Statoil

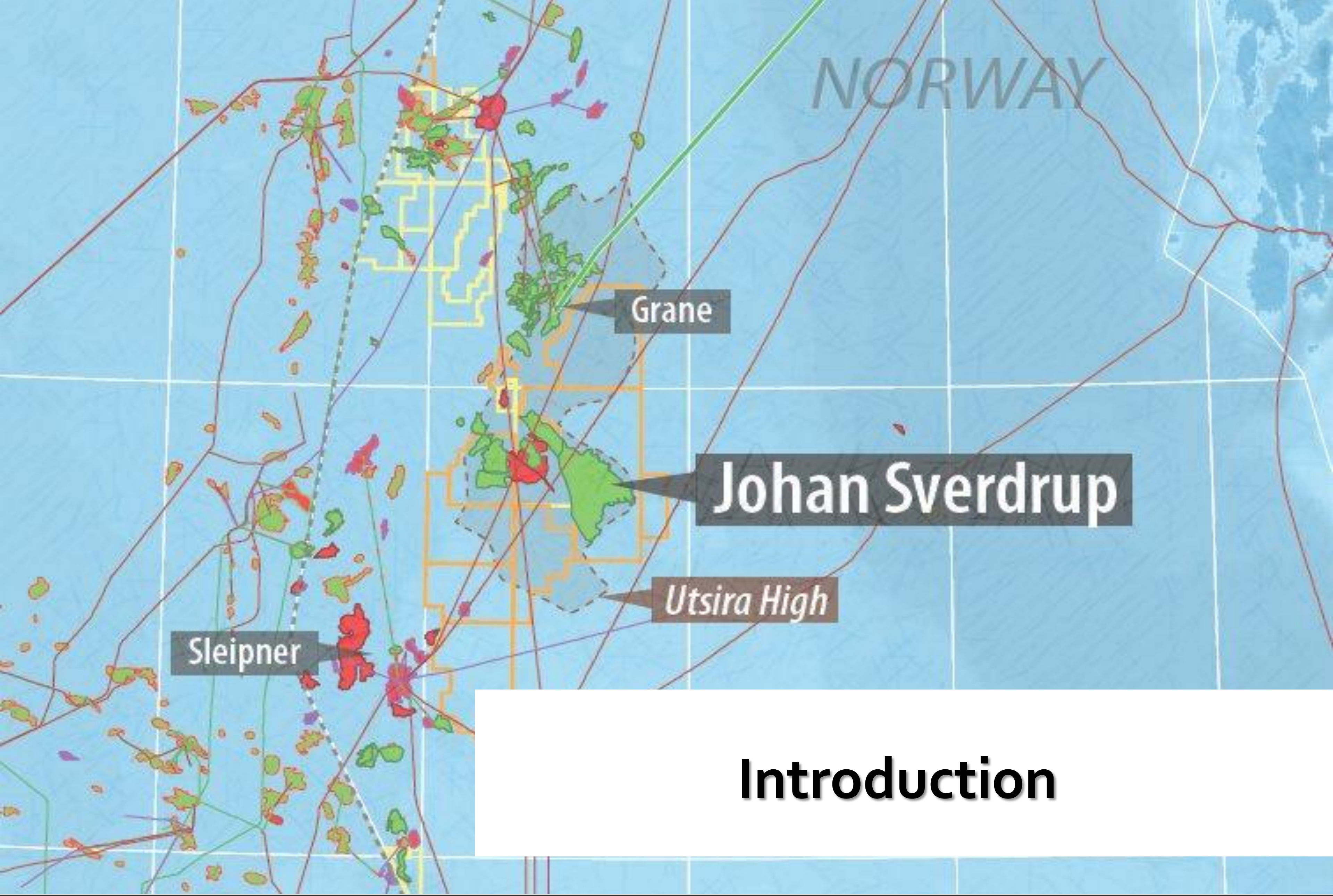
Johan Sverdrup – Polymer

Force Seminar, Stavanger

April 5th, 2016

Outline

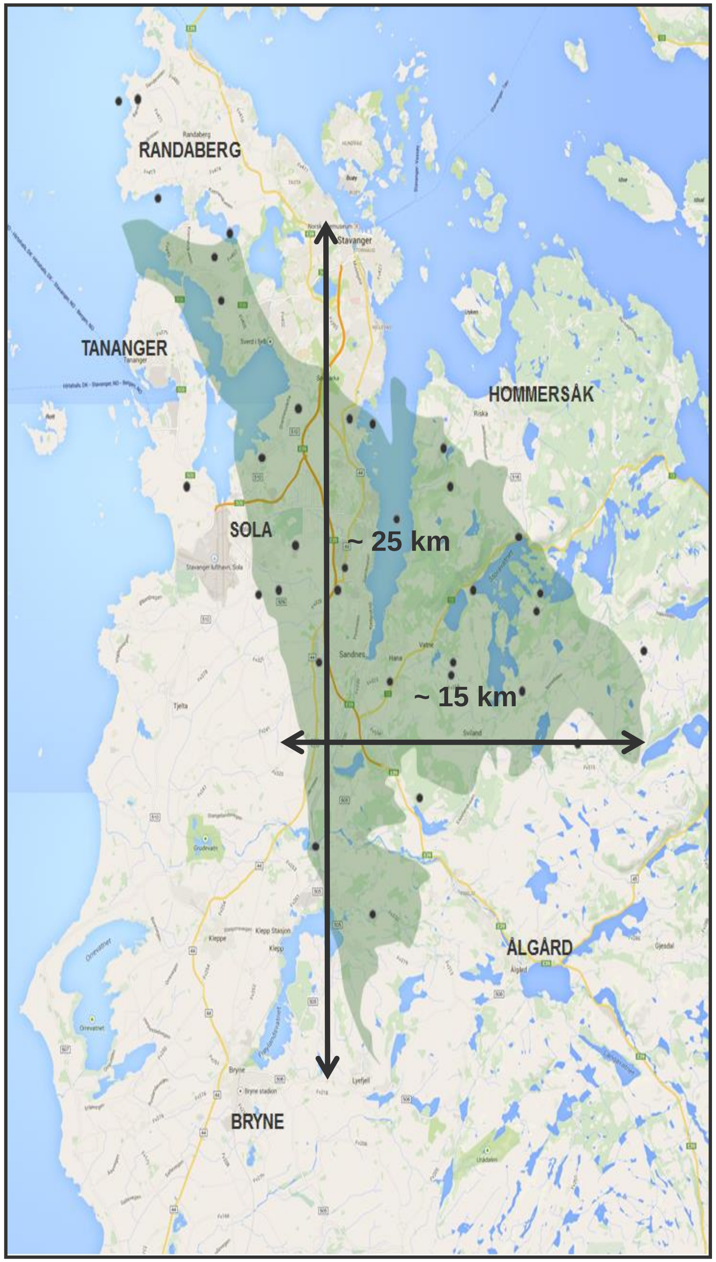
- Introduction to Johan Sverdrup
  - Reservoir data and IOR potential
  - Requirement for polymer pilot (White Paper Phase 1 approval)
- Polymer flooding
  - Mechanism and potential
  - Risks involved
  - Laboratory work
- Polymer pilot
  - Test parameters
  - Test design and timing
- Concluding remarks



Introduction

Reservoir data

GENERAL	
Reservoir apex	~ 1800 m TVD MSL
Water depth	~ 110 meter
FWL	1922 - 1934 m TVD MSL
Area	~ 200 km^2
Pressure	Hydrostatic (ongoing depletion)
Max dip	~ 2 degrees
Age	Jurassic and Late Triassic (main reservoir)
Recoverable resources	1.7 – 3.0 billion boe (full field)
RESERVOIR AND FLUID	
Reservoir quality	▸ Excellent reservoir properties ▸ Multi-Darcy permeability ▸ Porosity ~ 25 - 30%
Reservoir thickness	Varying, 4-146 m (well observations)
Reservoir fluid	▸ Highly under-saturated oil, low GOR ▸ Viscosity ~ 2 cP Density ~ 800 kg/Rm3 ▸ No initial gas cap



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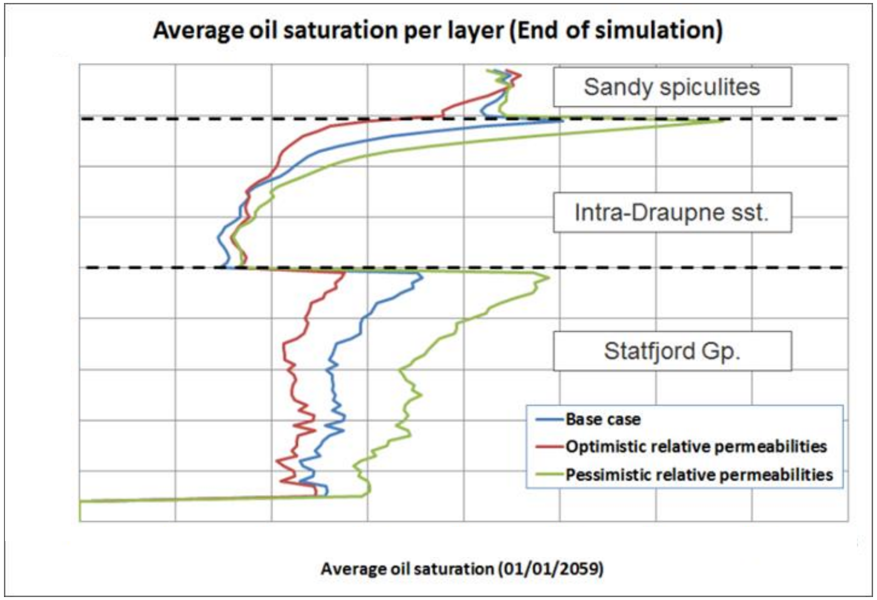
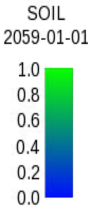
IOR Potential

- Remaining oil in 2059 after water flooding shows a potential for IOR
- Expected high recovery factors , but still large volumes of oil may be trapped in attics and un-swept areas
- Relative permeability and Pc are key uncertainties
    - Observation well planned in the central area





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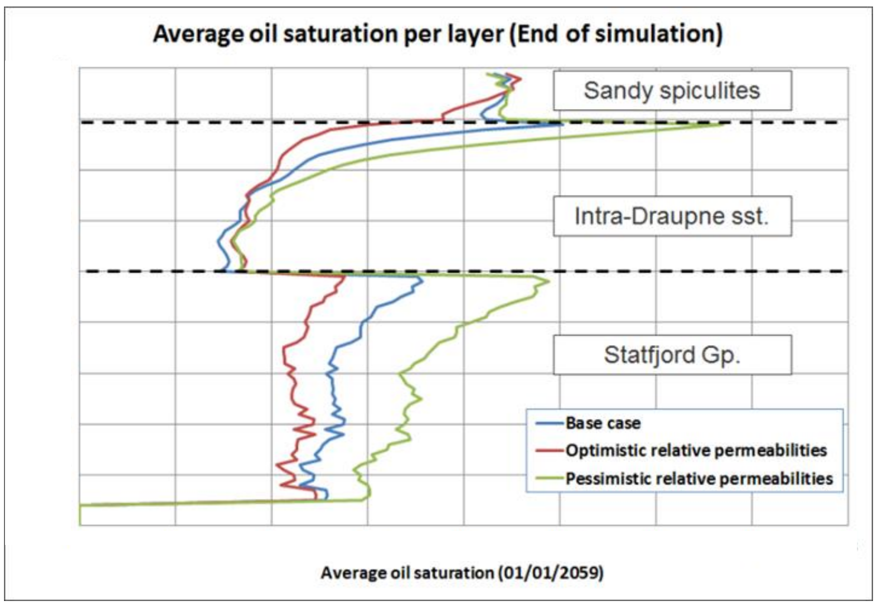
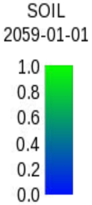
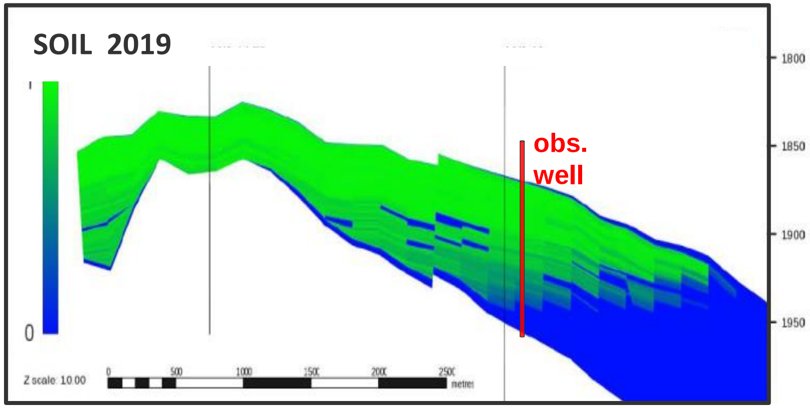
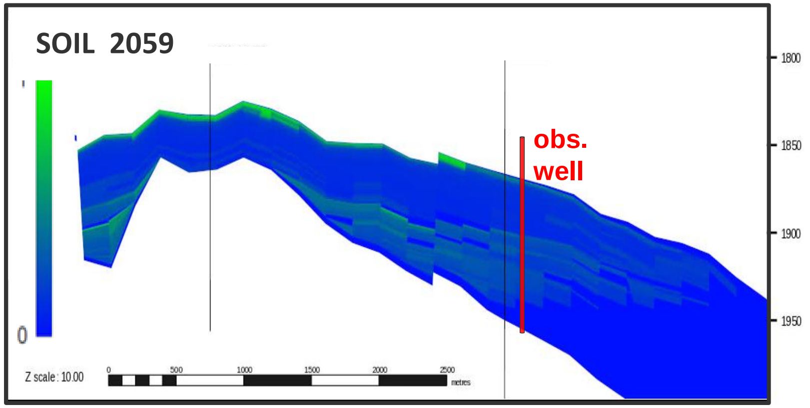








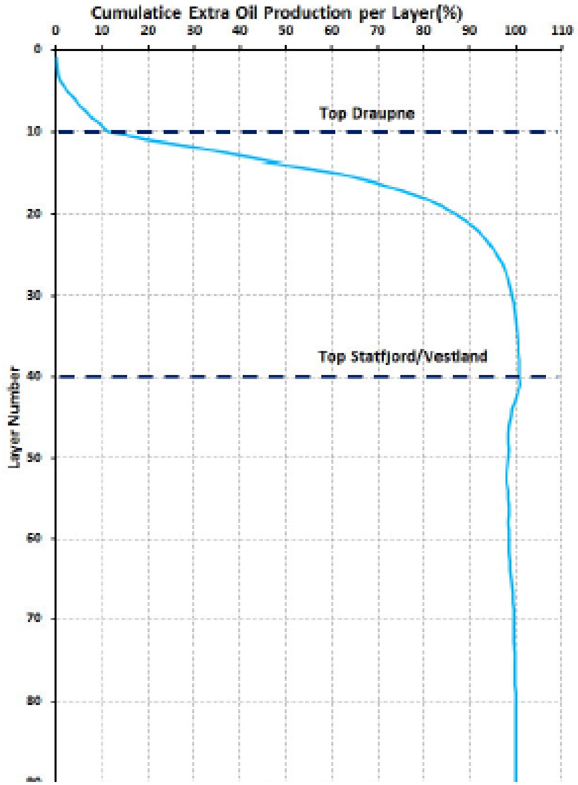
PDO Requirement Phase 1 Johan Sverdrup

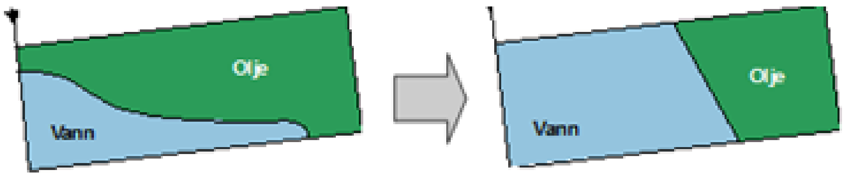
- A pilot project with polymer injection to be performed within 2 years after production start of Phase 1.
- The Pilot project shall be performed with **minimum one injector and one producer**.
- A decision basis to be presented to OED within 31.12.2017.
- An evaluation on further implementation within 1.7.2023.

Polymer flooding

Mechanism and Potential

- **Mobility control**
  - Oil viscosity ~ 2 cp
  - Water viscosity 0.4 cp
  - If early implementation; acceleration effect
- **Increased sweep**
  - Targeting attic oil
  - Kr and Pc important for potential
- **Moderate delta oil potential**
  - Competition with infill/WAG (?)





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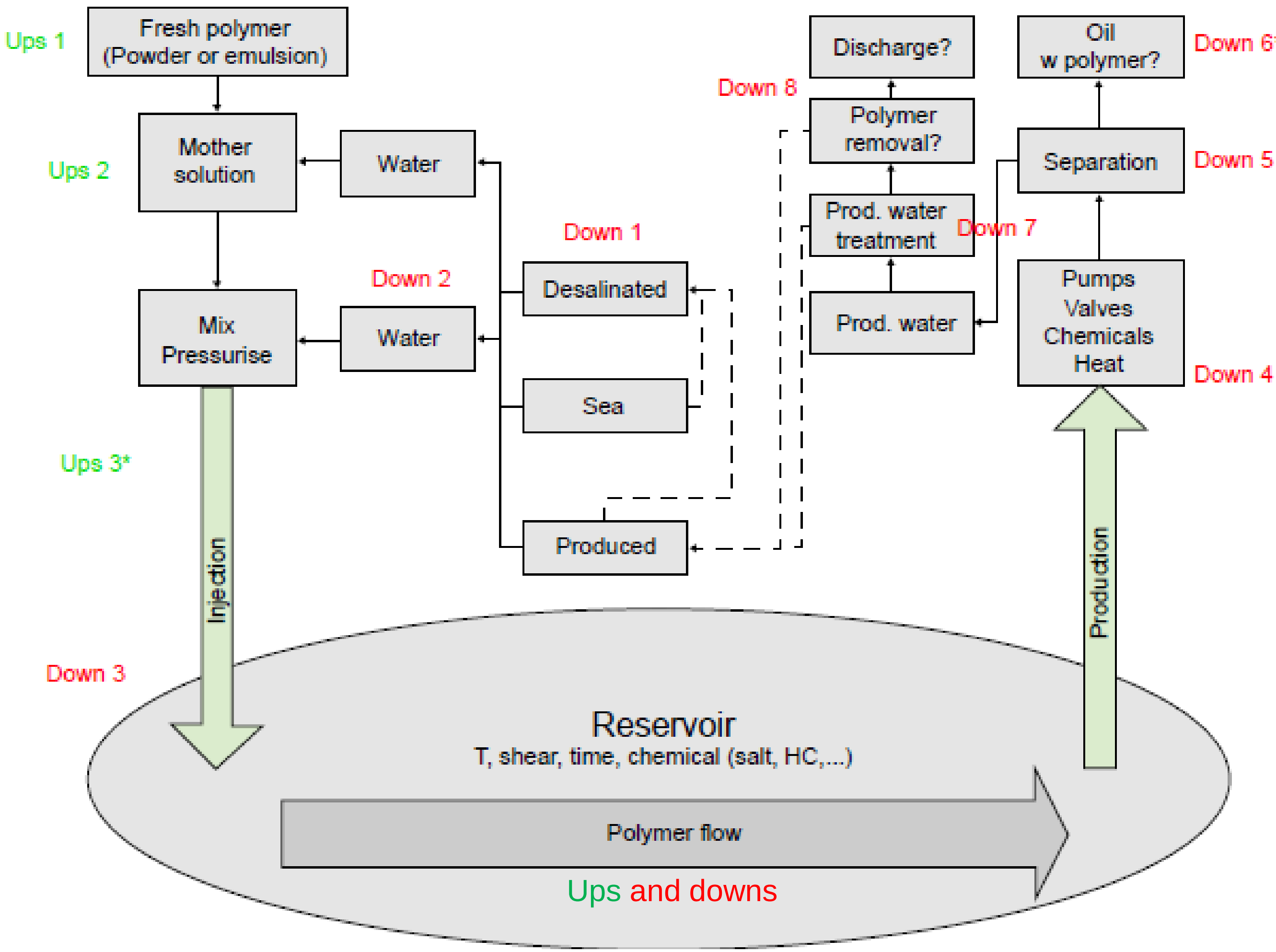
Risk issues – Value chain



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Laboratory work – provide polymer specific assumptions to business case

- **Ranking of suitable polymers**
  - Viscosifying ability (Logistics and OPEX)
  - Sustain high temperature 83 degrees C and high salinity
  - Modest adsorption and shear degradation
- **Perform core-flood (JS core and fluid)**
  - Lowsal/Seawater + polymer
- **Influence on oil-and water processing facilities due to production of polymer**
- **Impact of chokes on mechanical degradation**

- Ppm
- Adsorption
- IPV
- RRF
- Mixing water
- Risking
- Add. cost
- ...

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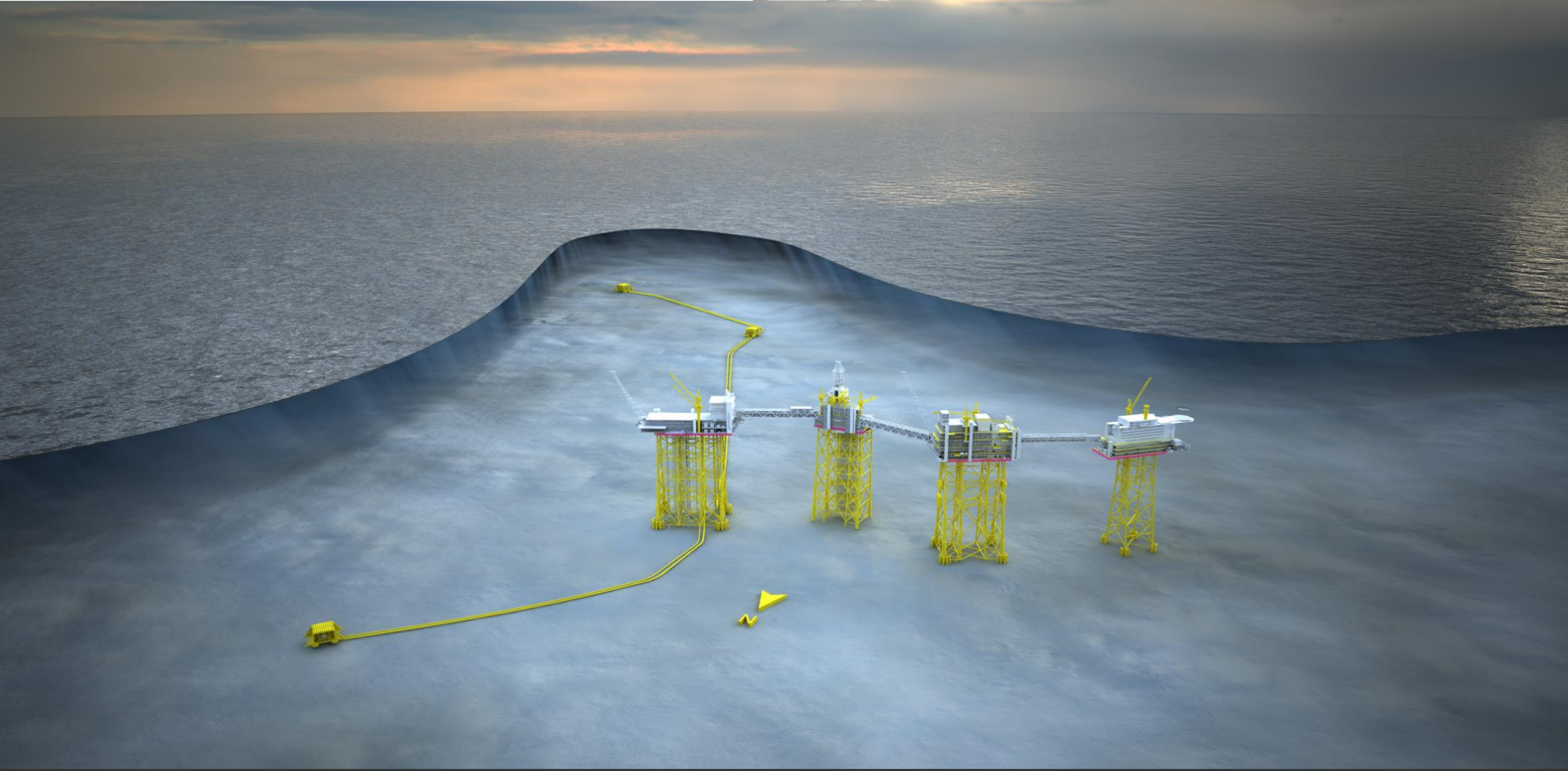
Polymer pilot



Test Parameters

- Logistic chain assessement
- Preparation and injection of polymerised water
- Polymer viscosity topside and in the reservoir
- EOR effect
- Measurement of back produced polymer
- Impact of produced polymer on oil and water processing
- Reinjection of produced polymer

Start-up: 2021/22 **Duration:**~ 18months **Injection Capacity:** up to 5 kSm3/d

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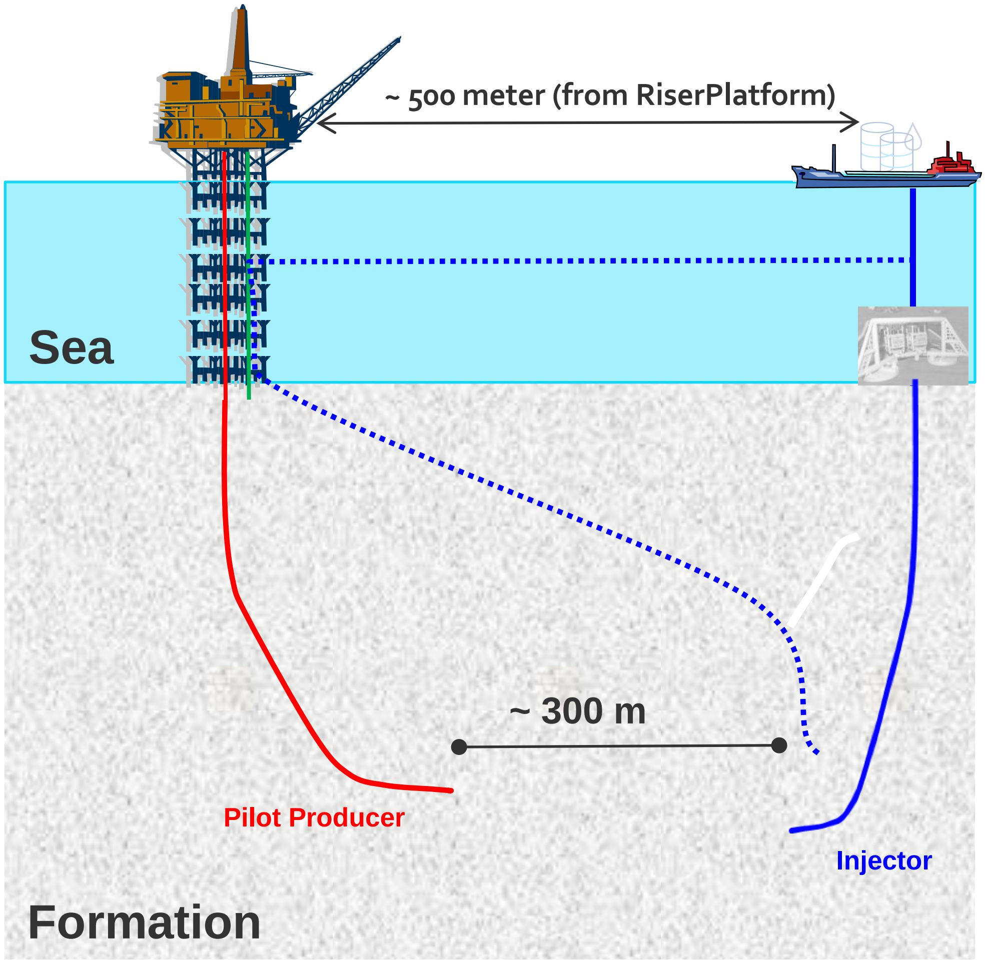
Pilot Sketch (1 Injector - 1 Producer)

- Prepared polymerised solution either on ship or at Riser Platform
- Injection in dry – or subsea injector
- Distance injector – producer ~ 300 meters



Pilot EOR Data Dathering (Petec scope)

Issue	Parameters	Data acquisition
Polymer medium quality (pre-injection)	μ(T), $C_{polymer}$, homogeneity, ionic composition (lowsal quality)	Topside sampling
Injectivity	Q/p	Well gauges; flowline rate gauge
In situ viscosity, injection {kh/μ}	p, T	Down Hole Gauges
In situ viscosity, injection {μ}	μ, T	Conditional DH sampling on WL in injector
Incremental oil {Qoil, Water Cut}	Q (oil, water, gas)	Test separator rate gauges;
Displacement, drainage, dilution	tracer, Cpolymer, ionic composition	Test separator sampling; producer flowline sampling
Degradation	μ(T), C, MWDpolymer, ionic composition	Test separator sampling; flowline sampling; DH sampling on WL in producer (conditional, but likely)
Injectivity of PW with residual polymer	Cpolymer, PW (oil in water,suspended solids, Q/p	Sampling in degasser, well gauges, downhole gauge

Concluding Remarks

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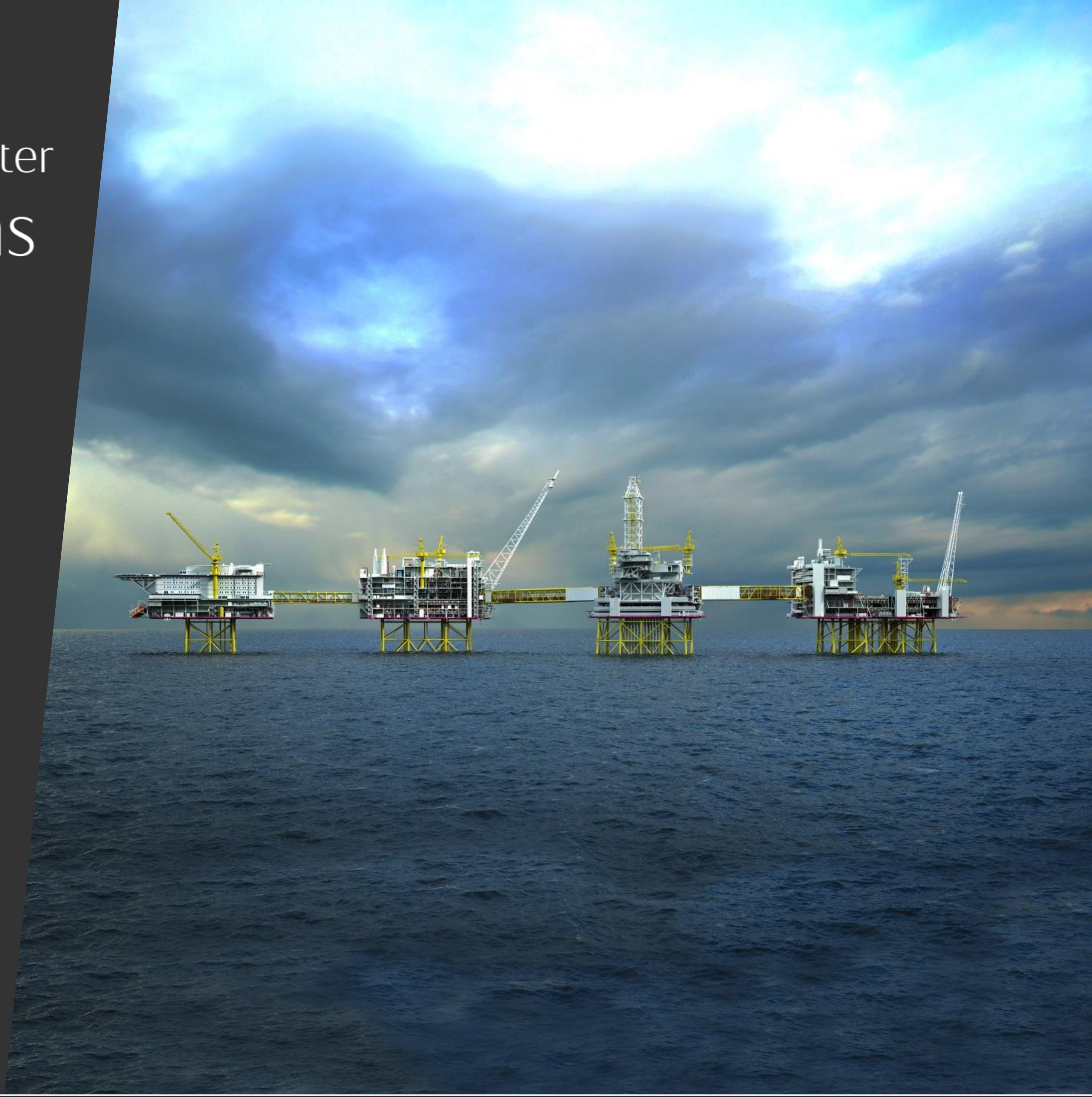
- **Johan Sverdrup is an unconventional polymer candidate**
  - Moderate Potential and challenging economy
  - High temperature, high salinity, long well spacing leads to employ lowsalinity water

- **Particular offshore risks;**
  - A subsea setting involves risk of choking leading to mechanical degradation
  - Compact water processing plant challenging

- **A pilot can/may provide some answers**
  - Preparation, injectivity, in-situ viscosity, EOR effect(if preflush), impact of produced polymer on facilities
  - Extrapolation of pilot results to other parts of the field not trivial (well spacing)
  - Other sources of information necessary for an update of field potential post pilot

There's never been a better time for good ideas



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