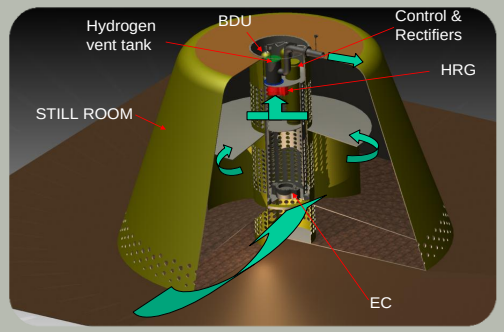
Subsea Water Treatment Comes of Age



FORCE Presentation – 30th May, Stavanger
by
Jan Olav Hallset, Well Processing AS

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Waterflood for Increased Oil Recovery

The easiest IOR technique

- Injection of seawater into an oil reservoir is the easiest and most common IOR technique
- Global water injection currently 240 million BPD i.e. 3 times global oil production
- Global WI projected to 7 times global oil production by 2020

The most effective IOR technique

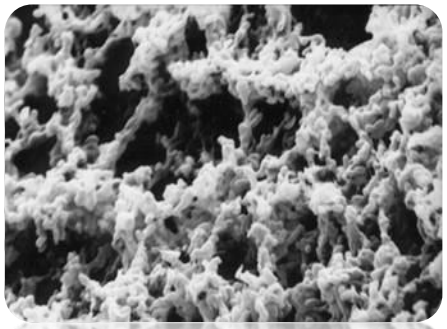
- Water Injection will typically double recoverable reserves compared to a traditional pressure depletion (from 18-22% to 35-45%)
- Optimised waterflooding may add even further increase recoverable reserves by up to 10% points (to 45-55%)
- Additional IOR techniques combined with WI (LoSal, WAG, Surfactants etc.) will further raise recoverable reserves

Why Treat Seawater?

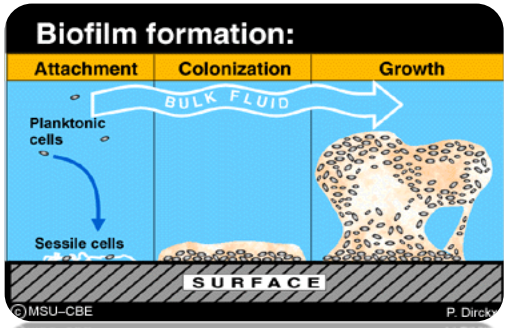
Water treatment has an important for sweep efficiency of waterfloods:-

- Water injected has to displace as much oil as possible – e.g. avoid plugging
- Prevent the reservoir from turning sour.

MAIN CHALLENGES:



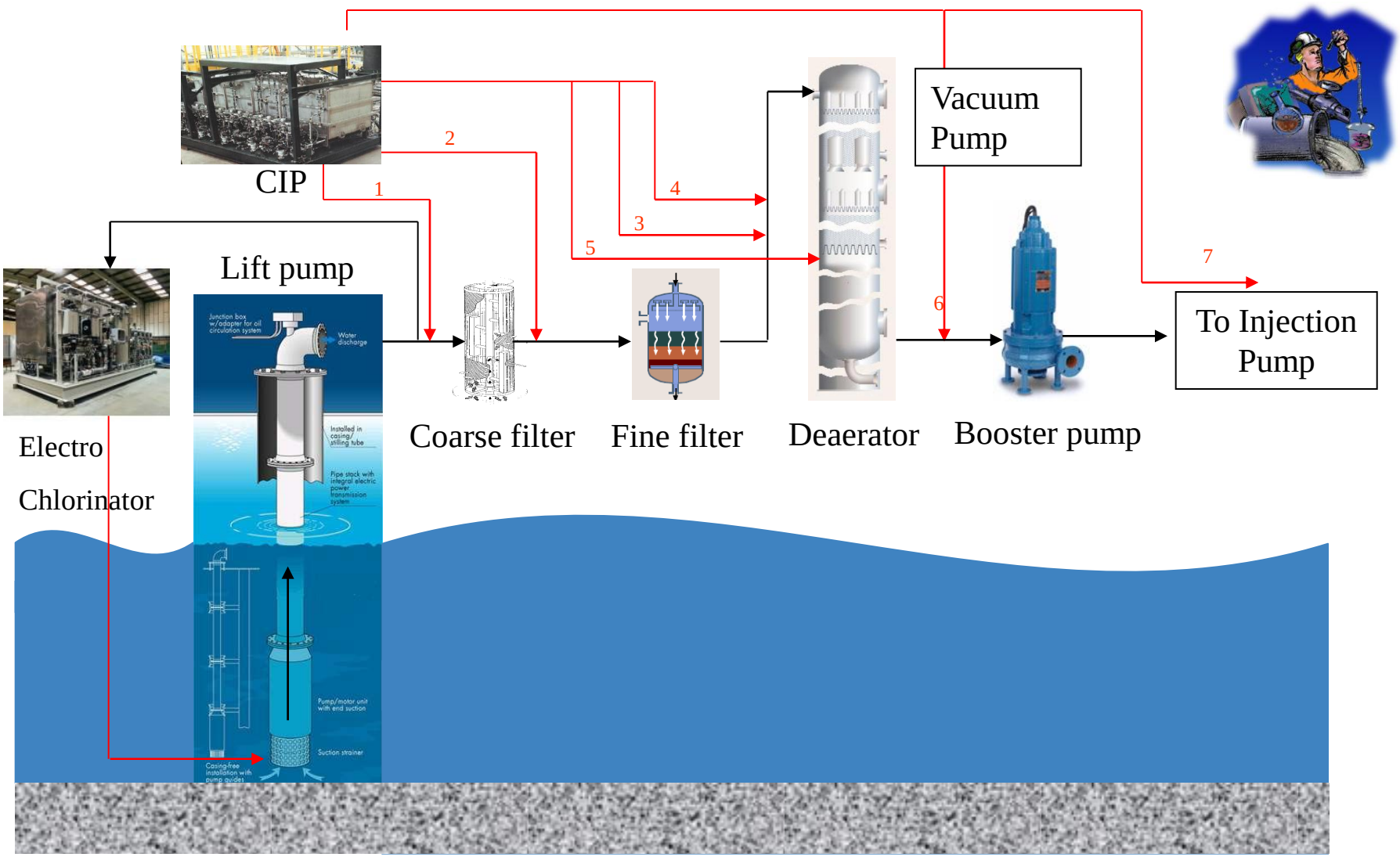
Blocking / plugging of the reservoir injection zones (solids / scaling / microbial growth)



Microbiological activity needs to be controlled (biofilm and bacterial growth)

H_2S – Souring and MIC

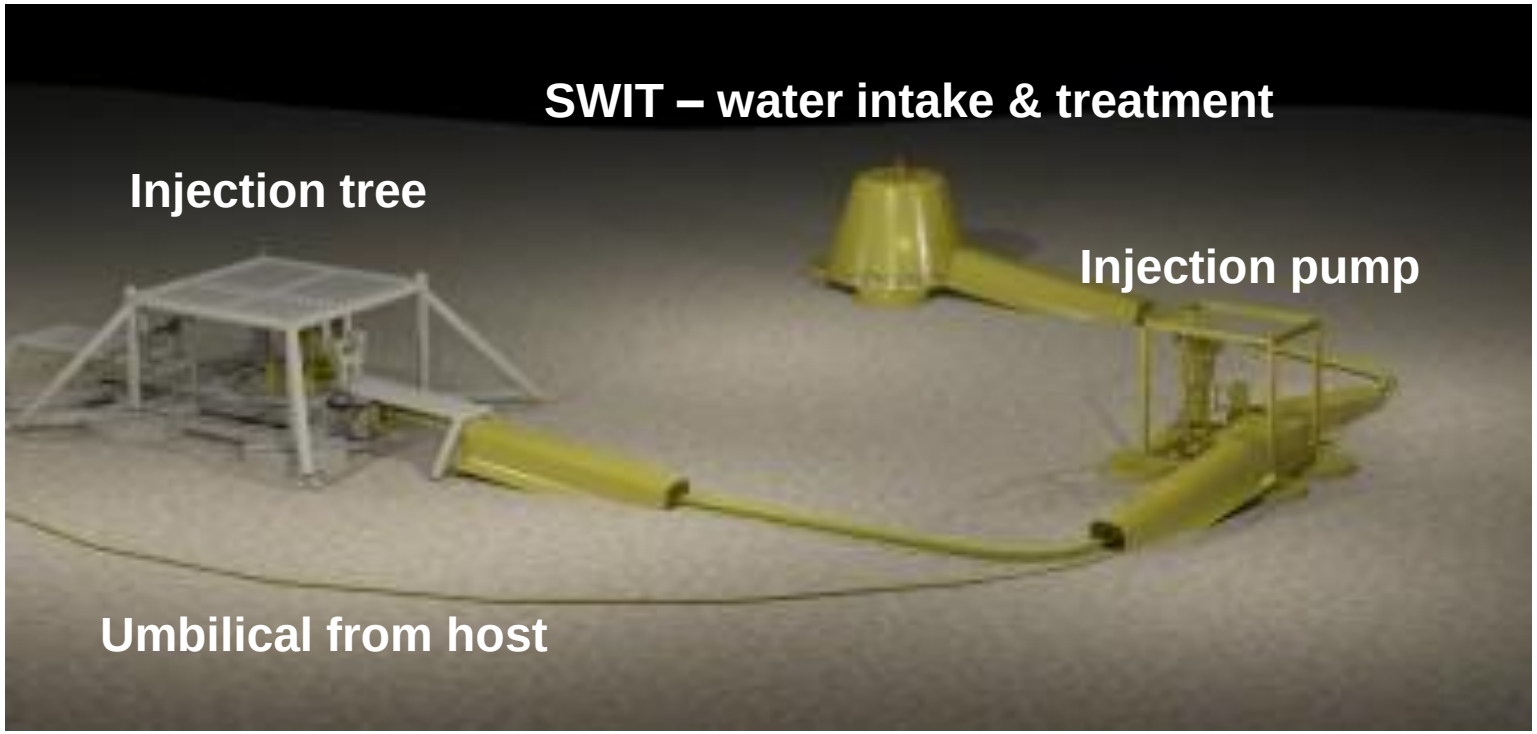
Seawater Injection – Traditional Topsides Treatment



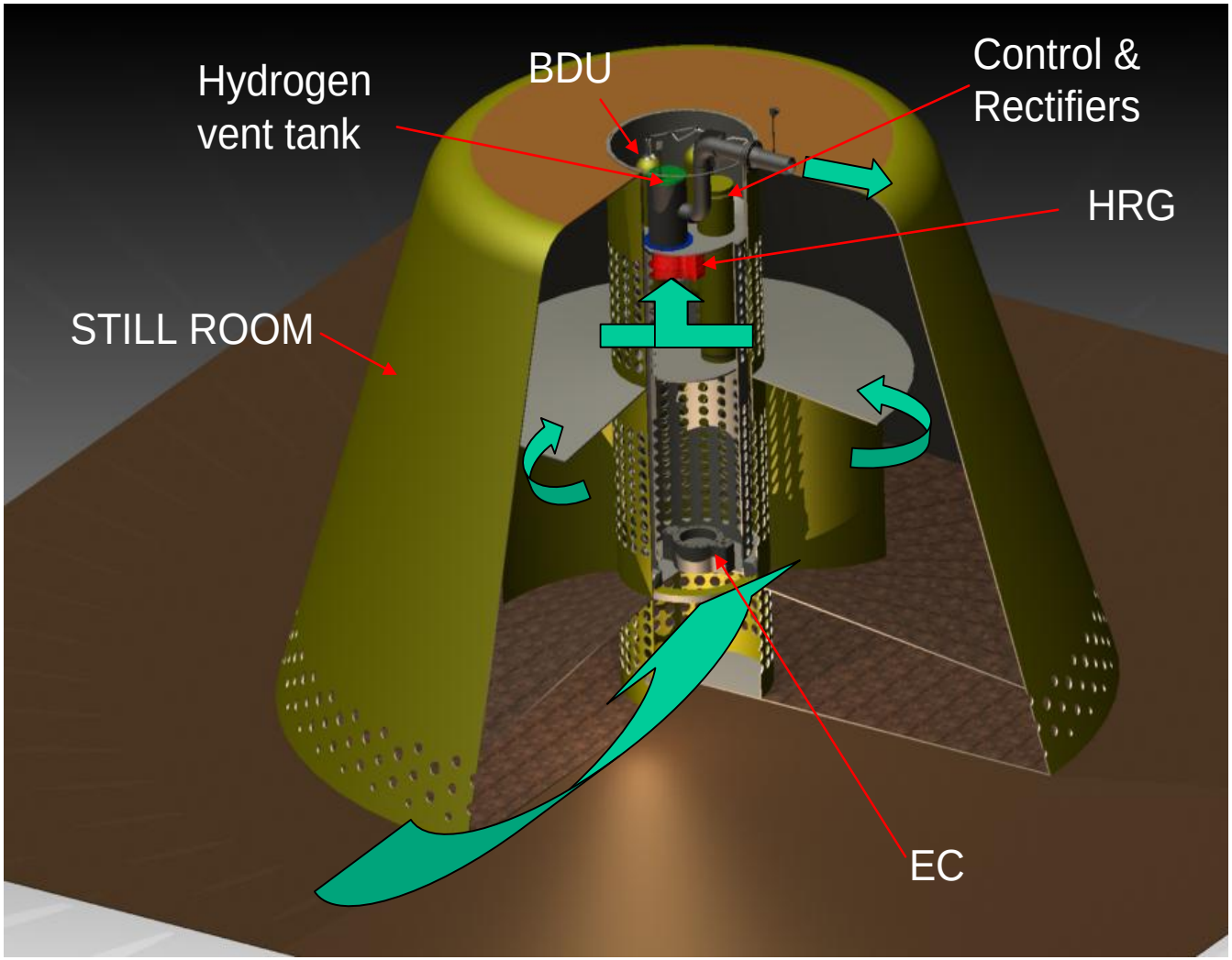
Possible Seabed based Water Injection & Treatment

Objective: A subsea water treatment plant that provides water quality essential for waterflooding

Challenge: To establish confidence in the proposed technology of subsea water treatment



Subsea Water Treatment - Pilot Unit



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Pilot Installation July 2009

Solids settling chamber with disinfection equipment

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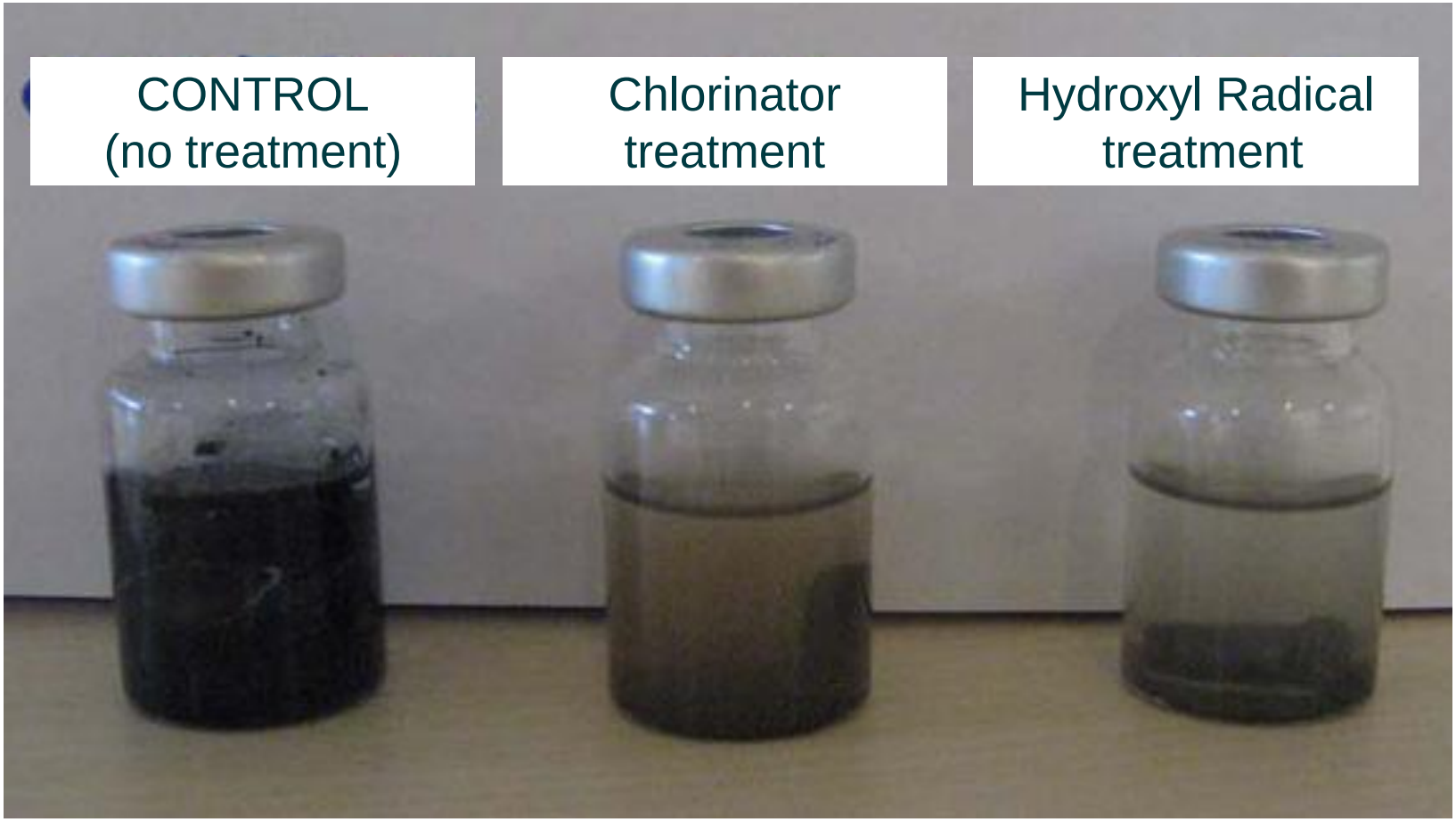
Water Quality – Bacteria



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Pilot Retrieval – October 2010 (99.7% availability)

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Water Quality Solids

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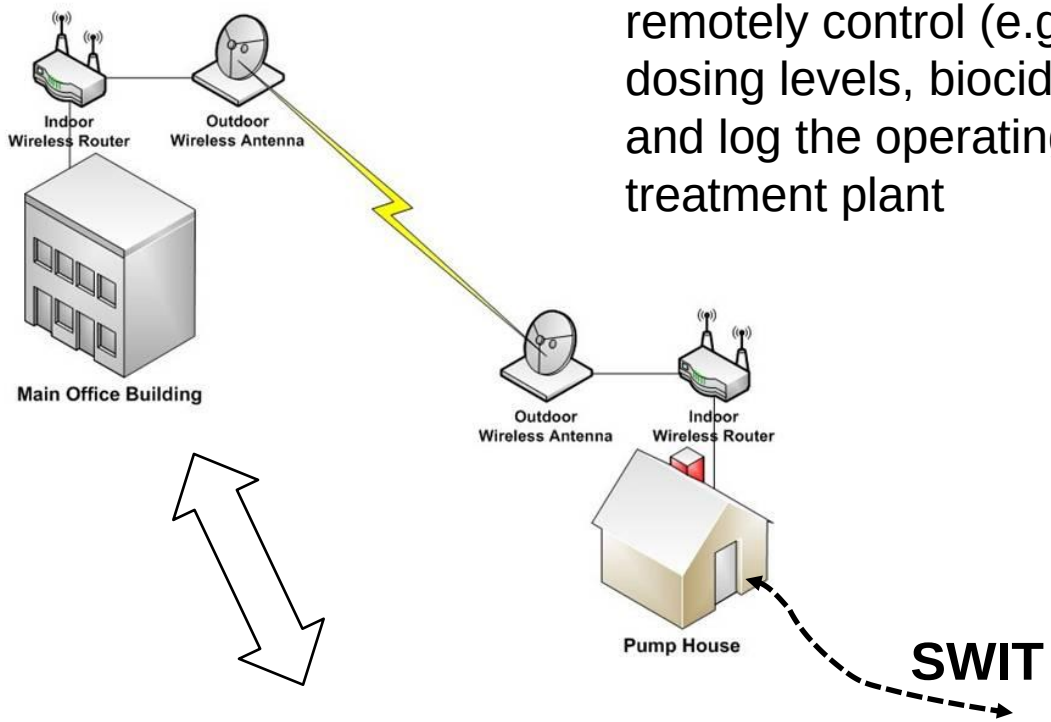
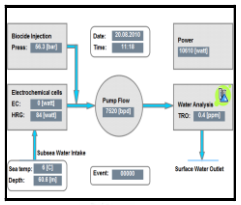
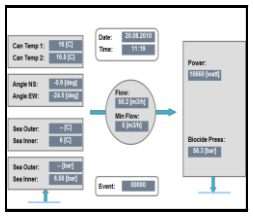
Remote Operation and Control

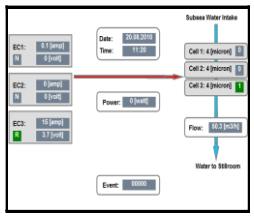


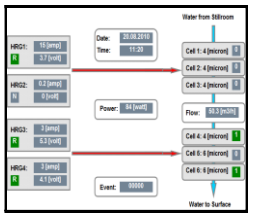
During the testing it was possible to remotely control (e.g. EC and HRG dosing levels, biocide dosing) monitor and log the operating conditions of the treatment plant

The subsea water treatment system was inherently simple to operate with no moving parts. Particularly pleasing was the ability to control and maintain chlorination (TRO) to very fine tolerances.









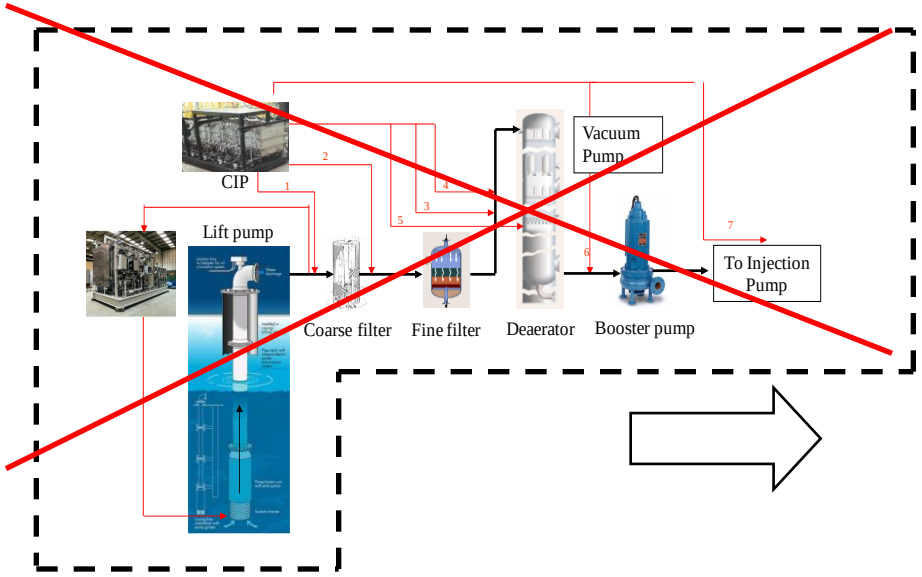
Did We Meet our Objectives / Challenges?

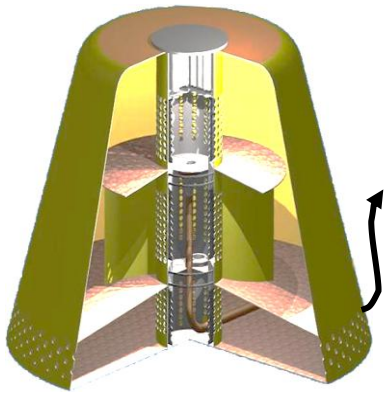
Water quality:

- Biomass – significantly delayed biofilm growth
- Solids – to 10 micron level
- Subsea chemical dosing accomplished
- Reservoir souring – no SRB's after 1 years testing

Establish confidence:

- 99,8% availability
- Reliable control and operability
- TRL 8 by major oil company.





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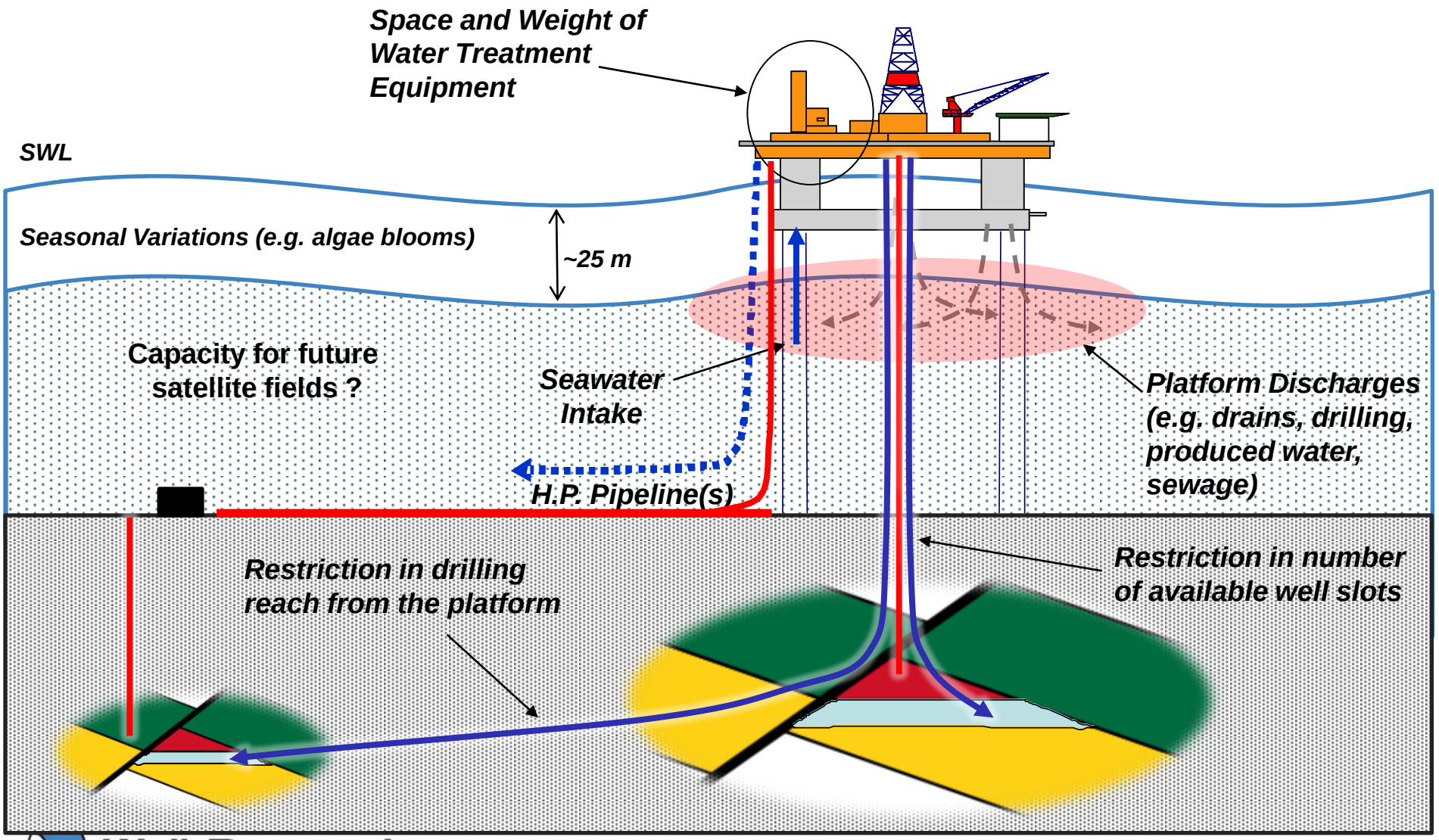
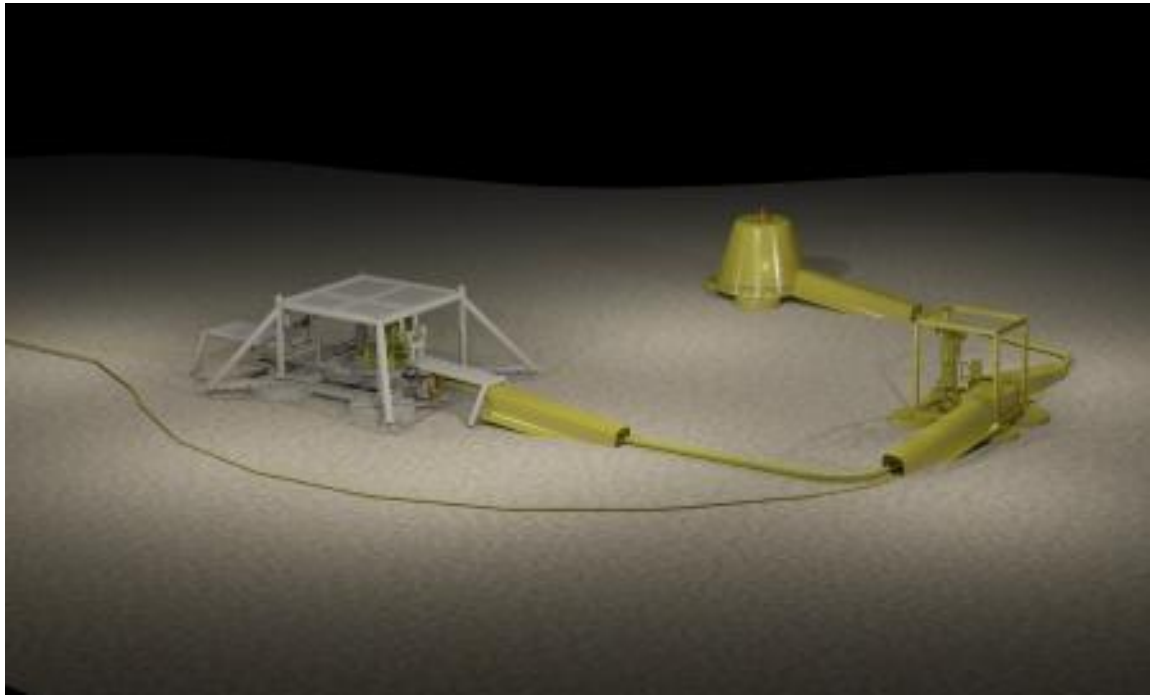
Topsides Water Injection – Practical Restrictions:



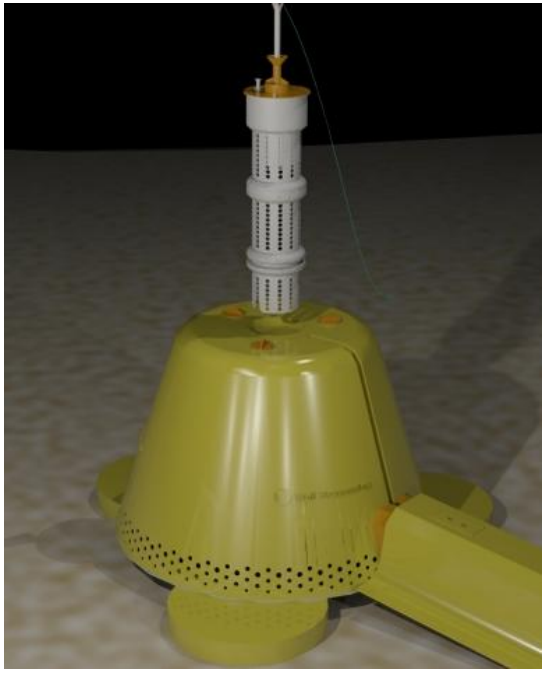
 Difficulty in achieving optimal flood regime

New Field Application

Stand alone treatment and injection system at any desired water depth



Treatment unit (SWIT) - Sub sea pump - Wellhead



Retrievable processing unit for easy intervention and low OPEX

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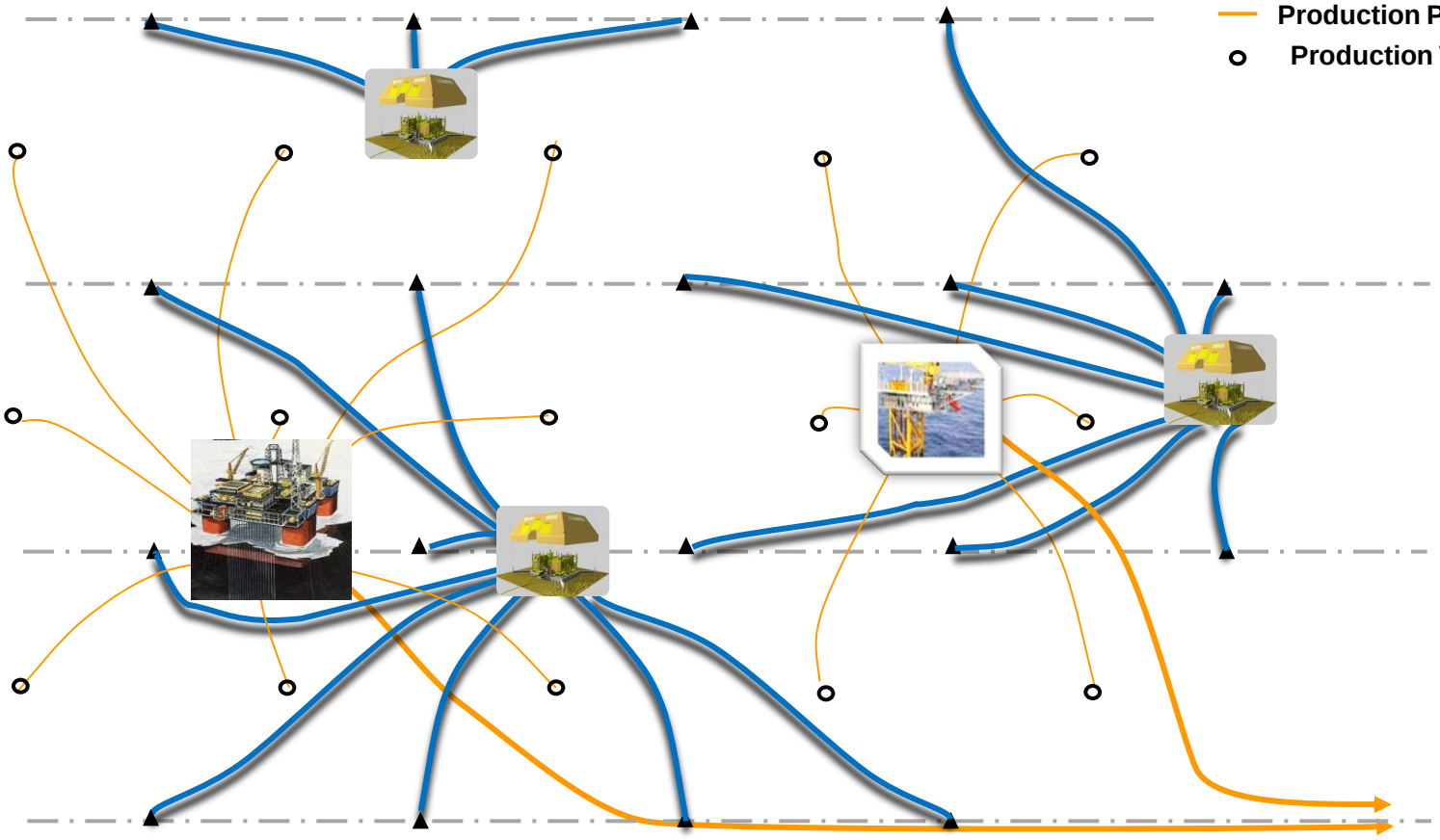
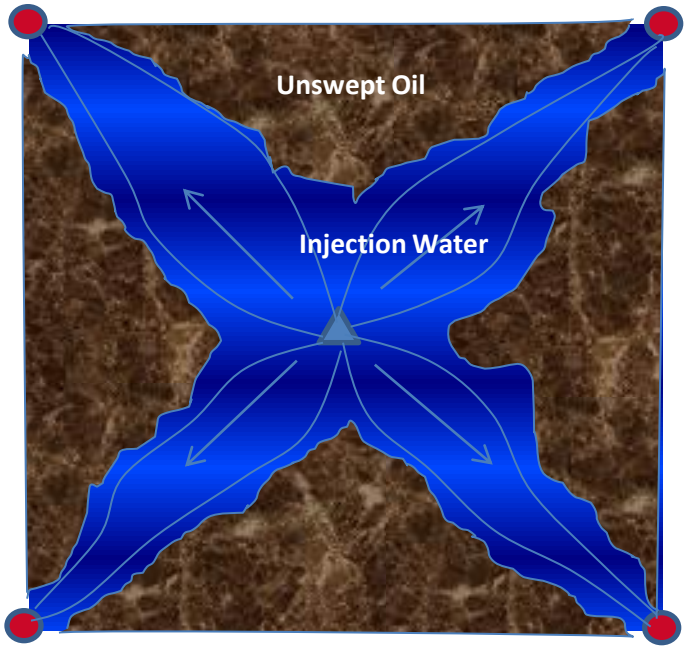
Subsea Waterflood - Total Flexibility

e.g. Subsea Flood Patterns:-

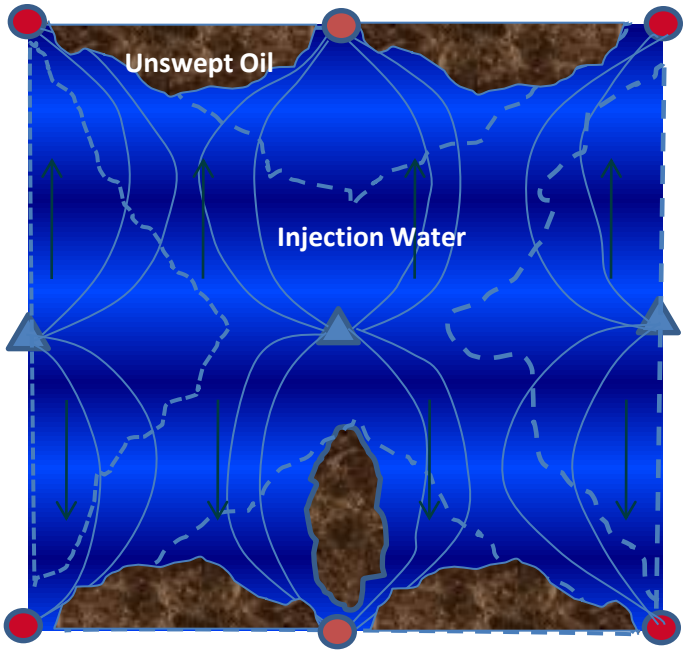


Total Flexibility with Subsea Waterflood

Infill Drilling is an example of how SWIT can be effectively used offshore:-



- Long time to increase production (large distances between inj. and prod. wells)
- Difficult to maintain pressure - due to water required balance inj. and prod. rates

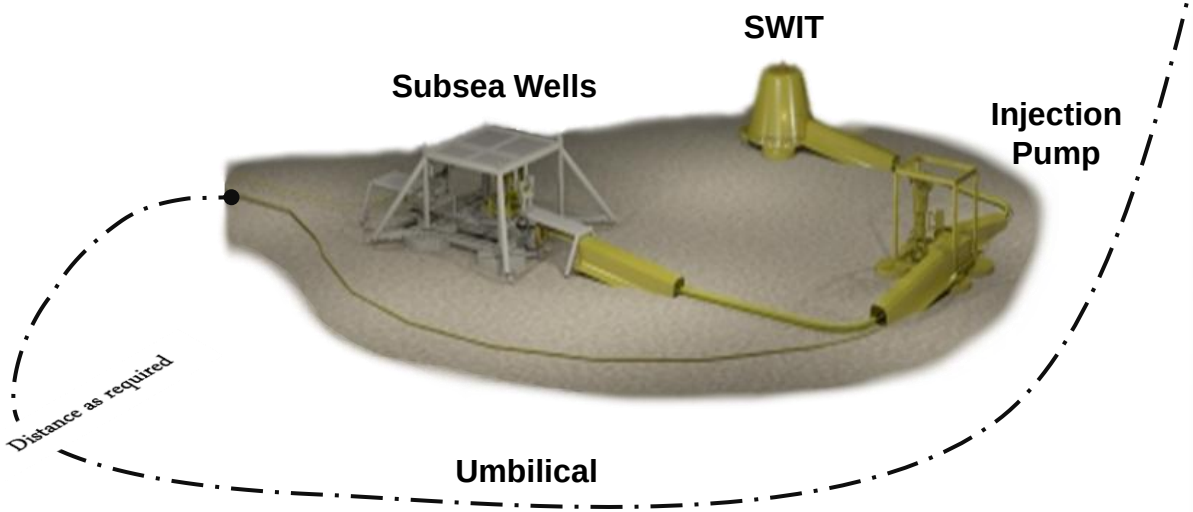


- Crossflooding of the pattern can contact new undisplaced oil and significantly add to the ultimate recovery from a field
- Can maintain pressure by balancing prod and injection volumes
- Reservoir heterogeneity and layer discontinuity can be controlled

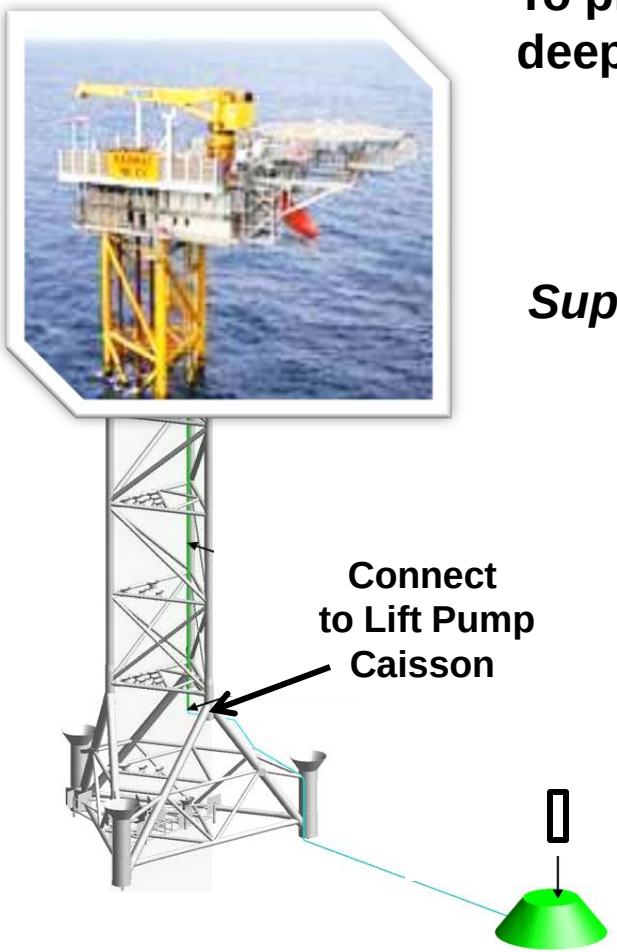
Satellite Field Application

Waterflooding of remote satellite fields can become economically viable

Increased Oil Recovery from a satellite reservoir(s)



Topside Well Application



To provide good quality water from other / deeper locations

Supply of treated water for topsides injection:-

- Allows for topsides dry well(s)
- Allows for topsides injection pump (if required)
- Local positioning allows for access from topsides crane
- Avoids biofouling – could be useful in other seawater systems – e.g. firewater / cooling water systems

Next Step – Designer Seawater

Quality – Use good quality SWIT treated Seawater to achieve:-

- Membrane treatment for Low Salinity water injection
- Membrane treatment for Low Sulphate water injection
- Chemical injection e.g.:-
  - Nitrate
  - Polymers
  - Brightwater

Pressure – Use pump pressure to match reservoir heterogenity

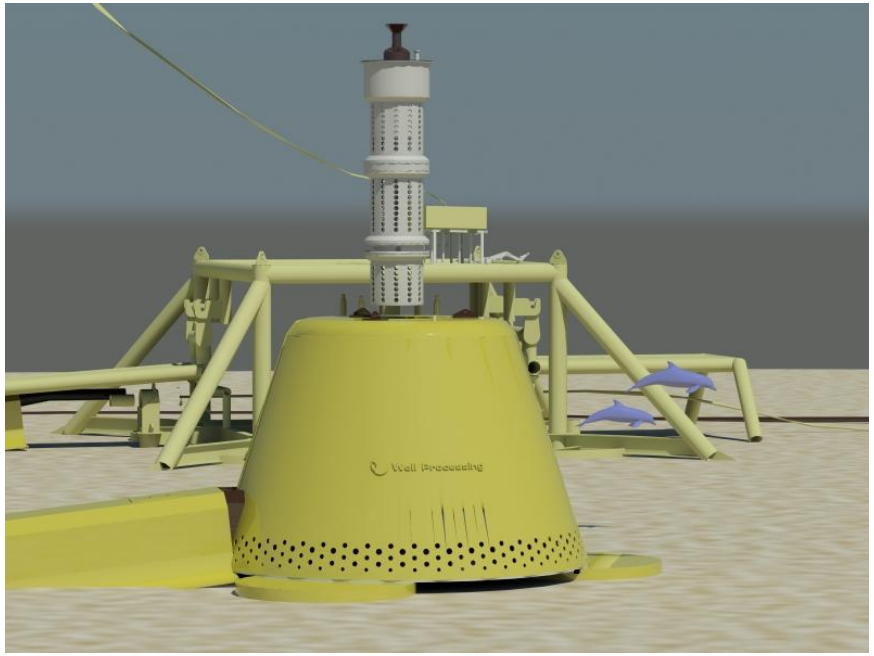
- Specific pump design

SWIT Benefits

- SWIT moves processing and equipment from topside facilities to the subsea - independant of restrictions such as weight, space or number of wellslots plus freeing up topside capacities for production / other IOR methods.
  - **SWIT can make non economic discoveries economical viable**

- SWIT may significantly improve flexibility in field drainage strategy both for new fields and for field redevelopments

➔ SWIT provides smart waterflood options for offshore oilfields



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