Practical Workflows for Reservoir Management and Production Enhancement in Fields under Waterflooding

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What's Next?
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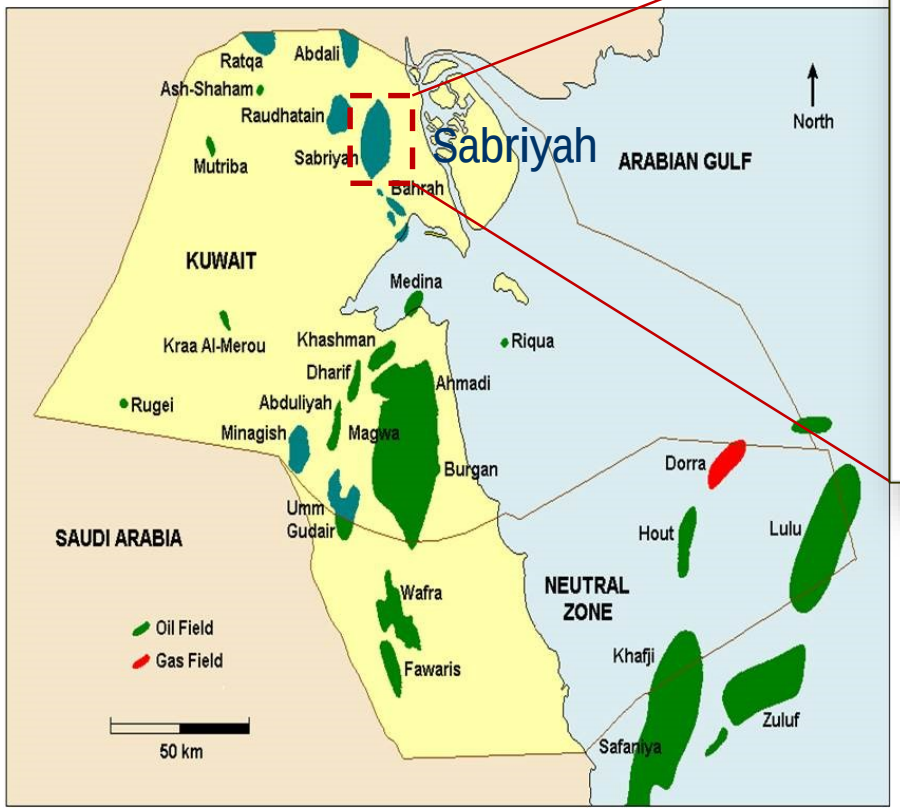
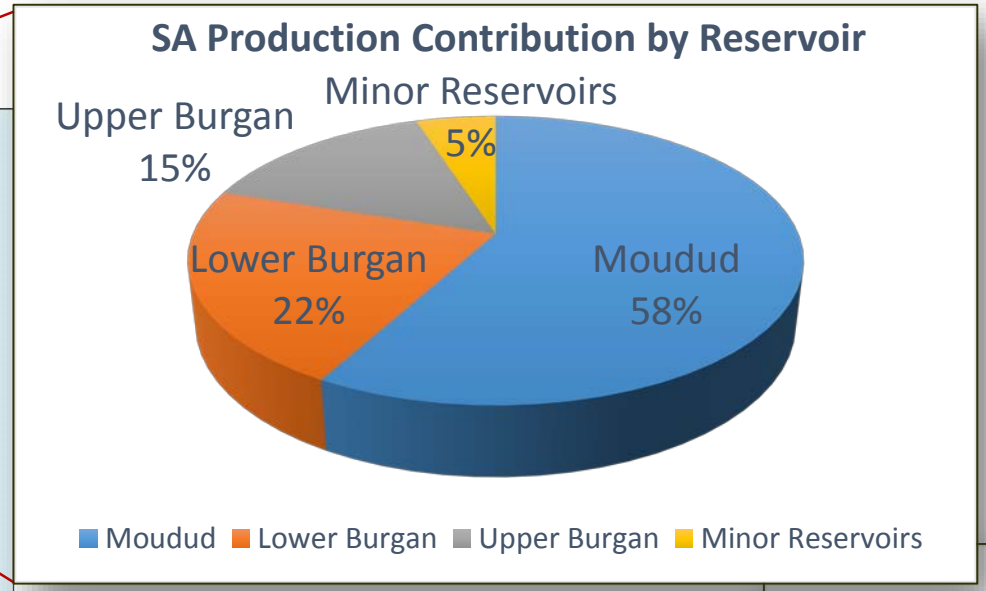
Agenda

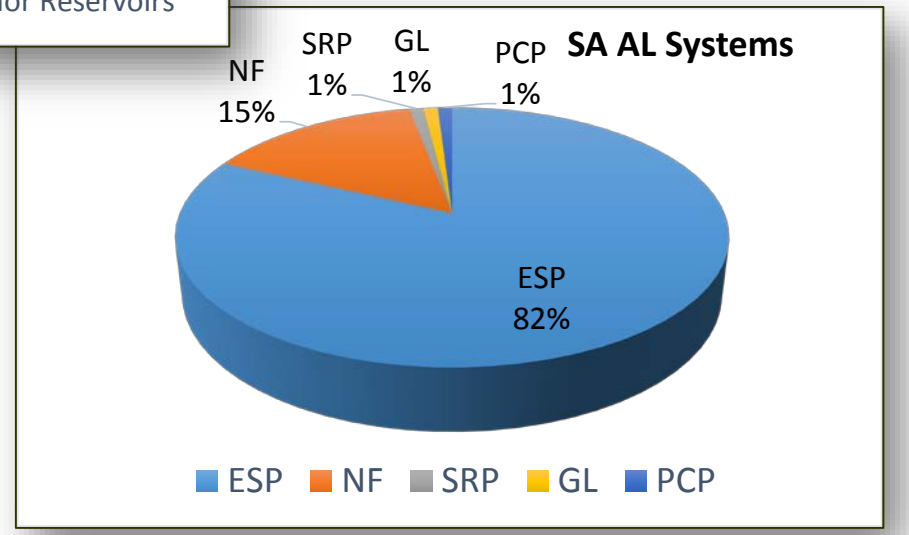
1. Sabriyah Field Introduction
2. Challenges
3. Workflows Overview
4. Examples
5. Results & Conclusions

1. Sabriyah Field Overview

6 Complex Heterogeneous Reservoirs, ~3000 ft Gross Thickness, >600 Active Wells

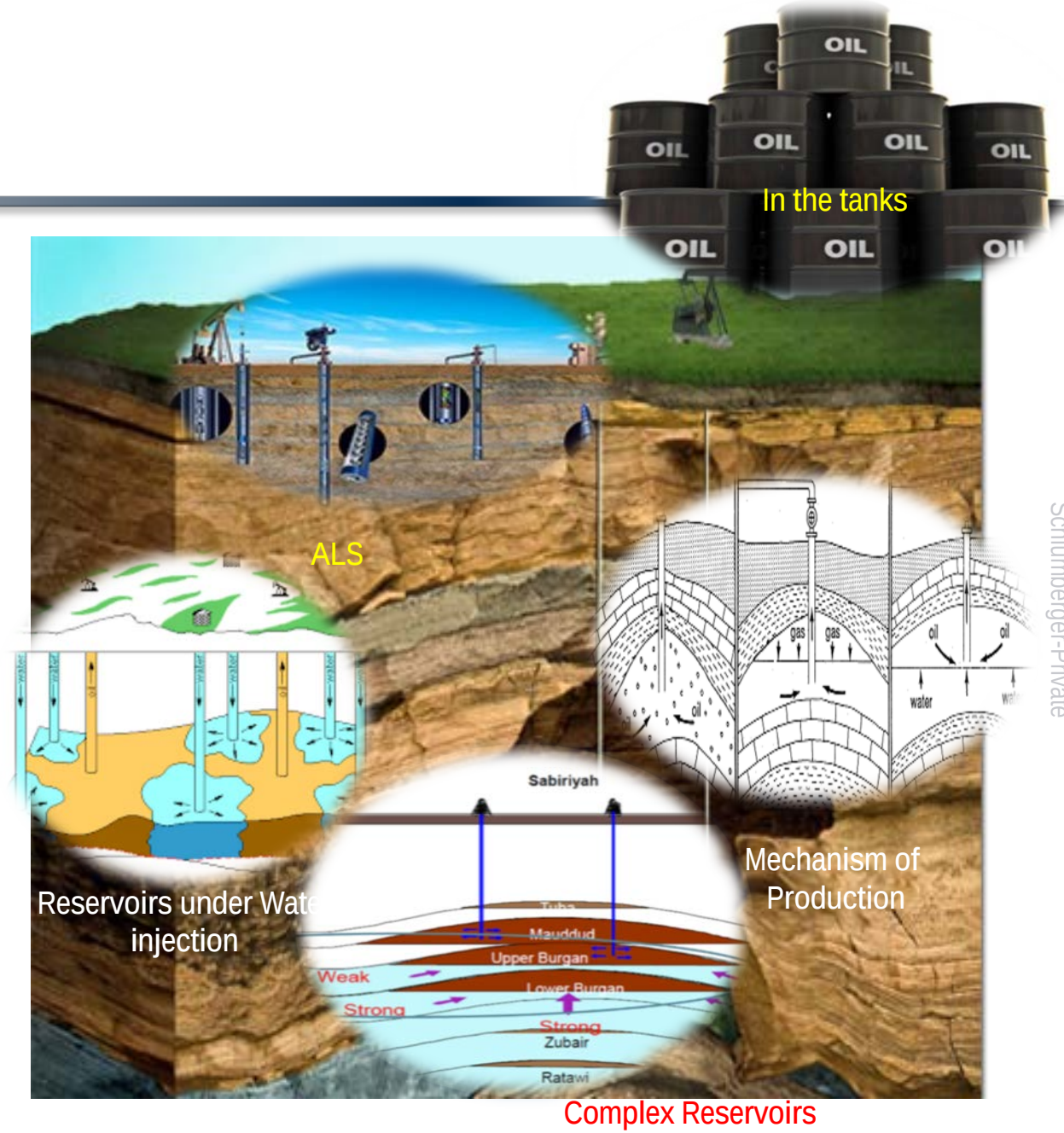






2. Challenges

- Heterogeneous Reservoirs
- Different drive mechanisms
- Several Artificial Lift systems
- Reservoir accessibility (Few Y-Tool)

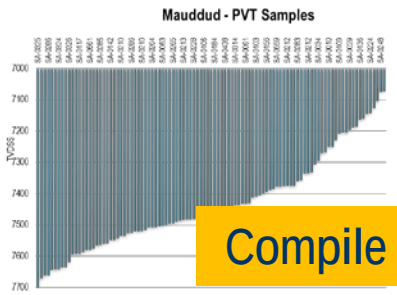


3.Process and Workflow Enablers

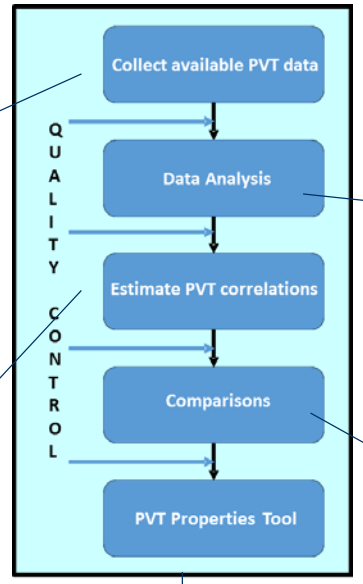
- Workflows to Recover More Hydrocarbons

  - *PVT properties Tool©*
  - *Opportunity Maps©*
  - *Patterns/segments review workflow©*
  - *Injection Allowable Tool©*
  - *Structured integrated proactive production optimization workflow©*

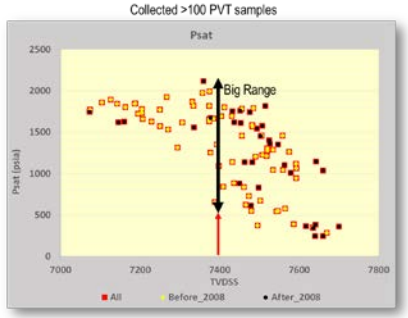
3.1. PVT Properties Tool

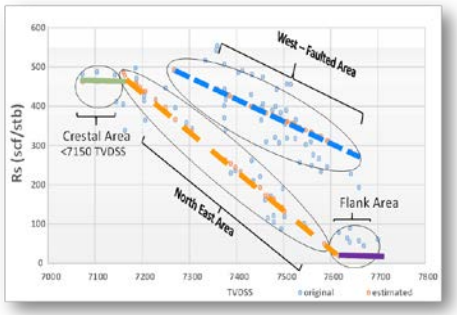


Compile

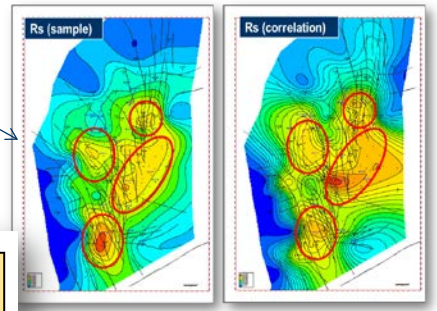


Analyze

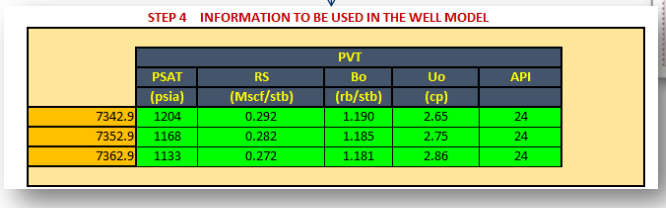




Correlations



Map



	PVT				
	PSAT (psia)	RS (Mscf/stb)	Bo (rb/stb)	Uo (cp)	API
7342.9	1204	0.292	1.190	2.65	24
7352.9	1168	0.282	1.185	2.75	24
7362.9	1133	0.272	1.181	2.86	24

Interactive Interface

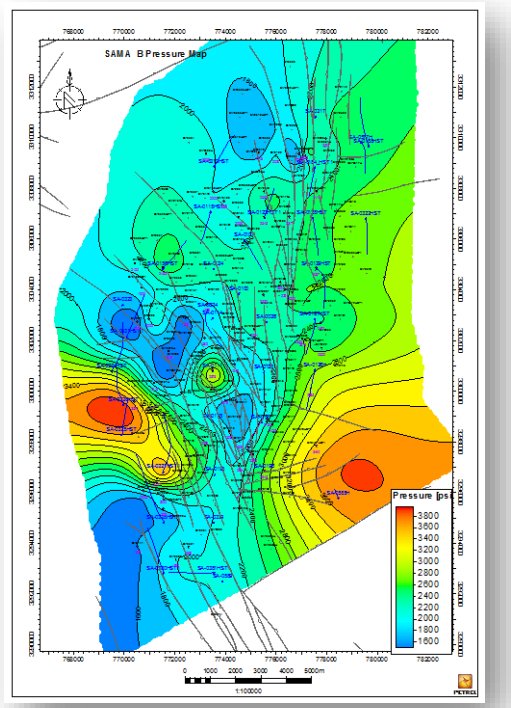
Applications:

- ALS Design for production increase
- Wellbore modeling

This workflow is designed to calculate the oil properties in any place of the reservoir taking into consideration areal and vertical variations based on trends.

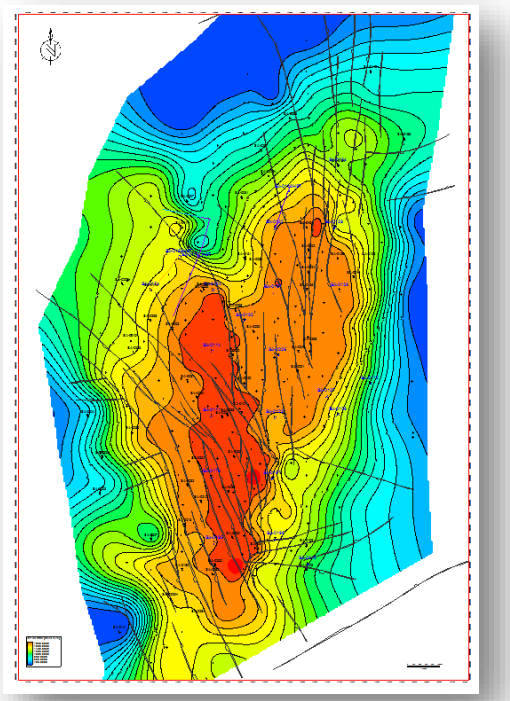
3.2. Pressure Opportunity Map

Reservoir pressure



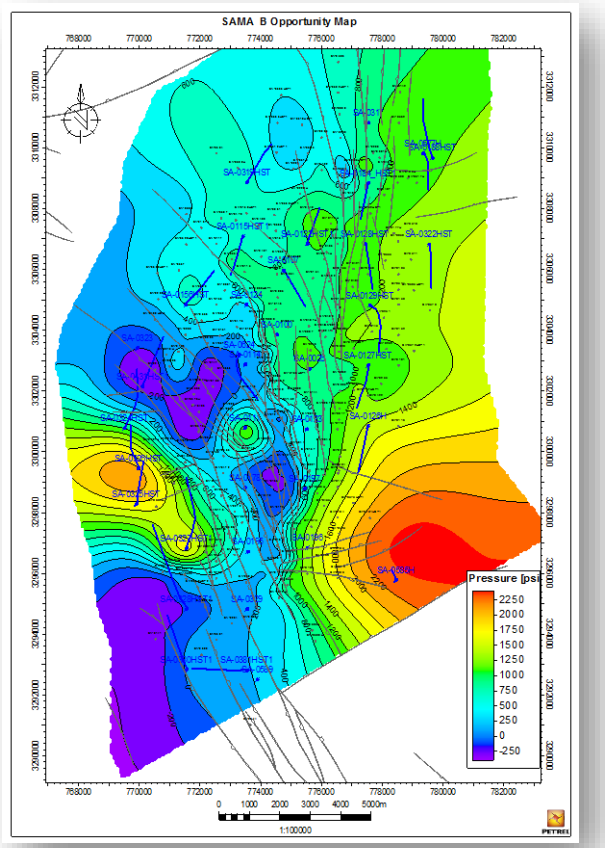
- Review SBHP/RFT's
- Review PIP
- Updated pressure maps by layer

Saturation Pressure (PVT Property Tool)



- Review all PVTs
- Build maps for each property

Opportunity Maps



- Difference of Res Pressure - Sat Pressure

Applications:

- Properly manage reservoir decisions
- Identify candidates to increase production / injection

This is a combination of updated reservoir pressure and fluids' properties to provide a fast way to identify areas of opportunity to increase/decrease injection or production based on the development strategy.

Opportunity Map (Delta P(psia)) = Reservoir Pressure (psia) – Saturation Pressure (psia)

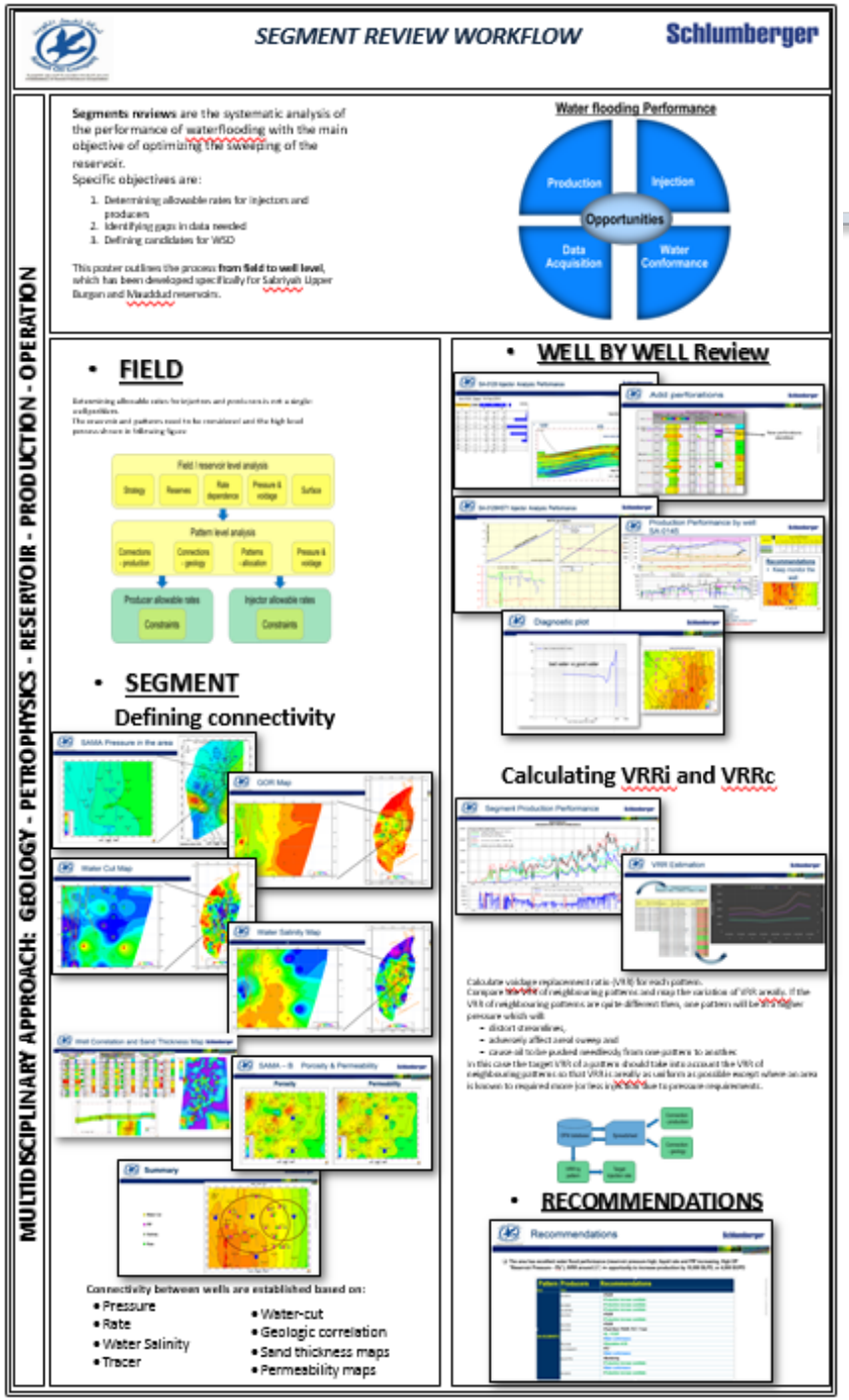
3.3. Waterflooding Segments Review

Well	Recommendations	Data Surveillance Needed
SA-0477	Monitoring (Important)	PGORt
	Stimulate UB-1 and UB-2	-
	WSO of UB-4	-
SA-0552H	Stimulate UB-1 (Fracturation)	-
SA-0084	Add new perforation in UB-1 and UB-4	PNC
	Change lifting system from PCP to ESP	-
SA-0035	Monitoring (Important)	PGORt
	Add perforation in UB-1 (4 to 8 feet)	PNC
	ESP optimization	
SA-0092	Monitoring (Important)	PGORt
	ESP optimization (up-size)	
SA-0088	Keep monitor the well	-
		PLT
SA-0532H	Keep monitor the well	PGOR
SA-0119	ESP optimization (increase Hz)	
SA-0459	WSO of UB-4	PLT and or PNC
	ESP optimization (BU, Hz, up-size)	
SA-0090	ZT from MA to UB	PNC and well integrity
		PLT
SA-0124	WFR: Need injection in UB-1 and UB-2	PNL

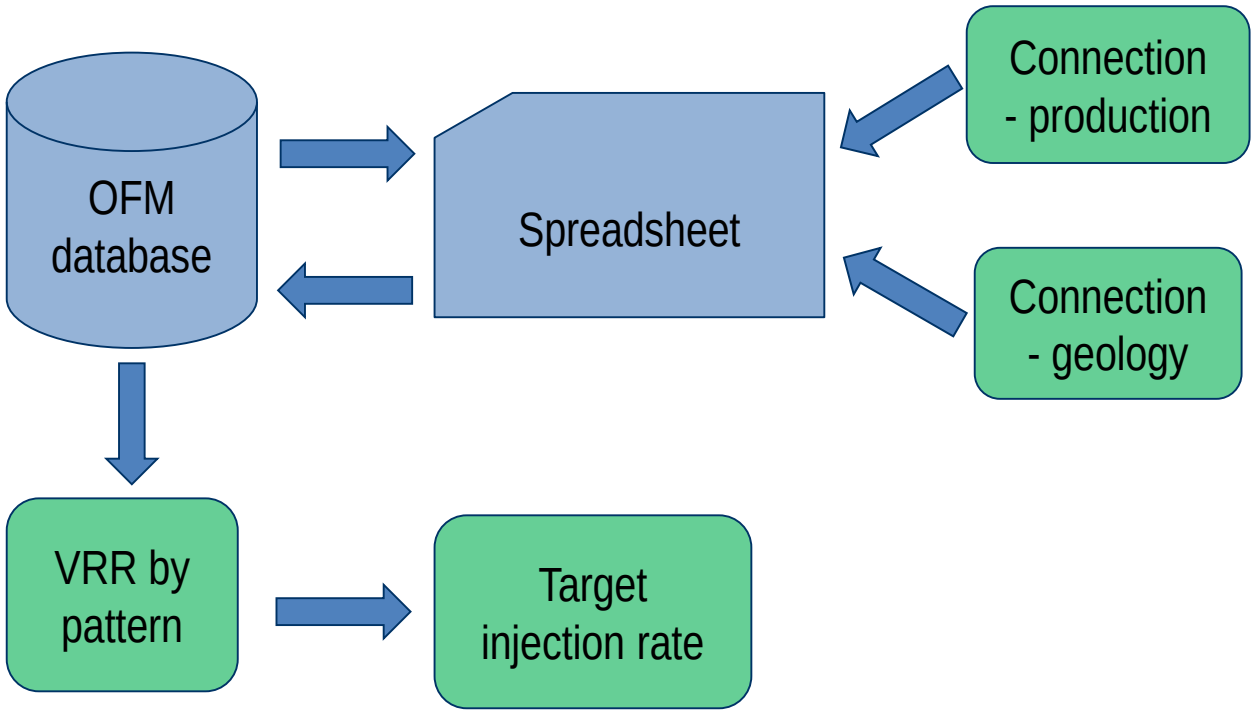
Applying Best Practices for Reservoir Management

- Improve the sweep efficiency
- Increase the recovery factor
- Maximize production

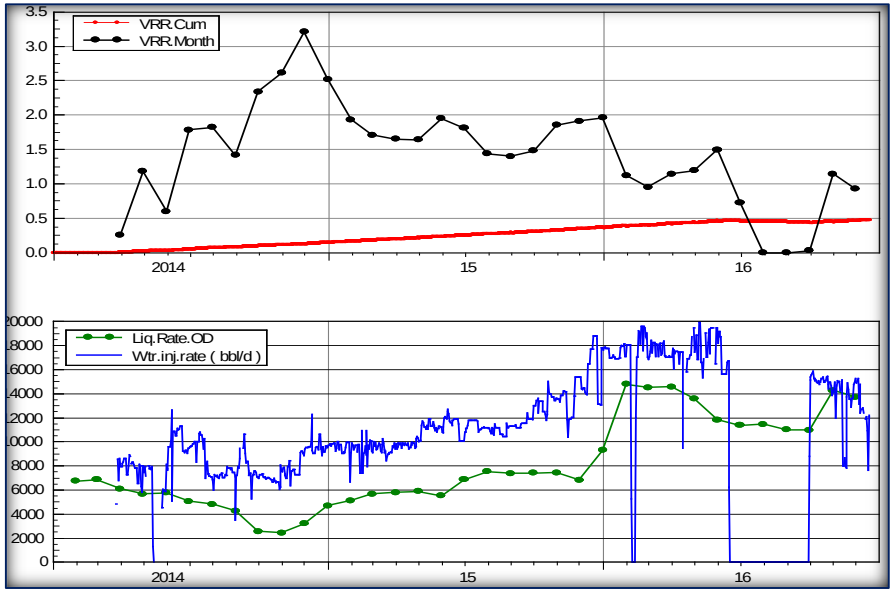
This integrated analytical workflow includes several tools like analysis of production and injection trends, diagnostic plots mostly in OFM to assess good vs. bad water, Hall plots, reservoir pressure data, tracer data, salinity changes, and PIP trends. Geological analysis (cross-section, well correlation, sand thickness map) for each layer is integrated in each pattern/segment review to support connectivity (or lack of).



3.4. Injection Allowable Tool



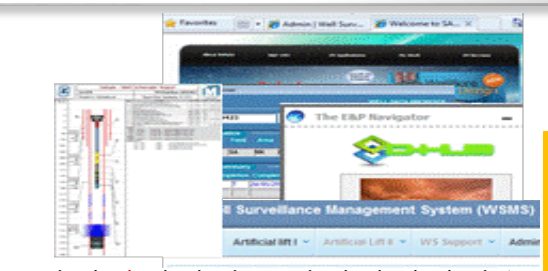
Injector	Producer	Direct Distance [m]	Active UB Now	Producer response? Pressure	Rate	Salinity	Tracer	Wcut	Intervening active well?	Sealing fault?	Juxtapos	Formation continuous? UB-1	UB-2	UB-3	UB-4	UB-5	Connectivity Wt. Ave.	Connected
SA 0111	SA 0277	469								no		Yes	Yes	No	Yes	Yes	37045	Possible
SA-0111	SA-0355	1175								No		Yes	Maybe	No	Yes	yes	24357	Possible
SA 0111	SA 0836	408								No		Yes	Yes	No	Yes	Yes	43175	Possible
SA-0411	SA-0005	880	Yes	Maybe	Maybe	Maybe	Maybe	Maybe	No	No		Maybe	Maybe	No	Maybe	No	4375	Maybe
SA-0411	SA-0022	1530	No														892	Maybe
SA-0411	SA-0046	895	No							No		Maybe	No	No	Yes	No	4445	Possible
SA-0411	SA-0082	790	Yes	Maybe	Maybe	Maybe	Maybe	Maybe	No	No		No	Maybe	No	No	No	1558	Maybe
SA-0411	SA-0167	495	No							No		Maybe	Yes	No	Yes	No	8549	Possible
SA-0411	SA-0163	1931	No														1788	Maybe
SA-0411	SA-0164	1954	No														1722	Maybe
SA-0411	SA-0173	1830	No														666	Maybe
SA-0411	SA-0180	358	Yes	Yes	Yes	Yes	No	Yes	No	No		Maybe	Maybe	No	Yes	No	4040	Yes
SA-0411	SA-0190	1896	Yes		No	No	No	No	Yes								1977	No
SA-0411	SA-0191	1280	No							No		Maybe	Yes	No	Yes	No	3047	Possible
SA-0411	SA-0193	1560	No														2732	Maybe
SA-0411	SA-0194	1723	No														2444	Maybe
SA-0411	SA-0204	1118	Yes	Maybe	Maybe	Maybe	No	Maybe	No	No		Maybe	No	No	Yes	No	3570	Possible
SA-0411	SA-0205	1735	Yes		Maybe	No	No	Maybe	Maybe			No	No	No	No	Maybe	1964	Maybe
SA-0411	SA-0206	1136	No	No	No	No	No	No	Maybe	Yes		No	No	No	No	No	3007	No
SA-0411	SA-0216	1521	Yes		Maybe	No	No	Maybe	Maybe			Maybe	No	No	Maybe	No	2183	Maybe
SA-0411	SA-0218	1450	Yes	Maybe	Maybe	Maybe	Maybe	Maybe	Yes	No		Maybe	Yes	No	Maybe	No	2546	No
SA-0411	SA-0221	1615	Yes	No	Maybe	No	No	No	No								2076	Maybe
SA-0411	SA-0227	1041	Yes	Maybe	Maybe	Maybe	Maybe	Maybe	No	No		Maybe	No	No	Yes	No	2069	Possible

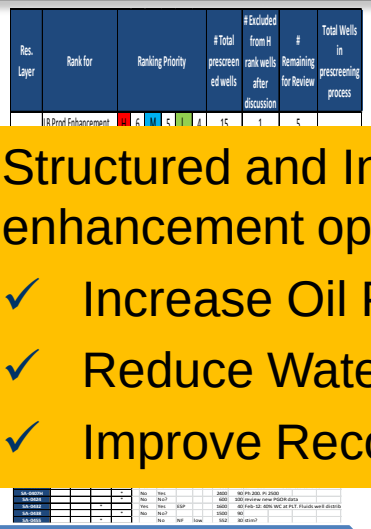


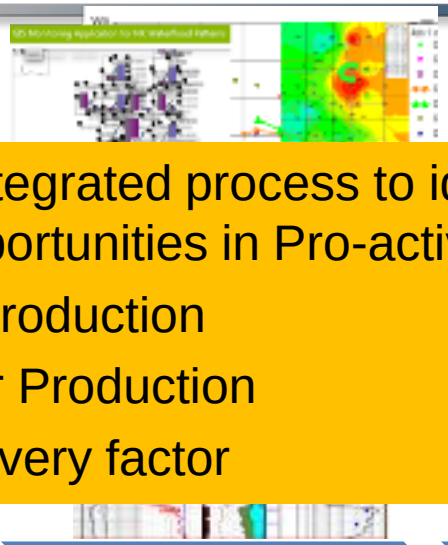
Instantaneous and cumulative VRR are calculated and compared with overall exploitation strategy.

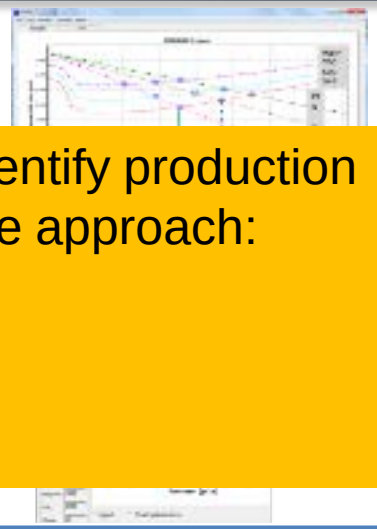
3.5. Structured Integrated Proactive Production Optimization Workflow©

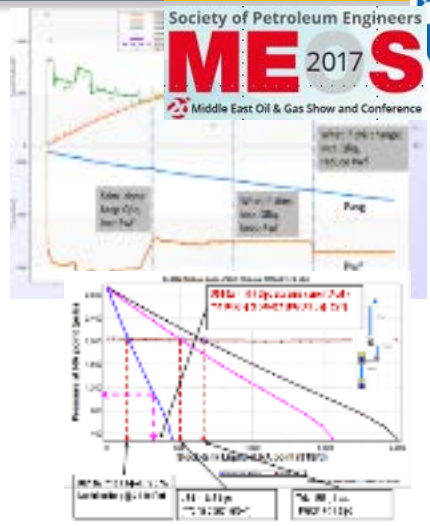
SPE-183952-MS

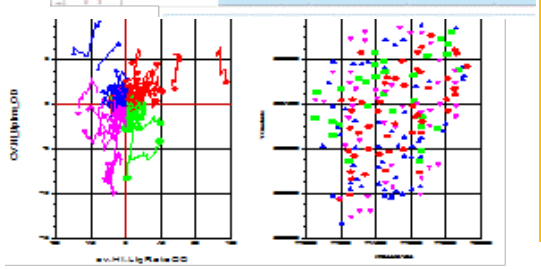












Structured and Integrated process to identify production enhancement opportunities in Pro-active approach:

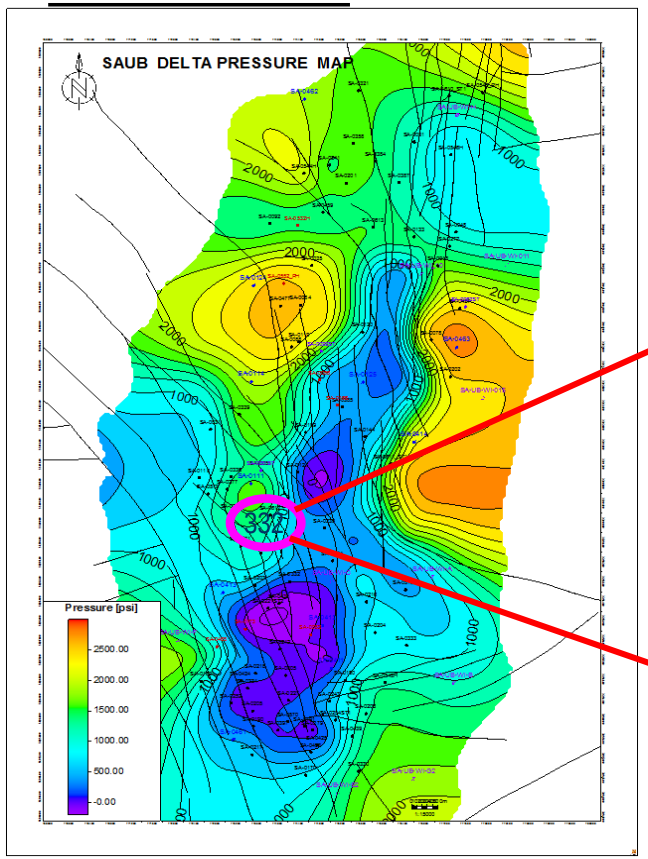
- ✓ Increase Oil Production
- ✓ Reduce Water Production
- ✓ Improve Recovery factor

Data Collection & Screening	Identify Gaps & Opportunities	Detailed Well Diagnostics	Solution Design & Recommendation	Post Job Evaluation & follow up
OFM Templates Heterogeneity Index PASS Techniques	Candidate Ranking & Selection Log analysis Production history Pressure depletion Productivity WC & GOR	Single well modeling & Nodal analysis Pressure & Rate transient analysis Perforation analysis Stimulation analysis	Confirm candidates Analyze options & apply best solutions Perf, Stimulation, Water shut-off Change lifting system	Compare actual vs. expected results Feedback for continuous improvement

ESP Optimization Example

ESP Production Enhancement Opportunities
- Upsizing (bigger size)
- Bean Up and/or VSD

Criteria:
- High Pr-Pb areas,
- Increasing intake pressure and
- Water cut <70 %

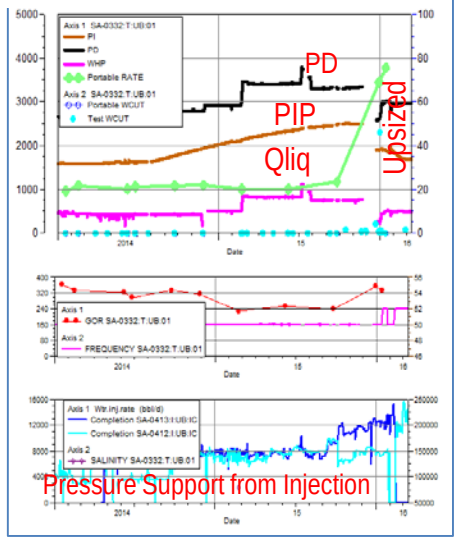


Opportunity Map (Pr-Pb)

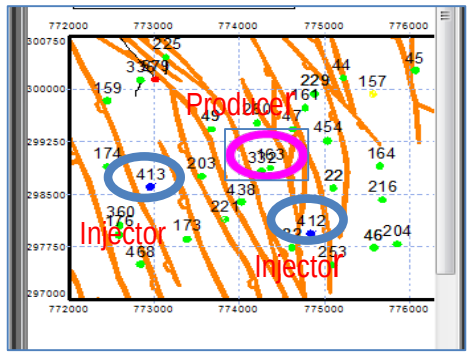
Oil Gain Opportunity

ESP parameter and production history

Well Review Performance

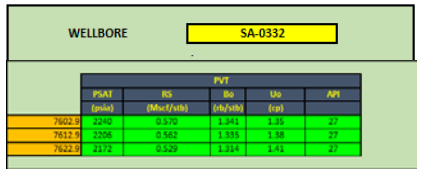


Pattern Review Performance

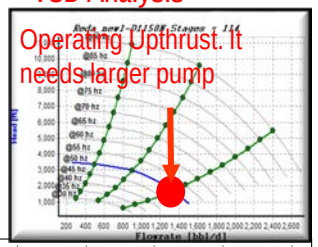


Pattern/Segment Reviews

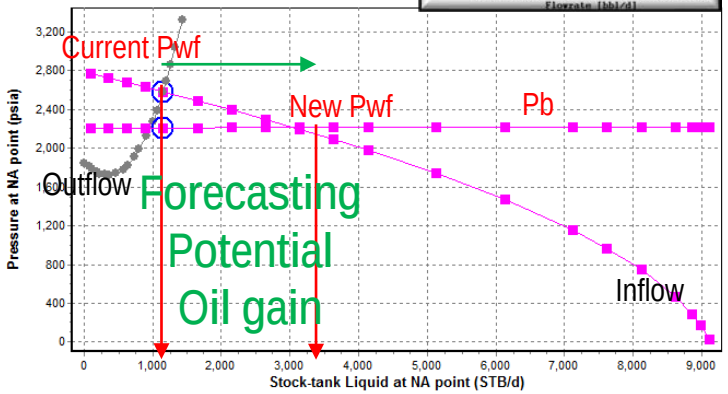
PVT Properties Tool

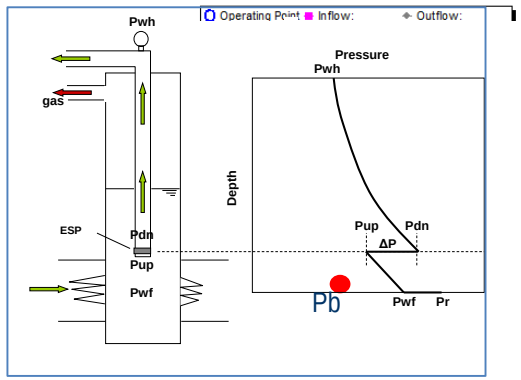


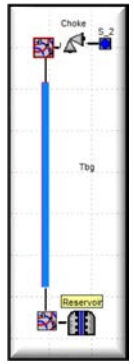
VSD Analysis



Well Modeling @ Sand Face Condition. Pwf





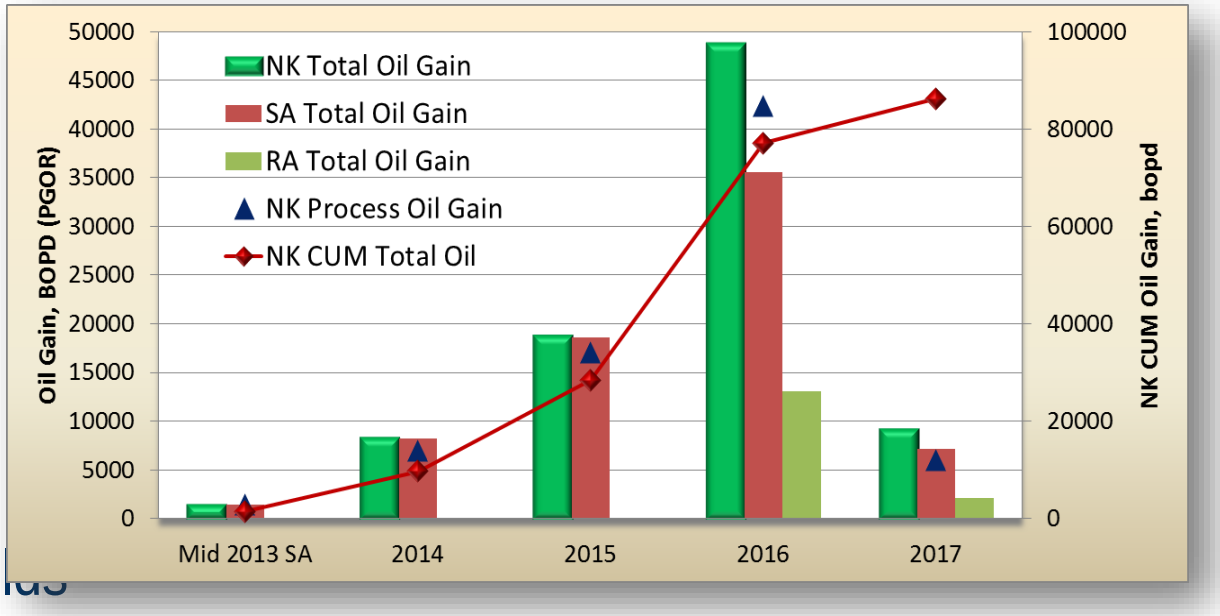


Production Optimization

Conclusions and Way Forward

Conclusions

- Workflows have played a key role:
  - Achieve Production goals
  - Reservoir Management Best Practices
  - Multidisciplinary integration



Way Forward

- Standardization across the reservoirs and fields
- Automation into OFM, Petrel, PetrelRE

Acknowledgements / Thank You / Questions

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