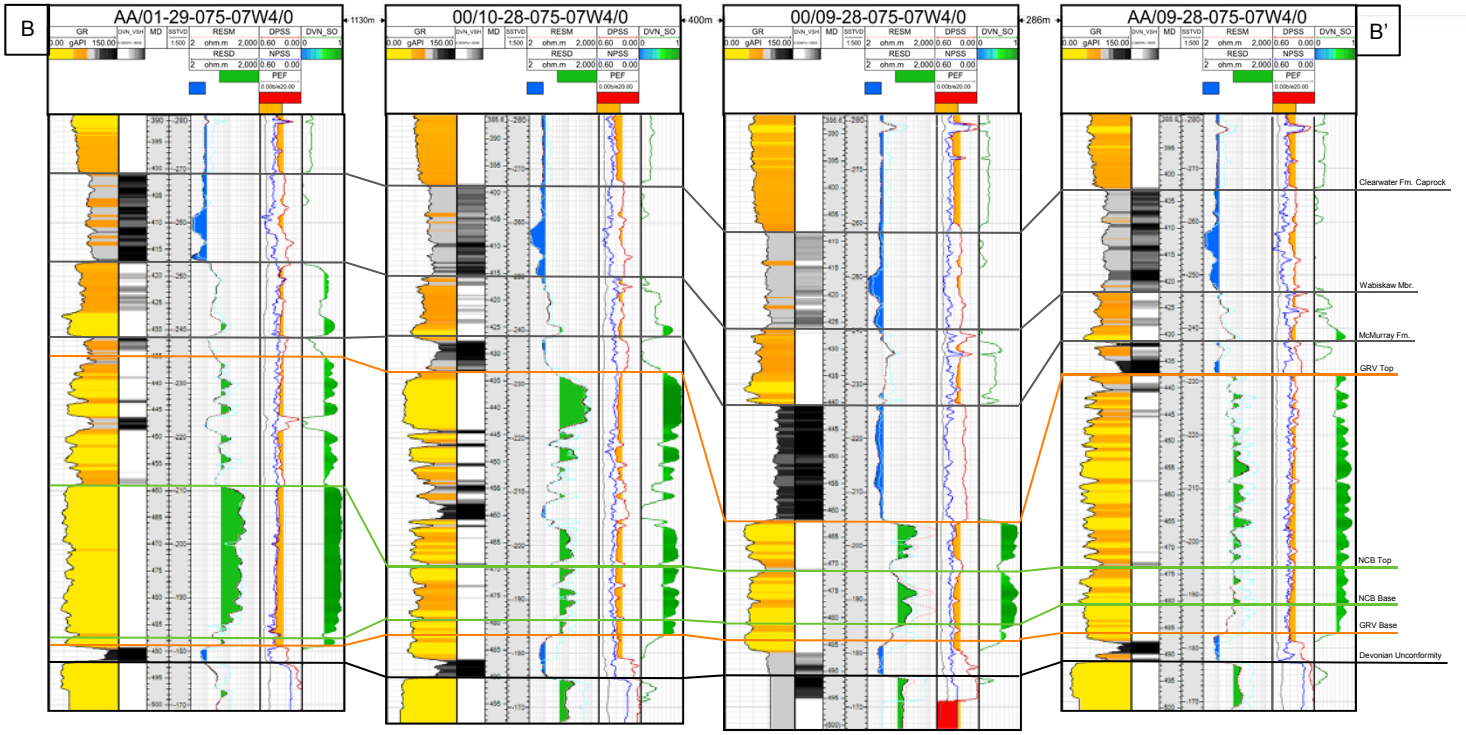


Geology

Jackfish 2 Representative Structural Cross-section

3.1.1-2i

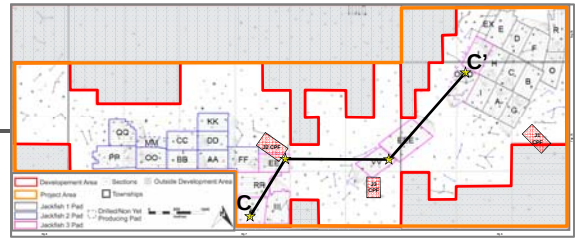


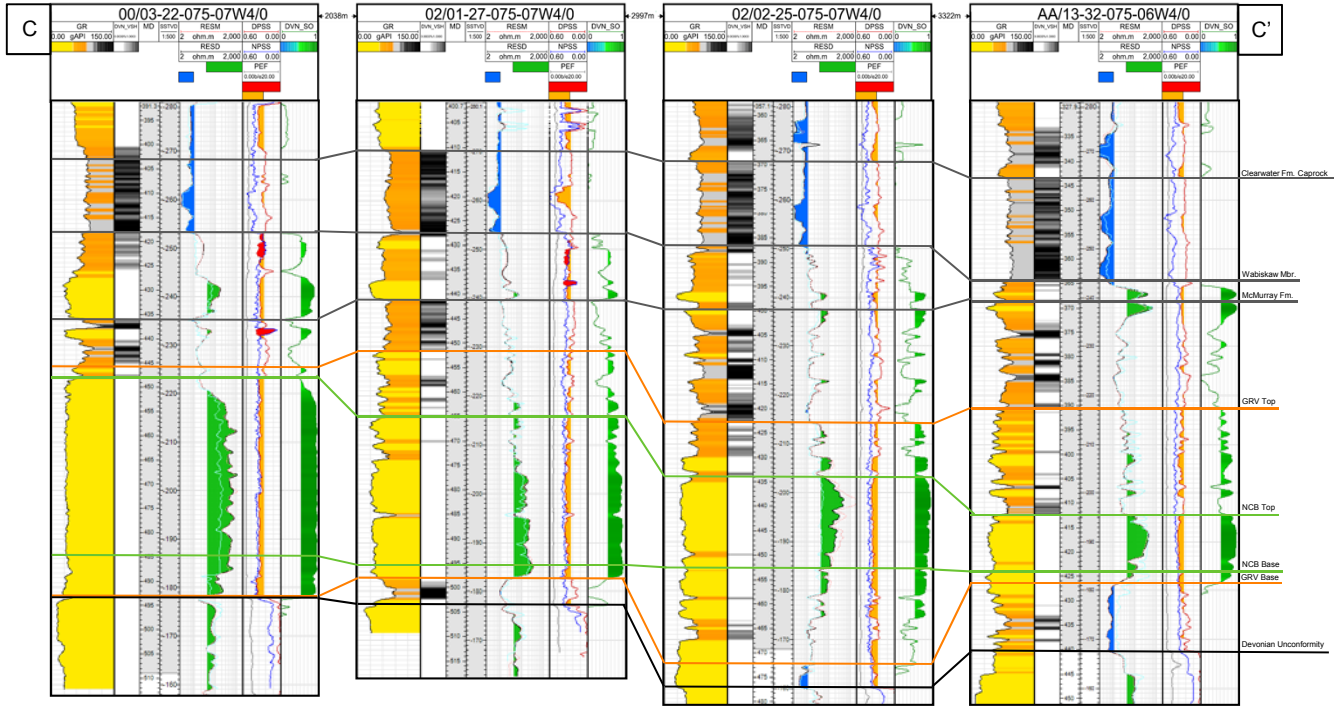


Geology

Jackfish 3 Representative Structural Cross-section

3.1.1-2i

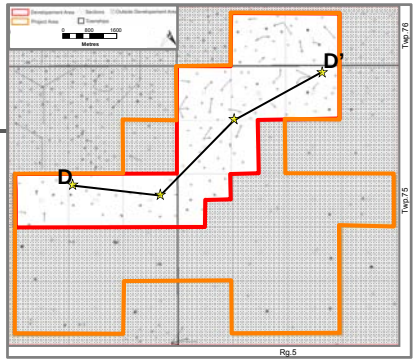


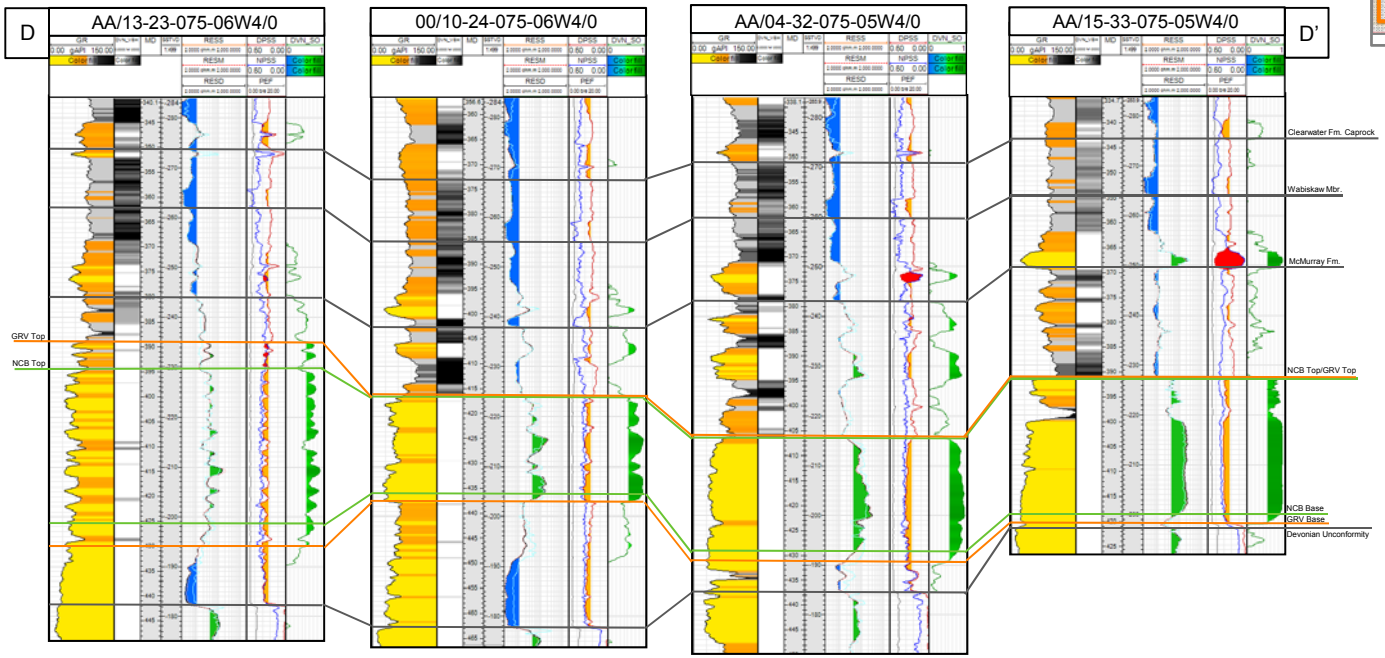


Geology

Jackfish Expansion Representative Structural Cross-section

3.1.1-2i

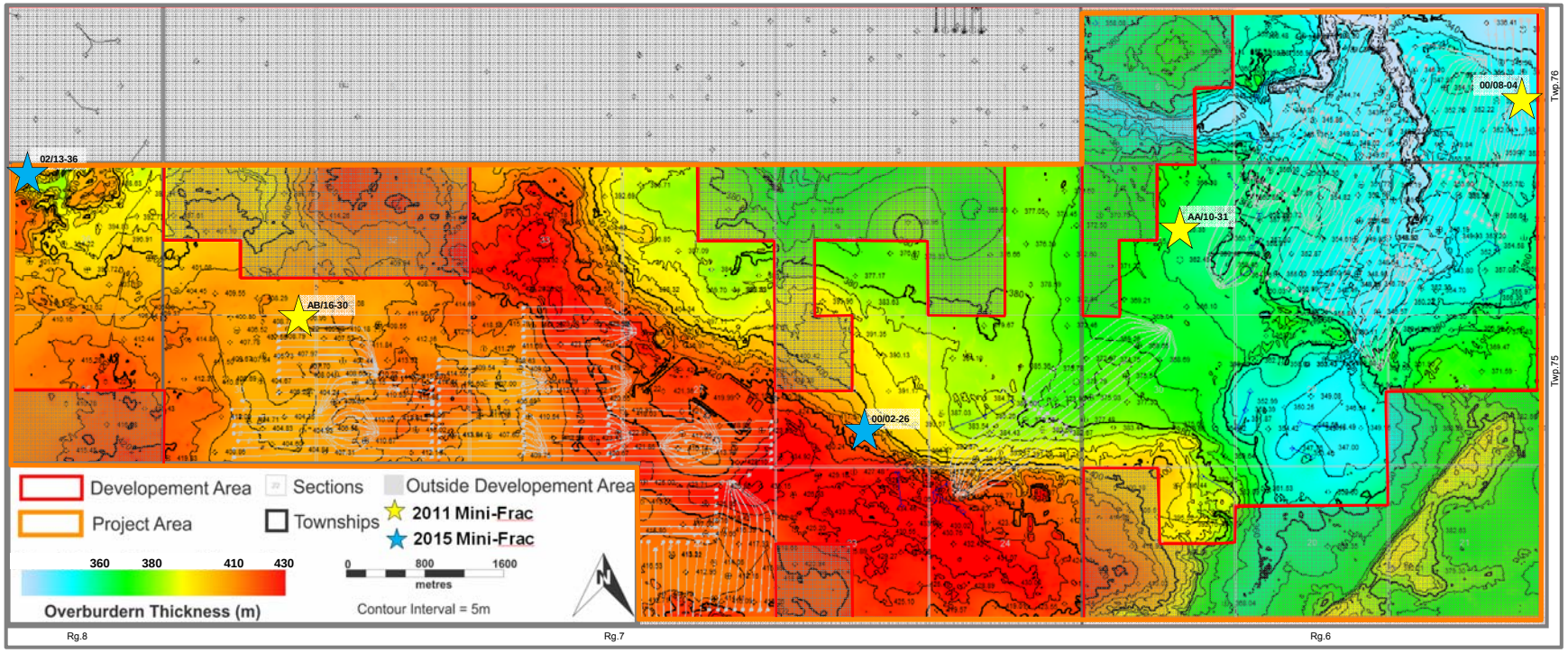




Geology

Jackfish Caprock Overburden Map and Mini Frac Wells

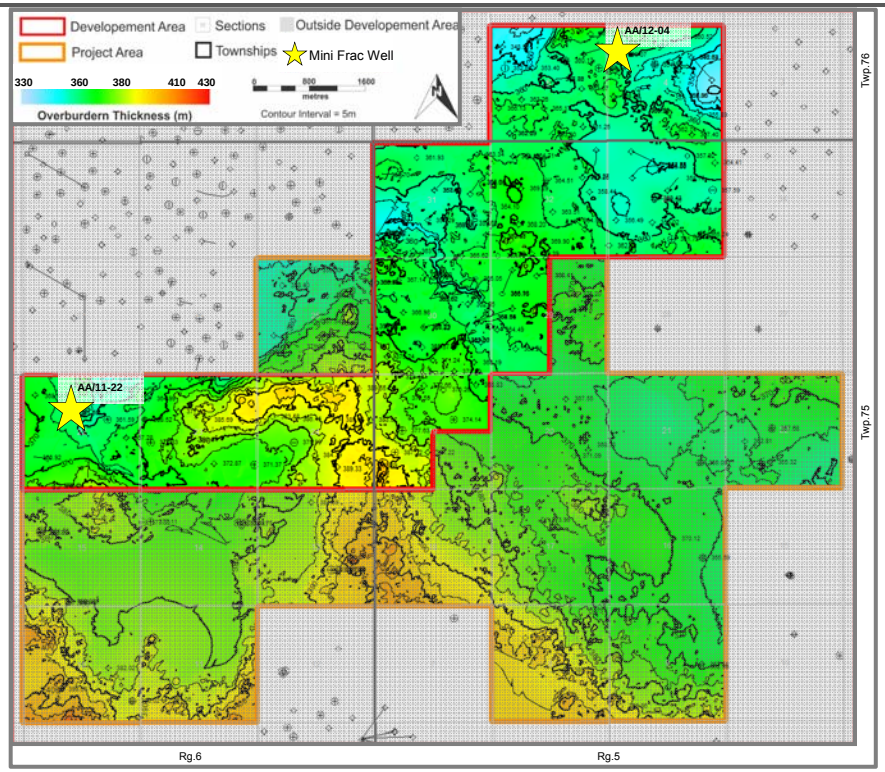
3.1.1-2m



Geology

Jackfish Expansion Caprock Overburden Map and Mini Frac Wells

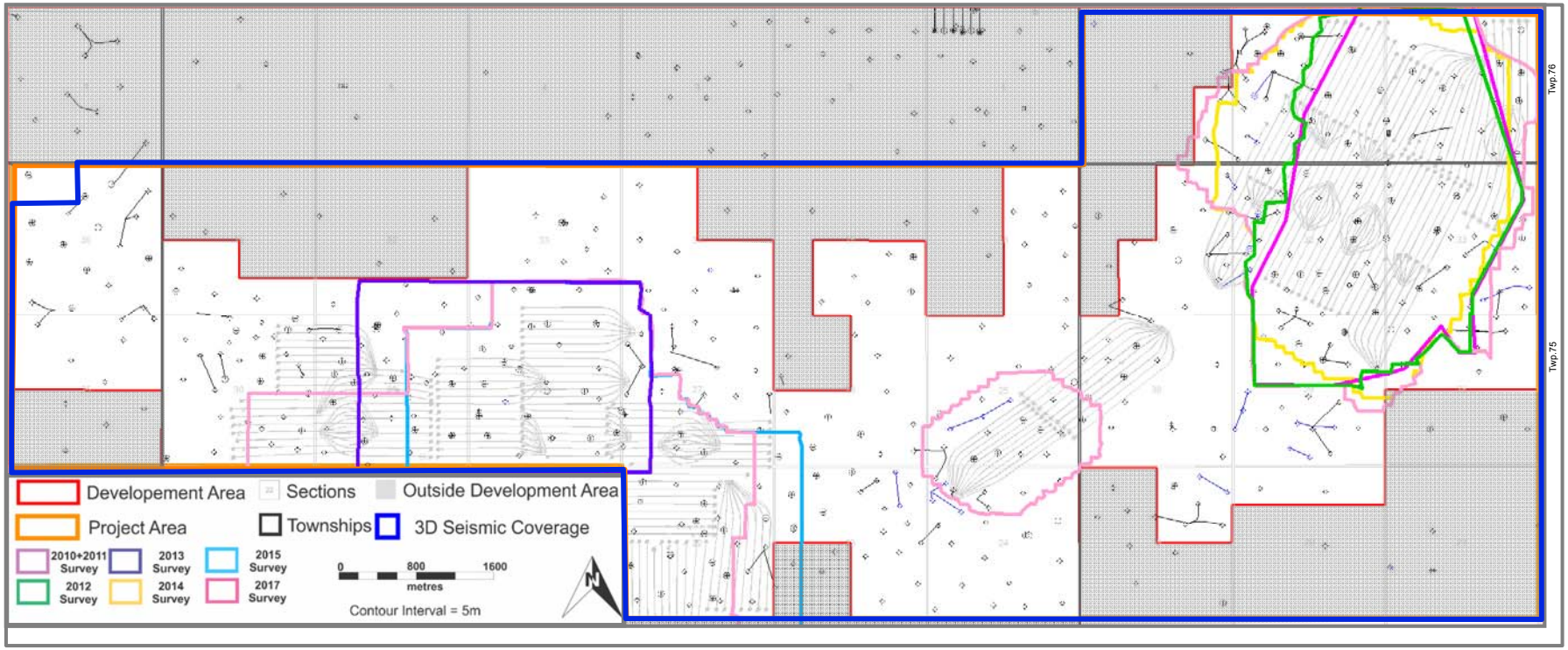
3.1.1-2m



Seismic

Jackfish Historical Surveys

3.1.1-6a

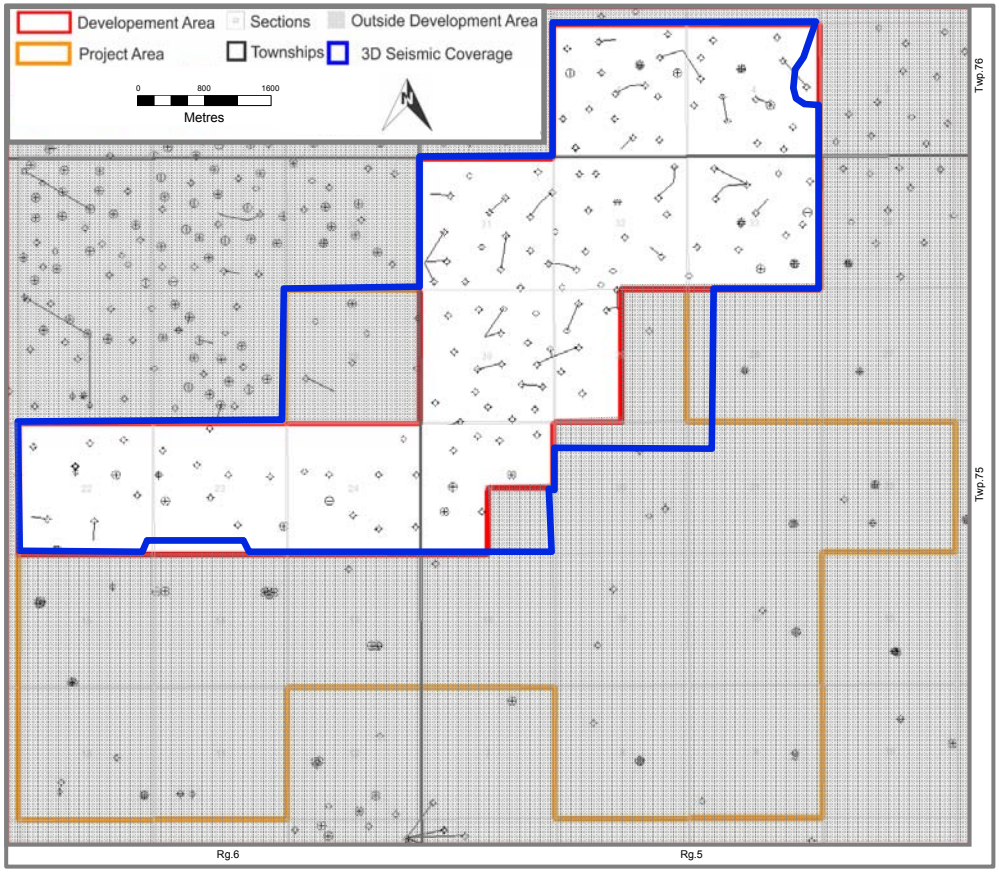


- No seismic was acquired in 2019
- Historically, seismic acquisition is extensive, totaling 21.7 km^2

Seismic

Jackfish Expansion Historical Surveys

3.1.1-6a



Canadian Natural

Drilling and Completions
3.1.1-3

Drilling and Completions

Overview

3.1.1-3a

Operating SAGD Horizontal Wells

- **Jackfish 1:** 78 well pairs on eleven pads (horizontal sections are 790 – 1,200m)
- **Jackfish 2:** 60 well pairs on eight pads (horizontal sections are 790 – 1,200m)
- **Jackfish 3:** 51 well pairs on seven pads (horizontal sections are 720 – 1,200m)

Observation Wells

- 61 active SAGD observation wells
  (two to three wells per operating pad)
- 21 regional multi-zone monitoring wells equipped with piezometers

Service Wells

- Six Grand Rapids brackish source water wells
- Two McMurray brackish source water wells
- 14 water disposal wells (Class 1b)
  - 12 active wells
  - 1 inactive well (102/12-05-076-06W4)
  - 1 suspended well (102/03-22-075-06W4)

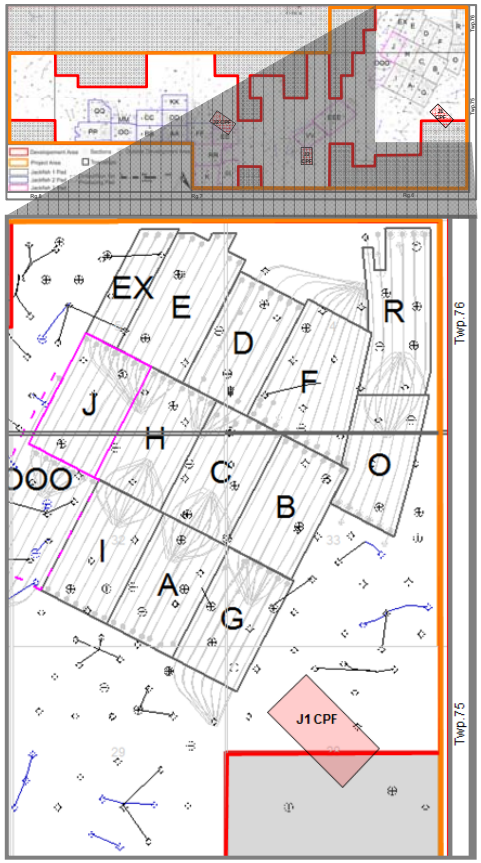
Drilling and Completions

Jackfish 1 Overview – SAGD Wells

3.1.1-3a

Existing Pads

- Pad A, B, C, D, E, G, H, I, O: Seven well pairs per pad
- Pad F: Nine well pairs and three additional producers
- Pad R: Six well pairs
- Pad EX: Three well pairs, planned for steam Q4 2019
- Two observation wells per pad (heel and toe)



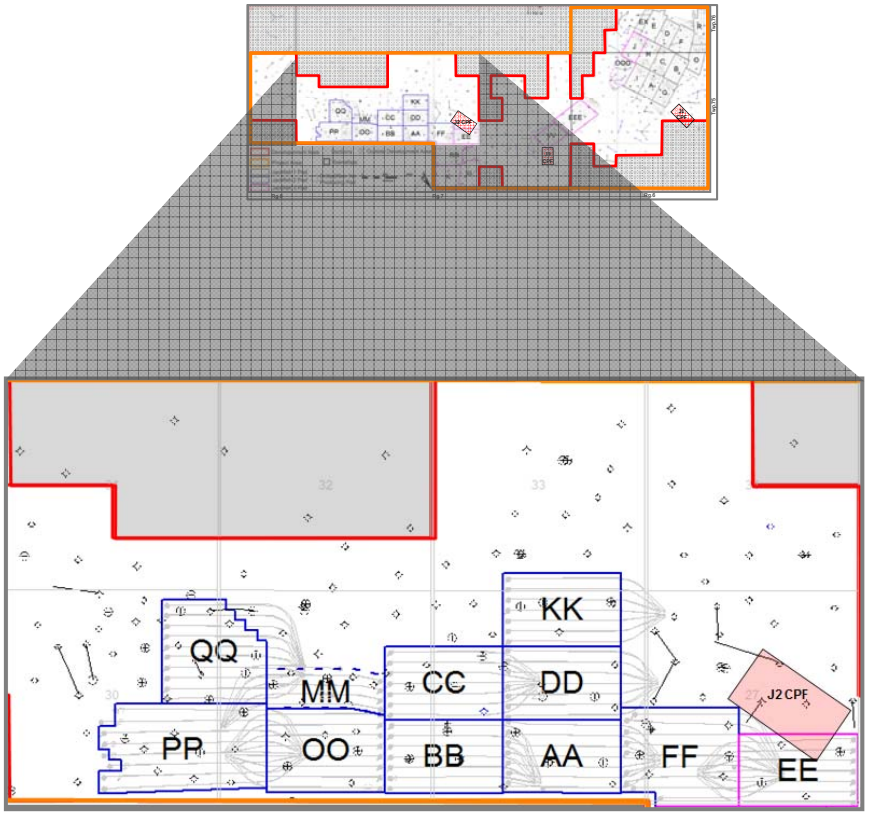
Drilling and Completions

Jackfish 2 Overview – SAGD Wells

3.1.1-3a

Existing Pads

- Pad AA, BB, CC, DD, and KK: Seven well pairs per pad
- Pad OO and PP: Eight well pairs per pad
- Pad FF: Nine well pairs
- Pad QQ: Ten well pairs, planned for steam Q4 2019
- Pad MM: Four well pairs, planned for steam Q4 2019
- Two observation wells per pad (heel and toe), three wells at Pad FF



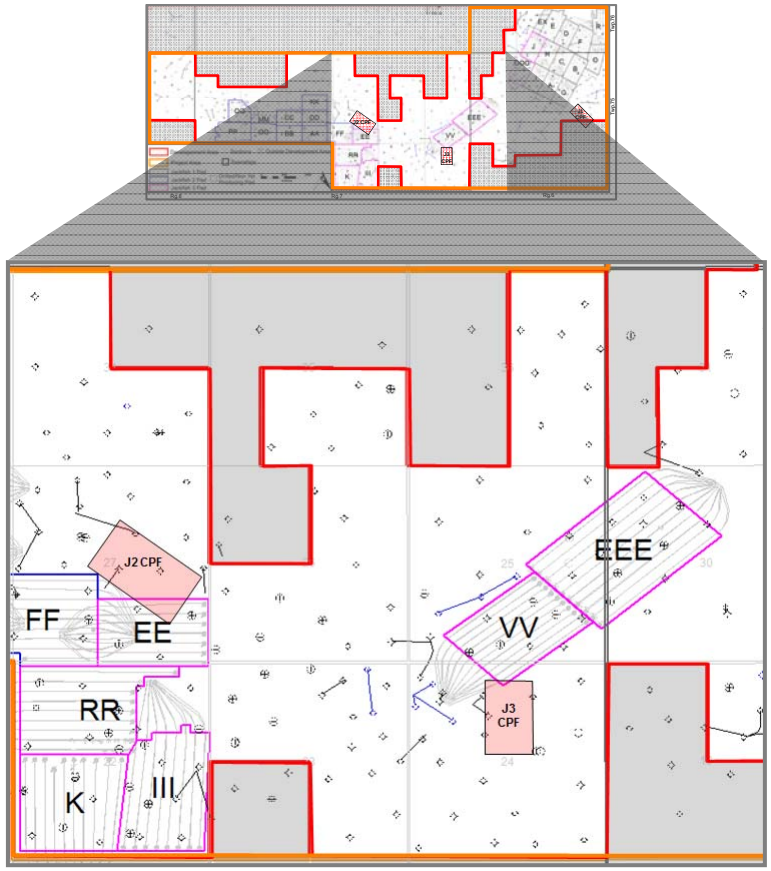
Drilling and Completions

Jackfish 3 Overview – SAGD Wells

3.1.1-3a

Existing Pads

- Pad J and EE: Seven well pairs per pad
- Pad VV and K: Ten well pairs per pad
- Pad RR: Nine well pairs
- Pad EEE: Ten well pairs, five operating
- Pad III: Eight well pairs, three operating
- Two observation wells per pad (heel and toe)



Drilling and Completions

Jackfish Inter-well Spacing

3.1.1-3a

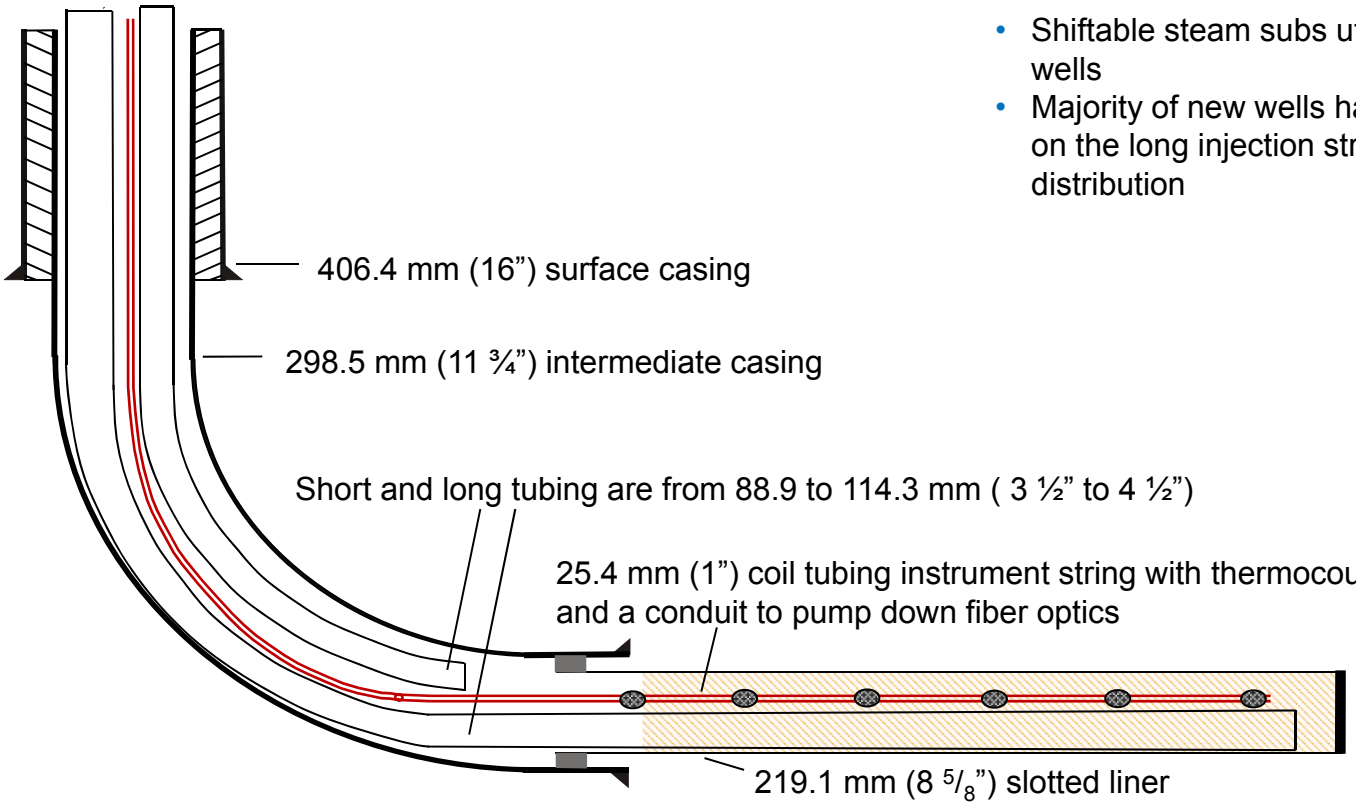
- Standard lateral inter-well spacing at Jackfish is 80m

- Currently drilled pads that differ from the standard are:
  - Pad VV: Spacing of 60m
  - Pad F: Spacing of 60m at the heels fanning to 90m at the toes
  - Pad O: Spacing of 75m at the heels fanning to 90m at the toes
  - Pad R: Spacing varies from 71 to 90m due to boundary restrictions
  - Pad III: Spacing of 80m at the heels fanning to 90m at the toes

Drilling and Completions

Typical Injection Well Schematic

3.1.1-3c



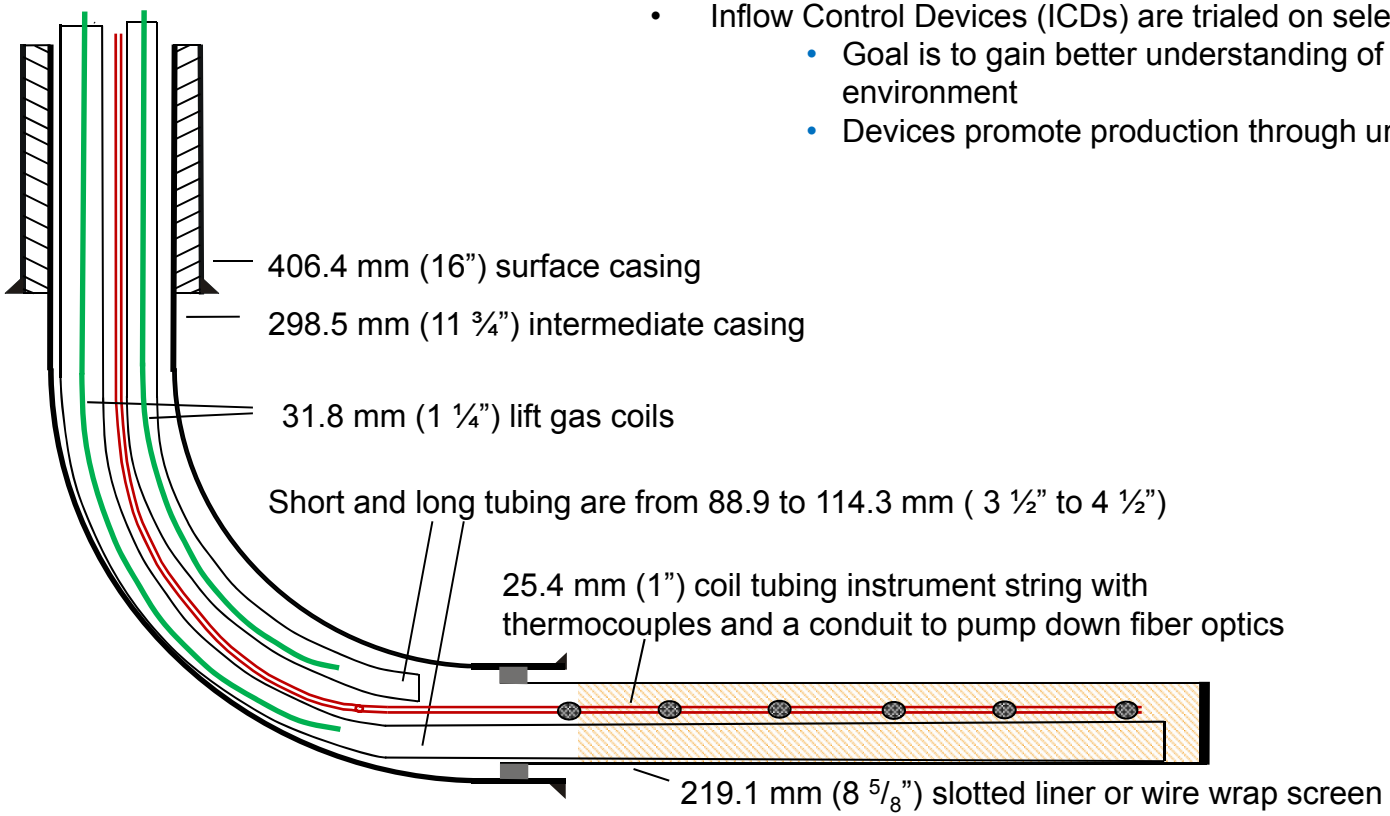
- Shiftable steam subs utilized on several injection wells
- Majority of new wells have steam sub(s) installed on the long injection string to improve steam distribution

Drilling and Completions

Typical Gas Lift Production Well Schematic

3.1.1-3c

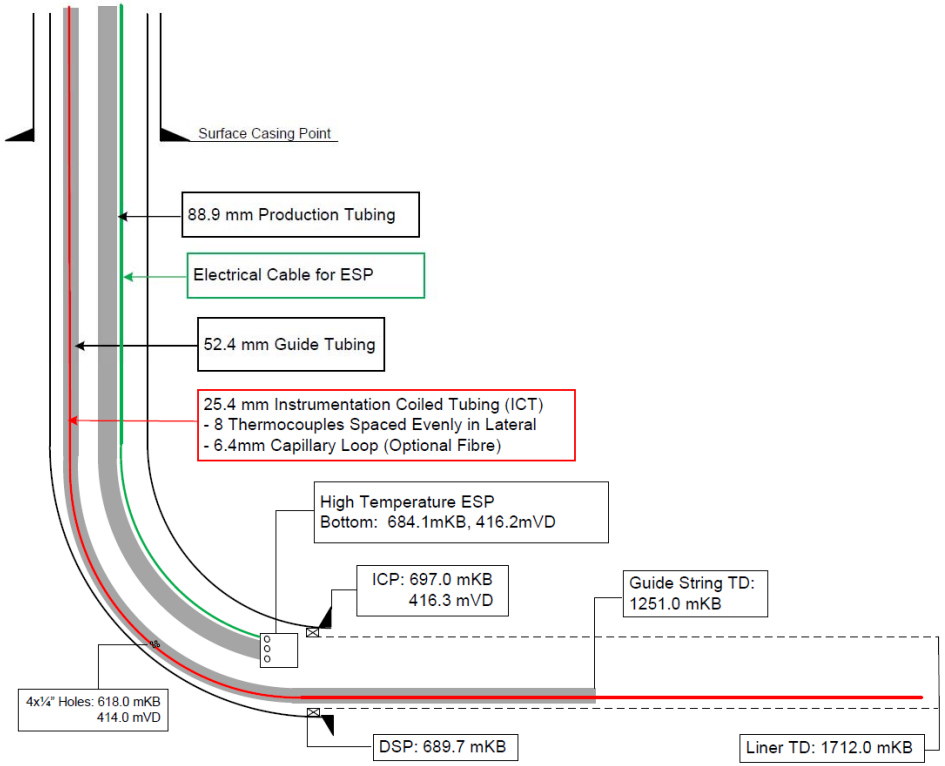
- Inflow Control Devices (ICDs) are trialed on select wells
  - Goal is to gain better understanding of this technology in SAGD environment
  - Devices promote production through uniform inflow



Drilling and Completions

Typical ESP Production Well Schematic

3.1.1-3c



Drilling and Completions

Inflow Control Devices (ICDs)

3.1.1-3c

- Tubing-deployed systems on wells CC1P, DD2P, DD7P, OO1P, OO8P
  - Installed successfully via service rig
- Liner-deployed systems on wells RR2P, RR6P, QQ(1,3,5,7,9)P, III3P, III5P
  - Installed successfully via drilling rig
- Key learnings to date:
  - Actual pressure drops in original ICDs different than design.
  - Incorporated lab test data in recent deployments and pressure drop to date is within expected design range.
  - Observed well production improvements range from 0 to 100%, uplift sustainability is being evaluated
  - Able to operate wells at lower subcool with positive impact on temperature conformance

Drilling and Completions

Wire Wrapped Screens

3.1.1-3c

- Expected benefits of wire wrapped screens:
  - Reduced liner pressure drop
  - Increased open flow area
  - Mechanical strength
  - Sand control

- Recent implementation at Jackfish includes Pad F, Pad O and Pad R
  - Successful start-up of these wells using wire wrapped screens

Canadian Natural

Artificial Lift
3.1.1-4

Artificial Lift

Summary

3.1.1-4a,b

- Combination of Gas lift and ESP utilized for artificial lift at Jackfish District

- Gas lift continues to be an effective lift strategy for Jackfish operating conditions
  - Typical producer operating pressure above 1,800 kPag
  - Ability to handle over 1,000 m^3/day emulsion flow
  - No operating temperature limitation

- ESP use has expanded from single well (B3P) in 2015 to full pad installation over past 2 years
  - ESP Wells: B3P, F10-F12P, O1-O7P, R1-R6P
  - Upcoming ESP Wells: MM1-MM4P, EX8-EX10P (Pads pending circulation)
  - Plan to continue to deploy ESPs as deemed necessary

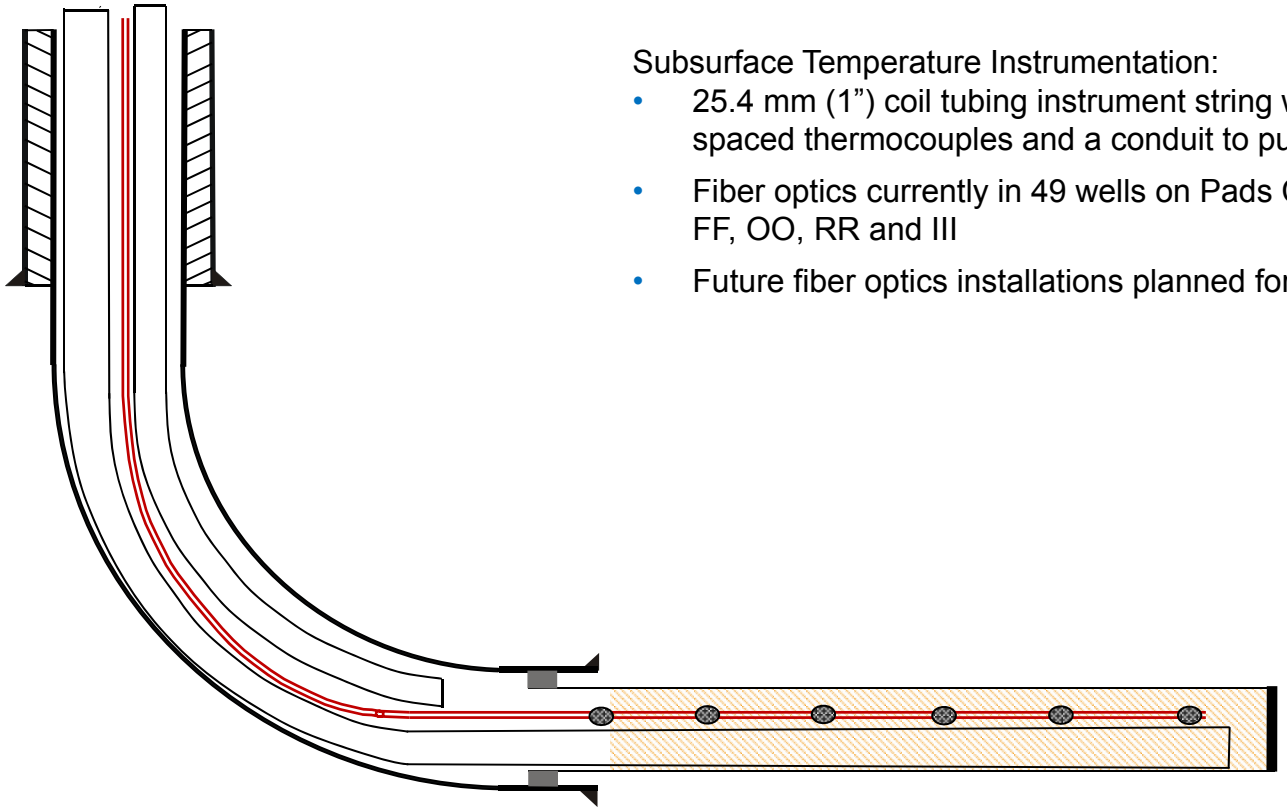
Canadian Natural

Instrumentation
3.1.1-5

Instrumentation

SAGD Injection and Producer Wells

3.1.1-5b



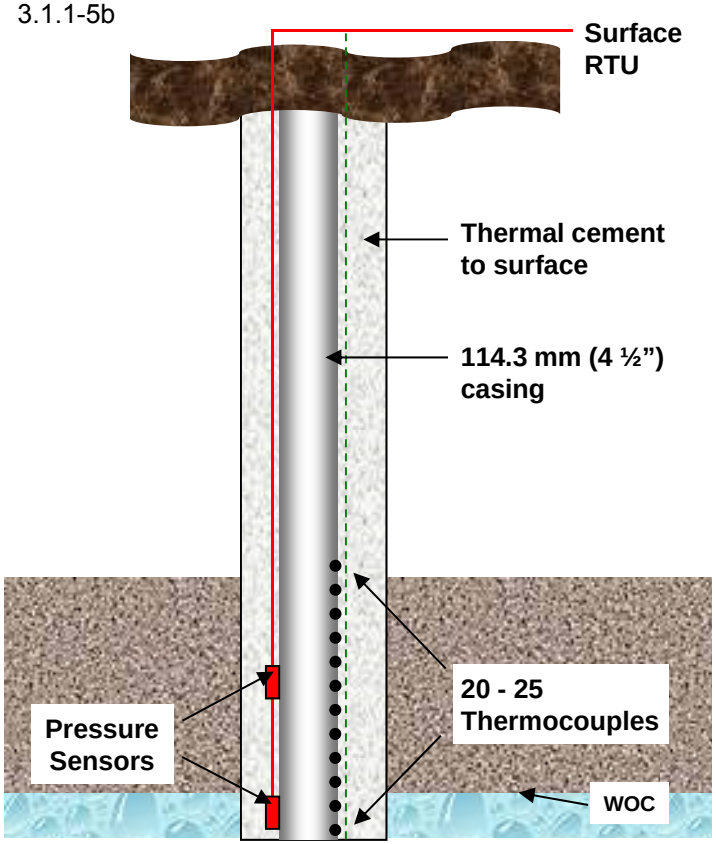
Subsurface Temperature Instrumentation:

- 25.4 mm (1”) coil tubing instrument string with four to eight evenly spaced thermocouples and a conduit to pump down fiber optics
- Fiber optics currently in 49 wells on Pads C, G, I, J, CC, DD, EE, KK, FF, OO, RR and III
- Future fiber optics installations planned for Pad QQ producer wells

Instrumentation in Wells

SAGD Observation Wells

3.1.1-5b



Jackfish 1, 2, and 3 SAGD observation wells contain:

- 20 points thermocouples (25 points in more recently drilled wells), spaced above, below, and within pay interval
- Two to four pressure sensors spaced above, below, and within pay interval

Instrumentation in Wells

Regional Multi-Zone Monitoring Wells

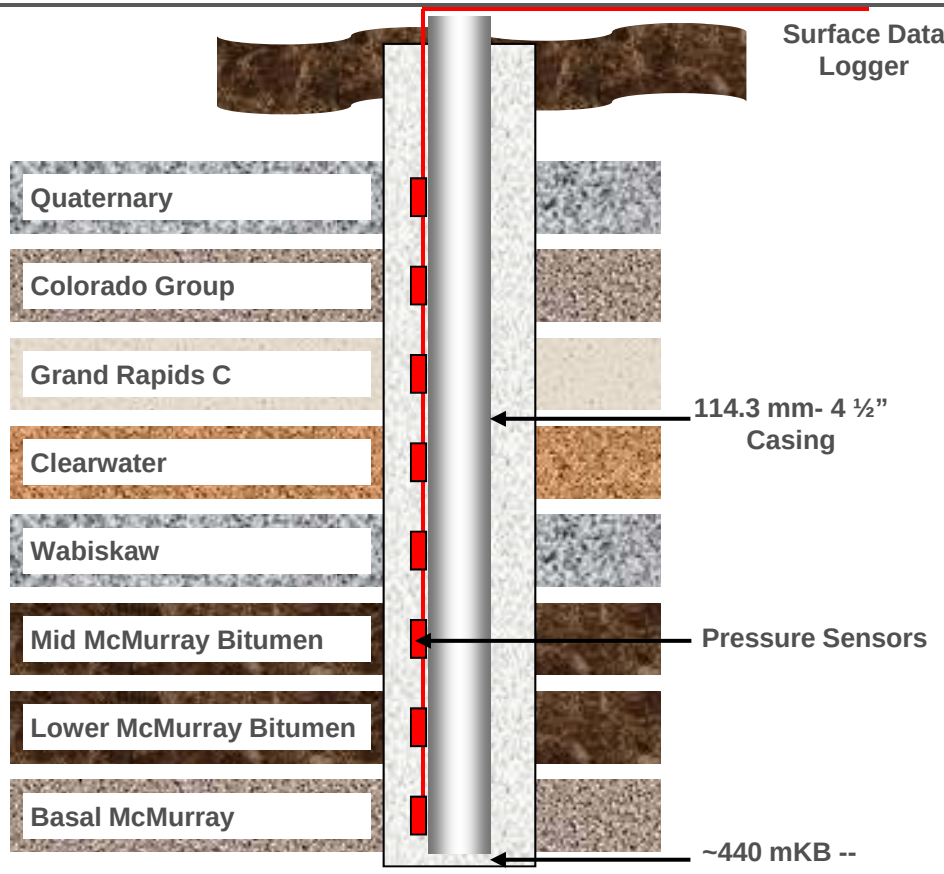
3.1.1-5b

Twenty-one monitoring wells cover areas of Jackfish 1, 2, and 3

- 00/07-32-75-6W4 (5 piezometers)
- F1/08-28-75-6W4 (4 piezometers)
- F1/09-14-75-6W4 (4 piezometers)
- F1/12-31-75-6W4 (4 piezometers)
- F1/10-22-75-6W4 (5 piezometers)
- F1/04-26-75-7W4 (5 piezometers)
- F1/06-28-75-7W4 (5 piezometers)
- F1/15-19-75-6W4 (5 piezometers)
- F1/09-24-75-7W4 (5 piezometers)
- F1/14-25-75-6W4 (5 piezometers)
- F1/05-12-75-6W4 (5 piezometers)
- F1/09-22-75-7W4 (4 piezometers)
- 02/12-23-75-7W4 (4 piezometers) *
- 02/01-35-75-7W4 (3 piezometers)
- 00/15-07-75-5W4 (4 piezometers)
- 00/07-22-75-7W4 (2 piezometers)
- 00/03-15-75-6W4 (3 piezometers) **
- 02/09-33-75-6W4 (4 piezometers)
- 00/04-30-75-7W4 (3 piezometers)
- 00/01-19-75-6W4 (3 piezometers) **
- AA/11-30-75-6W4 (5 piezometers)

* Perf with a Level Logger

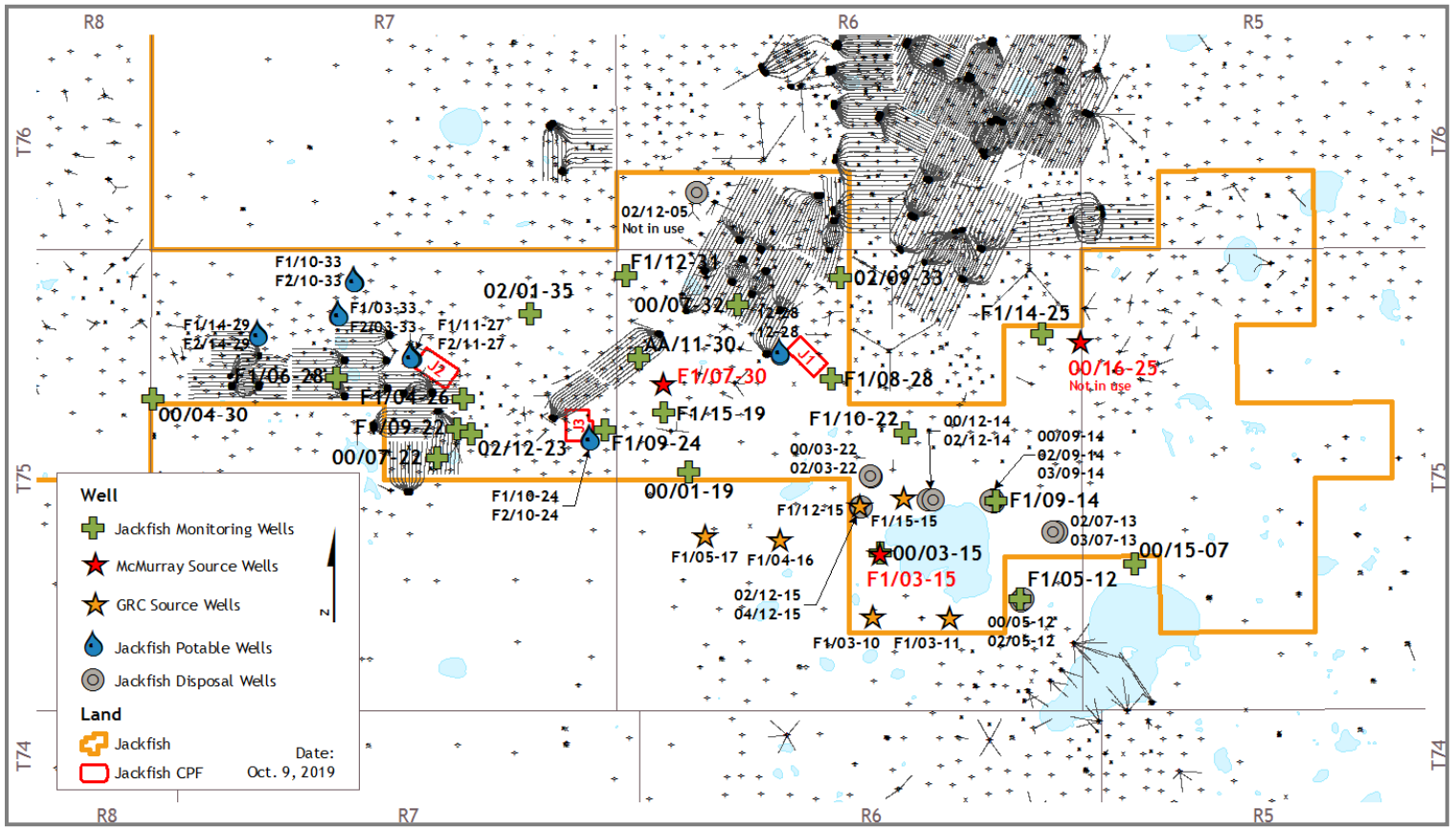
** Perf for water sampling



Instrumentation in Wells

Regional Monitoring Well Locations

3.1.1-5b



Instrumentation in Wells

Regional Multi-zone Monitoring Wells

3.1.1-5b

UWI	Rig Release	Quaternary	Colorado Group	Grand Rapids	Clearwater	Wabiskaw	McMurray Bitumen	Basal McMurray Water
00/07-32-075-06W4	2004/03/11			X		X	X	X
F1/08-28-075-06W4	2006/03/11			X	X	X		X
F1/09-14-075-06W4	2006/03/12			X	X	X		X
F1/12-31-075-06W4	2007/01/24			X	X	X		X
F1/10-22-075-06W4	2007/01/29		X	X	X	X		X
F1/04-26-075-07W4	2007/02/19			X	X	X	X	X
F1/06-28-075-07W4	2007/02/26			X	X	X	X	X
F1/15-19-075-06W4	2007/03/05		X	X	X	X		X
F1/09-24-075-07W4	2008/02/27		X	X	X	X		X
F1/14-25-075-06W4	2008/03/03		X	X	X	X		X
F1/05-12-075-06W4	2008/03/06			X	X	X		X
F1/09-22-075-07W4*	2008/03/07	X		X	X	X		
02/12-23-075-07W4	2012/03/05	X						
02/01-35-075-07W4	2012/03/06	X						
00/15-07-075-05W4	2012/03/09			X	X			X
02/09-33-075-06W4	2013/01/10	X		X	X			X
00/03-15-075-06W4	2013/01/18	X		X	X			
AA/11-30-075-06W4	2013/01/18							X
00/01-19-075-06W4	2013/02/17	X		X	X			
00/04-30-075-07W4	2013/03/03	X		X	X			
00/07-22-075-07W4	2013/03/13			X	X			

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Scheme Performance
3.1.1-7

Performance Prediction

3.1.1-7a

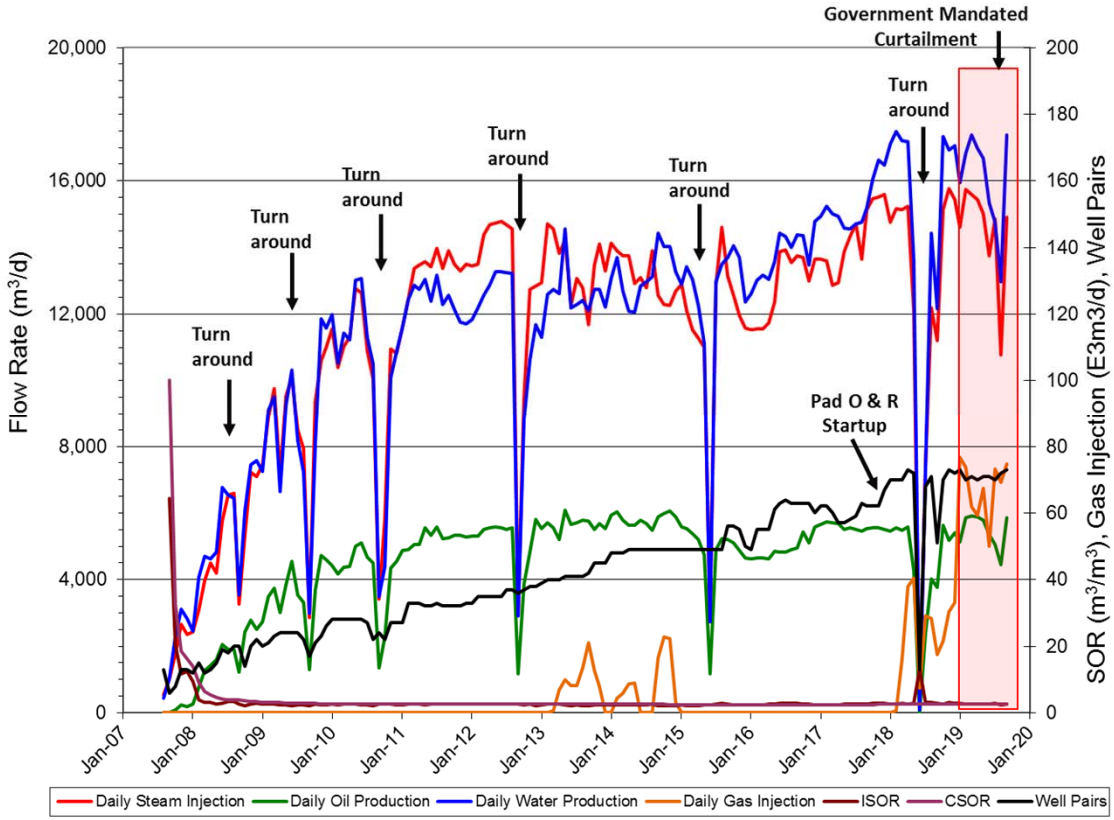
- Well pad performance forecasts generated using Jackfish and industry analogues; validated with numerical simulation and analytical methods

- Facility service factors based on historical data, future plans, and quantified risks

Scheme Performance

Jackfish 1 Project Life Plot

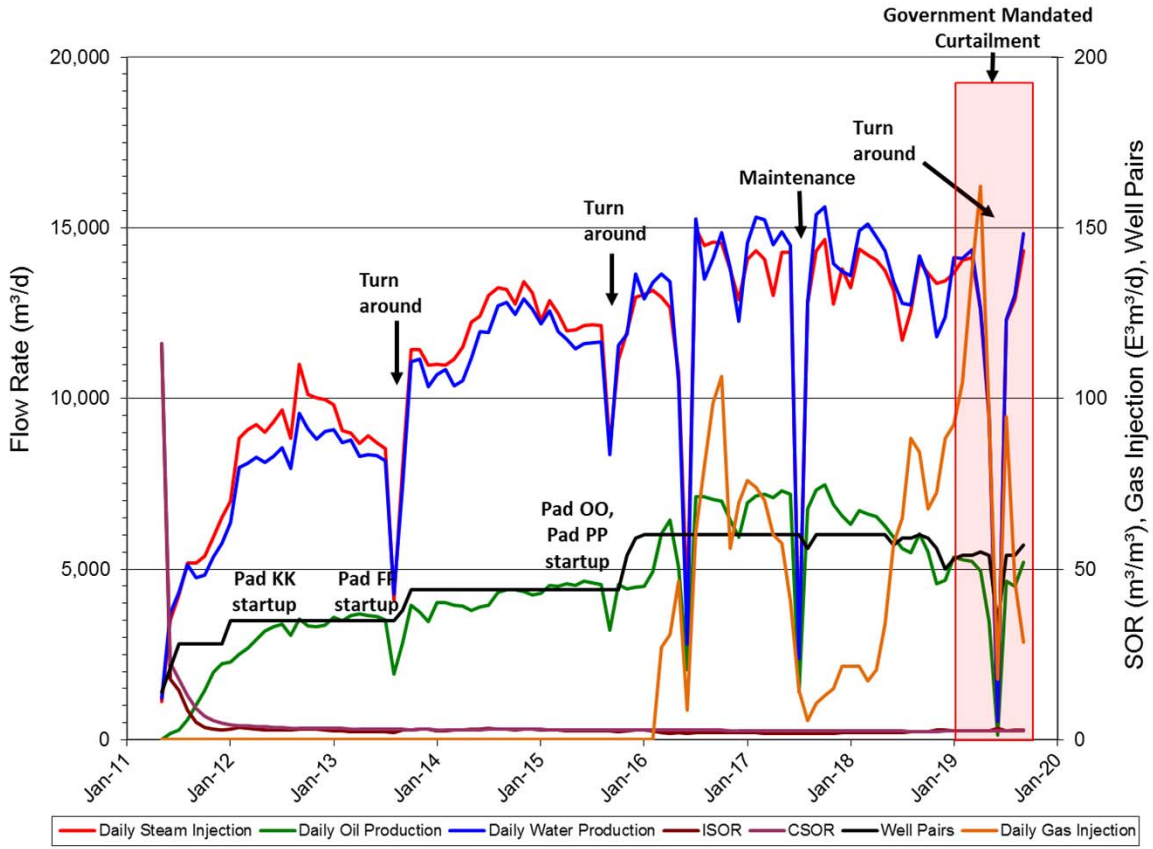
3.1.1-7a



Scheme Performance

Jackfish 2 Project Life Plot

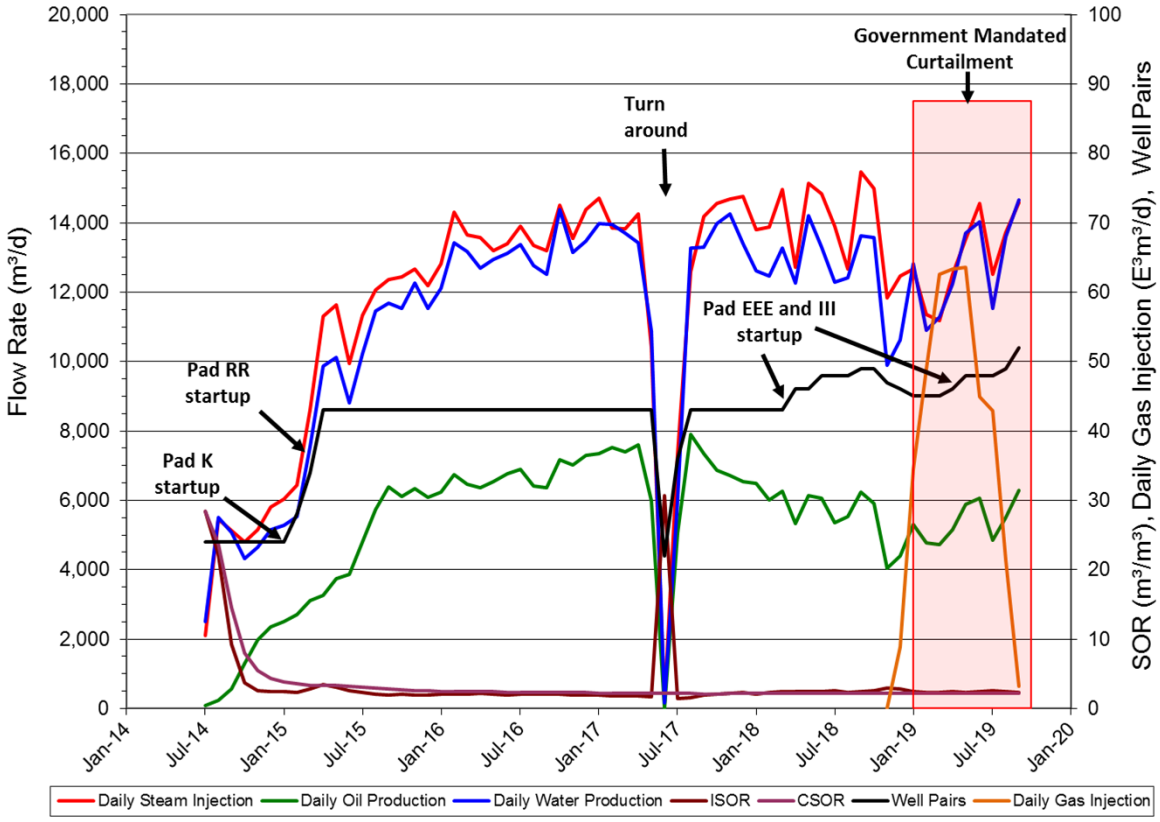
3.1.1-7a



Scheme Performance

Jackfish 3 Project Life Plot

3.1.1-7a



2019 Scheme Performance

Jackfish 1 Pad Recoveries

3.1.1-7c

Pad	Area (m^2)	Avg. GRV Pay (m)	Net GRV Pay S_o (%)	Net GRV Pay Porosity (%)	OBIP (10^6m^3)	Ult Rec (10^6m^3)	Cum Prod (10^6m^3)	RF (%) to Date
A	529,788	42	80	33	6.0	4.9	4.5	75
B	532,736	44	75	34	5.9	3.2	2.5	42
C	530,374	42	78	34	6.0	3.0	2.8	47
D	531,192	46	79	34	6.6	3.5	2.5	38
E	603,919	43	74	34	6.4	3.9	2.5	39
F	675,933	37	77	34	6.6	4.4	1.3	20
G	525,388	34	80	34	4.8	2.4	0.6	13
H	530,352	34	70	33	4.2	2.3	1.8	43
I	530,093	36	76	34	4.8	2.9	1.1	23
O	509,016	30	75	34	4.3	2.6	0.2	5
R	587,459	36	75	34	5.3	3.3	0.1	2

2019 Scheme Performance

Jackfish 2 Pad Recoveries

3.1.1-7c

Pad	Area (m^2)	Avg. GRV Pay (m)	Net GRV Pay S_o (%)	Net GRV Pay Porosity (%)	OBIP (10^6m^3)	Ult Rec (10^6m^3)	Cum Prod (10^6m^3)	RF (%) to Date
AA	501,959	32	78	34	4.3	2.4	1.6	37
BB	505,867	46	77	34	6.0	4.3	3.7	62
CC	506,800	38	74	34	4.8	1.4	0.8	17
DD	506,799	39	76	34	5.1	1.6	1.0	20
FF	653,895	32	76	34	5.4	3.2	1.6	30
KK	506,801	31	77	34	4.1	1.3	1.0	24
OO	573,574	40	82	34	6.4	4.1	1.5	23
PP	802,652	31	81	35	7.0	5.0	2.5	36

2019 Scheme Performance

Jackfish 3 Pad Recoveries

3.1.1-7c

Pad	Area (m^2)	Avg. GRV Pay (m)	Net GRV Pay S_o (%)	Net GRV Pay Porosity (%)	OBIP (10^6m^3)	Ult Rec (10^6m^3)	Cum Prod (10^6m^3)	RF (%) to Date
J	530,754	38	71	34	4.9	2.7	1.1	22
K	671,303	46	84	34	8.8	6.3	3.3	38
EE	506,800	47	76	33	6.1	3.5	2.1	34
RR	724,014	34	80	34	6.7	3.5	1.8	27
VV	558,761	44	75	34	6.2	2.9	1.7	27
EEE	1,001,409	33	75	34	8.4	4.4	0.2	3
III	665,081	36	82	34	6.6	4.7	0.0	0

Jackfish 2 – Pad DD Highlights

Low Performer

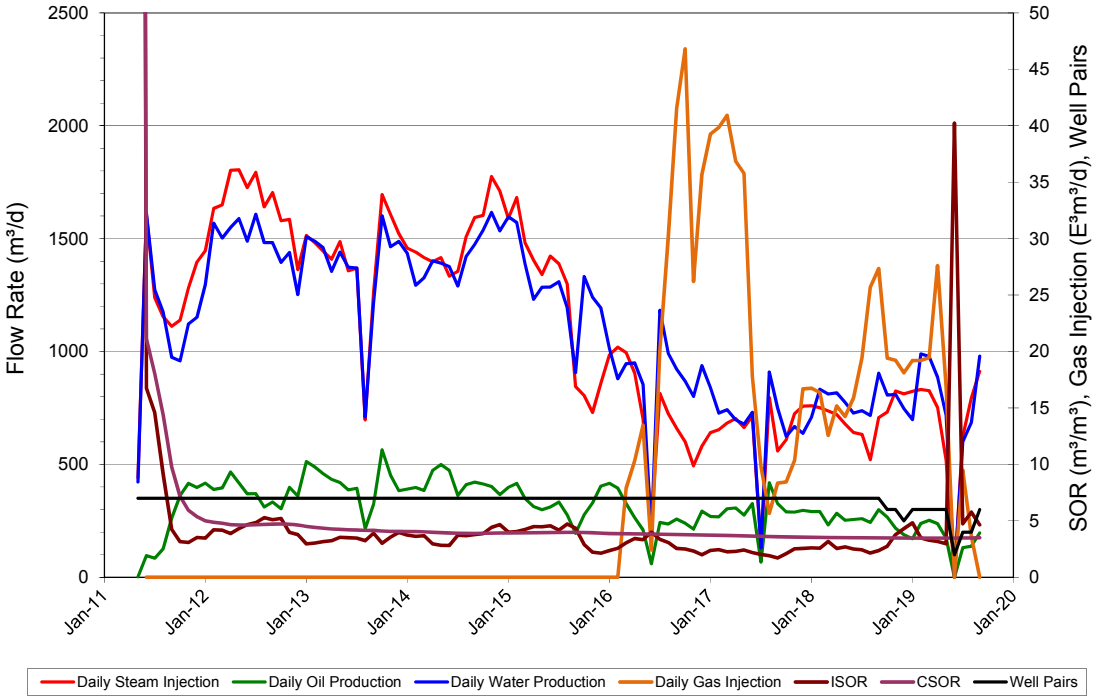
3.1.1-7c

- First steam occurred in June 2011
- NCG injection commenced as of March 2016 on wells DD1, DD3, DD5, and DD6
- Heterogeneous reservoir with low mid-heel ceiling of ~5m pay thickness
  - Limited vertical steam chamber growth
  - Regions of poor temperature conformance
- Inflow Control Device installed in September 2013 (DD2)
- Inflow Control Device installed in November 2014 (DD7)
- Potential fluid interaction with Pad AA due to chamber growth on DD1-DD3 wells

Pad DD Performance

Jackfish 2 Pad DD Life Plot

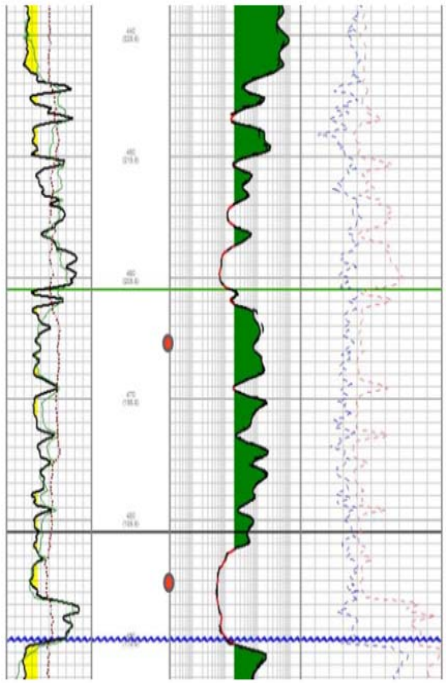
3.1.1-7c

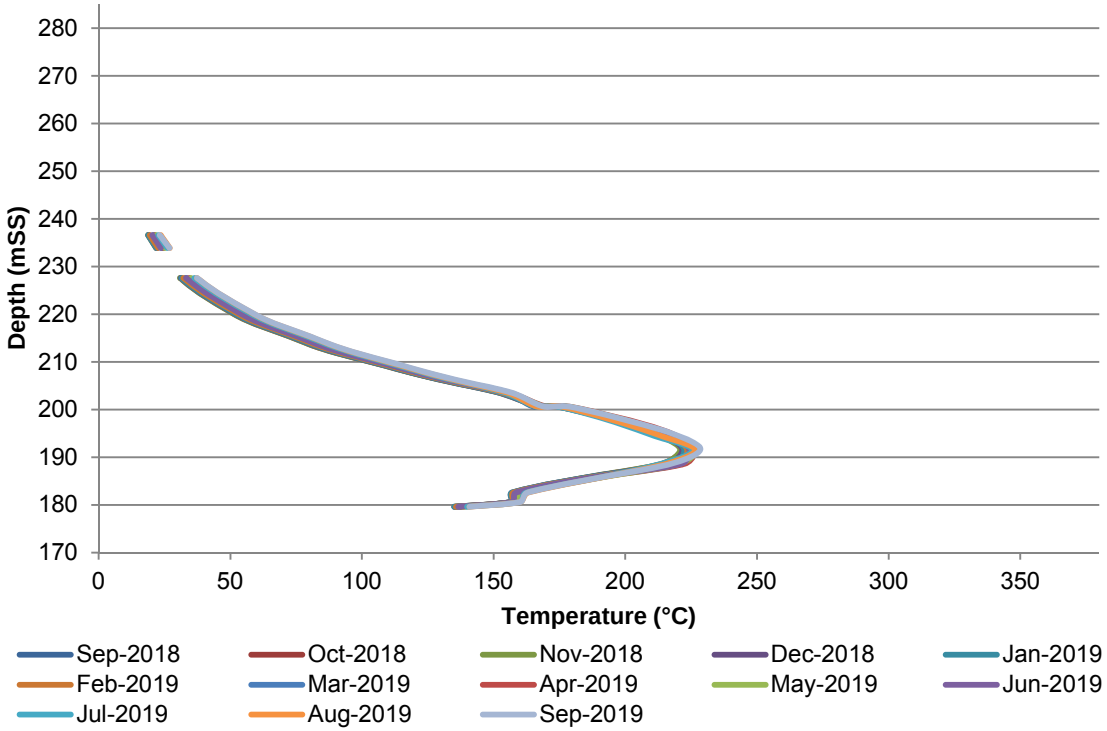


Pad DD Toe Observation Well Temp

(10.5m from DD3 well pair)

3.1.1-7c





Jackfish 3 – Pad EE Highlights

Medium Performer

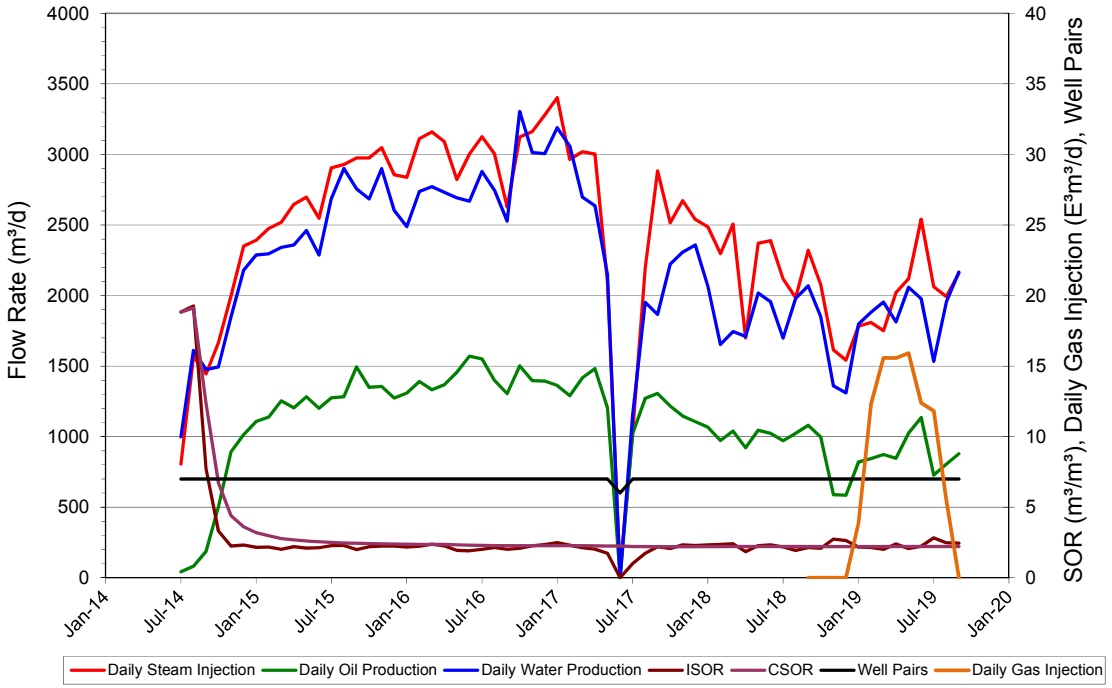
3.1.1-7c

- First steam occurred in July 2014
- Seven well pairs in operation
- Production currently in plateau phase
- Wells EE1 – EE5 have clean sand with uniform ceiling
- Wells EE6 – EE7 have low ceiling at toe of wells
- Steam subs opened on EE1 – EE5 in 2015 to increase steam injection rates
- Pad SOR historical average between 2.0 – 2.5
- EE exhibiting signs of transition into decline

Pad EE Performance

Jackfish 3 Pad EE Life Plot

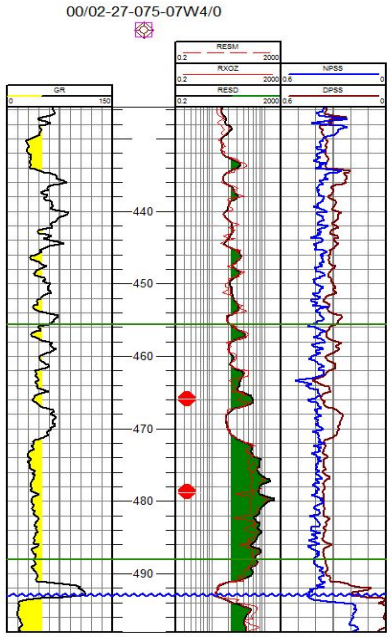
3.1.1-7c

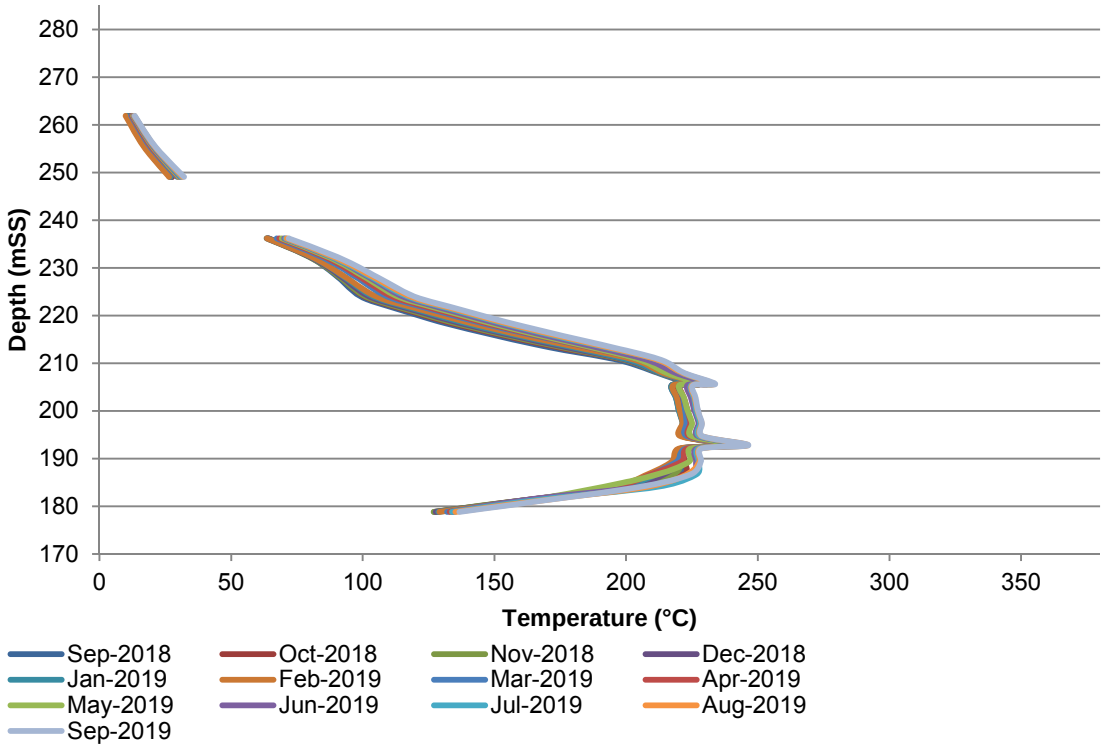


Pad EE Heel Observation Well Temp

(4.8m from EE5 well pair)

3.1.1-7c





Jackfish 3 – Pad K Highlights

High Performer

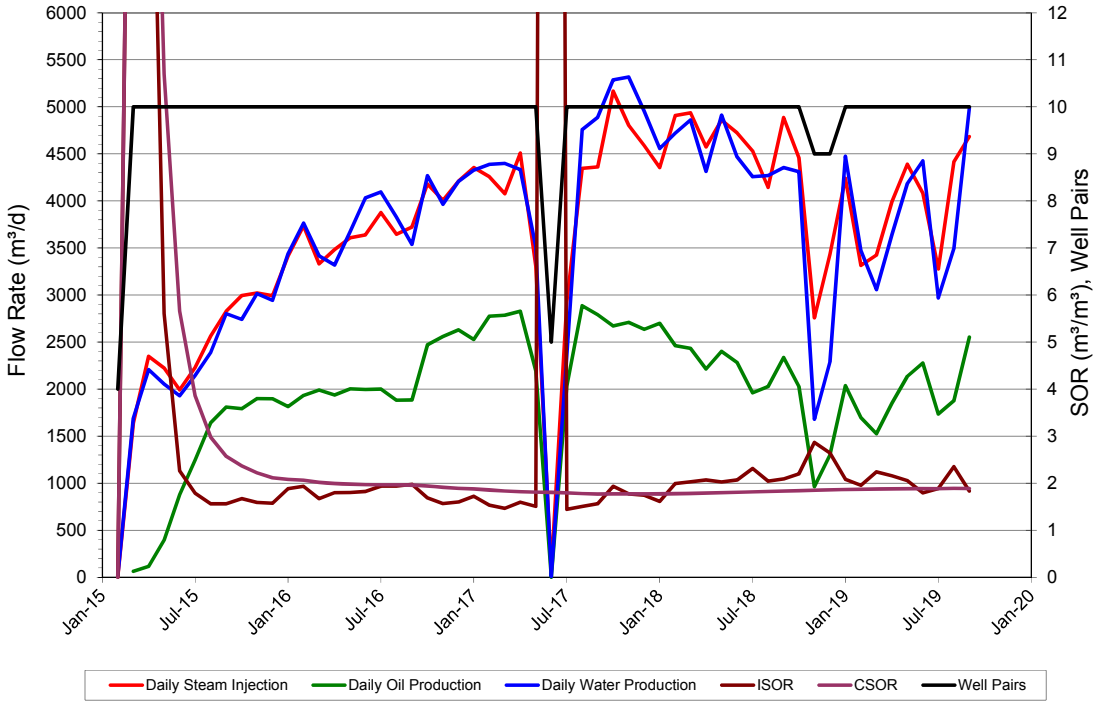
3.1.1-7c

- First steam occurred in February 2015
- Ten well pairs are in operation
- Best performing pad at Jackfish 3
- Clean sand throughout all ten well pairs
- Historical SOR < 2
- Pad K starting to exhibit signs of potential decline

Pad K Performance

Jackfish 3 Pad K Life Plot

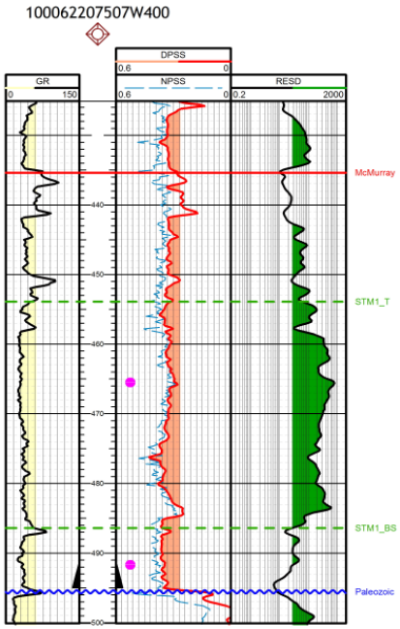
3.1.1-7c

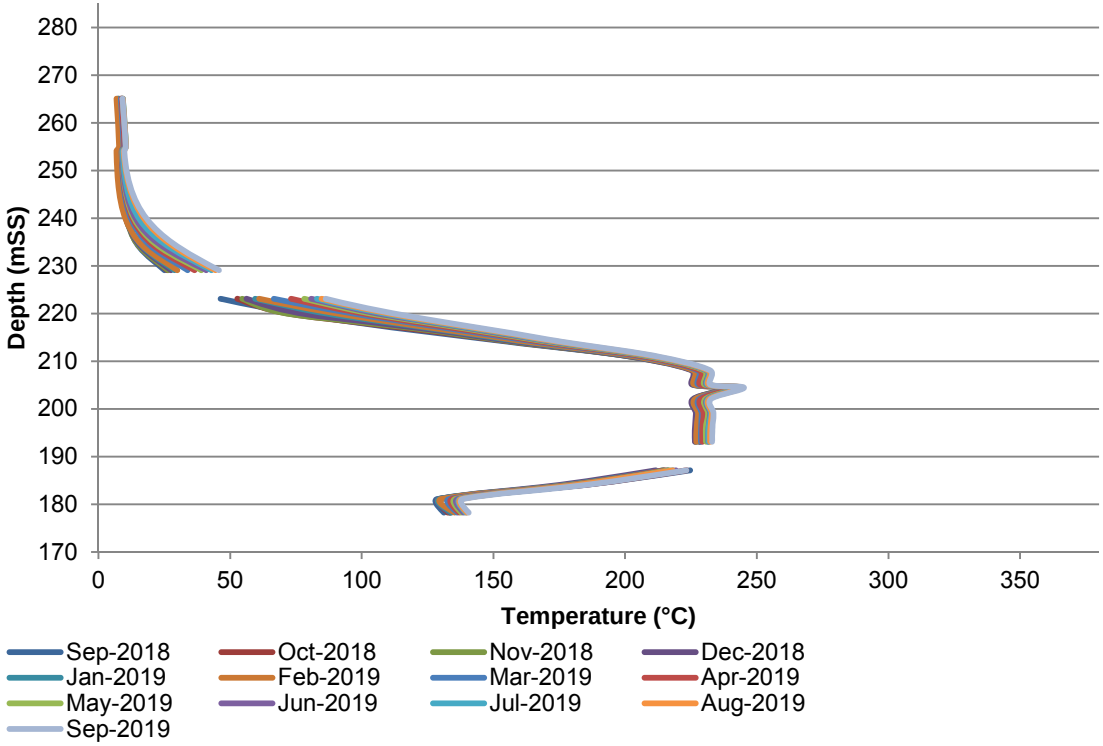


Pad K Toe Observation Well Temp

(9.5m from K5 well pair)

3.1.1-7c





Five Year Outlook

Jackfish Pad Abandonments

3.1.1-7c

- No anticipated pad abandonments at Jackfish within the next five years

Five Year Outlook

Wellhead Steam Quality

3.1.1-7d

	Pressure (kPag)	Temperature (°C)	Quality (%)
Plant Gate	9,600	311	100
JF1 Wellhead	2,500-3,700*	226-246	97
JF2 Wellhead	2,500-4,400*	226-256	97
JF3 Wellhead	2,500-4,400*	226-256	97

* Maximum injection pressure for each facility in line with MOP

- Losses in steam quality occur as steam is transported to the pads
- Utilize condensate traps at each pad to maximize wellhead steam quality

NCG Co-injection

3.1.1-7e,g

- Overview:
  - NCG source is fuel gas, primarily composed of methane
  - 16 Pads with NCG co-injection capability:
    - JF1: A, B, C, D, E, H, and I
    - JF2: AA, BB, CC, DD, FF, KK
    - JF3: EE, RR, and VV

- Learnings to date:
  - NCG injection rates within expected range
  - NCG successful in maintaining chamber pressure with reduced steam
  - No negative impact to resource recovery observed in late life NCG co-injection
  - Improved SOR observed

- Go Forward Plan:
  - Continue to monitor and evaluate NCG utilization and performance

Steam Additive

3.1.1-7e,g

- Overview:
  - Chemical additive co-injected with steam into two injection wells on pad OO (Jackfish 2)
  - Limited scale pilot
  - Executed May 2018 – February 2019

- Pilot results inconclusive at this time
- Learnings to date:
  - Chemical additive impact on the downstream Central Processing Facility (CPF)
  - Identifying appropriate selection criteria for a steam additive pilot
  - Appropriate plan, design and facility construction
  - Testing and monitoring techniques, such as sample points selection and sampling frequency
  - Chemical additive transportation and logistics

Jackfish Performance

Key Learnings

3.1.1-7f

- District SOR improvements tied to pressure reduction and optimization
- Maintained focus on pressure balance with the aquifer is beneficial
- Successful use of NCG enables steam transfer to higher quality pads

Canadian Natural

Future Plans
3.1.1-8

Jackfish Performance

Well Operations, Drilling, and Trials

3.1.1-8a,b

- Jackfish 1
  - Pad EX – Startup planned Q4 2019
  - Pad A – 3 additional producers drilling planned Q3 2020
  - Pad S – SAGD drilling planned Q4 2020
- Jackfish 2
  - Pad MM – Startup planned Q4 2019
  - Pad QQ – Startup planned Q4 2019
  - Pad TT – SAGD drilling planned Q1 2021
  - Pad XX – SAGD drilling planned Q3 2021
- Jackfish 3
  - Pad OOO – drilled Q2 2019

Jackfish Performance

Jackfish District Steam Strategy

3.1.1-8c

- Jackfish 1
  - Utilizing steam capacity while managing SOR through steam allocation, execution of NCG co-injection, and continuing to balanced chamber pressures with aquifer
- Jackfish 2
  - Utilizing steam capacity while managing SOR through steam allocation, pressure management, and leveraging NCG co-injection across asset
- Jackfish 3
  - Utilizing steam capacity while managing SOR through steam allocation, pressure management, and leveraging NCG co-injection across asset

Canadian Natural

Surface Operations

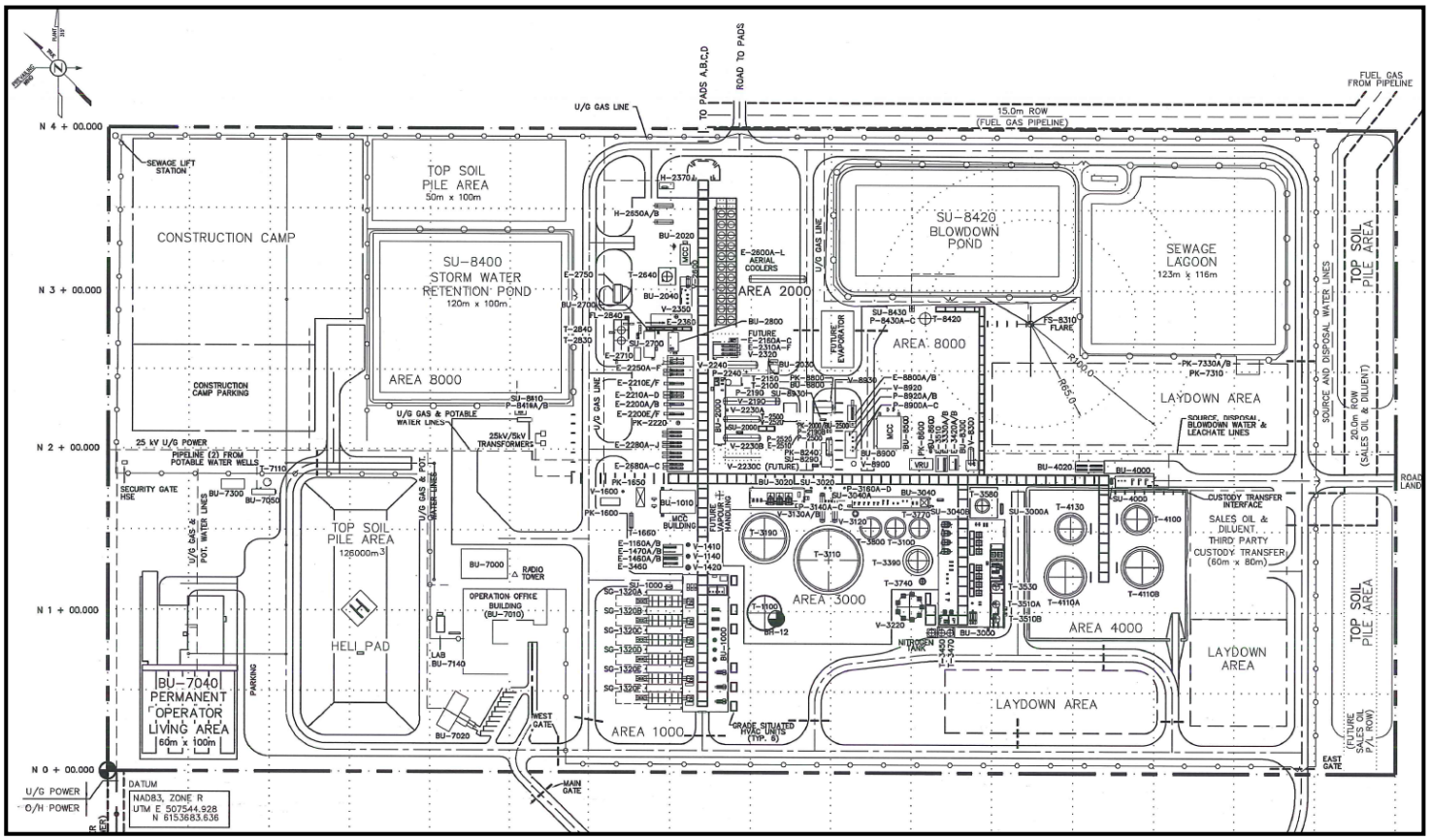
Canadian Natural

Facilities Overview
3.1.2-1

Facilities

Jackfish 1 Plot Plan

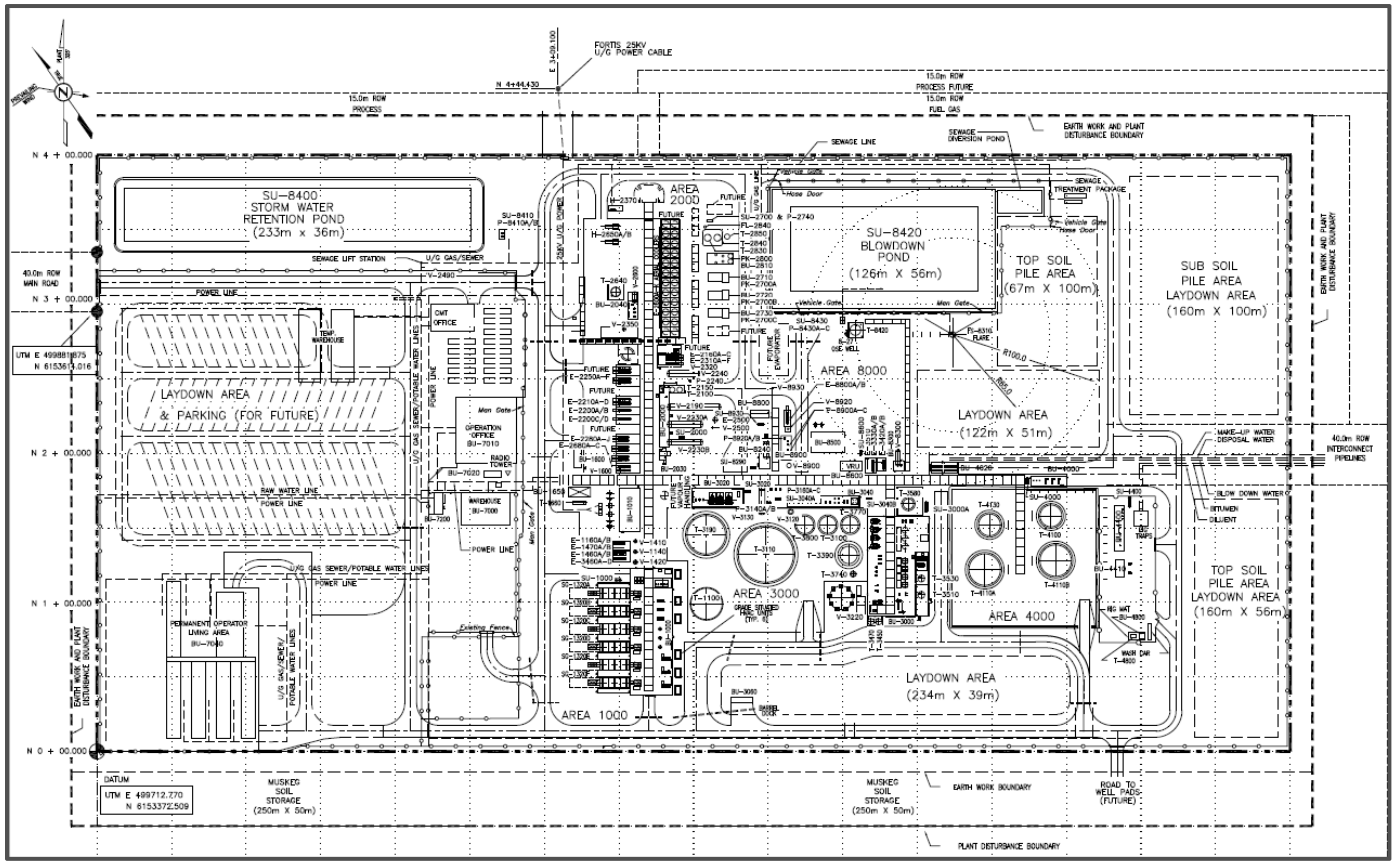
3.1.2-1a



Facilities

Jackfish 2 Plot Plan

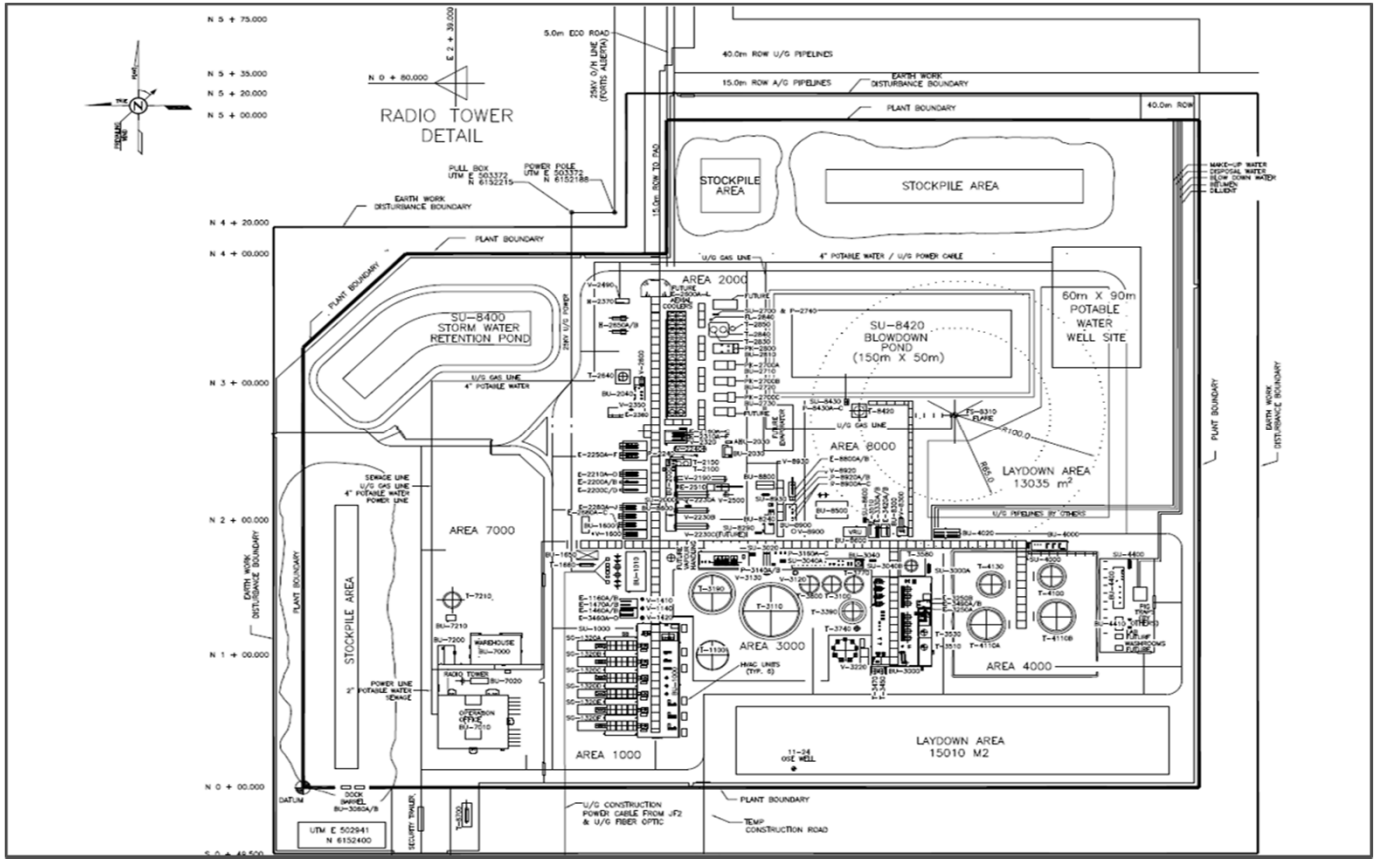
3.1.2-1a



Facilities

Jackfish 3 Plot Plan

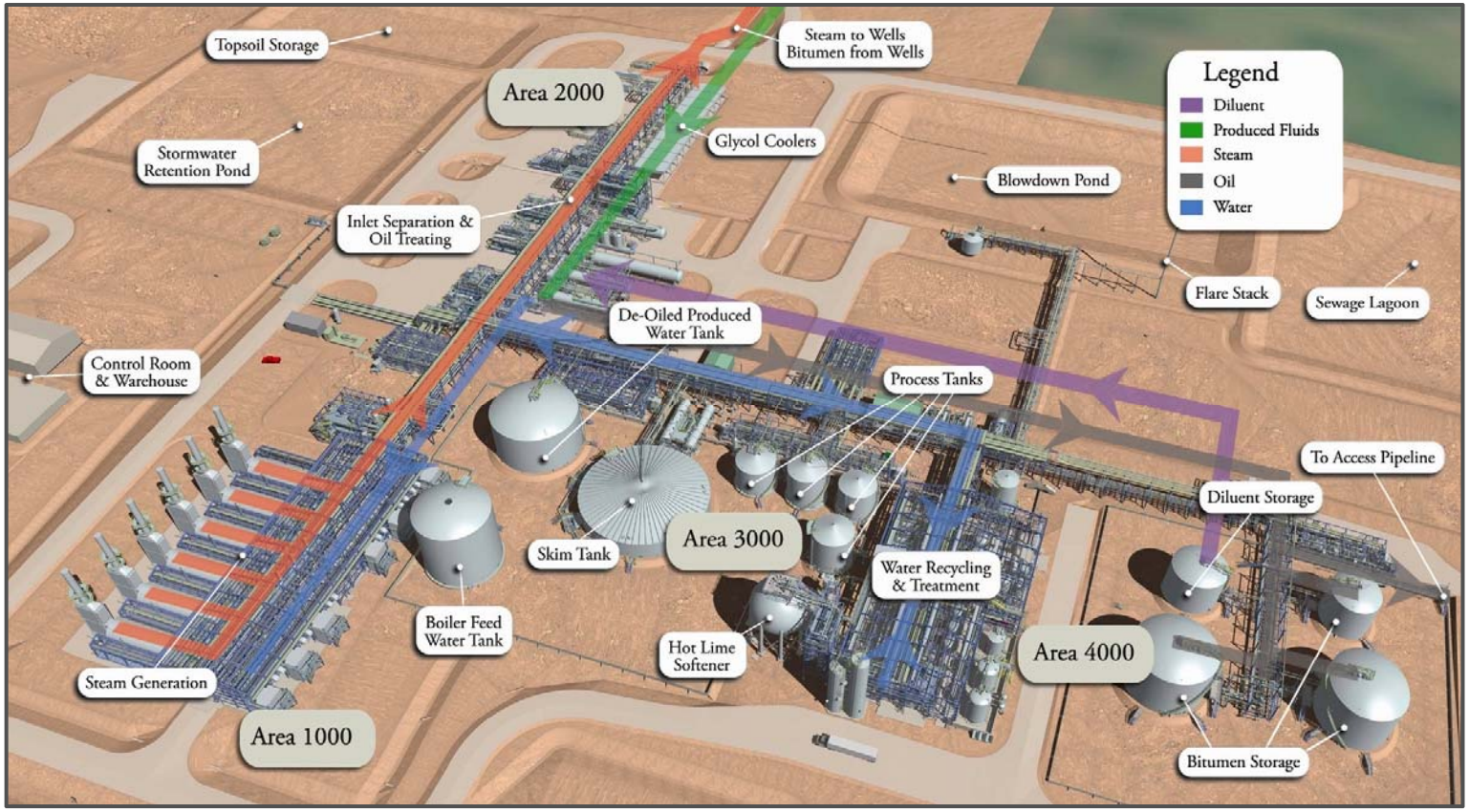
3.1.2-1a



Facilities

Plant Schematic

3.1.2-1b



Facilities

Plant Performance

3.1.2-d

Turnarounds/Outages

- Jackfish 2 maintenance turnaround completed June 2019

Bitumen Treatment

- Stable operation and production rates at Jackfish 1 and Jackfish 3

Water Treatment

- Utilized brackish water wells with TDS ranging from greater than 4,000 - 22,000 ppm for all make up water requirements

Steam Generation

- 80% overall steam quality targeted to decrease blowdown disposal volumes and increase steam generation

Canadian Natural

Measurement and Reporting
3.1.2-2

Measurement and Reporting

Methods

3.1.2-2a

- **Well Bitumen / Water Production**
  - Total battery production is allocated to each SAGD producing well based on individual well tests
  - Battery Bitumen Production = Dispositions – Receipts + ΔInventory + Blending Shrinkage
  - Battery Water Production = Inlet Produced Water + ΔInventory + Truck Out – Truck in – Desand Water to Treater and FWKO
  - Individual well test:
    - Each pad equipped with test separator along with coriolis meter and watercut analyzer on liquid leg
    - Vortex meter for gas measurement / water vapor calculation
    - Tested water volume includes the calculated water vapor (from $P_{sat}/P_{measured}$)
    - Typical well test duration is nine hours

Measurement and Reporting

Methods

3.1.2-2a

- **Well Gas Production**
  - Well Estimated Test Gas Production = (GOR) x (Test Bitumen Production)
  - Battery Gas Production = Fuel + Fuel to IF + Flare – TCPL Purchase – Receipt Gas – Diluent Flash
  - Battery gas is allocation to each well based on well test

- **Steam Injection**
  - Total steam to field measured downstream of HP separators minus the steam condensate
  - Vortex meters at each wellhead are used to allocate total steam

Measurement and Reporting

Water Balance and Compliance

3.1.2-2b

Water Balance

- Water balance is done on each of the reporting injection facilities (4 total) included in the scheme

Calibration

- All meters used in water balance are verified and inspected as per Directive 017

Accuracy / Location

- Meter accuracies and locations have been reviewed for all water meters used for volume reporting

Measurement and Reporting

NCG Injection, Production Reporting

3.1.2-2d

- NCG being used across scheme as co-injection strategy as per approval
- NCG sourced from existing lift gas infrastructure (purchased TCPL gas)
- NCG injection is metered on a per well basis using vortex meters with live pressure and temperature correction applied
- As all gas production is consumed as fuel, NCG recovery is not estimated for Petrinex volumetric reporting

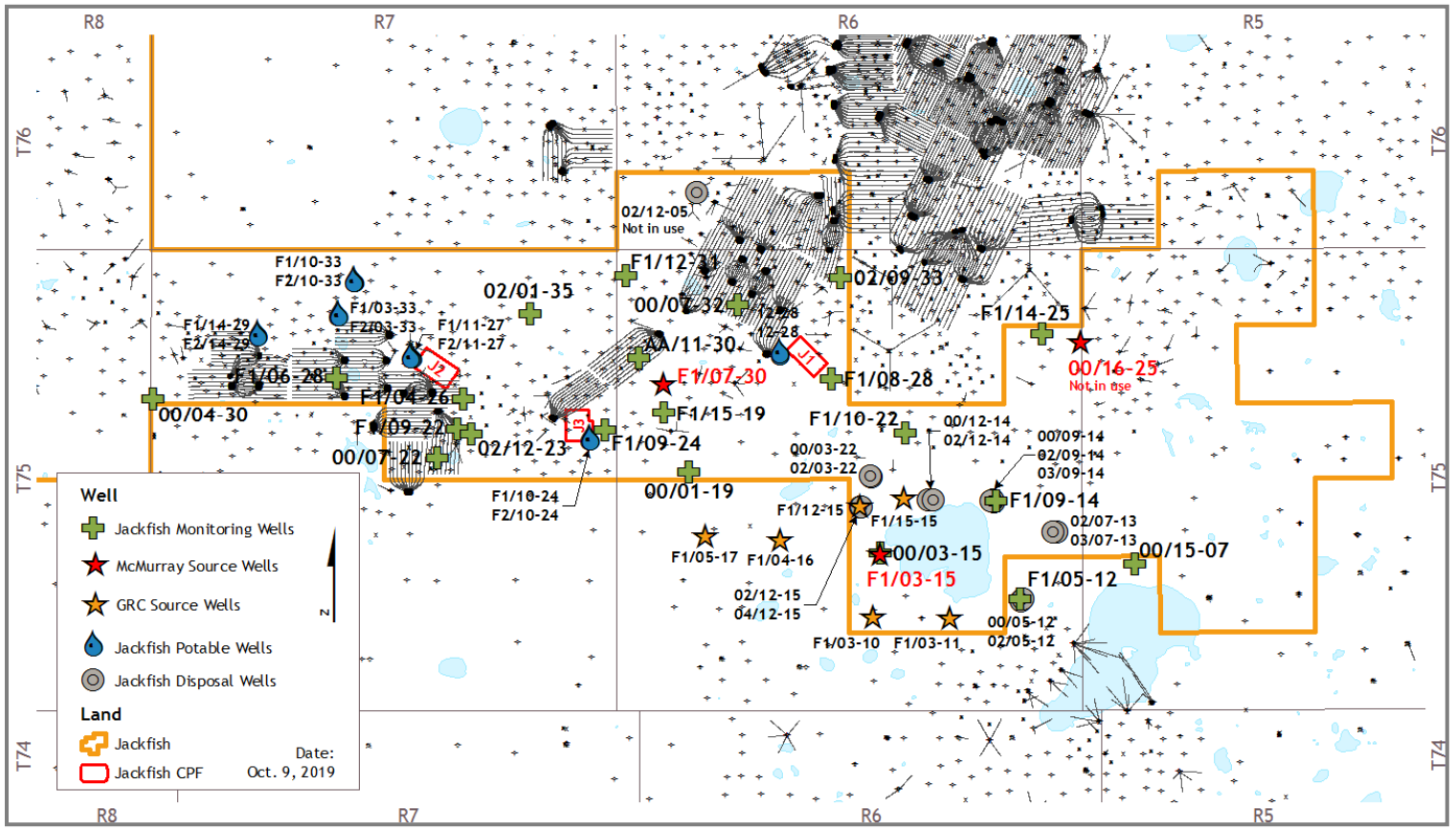
Canadian Natural

Water Production, Injection, and Uses
3.1.2-3

Water Disposal and Source Water

Well Locations

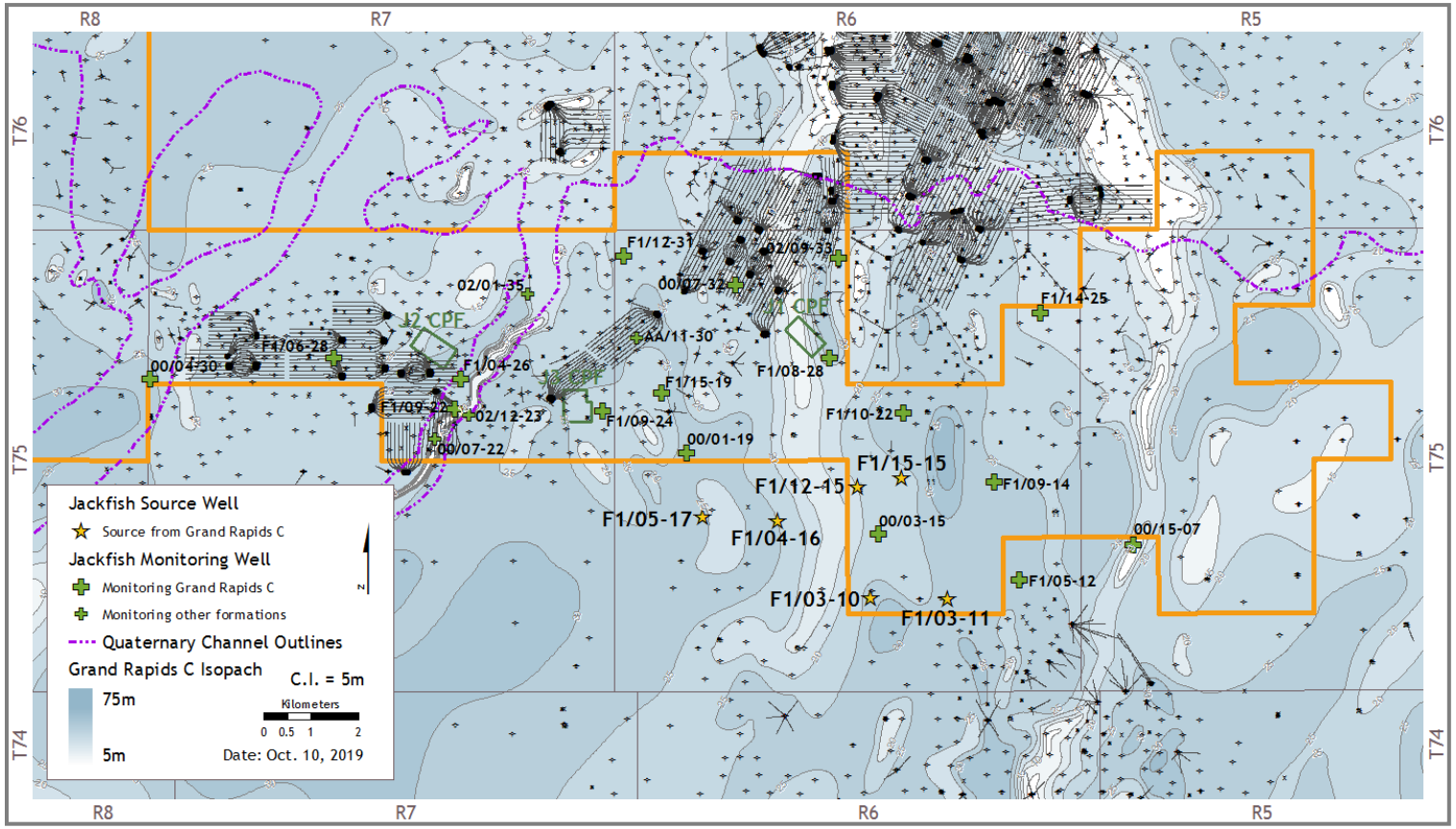
3.1.2-3a



Source Water Geology

Grand Rapids C Aquifer

3.1.2-3a

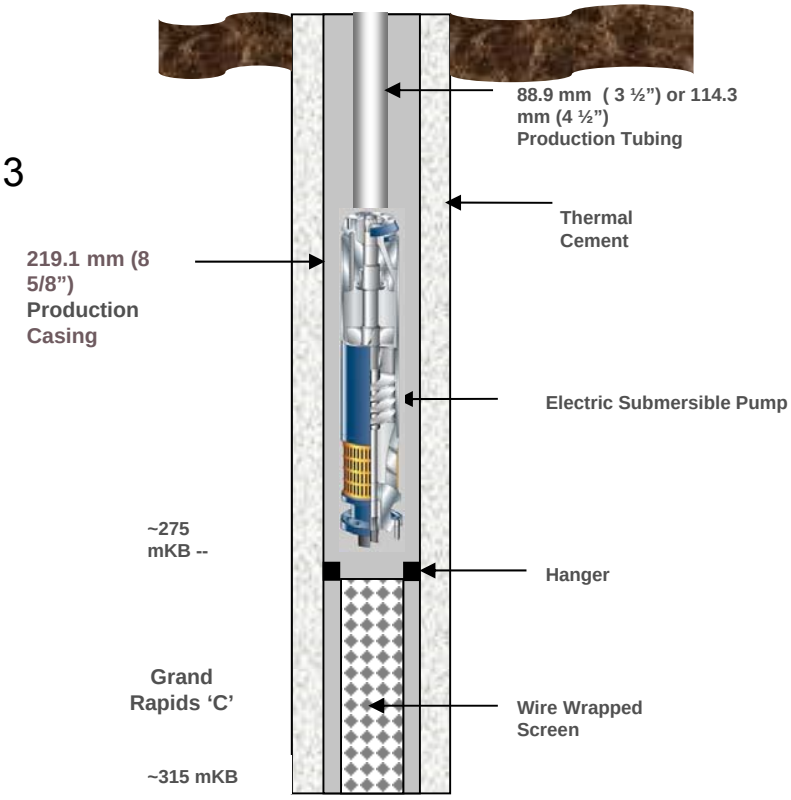


Water

UWI of Fresh and Brackish Wells

3.1.2-3a

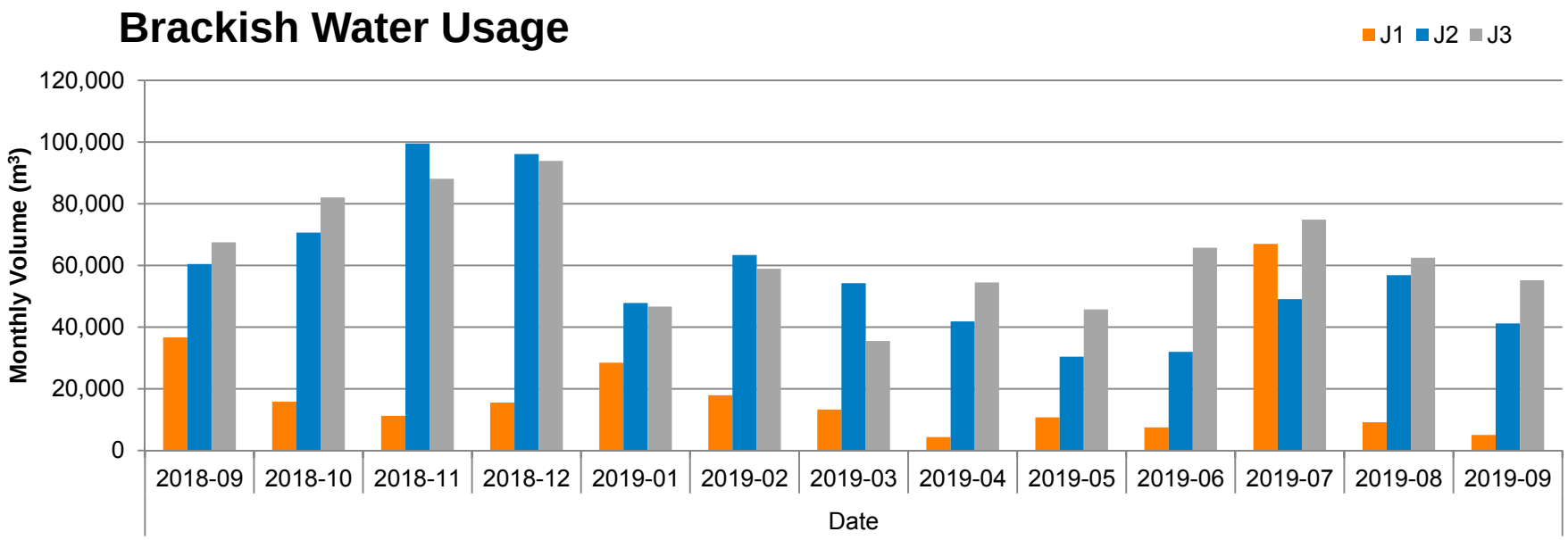
- Brackish source water produced from the Grand Rapids ‘C’ and McMurray zones
- Available for Jackfish 1, Jackfish 2, and Jackfish 3
- Two McMurray Wells:
  F1/07-30-075-06W4
  F1/03-15-075-06W4
- Six Grand Rapid Wells:
  F1/12-15-075-06W4
  F1/15-15-075-06W4
  F1/03-10-075-06W4
  F1/03-11-075-06W4
  F1/04-16-075-06W4
  F1/05-17-075-06W4



Water

Uses and Volumes Needed for Fresh and Brackish Water Make-Up

3.1.2-3b



Canadian Natural

Water Treatment Technology
3.1.2-4

Water Treatment Technology

3.1.2-4

- New water treatment technology in the Jackfish District includes:
  - Implementation of permanent polymer skids at Jackfish 1, 2, and 3
  - Upgraded lime and magox feeder
  - Implementation of soda ash feed for HLS across Jackfish district

Canadian Natural

Water, Disposal Wells, Landfill Waste
3.1.2-5

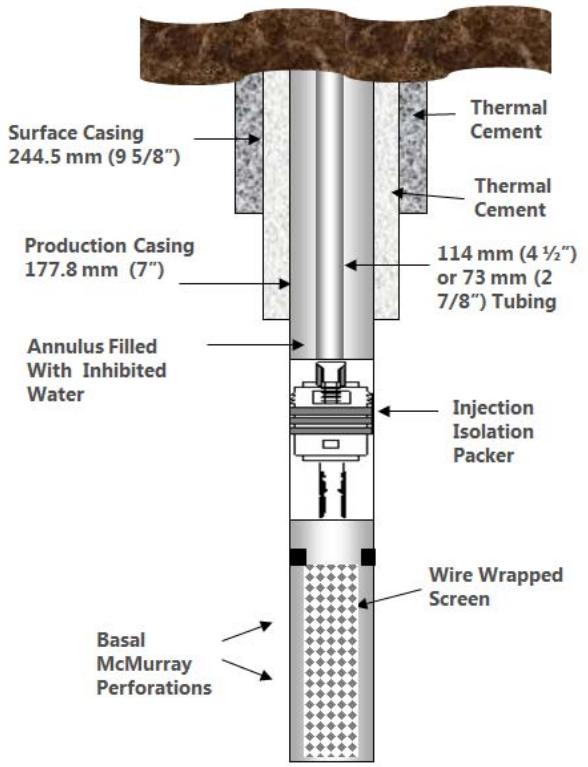
Water, Waste Disposal Wells, and Landfill Waste

UWI's of Disposal wells

3.1.2-5a

Disposal System is shared between Jackfish 1, 2, and 3

- Two disposal streams:
  - Blowdown and regen waste
- Fourteen Class 1b disposal wells in total:
  - Twelve active (see list below)
  - One inactive (102/12-05-076-06W4)
  - One suspended (102/03-22-075-06W4)
- Approved MWIP of 6,000 kPa (July 2009)
- Jackfish 1 disposal wells:
  - 00, 02, and 03/09-14-075-06W4 (blowdown)
  - 00 and 02/12-14-075-06W4 (regen)
- Jackfish 2 disposal wells:
  - 02 and 03/07-13-075-06W4 (blowdown)
  - 02 and 04/12-15-075-06W4 (regen)
- Jackfish 3 disposal wells:
  - 00 and 02/05-12-075-06W4 (blowdown)
  - 00/03-22-075-06W4 (regen)

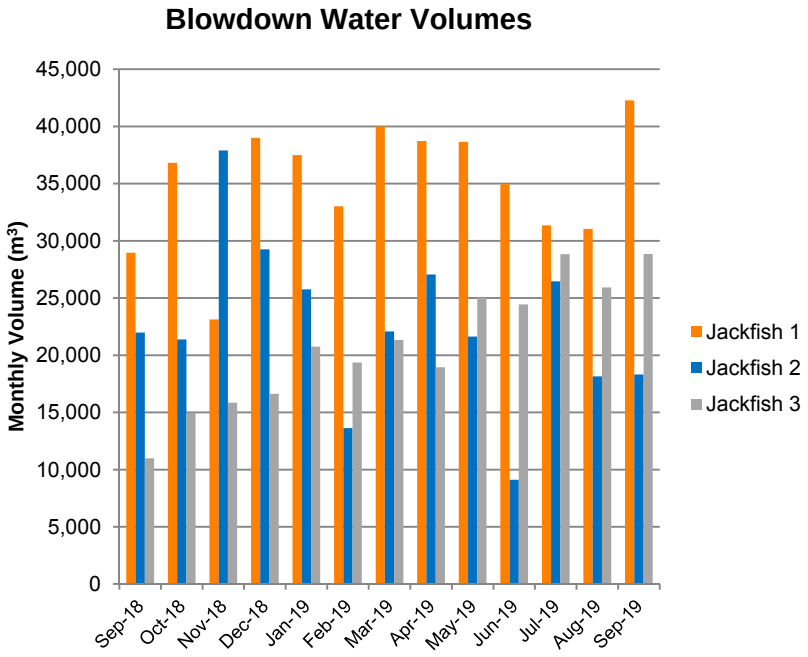


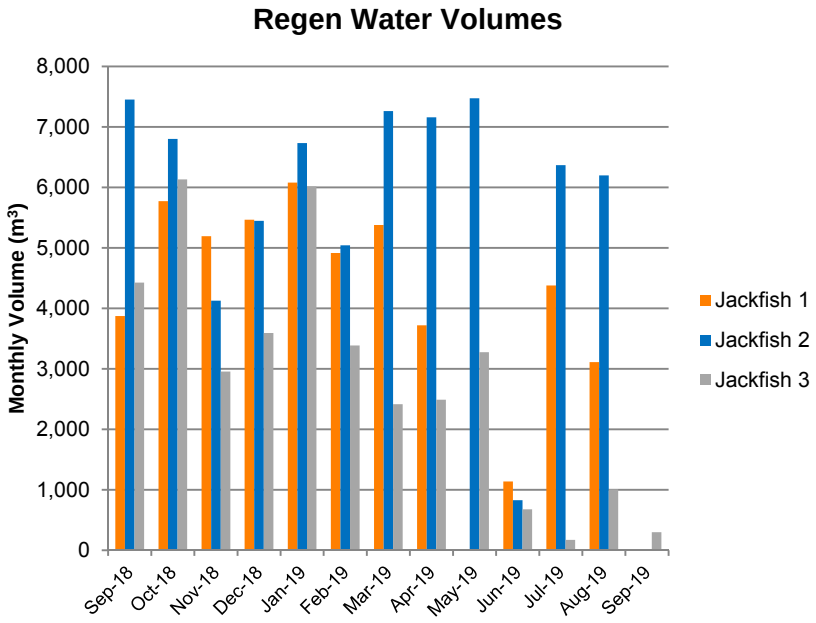
Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

3.1.2-5b

- Volume Summary - Approval No. 10790

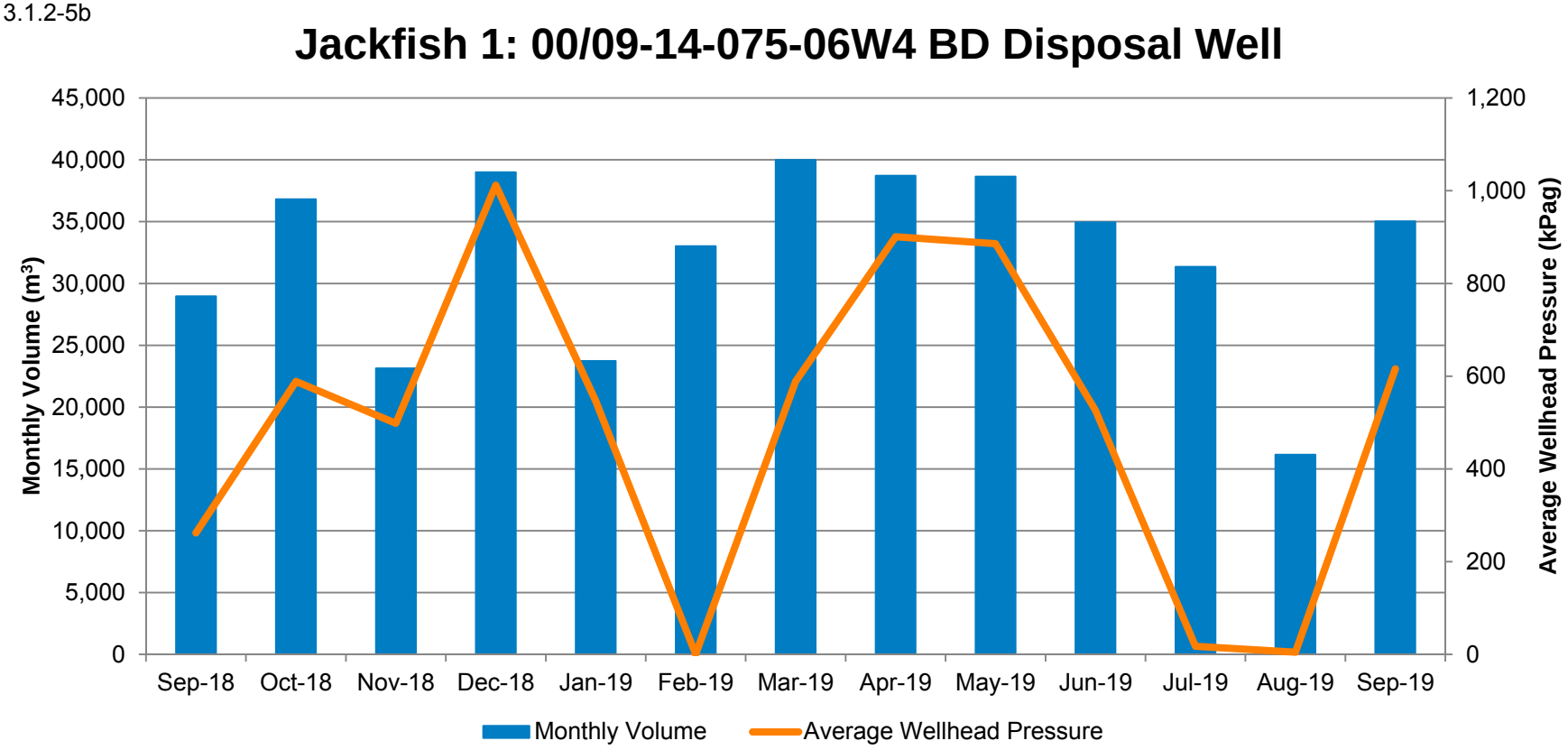




Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

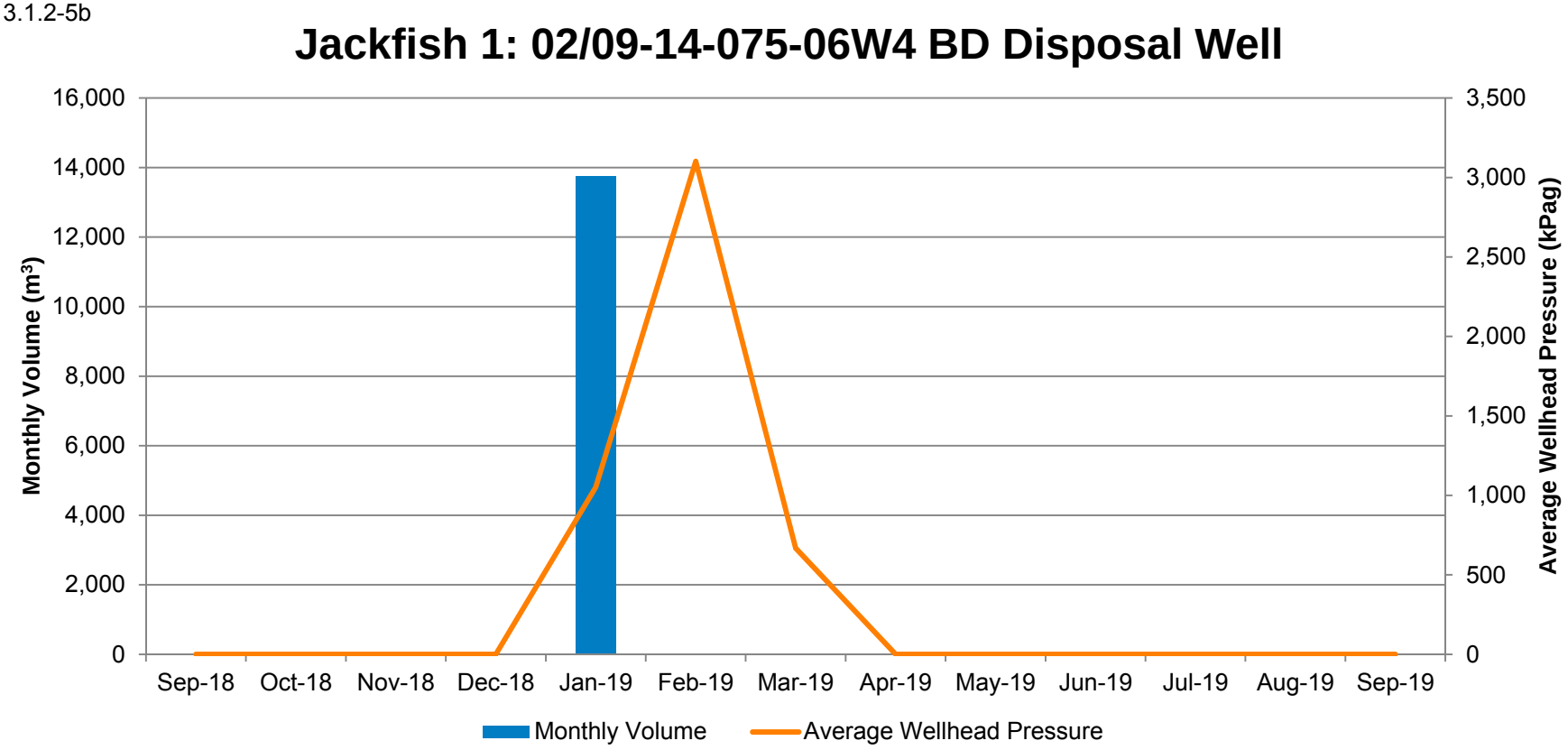
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

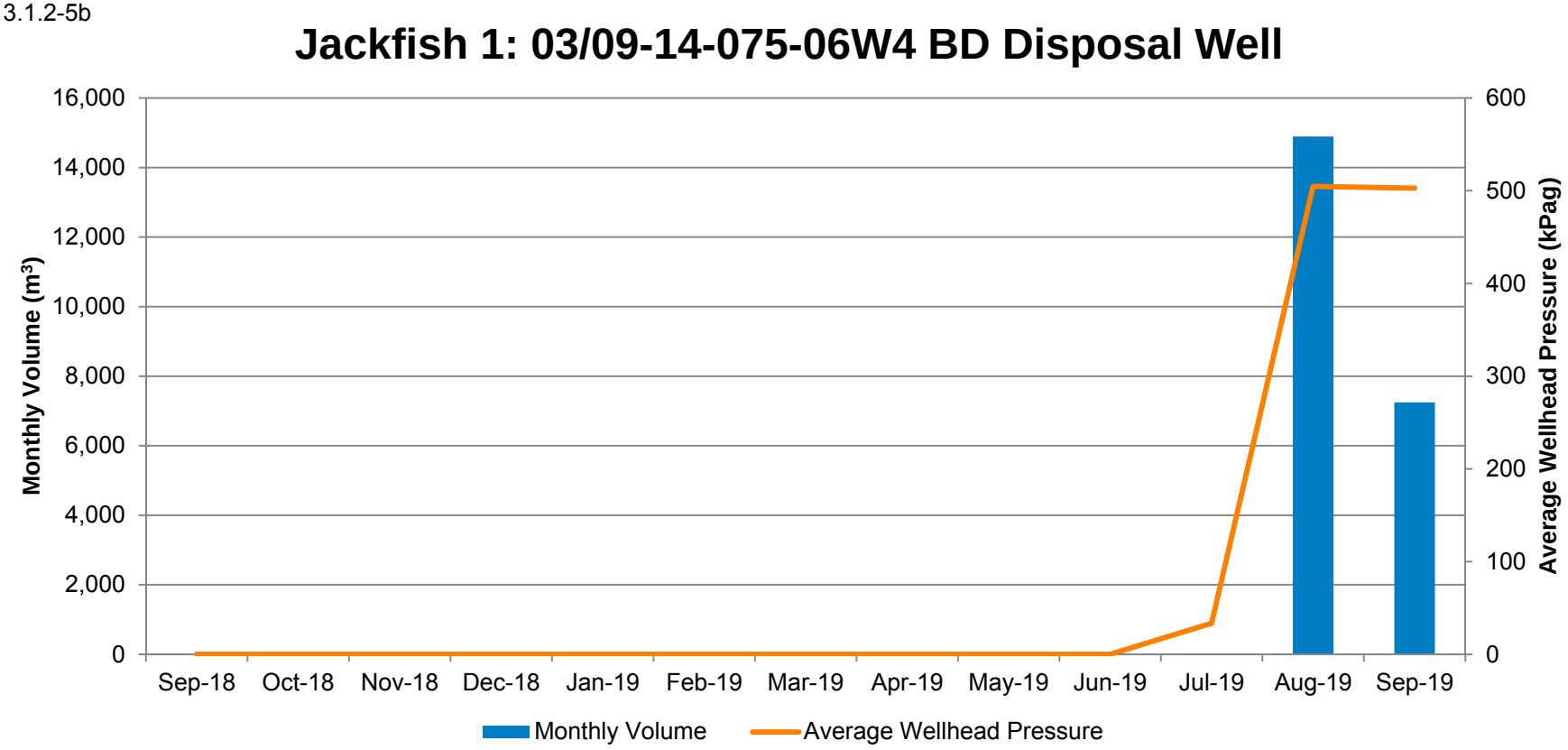
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

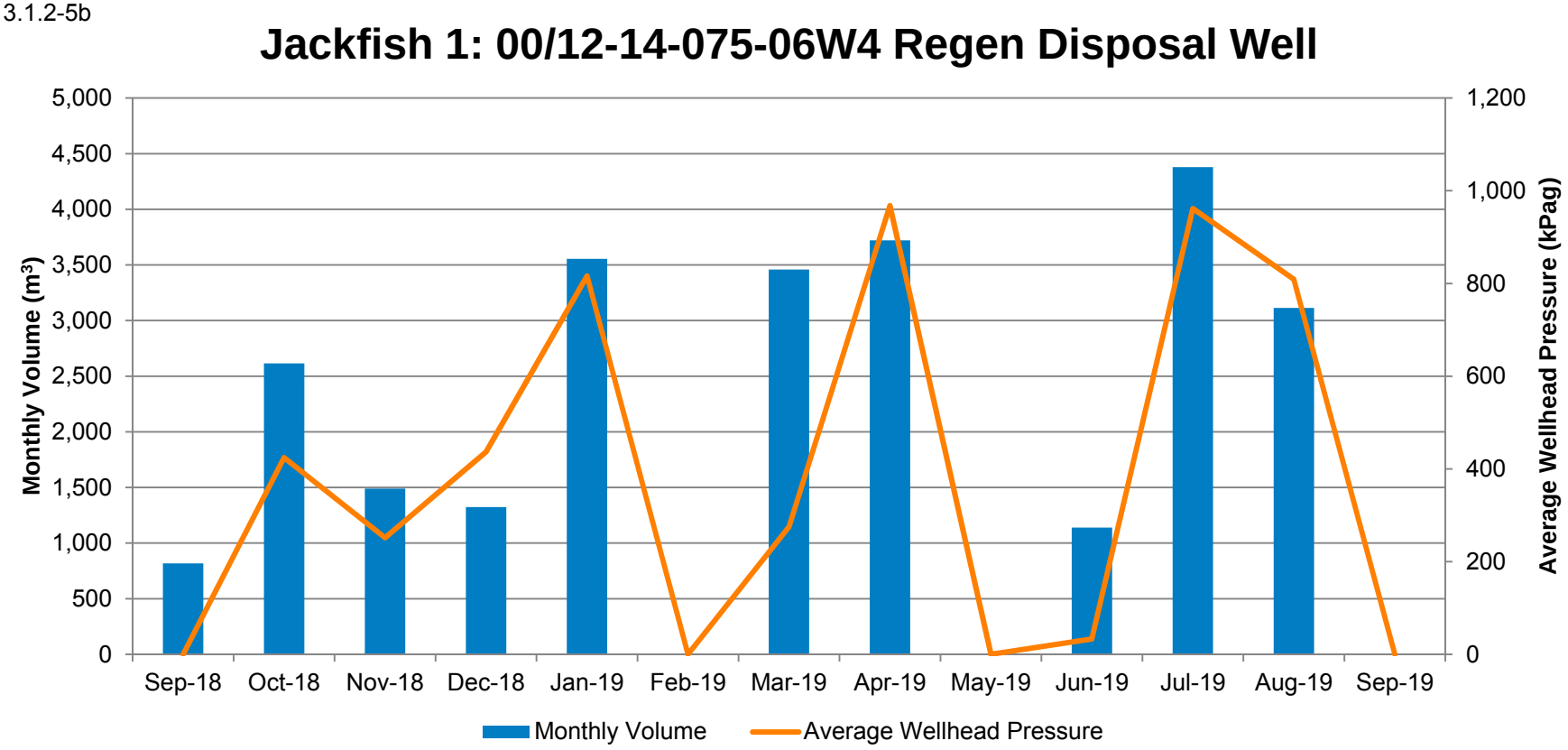
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

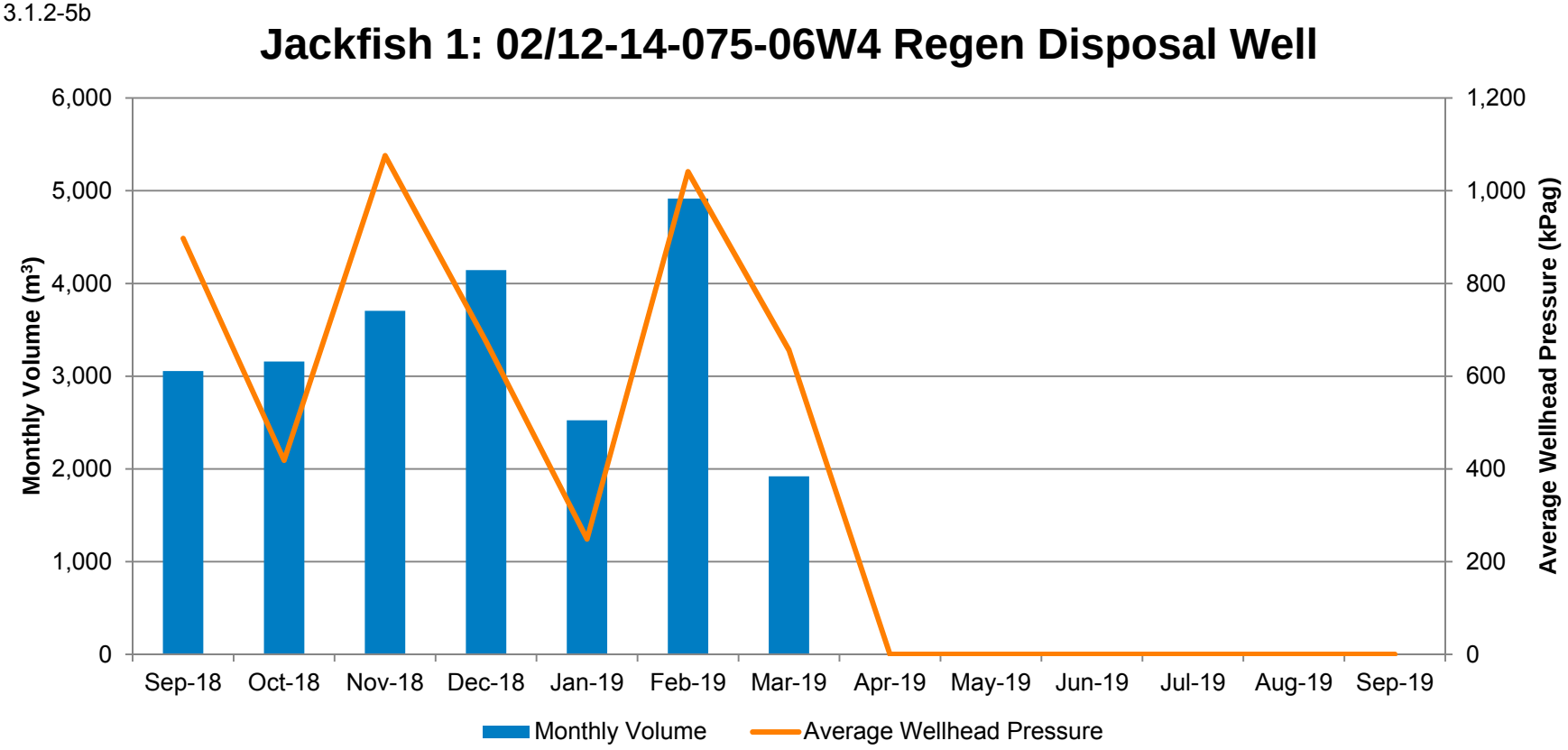
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

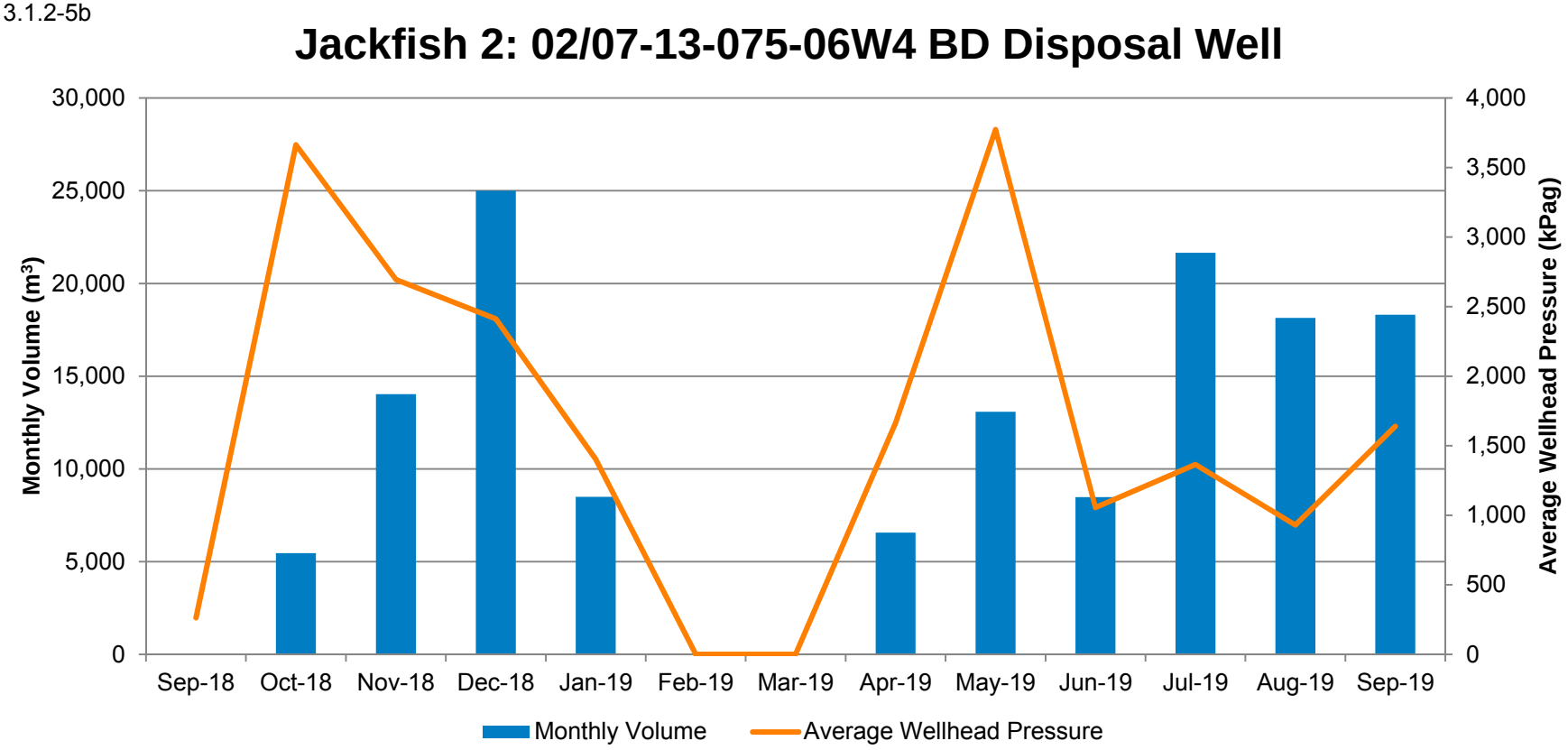
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

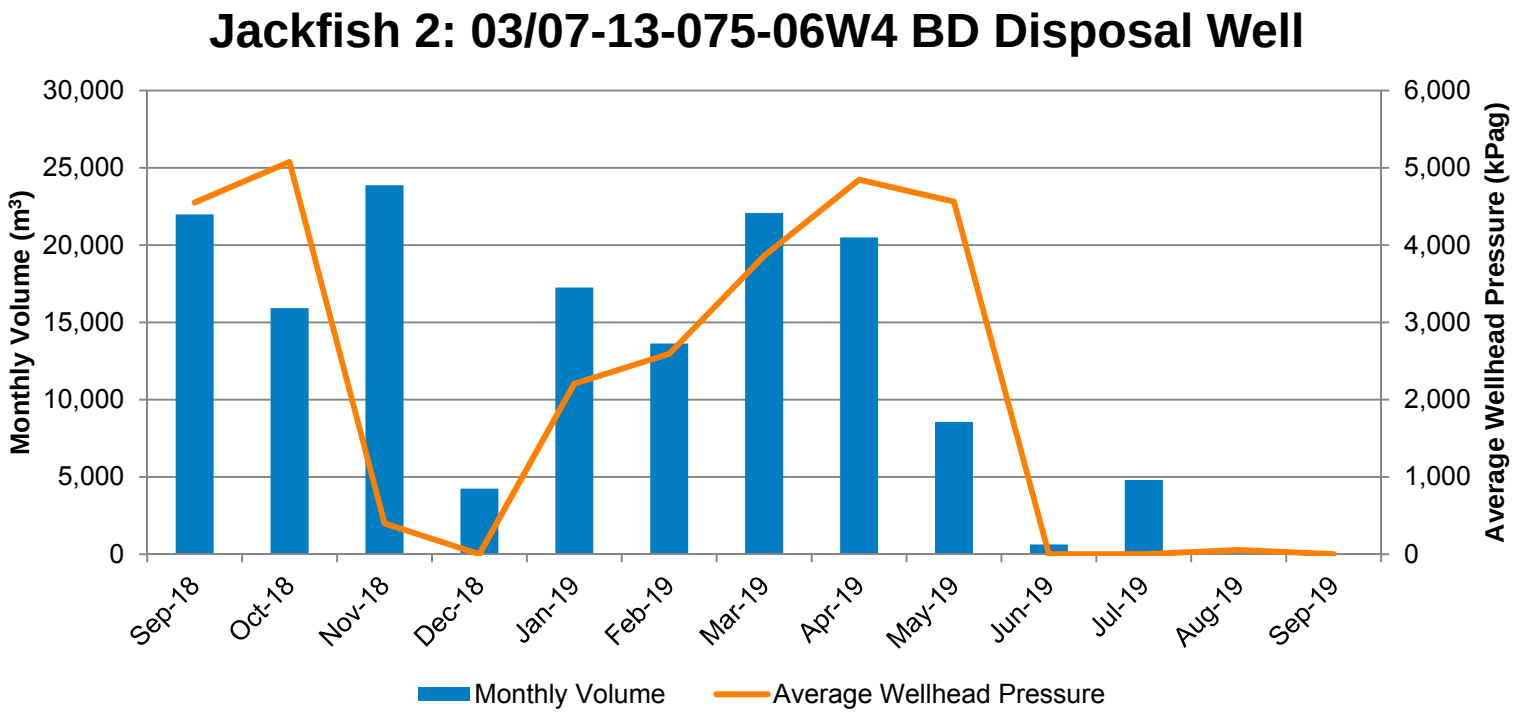
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

3.1.2-5b

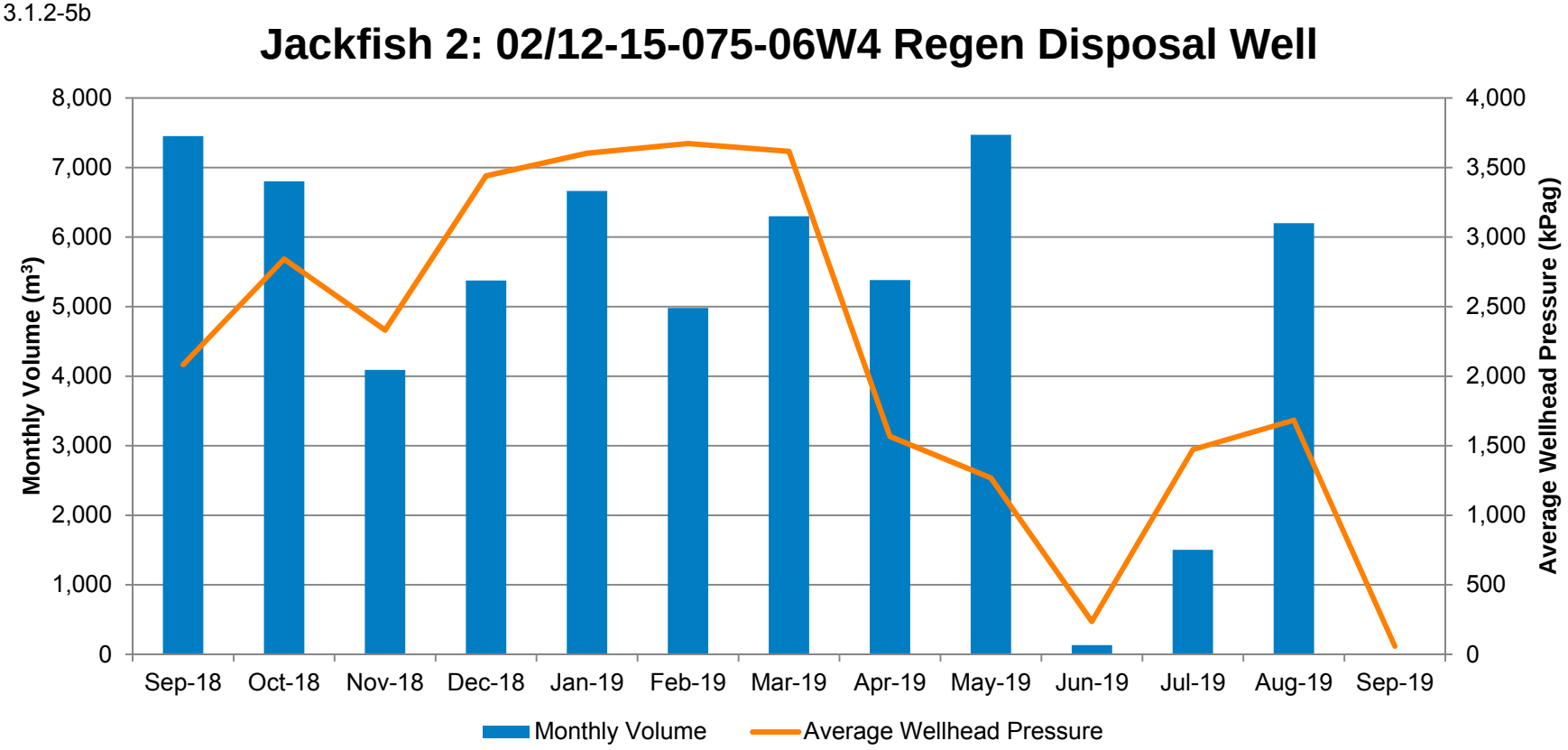


- Pressure transmitter failure mid November, brought back online late December

Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

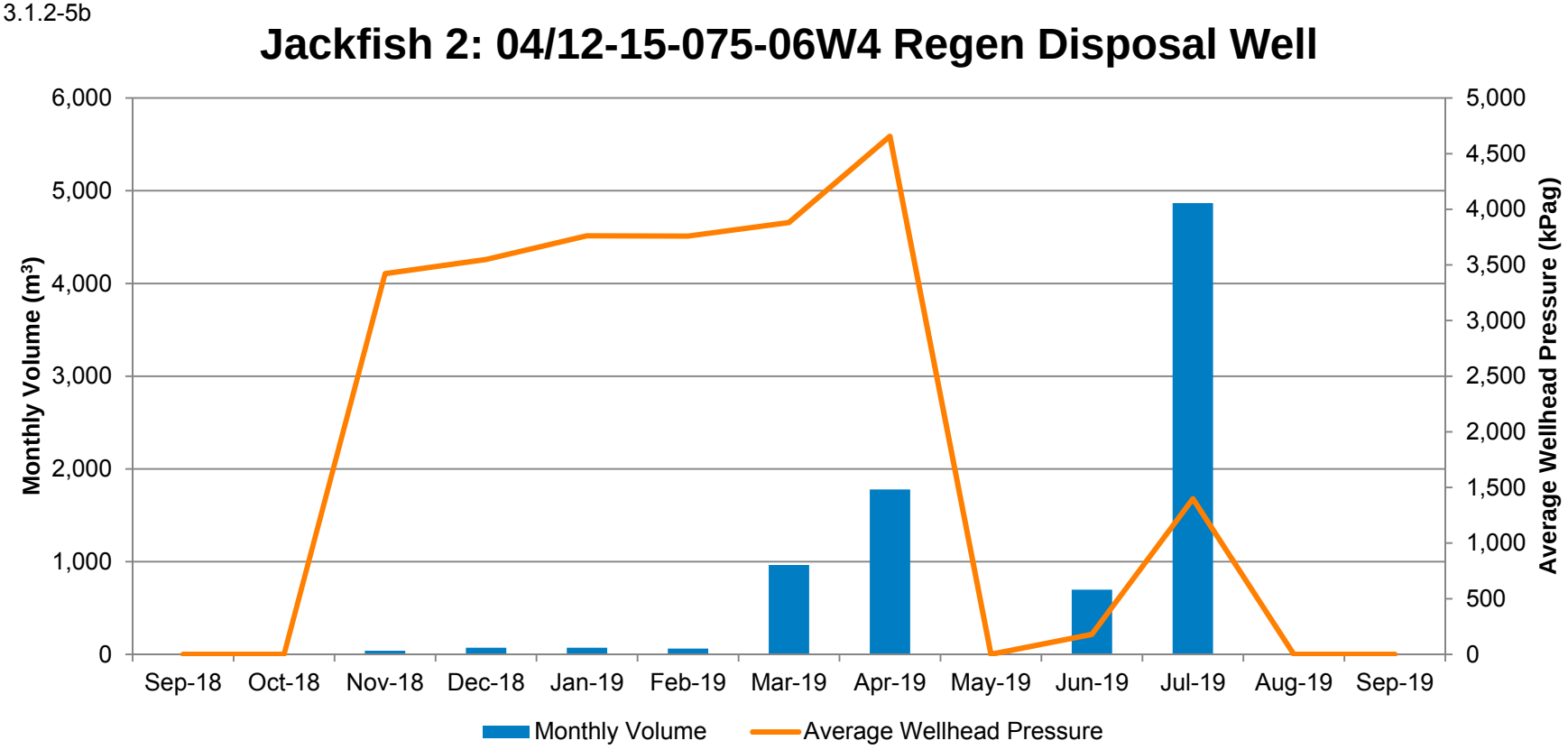
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

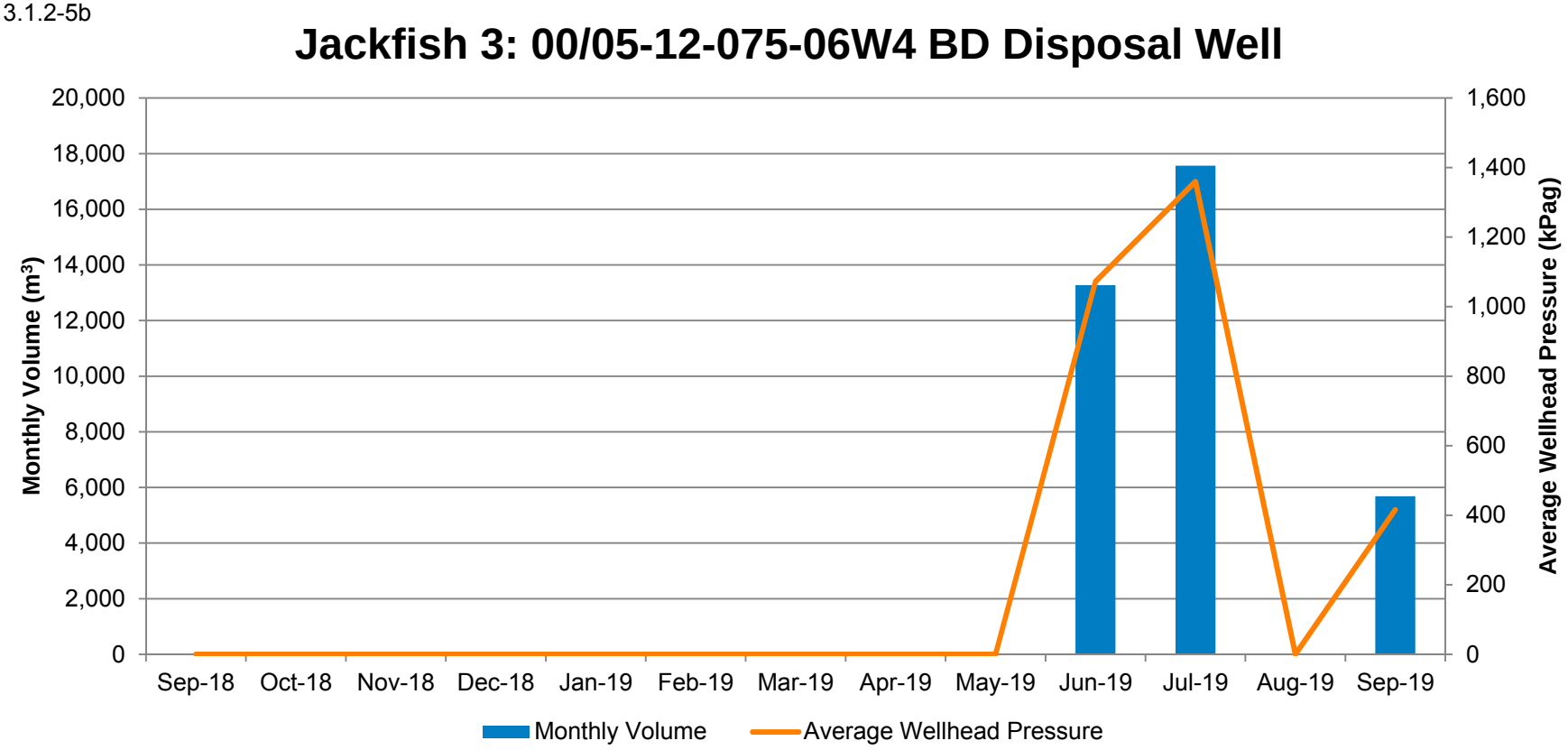
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

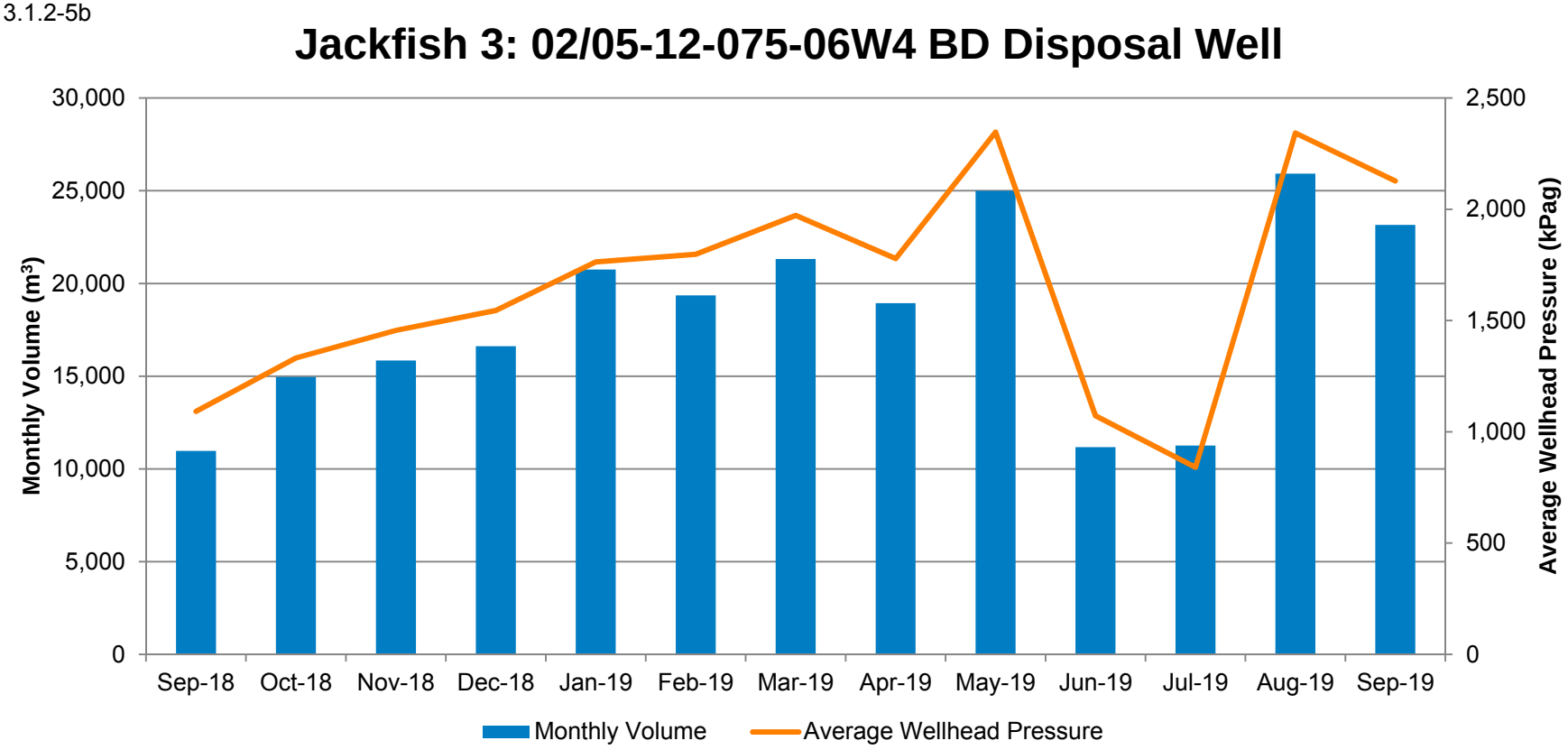
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

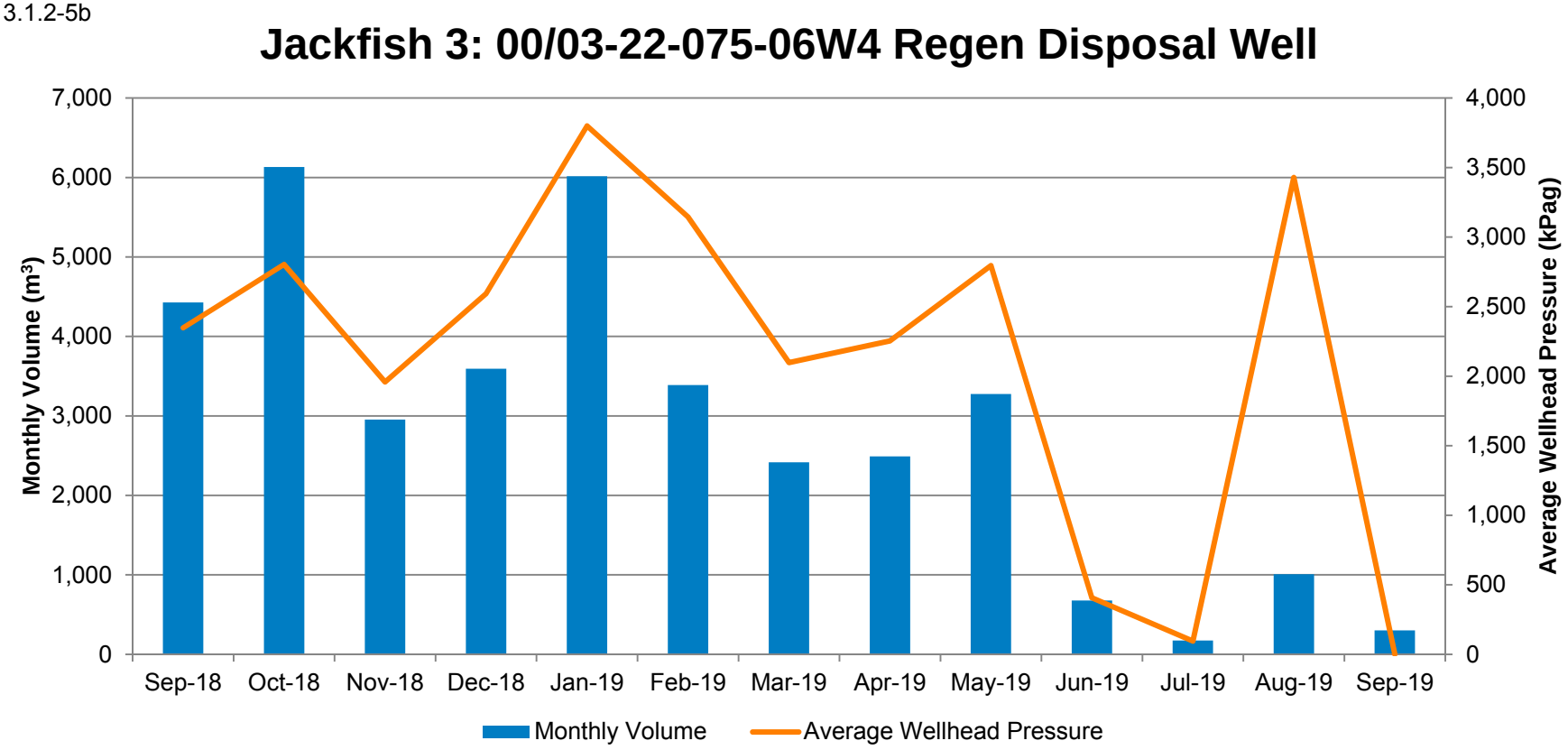
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Disposal Volumes, Pressure, Temperature

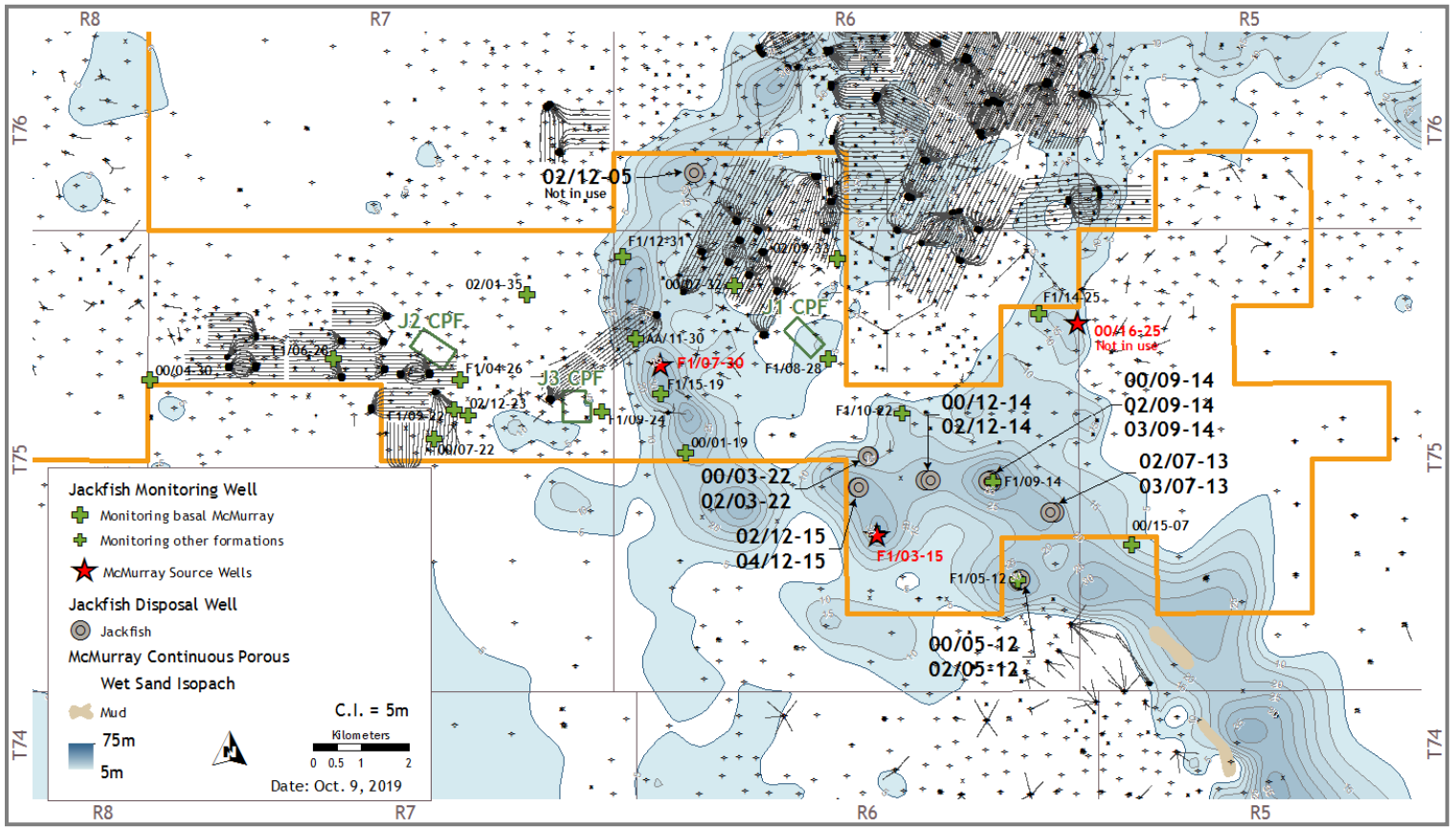
3.1.2-5b



Water, Waste Disposal Wells, and Landfill Waste

Basal McMurray Aquifer

3.1.2-5c



Water, Waste Disposal Wells, and Landfill Waste

Location of waste disposal site and volumes associated with the scheme

3.1.2-5c

Disposal Facility	Volume Injected (m^3)
Tervita Lindbergh Cavern Facility (AB WP 0000557)	1,408
Cancen New Serepta (AB WP 0099677)	165
Tervita Ft. McMurray (AB WP 0133414)	923
CEIBA ATHABASCA (AB WP 0136010)	369
White Swan Atmore (AB WP 0139656)	112
White Swan Conklin (AB WP 0142079)	12,644
Cancen Morinville (AB WP 0144022)	2,997
Total	18,618

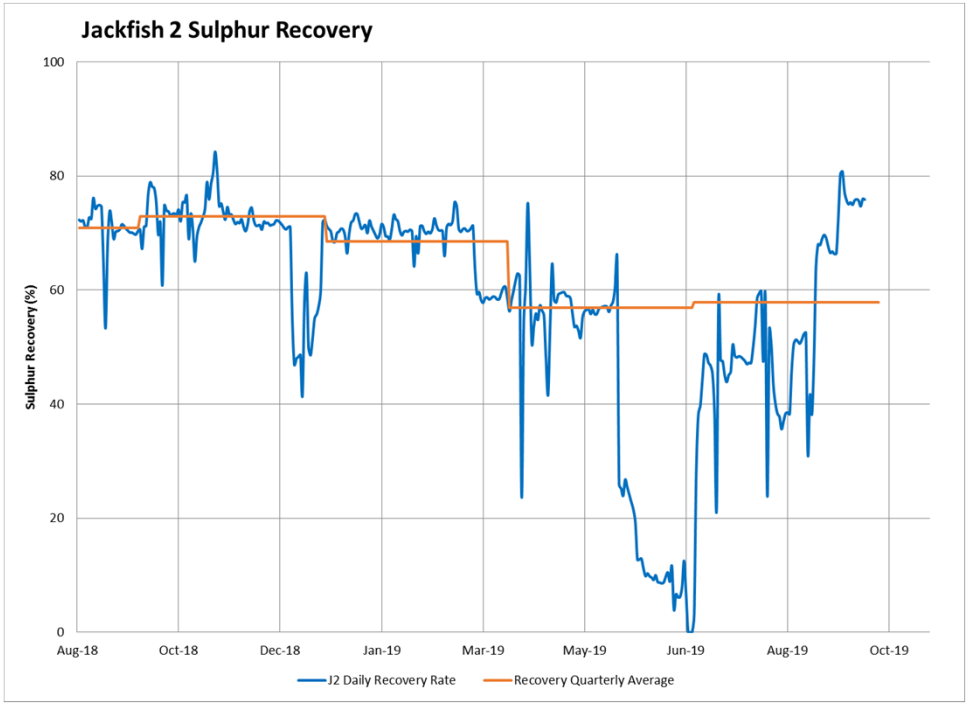
Canadian Natural

Sulphur Production and Air Emissions
3.1.2-6

Sulphur Production

Operations with Sulphur Recovery

3.1.2-6a (i) & (ii)

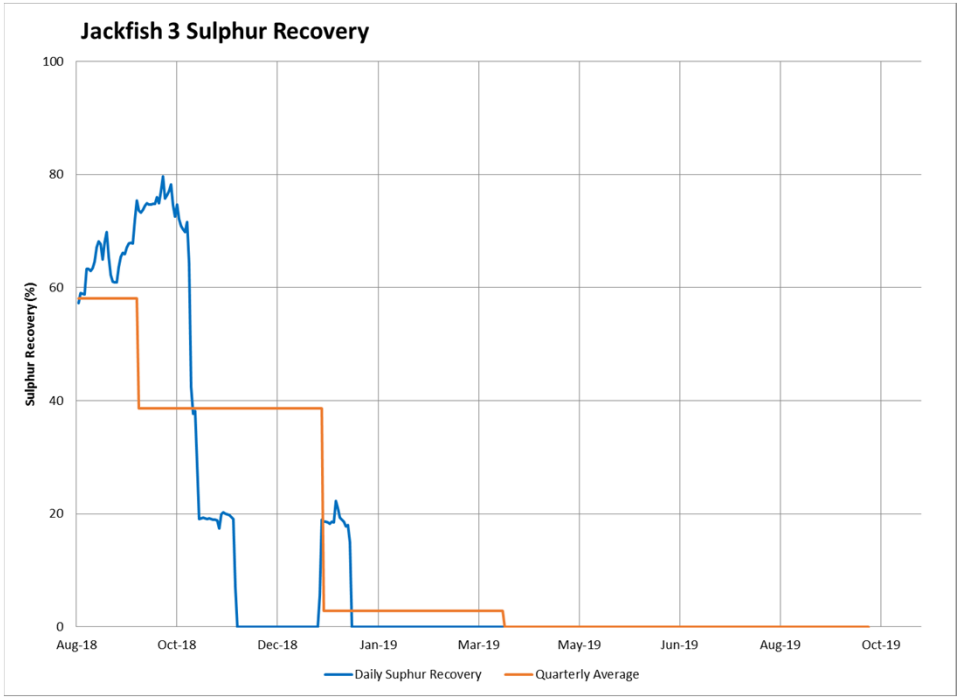


- Jackfish 1 – Sulphur Recovery not required as inlet Sulphur content <1 t/d
- Jackfish 2 – ID 2001-3 temporary waiver from recovery requirement. Sulphur recovery reduced in December 2018, March 2019 and August 2019 for maintenance. Planned facility turnaround June 2019

Sulphur Production

Operations with Sulphur Recovery

3.1.2-6a (i) & (ii)

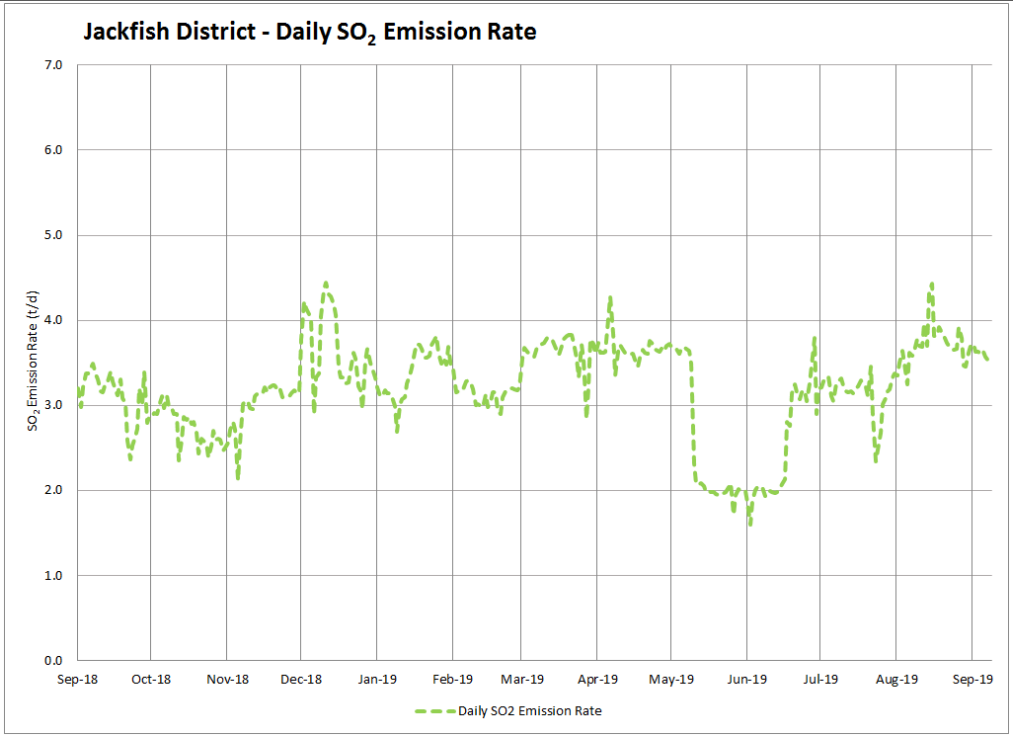


- Jackfish 3 – Sulphur Recovery Unit run intermittently to maintain facility and district compliance

Sulphur Production

Peak Daily SO_2 Emissions

3.1.2-6c



- Sulphur recovery reduced in December 2018, March 2019 and August 2019 in line with outage allowance in EPEA approval
- Emissions throughout year remained below allowable emissions limits stipulated by EPEA approval

Ambient Air Quality Monitoring

Summary

3.1.2-6d

Passive air monitoring

- At minimum there are four passive stations located at each Jackfish site to monitor sulphur dioxide and hydrogen sulphide
- Monitored parameters: sulphur dioxide and hydrogen sulphide

Continuous ambient monitoring

- September 2018: Jackfish 1 and Jackfish 2/3 continuous monitoring stations joined the Wood Buffalo Environmental Associations (WBEA)'s integrated monitoring network. The monitoring stations are now operated by WBEA, on behalf of Canadian Natural
- Monitored parameters: sulphur dioxide, hydrogen sulphide, nitrogen dioxide, total hydrocarbons, wind speed, and direction

All ambient air quality monitoring and reporting requirements were satisfactorily met in 2017-2018.

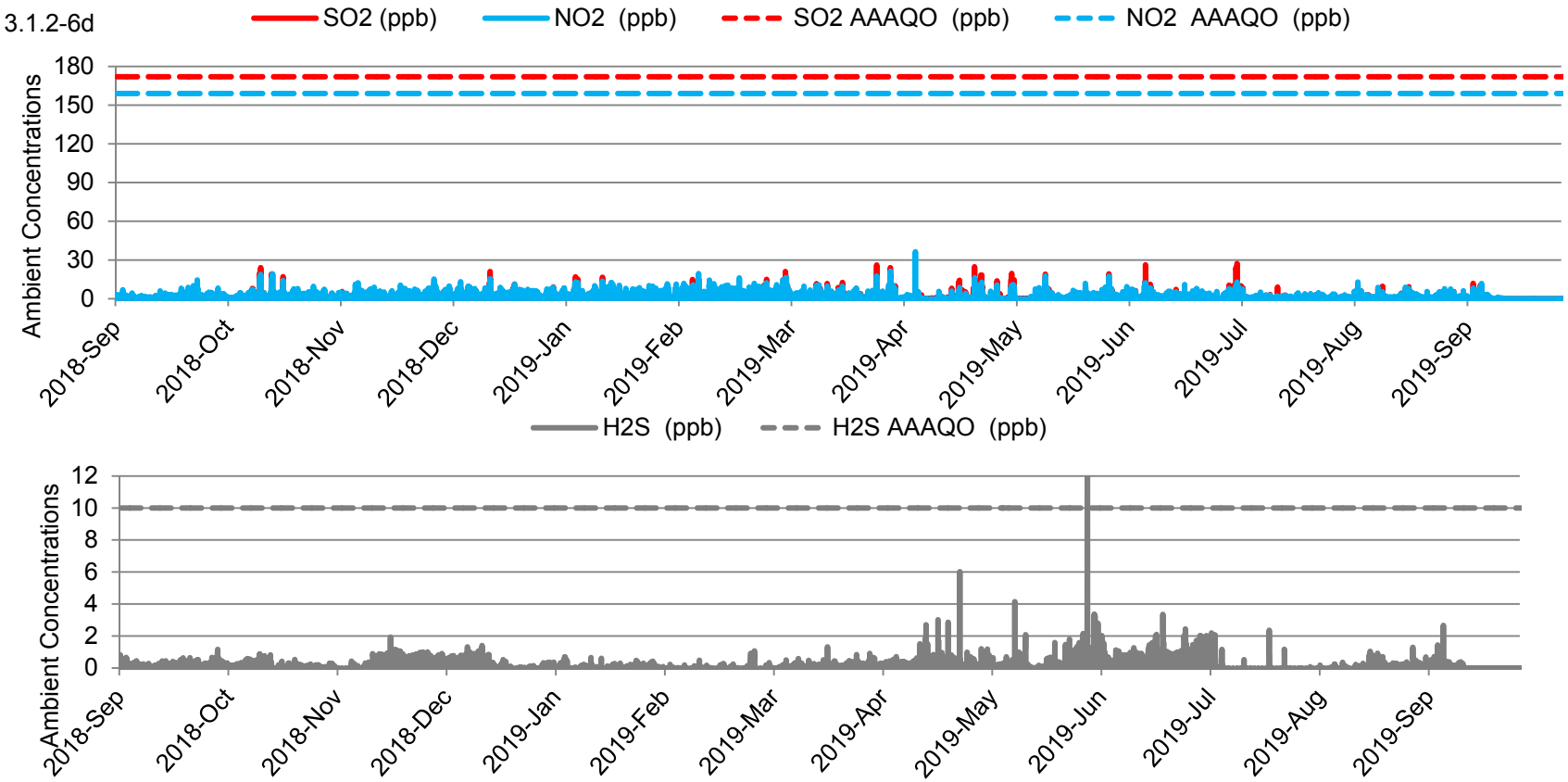
Ambient Air Quality Monitoring

Air Monitoring Station Map

3.1.2-6d

Ambient Air Quality Monitoring

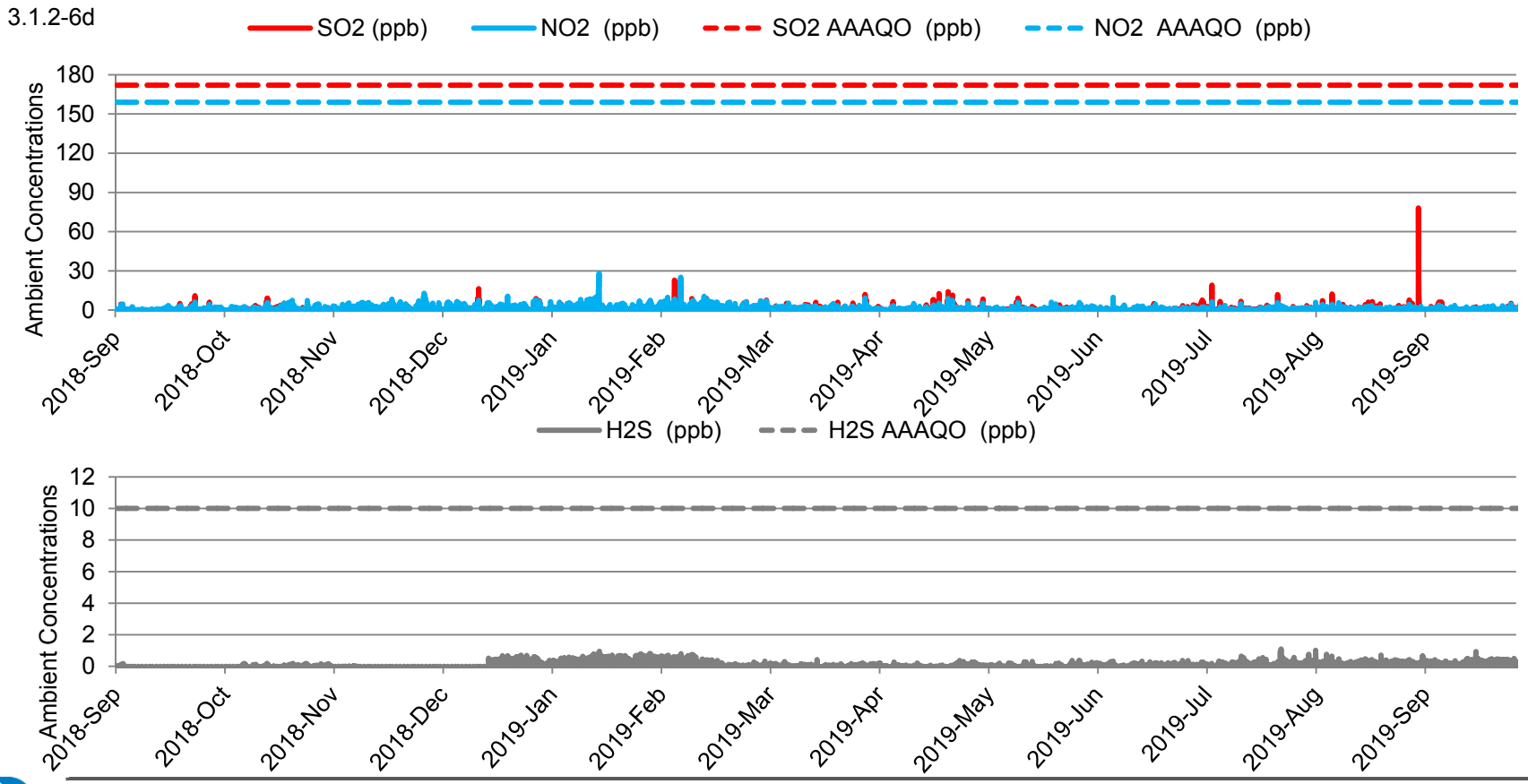
Jackfish 1 Continuous Results



May 31st 2019 one-hour H_2S limit exceedance not attributable to Operations, reference WBEA report

Ambient Air Quality Monitoring

Jackfish 2/3 Continuous Results



Canadian Natural

Environmental Issues
3.1.2-7

AER Regulatory Approval Summary

D78 Amendments

3.1.2-7b

Amendment			Category
Jackfish 3 Pad OOO and Jackfish 1 Pad S Proposal	October 25, 2018	100977TT	2
Jackfish Sulphur Recovery Variance	November 29, 2018	100977UU	2
Jackfish Expansion Area	December 19, 2018	10097VV	3
Jackfish NCG Blowdown Application for Pads A, C, D & KK	January 11, 2019	100977WW	2
Jackfish 1 Pad F PLECO Proposal	January 24, 2019	100977XX	2
Jackfish 1 Pad P Proposal	February 26, 2019	100977YY	2
Jackfish Sulphur Recovery Waiver	March 11, 2019	100977ZZ	2
Jackfish 1 Pad S Proposal	May 6, 2019	100977AAA	2
Steam Additive Reporting Deferral	June 7, 2019	100977BBB	1
Jackfish 2 Pad XX Proposal	July 23, 2019	100977CCC	2
Devon to Canadian Natural Ownership Transfer	August 9, 2019	100977DDD	-

AER Regulatory Approval Summary

Jackfish District

3.1.2-7b

Pad VV and Pad EE NCG Amendment letter

- Approved November 2018

Landfill WM 105G

- Approval for Cell 3

AER Regulatory Approval Summary

Jackfish District

3.1.2-7b

Water Diversion Licenses

- Potable Water Act Amendment approved December 2018

Water Act Approval (383056-00-01)

- Amendment for diversion of groundwater relating to Landfill Underdrains

CEMS Monitoring Plans

- Monitoring plans approved April 2019
- Certification testing ongoing

Sewage Lagoon Approval for use as temporary storage

- Approved May 2019

Water Management

Jackfish 1, 2, and 3

3.1.2-7c

Groundwater

- Jackfish 1, 2, and 3 groundwater monitoring occurs twice per year
- No significant impacts observed
- Revised proposal including Thermally Mobilized Constituents submitted Q2 2019

Surface Water – Groundwater Interaction Monitoring Program

- Remained within the expected variability
- No noticeable influence from project related effects

Wetlands

- Wetland monitoring sites surveyed Q2 and Q3 2019
- No significant impacts observed to date
- Revised proposal due Q4 2019

Soil Monitoring and Soil Management

Jackfish 1, 2, and 3

3.1.2-7c

District soil monitoring program for Jackfish 1, 2, and 3 was executed August 2017

- Soil monitoring proposal submitted to AER November 2017
- Execution of the soil management occurred in Fall 2018:
- Soil Management Program report submitted to AER March 2019
- No additional soil management required for the Jackfish projects

Next Soil Monitoring Program proposal due November 2020

AER Regulatory Reporting Requirements

3.1.2-7c

- Industrial Wastewater and Industrial Runoff Report
- Groundwater Monitoring Report
- Wetland and Waterbody Monitoring Report
- Potable Water Monitoring Report
- Air Monitoring Report
- Soil Management Report
- Soil Monitoring Report
- Conservation and Reclamation Annual Report
- Comprehensive Wildlife Report

Environmental Monitoring and Progress

Wildlife Monitoring

3.1.2-7c

Wildlife & Caribou Mitigation and Monitoring

- Jackfish Wildlife Monitoring Program was authorized July 2012
- Comprehensive Wildlife Reports submitted in 2015 and 2019
- Long term monitoring ongoing
- No significant project related impacts observed to date

Reclamation Program Work

3.1.2-7e

Summary of Jackfish construction, operation and land reclamation activities from 2005 to 2018:

- Total area of lands on which Jackfish activities occurred as of the end of 2018: 681.4 ha
  - 71.8 ha under construction
  - 586.3 ha operational
  - 23.3 ha undergoing permanent reclamation

- Reclamation Monitoring Program proposal currently due Q4 2019

Canadian Natural

Compliance
3.1.2-8,-9

Statement of Compliance

3.1.2-8

Canadian Natural believes the Jackfish Project is in compliance with AER approvals and regulatory requirements. As of September 30/2019, Canadian Natural has no unaddressed non-compliant events.

Summary of Spill Releases

3.1.2-9

The following list summarizes spills reported to the AER within the reporting period

AER Release Reporting		
Site	**No. of Reportable Releases**	**Volume released(m^3)**
Jackfish 1	4	47.2
Jackfish 2	5	0.5
Jackfish 3	3	1.1

AER Summary of Noncompliance

3.1.2-9

The following list summarizes non-compliant events within the reporting period. For all events corrective actions were identified and are being tracked to completion.

Date	Event	Corrective Action
March 1, 2019: Jackfish 1, 2 and 3	Did not meet 90% uptime requirement in CEMS code – Approval Requirement	Install new CEMS units
May 1, 2019: Jackfish 2 and 3	Waste Water Limit Exceedance	Sampling error, sampling practices adjusted

Canadian Natural

Future Plans
3.1.2-10

Future Plans

Major Activities and Target Dates

3.1.2-10a-d

- No major projects for 2020
- Scheduled turnaround for Jackfish 3 Q3 2020
- Focus on reliability enhancements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