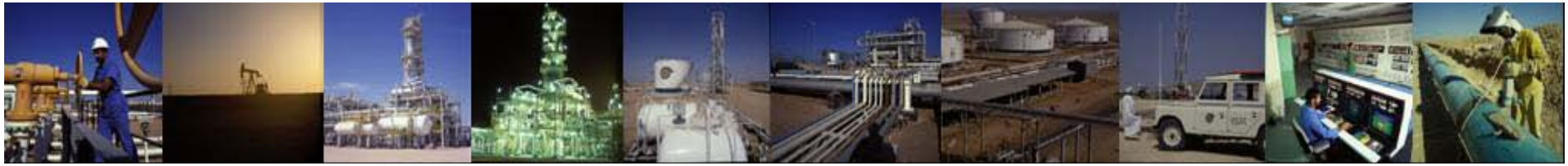
Produced Water Management & Treatment



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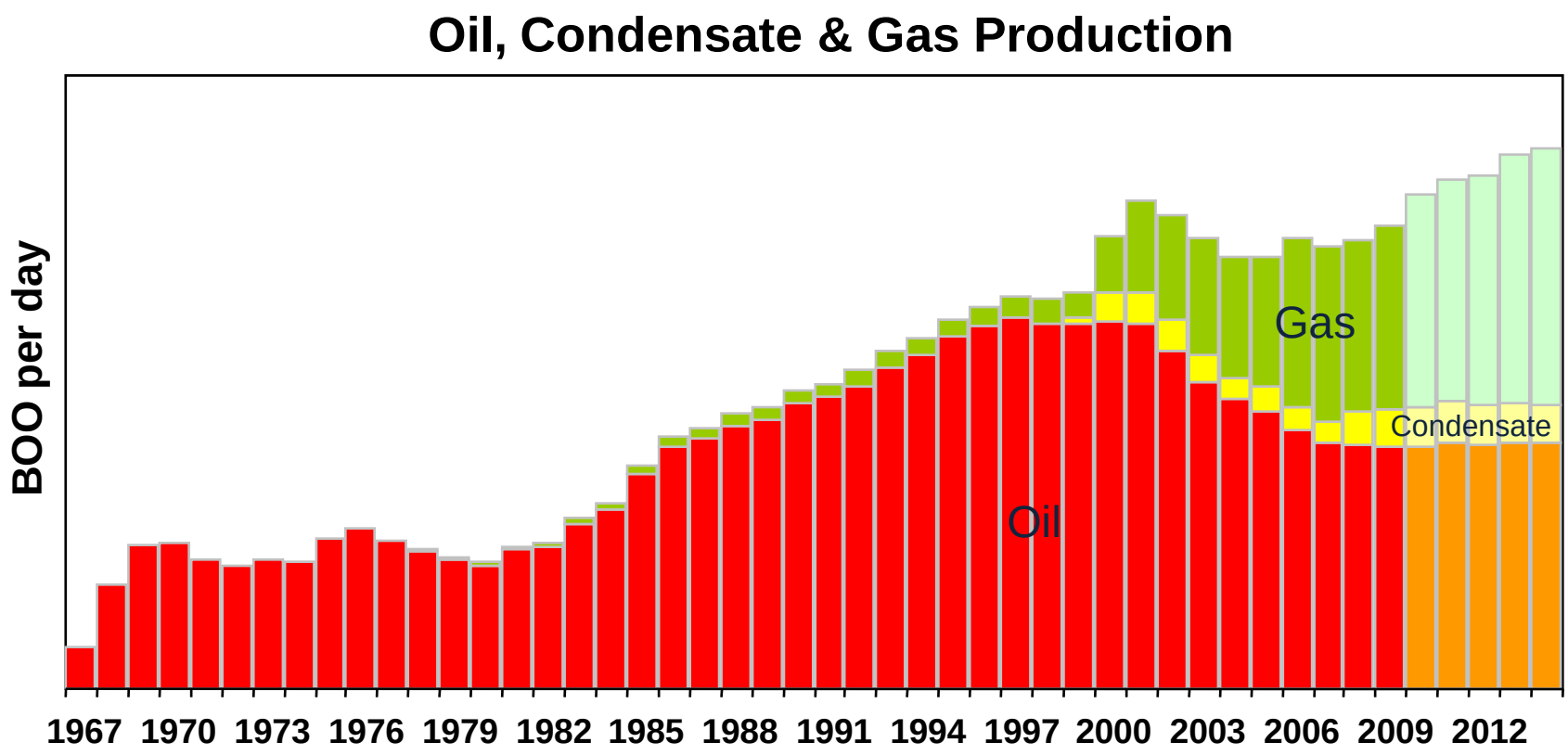
Outline

- Introduction
- Produced Water Treatment
- Produced Water Management
- Greening the Desert Initiative at Petroleum Development Oman
- Outcome of Desktop Study on Potential
- What are the Produced Water Management challenges?

Produced Water (PW) Definition

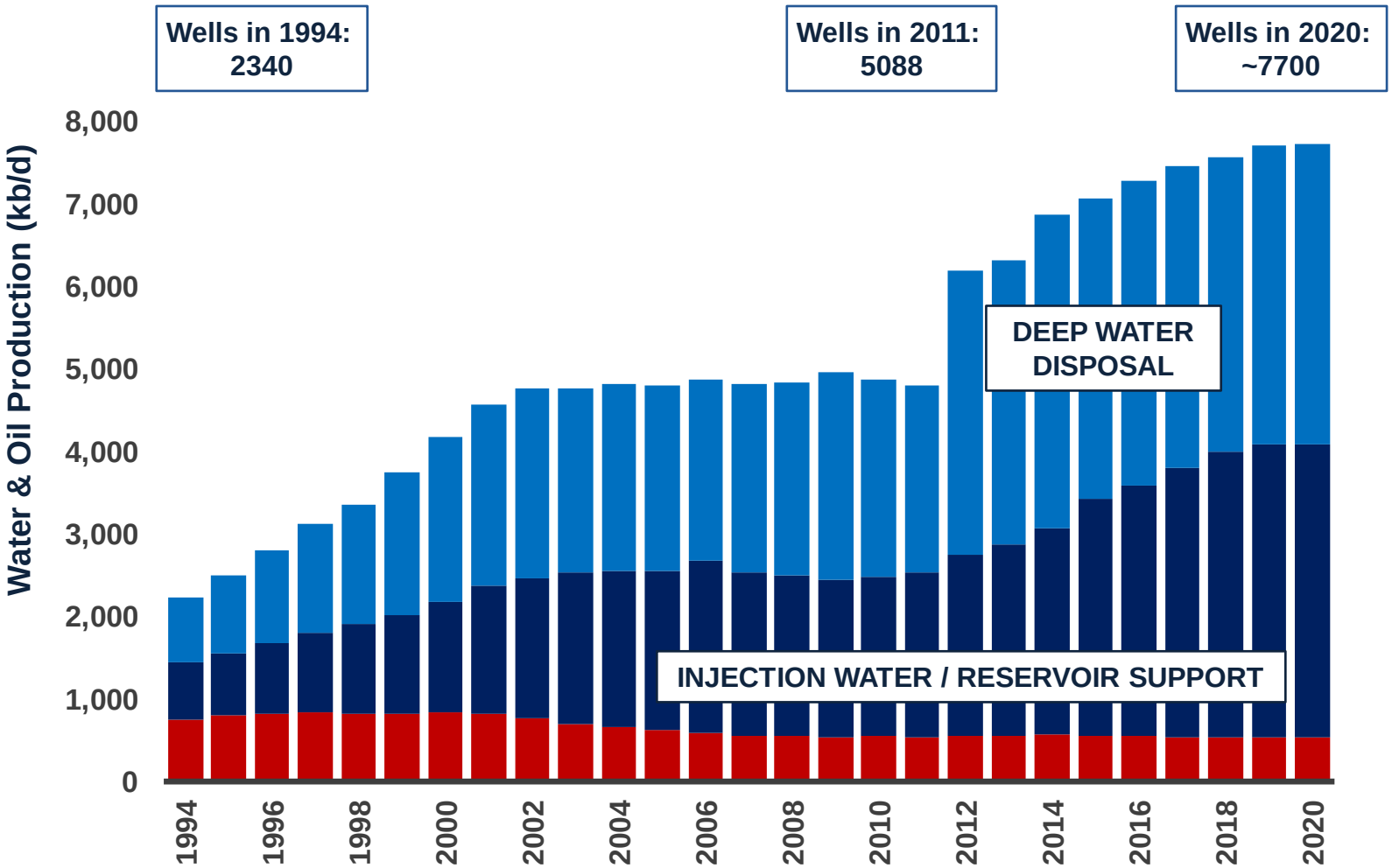
- Water trapped in reservoir (or below Oil zone) and brought to surface along with oil & gas production
- It usually contains oil (dispersed & dissolved), metals, (heavy metals), NORM, Salt, Chemical additives used during drilling, Suspended Solids….etc
- Quantities of Produced Water increase as Oil producing field matures
- Treatment of produced water is a major cost component of Oil production

Oil Production Growth



Excludes Associated Gas Production

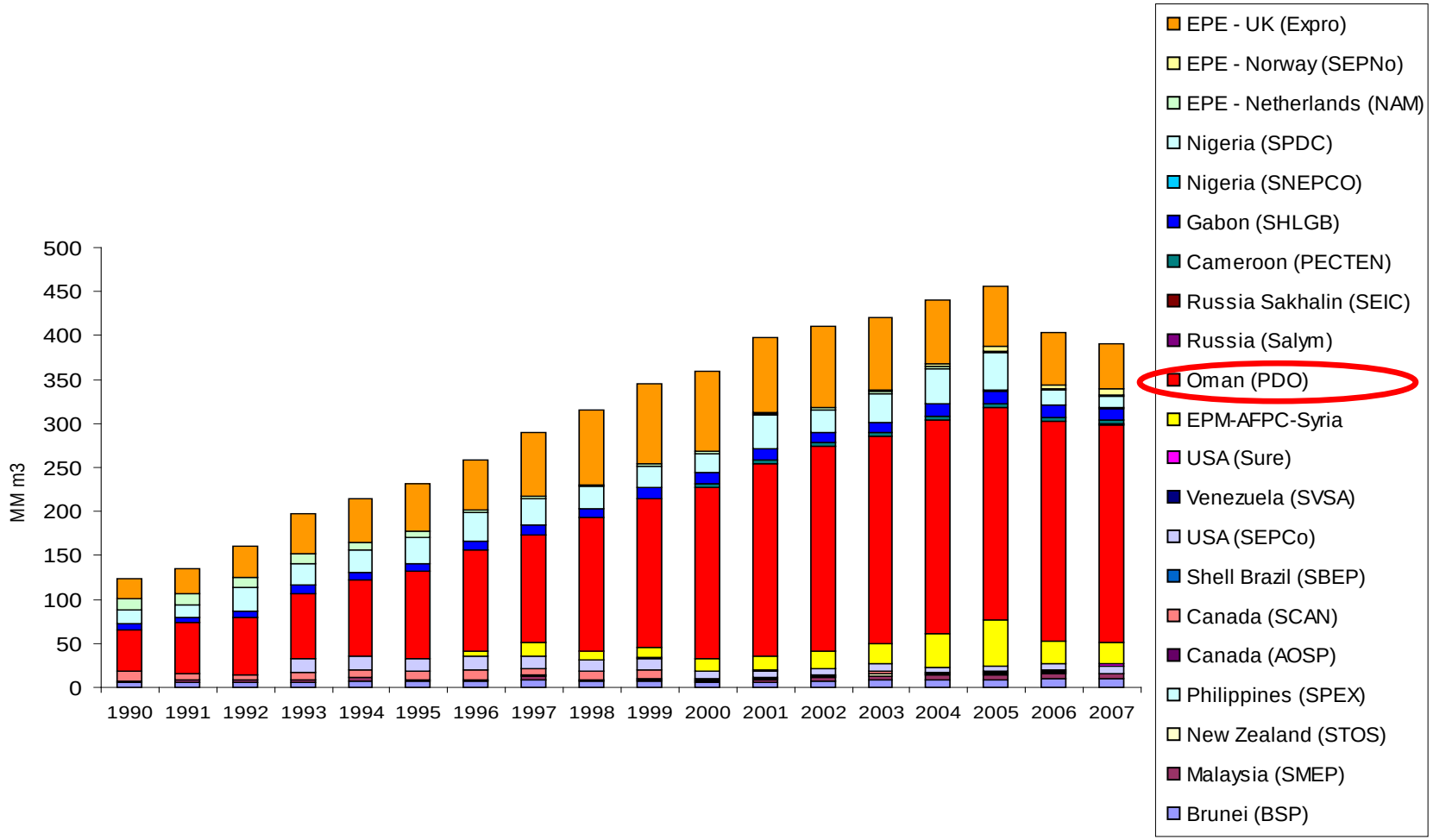
Oil Water Production Forecast



Worldwide Quantities of PW

- In the US, average water-to-oil ratio is 10 (2010)*
- Kuwait Oil Company produces 500,000 bbl/day of water Compared to 2.5 million bbl of oil
- ARAMCO produces approximately 5 Mbbl/day in comparison to 12 million bbl of Oil
- Oman (PDO) produces 5 Mbbl/day of water versus 550,000 bbl/day Oil

Oman: Largest Produced Water Quantities in Shell



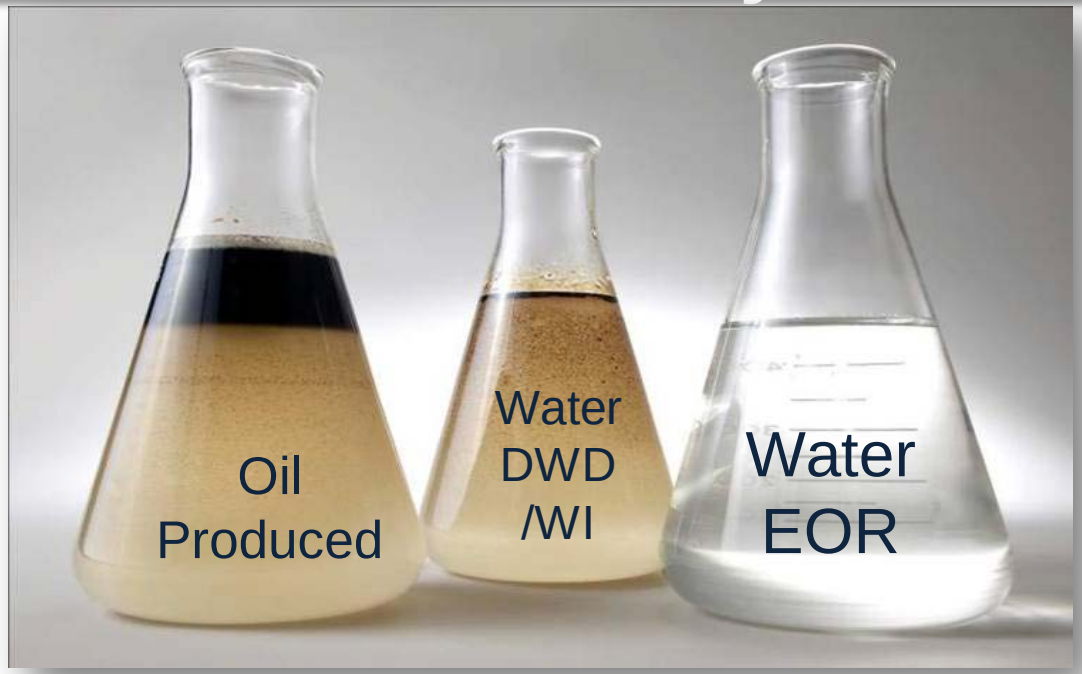
Oman Highest Water Producer

- Oman Oil fields reached maturity
- Oman has started exploring and implementing new technologies to extract difficult Oil
- Produced Water treatment and management are the major challenges in Enhanced Oil Recovery
  - Polymer Injection
  - Steam Injection
- Oman with all their experience and challenges faced, is an excellent candidate for Center of Excellence on Produced Water treatment & management

Fate of Produced Water (Petroleum Development Oman)

- One bbl of oil => 10 bbl produced water
  - 4.5 bbl Water Injection, Enhanced Oil Recovery to produce more Oil
  - 5.5 bbl Deep Water Disposal, Energy Intensive Operation up to **3 km** deep into ground at **120-170 bar** pressure - wasted energy & resource
- Nimr Water Treatment Plant (Reed Beds) is handling~100,000m3/d
- Alternatives are investigated for efficient utilisation of produced water - Aquifer Recharge, Bio-saline Agriculture, Trans-Oman Water line….

Produced Water Treatment Challenges in the Oil Industry



Produced Water Treatment Stages

- Water quality varies from one field to the other across Oman
- In past most Oil fields used Skim or settling tanks and CPIs for bulk water treatment
- Currently; water flood projects & Enhanced Oil Recovery projects require stringent water specifications and hence more complex water treatment equipment

Primary

- **Corrugated Plate Interceptors (CPIs)**
- **Tilted Plate Interceptors (TPIs)**
- **Skim Tanks**

DWD

Secondary

- **Hydro cyclones**
- **Gas Flotation Tank (GFT)**
- **Induced Gas Flotation (IGF)**
- **Centrifuges**

WI/DWD

Polishing/ Tertiary

- **Nutshell Filters**
- **Ceramic Membranes**
- **Ion Exchange**
- **Double Pass RO**

EOR/ Polymer Injection/Steam Injection

Water Treatment Challenges

- Improving Primary Separation
  - Performance of secondary and tertiary WT equipment depends on design and operation of primary separation
  - Increasing residence time improves primary separation and reduces cost of water treatment
- Troubleshooting of New Water Treatment Equipment
  - Some new technologies are being implemented for the first time e.g. GFT, Electro-coagulation and electro-floculation
  - This requires advanced expertise on Engineering, Maintenance & Operation
- Vendor Experience and Contracting Strategy
  - Vendor experience and references are of most importance
  - Investigating possibility of DBO&T, DBOO for water treatment

Water Treatment Facts

- Water treatment is crucial for Oil production
- Major cost of Oil production is attributed to water treatment and management
- Oil operators are developing more focused approach towards selecting appropriate water treatment technologies
- There is a clear gap between the demand in the Oil industry and what the market and water experts are providing
- Oil industry has the ability to move fast in developing new technologies simply because cost effective & continuous energy production is of highest importance

Produced Water Management (Utilisation) Drivers

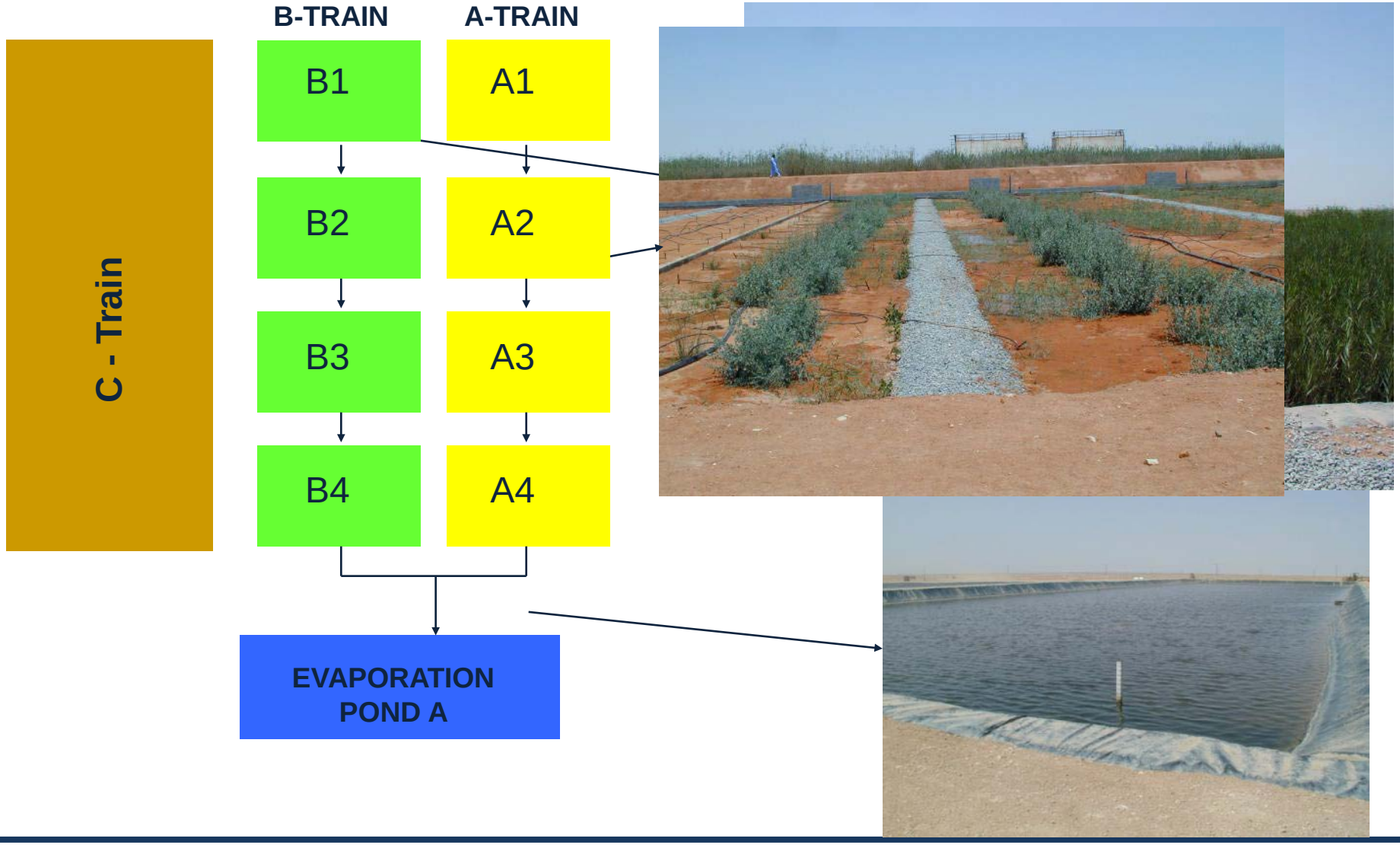
- Objective: Offset Deep Water Disposal high energy demand operation**-Cost**
- Relatively Good Water Quality in South Oman-low salinity (5000ppm) and increasing water rates
- An excellent Sustainable Development initiative & strategic move towards turning **PW from a liability into an Opportunity**
  - New business Opportunity for Oil companies by diversifying core activities; bio-fuels, carbon sinks, bio-saline forestry, water based industries, biomass production, aquifer recharge **-Game Changer**

Produced Water Management at Petroleum Development Oman (PDO)

a. **Greening the Desert Initiative**

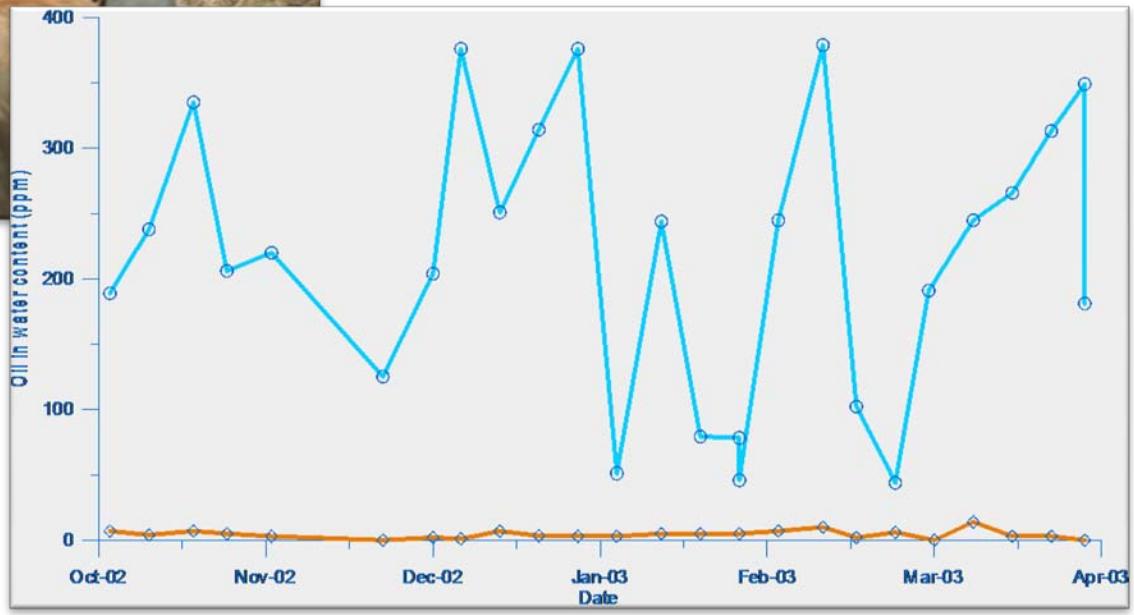
b. Desk Top Investigation of Potential Low Salinity Systems

Nimr Reed Bed Pilot-2000

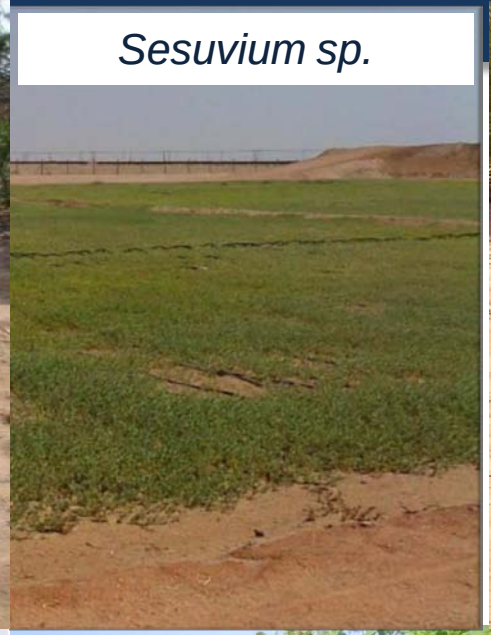


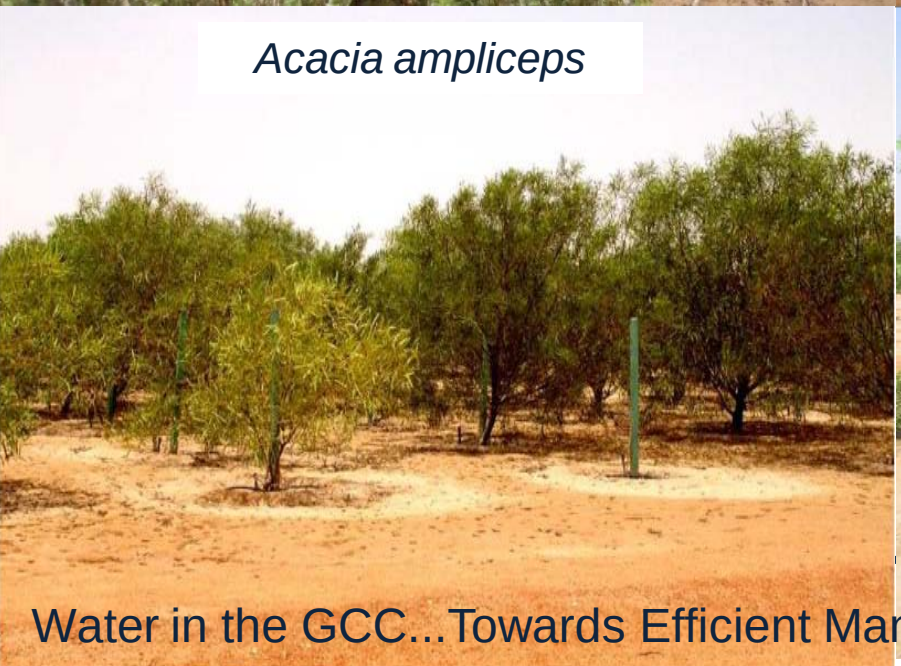
Pilot Performance Since 2002

- Avoid direct food chain
- Fodder- Racing Horses
- Timber for wood production
- Halophytes for landscaping
- Plants for CO2 sequestration

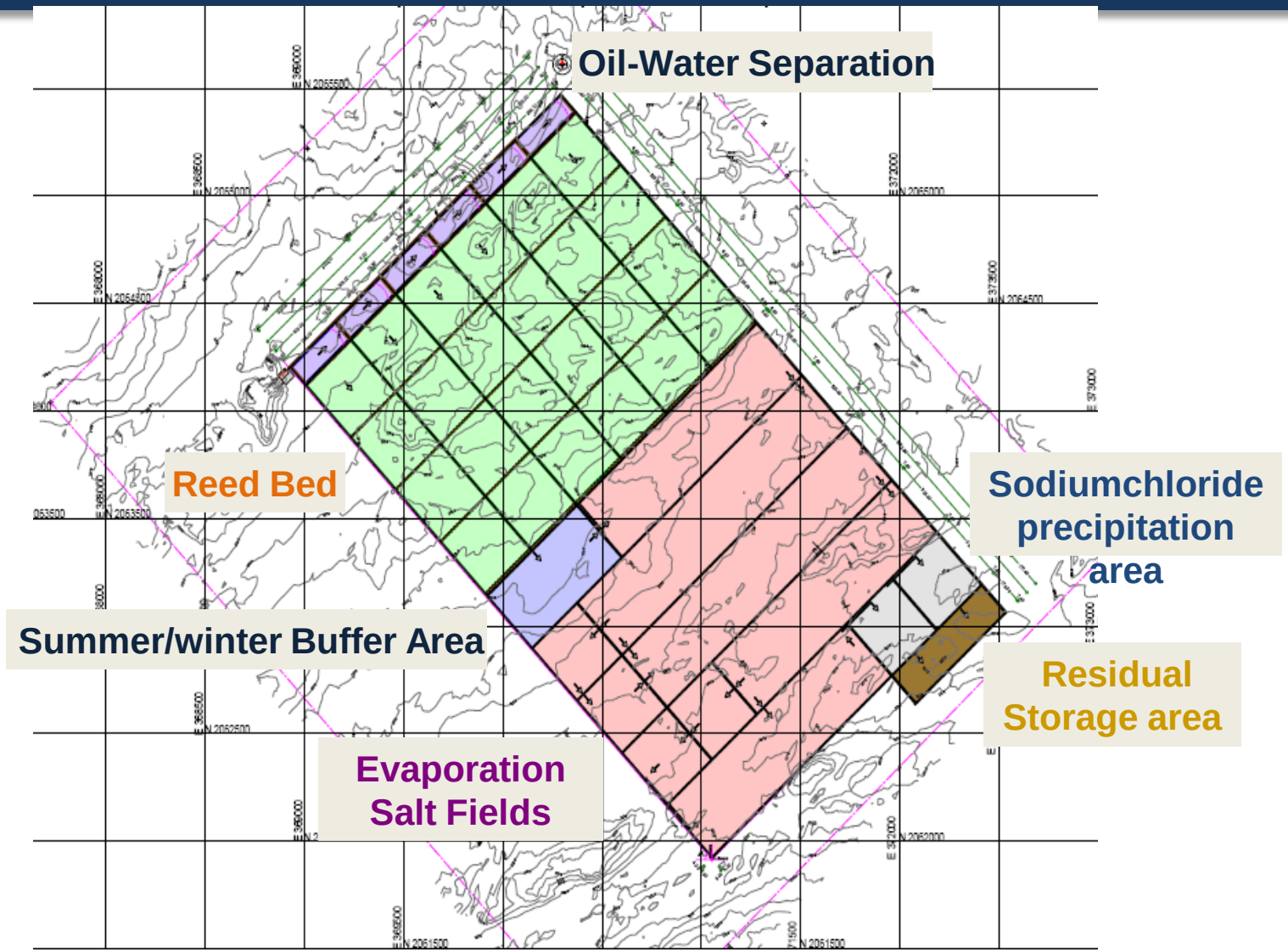


Status of Nimr Reed Bed Pilot 2013



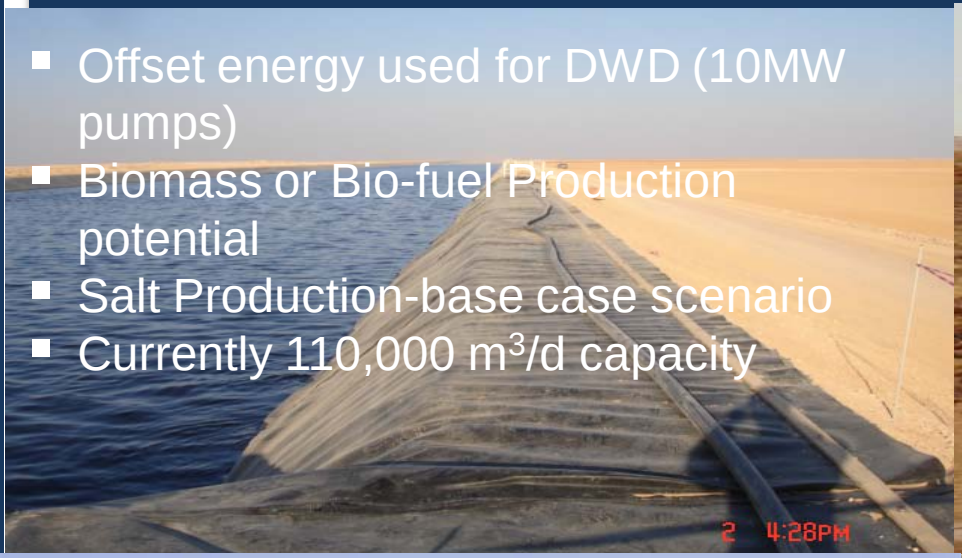


Nimr Water Treatment Plant



Nimr Water Treatment Plant

- Offset energy used for DWD (10MW pumps)
- Biomass or Bio-fuel Production potential
- Salt Production-base case scenario
- Currently 110,000 m^3/d capacity



Produced Water Management at Petroleum Development Oman (PDO)

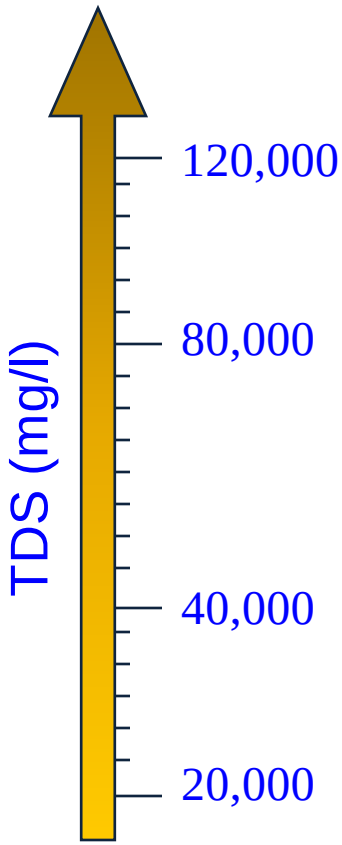
a. Greening the Desert Initiative

b. Desk Top Investigation of Potential Low Salinity Systems

Potential Utilisation Options for Produced Water

- Excess treated Produced Water can be used for;
  - Agriculture
    - Bio-Saline such as Jatropha ,Cotton and halophytes or forages
    - Spec B (Cereals, seed crops & fodder)
  - Aquifer recharge
  - Solar desalination
    - Fresh Water
    - Salt
  - Water Based Industries
    - CO2 sequestration
    - Pulp industry
    - Duqum area development (Industrial Use)

PW Management Critical Factors



- Water Quality in terms of salinity, heavy metals & Boron
- End Use/Product
- Treatment Requirements & Cost Benefit analysis
- Contracting Strategies (DBOO & DBOT)
- Vision 2020, 2030 (National SD Plans)

Produced Water Management Challenges

- Treating produced water as liability rather than resource
- Lack of recognition from water experts and Decision makers in order to develop & accelerate the process of PW utilization
- Full solutions are required from source (produced water) to sink (value product) to sustain Oil production
- Stakeholder serious commitment (Ministry of Water resources, Ministry of Environment, Ministry of Agriculture, Ministry of Commerce, Regulatory & International bodies to certify the Water Quality, …etc)
- Contracting Strategies a sub company of Oil operator, or different players ?!!
- Oil price fluctuations and National SD plans
- The legacy of time consuming R&D still prevailing despite the advances made worldwide
- Too many initiatives/pilots and lack of follow up
- Availability and reliability
- Ease of technology installation, operation & maintenance
- Continuous monitoring, evaluation and follow up

Way Forward

- An independent specialized **Produced Water Center of Excellence** has to be established that includes;
  - Water technologists/Experts
  - Government Representatives who are decision makers and able to influence the National Sustainable Development Plans
  - Industrialists who can manufacture & develop water treatment technologies – “In Country Value” Initiative
  - Experts that do base line assessment, define, select and assist in implementation of produced water utilisation options
  - Define & Certify water qualities per end use requirements
  - Guard the intellectual property of these technologies and initiatives in order to develop into new business portfolio for the country/company
- A center that is moving fast with technology taking into account the national and regional SD needs/plans

Close Out

- Oman is the lead in PW utilization field regionally and this in itself is a new business potential
- The produced water treatment and utilisation should involve other decision makers on National level
- There is a strong link between Water industry & Oil Industry
- Oil industry is willing to spend money on research and technology advancement however they need serious commitment & assurance from other key players
- Need for proper utilisation of Produced Water has to come from decision makers in the country and <u>not as a courtesy</u> from Oil industry