

## ***Waterflood Management***

### **Course Objective:**

This course provides a complete review of all aspects of waterflood schemes being the most proven, lowest cost, and applicable to various types of reservoirs to EOR. The various steps of waterflood implementation include cursory screening of candidate fields, scheme planning, project design (including pilot design), and the estimation of the expected incremental oil recovery and production performance, using the most common analytical and numerical methods in the industry, including the stiles and Dykstra-Parsons.

The different techniques used for surveillance and performance monitoring of waterflood projects to optimize oil recovery, will be discussed, including; the Hall Plot, VVR calculations, pattern balancing and re-alignment, volumetric sweep efficiency, production logging, injectivity problems and solutions, and conformance improvements. Numerous interesting case studies will be reviewed to illustrate the performance monitoring and optimization of waterflood projects from different parts of world. Add-on schemes to improve oil recovery including, polymer and gas injection will be discussed. Class problems and group exercise will be offered to the course attendees to emphasize the technical concepts taught. A detailed course hand-out in full colours; which is an excellent reference, will be provided.

### **Who Should Attend:**

This course is aimed at reservoir, petroleum and exploitation engineers/technologists, and geologists who are involved in the area of Waterflooding and EOR schemes.

### **Course Instructor:**

Mr. Saad Ibrahim, P. Eng, president of Petro Management Group Ltd. With over 35 years of diversified experience in the oil and gas industry. He is a worldwide highly recognized engineering consultant and a distinguished instructor (Please see his professional profile). Mr. Ibrahim is a member of APEGA and SPE.



## Course Agenda

### Introduction to Waterflooding and E.O.R

- Potential incremental reserves
- Statistics of waterflood and EOR schemes
- How various EOR schemes affect oil recovery

### Reservoir Characterization:

- A review the factors that can affect waterflood performance from worldwide projects
- Selective criteria to choose suitable candidate fields for EOR application
- Impact of reservoir facies and heterogeneity on waterflood performance of the West Eagle Unit (**case study**)
- Determine field suitability for waterflood from rock and fluid properties (**case study of Ekofisk Field**)
- Use of pressure data to characterize aquifer strength, vertical and areal reservoir communication

### Reservoir Drive Mechanisms & Reserves determination:

- Primary, secondary, and tertiary recovery schemes (**case study**)
- Performance characteristics of different reservoir drive mechanisms
- The use of reservoir drive indices to asses water injection requirements

### Reserves Determination:

- Volumetric, material balance, and probabilistic methods (**class problem**)
- OOIP estimate using “Material Balance Techniques”
- Use Reservoir Limit Testing (RLT) to estimate OOIP

## Design and Planning of Waterflood Schemes:

- Review and screening of EOR schemes
- Timing start of waterflood projects
- Water injection requirement and control methods of injection volumes
- Pattern vs peripheral injection
- Powerwave technology to improve water injectivity
- Water injection optimization in South Pierson Unit (**Case study**)
- Waterflood displacement mechanism (Frontal Advance Theory, by Buckley Leverett) – **class problem**
- Scheme planning and design; including pilot design (**case study**)
- Application of Multi-stage frac Horizontal Wells (MFHW) in waterflooding of tight formations (**case study**)
- Factors that impact oil recovery
- Prediction of recovery efficiency, using Dykstra and Parsons, Stiles, and other empirical techniques (**class problems**)
- Add-on schemes including, polymer and gas injection (**case study**)
- Illustration of “friendly-user” reservoir modeling/simulation to predict performance of waterflood projects.

## Performance Monitoring of Waterflood Schemes:

- Monitoring of reservoir pressure and different well testing techniques
- Voidage Replacement Calculations (VRR) and pattern balancing
- Bubble maps and various production/injection performance diagnostic graphs
- Use of PLT tools and tracer surveys (**case studies**)
- The use of conformance plots, including; WOR vs cumulative production
- **Group Exercise:** Evaluate performance of the Ferrier Cardium Unit #3 to identify operational problems and prepare recommendations
- Injection pattern re-alignment at Means San Andrews Unit (**Case study**)
- Understand water chemistry to identify potential scale problems and benefits of water compatibility tests
- Crude souring; causes and treatments
- Fine migration problems and critical velocity tests

- Water filter size determination
- A unique formation check-valve problem (**Case study**)
- Consideration of injection above the formation frac pressure
- Injection well completion aspects
- Well spacing and pattern selection (**Case study**)
- Evaluate water injectivity problems using the Hall Plot, injectivity fall-off and step-rate tests (**case studies**)
- Is injection above the formation fracture pressure allowed?
- Polymer flooding case study of the pelican lake (Canada).

### Operation problems:

- Tools to diagnose/identify the cause of the problem
- Available techniques to remedy production problems
- What to avoid to have a successful waterflood !

### Closing comments and questions

