An Integrated Technological Approach Towards Further Field Development and Production Enhancement

Case Study: Robertkiri Integrated FDP

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Lead, Gas Development,
Belemaoil Producing Limited

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Agenda

- Introduction
- Field Overview
- Challenges/Problem Statement/Objective
- Methodology/Integration
- Results/Field Development

Introduction: Case Study – Robertkiri FDP

- Belemaoil is in Joint Venture partnership with NNPC
- Acquired 40% interest in OML 55 in 2013
- Operator of OML 55 Asset
- Currently, the daily cumulative production is circa 10,000 bopd and most of the produced associated gas is flared with a small amount being used as fuel gas to meet the facilities instrument and power demand.
- Belemaoil intends to add to the depleting reserves
- To further develop the Oil and Gas resources in OML 55; increase gas supply into domestic market; implement Gas Flaredown Policy in OML 55

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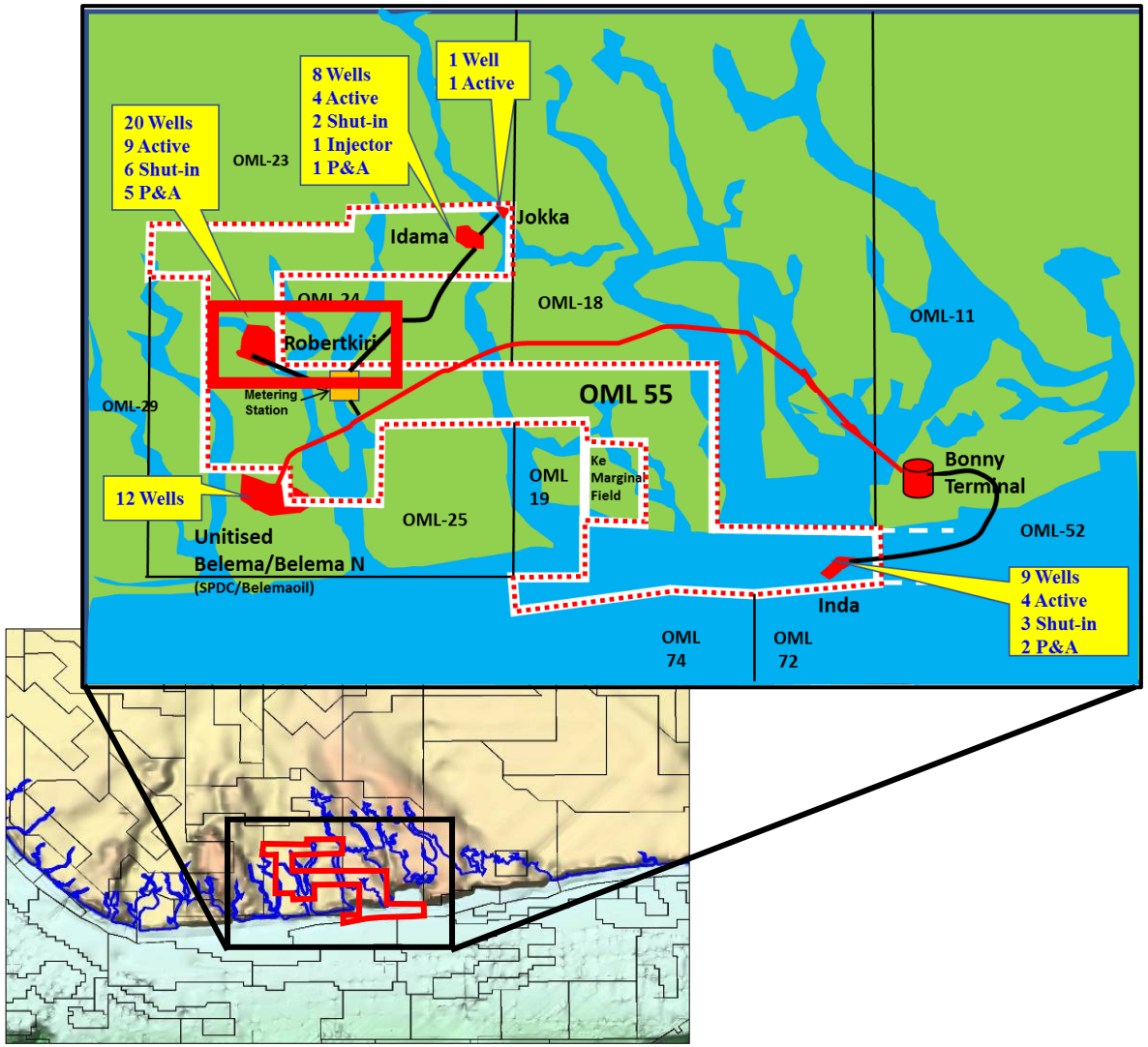
Field Overview



Robertkiri Field:

- Situated within the Coastal Swamp Depobelt of Niger Delta, Nigeria.
- Discovered in 1964 and production started in 1979
- HC accumulation is on the downthrown part of the Robertkiri fault
- Primary reservoirs are Miocene in age and middle to lower shoreface sand with some tidal channels
- About 20 wells drilled (9 active, 6 shut-in and 5 plug and abandoned) , 28 Oil and Gas bearing reservoirs
- Reservoir Depth 8,000 -16,000fts
- Porosity ranging between 18 -30%, Permeability of 500mD-2500mD and Water Saturation between 15-40%
- Robertkiri Production Facilities - Design Capacity of 22,540 BOPD, 10,000 BWPD and 36 MMSCFD Gas

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Objective

To use the State-Art-Technology to carry-out an Integrated Field Development Study to further develop the Robertkiri field potential.

- Evaluate Hydrocarbon reservoirs by analyzing static & dynamic uncertainties in Robertkiri Field Development Project.
- Select Fit-for-Purpose Models which would incorporate the range of uncertainty in key variables for use in concept selection and development planning scenarios.
- Assess and optimize various development scenarios and select optimum development wells on an individual reservoir level.
- Allocate areas of by-passed oil that can be a target for drilling.
- Propose a Field Development Plan that can improve production and maximize reserves.
- To deliver about 120mmscfd of gas into the domestic market.

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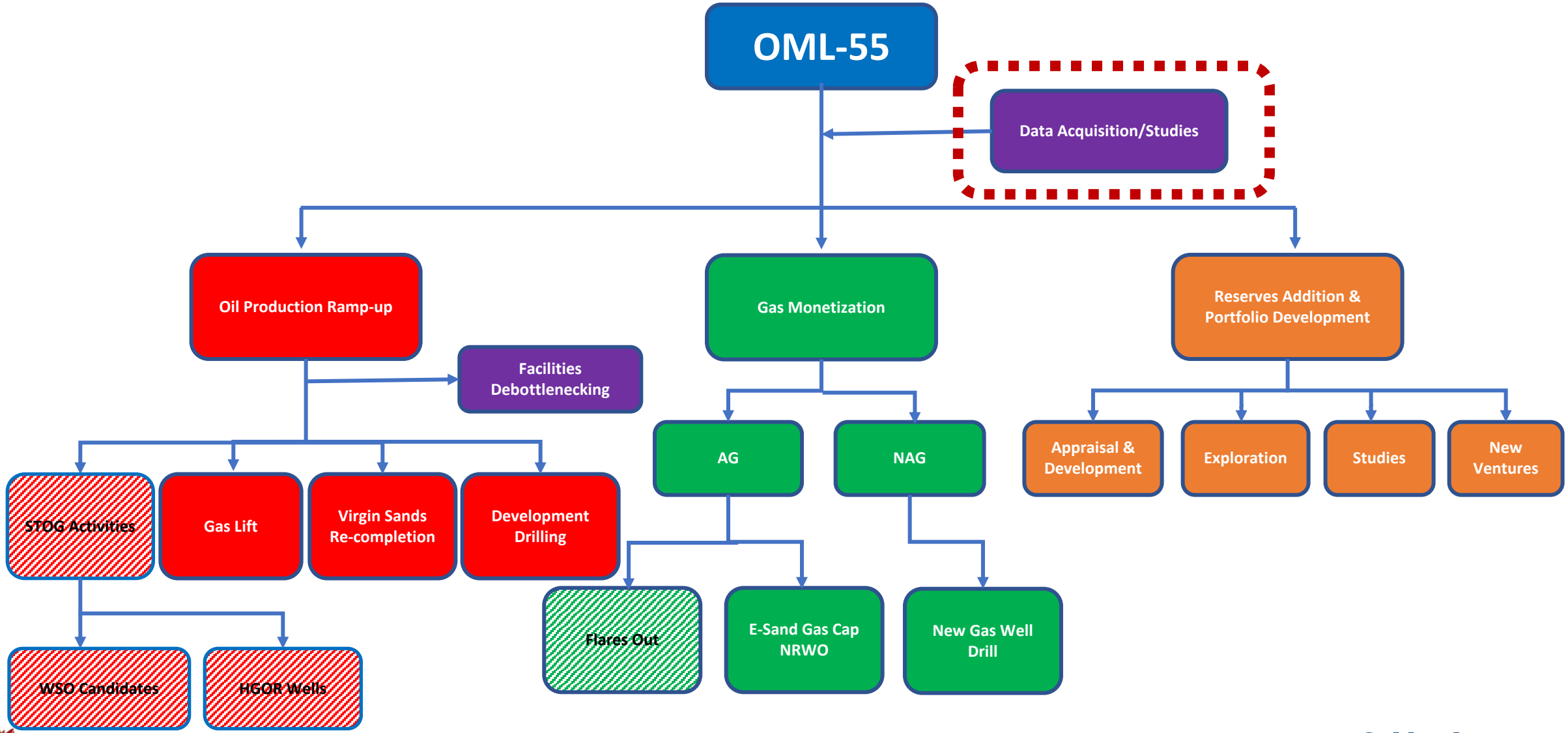
BPL Business Case



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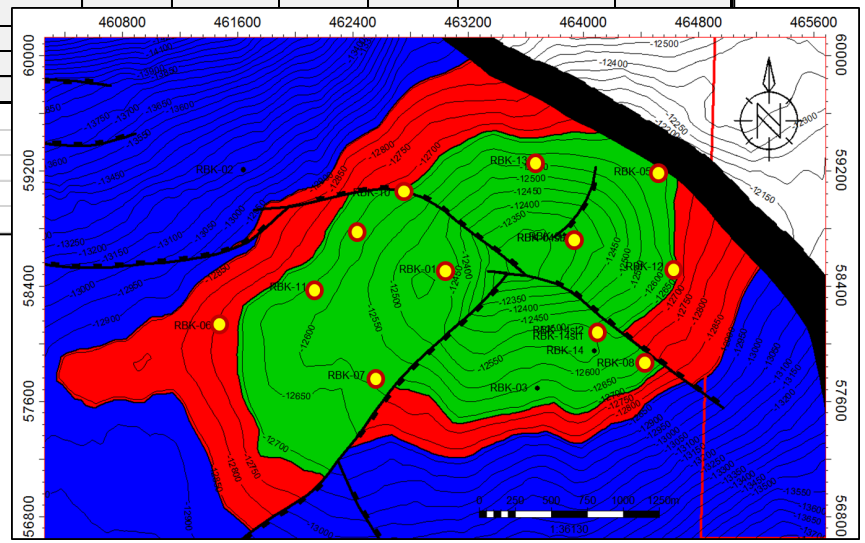
Data Acquisition - RST

SAND PENETRATION OF SELECTED ROBERTKIRI WELLS FOR RST ACQUISITION													
Wells	**1**	**4ST2**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14ST2**	**15**
Completion (SS)	D-01	RK_F-01C	**C-13**	E-01A	E-12	E-01A	**B-02**	E-01A	C-03_OWC	D-01	C-13	F-01A	C-01
Completion (LS)	F-01A	RK_F-01E	**E-12**	E-12	F-01A	E-12		E-12	F-01	E-12	D-01		E-01B
S/N													
1	D-01	RK_E-09	A-06	A-09	A-09	A-09	A-13	A-09	A-10	A-09	A-06	E-01	B-01
2	D-02	RK_E-12A	A-09	A-10	A-12	A-10	B-01	A-10	B-01	B-01	A-09	E-01A	B-02
3	D-05	RK_F-01A	A-10	B-01	B-01	A-12	B-02	B-01	B-02	B-07	A-10	E-01B	B-07
4	E-01	RK_F-01B	A-13	B-02	B-02	A-13	B-07	B-02	B-07	C-01	B-01	E-09	B-08
5	E-01A	RK_F-01C	B-01	B-07	B-07	B-01	B-08	B-07	B-08	D-01	B-02	E-12	C-01
6	E-01B	RK_F-01D	B-2	B-08	B-08	B-02	C-01	B-08	C-01	D-02	B-07	F-01A	C-03
7	E-09	RK_F-01E	B-07	B-08_B	C-01	B-07	C-03	C-01	C-03	D-05	B-08	F-01B	C-08
8	E-12	RK_F-01F	B-08	C-01	C-03	B-8	C-08	C-03	C-03_OWC	E-01	C-01	F-01C	C-13
9	F-01A	RK_F-01H	C-01	C-03	C-08	C-01	C-13	C-08	C-03_B	E-01A	C-03	F-01D	D-01
10	F-01B	RK_F-04	C-03	C-05_B	C-13	C-03	D-01A	C-13	C-08	E-01B	C-08	F-01E	D-02
11	F-01C	RK_F-05	C-06	RK_C06_E	D-01	C-08	D-01B	D-02	C-13	E-9	C-13	F-04	D-05
12	F-01D	RK_F-07A	C-8	C-08	D-02	C-13	D-02	D-05	D-01	E-12	D-01	F-05	E-01
13	F-01E	RK_G-01A	C-13	C-13	D-05	D-01	D-05	E-01	D-02	F-01A	D-02	G-01A	E-01A
14		RK_G-01B	D-01	D-01	E-01	D-02	E-01	E-01A	D-05		D-05	G-01B	E-01B
15		RK_G-01C	D-02	D-01_B	E-01A	D-05	E-01A	E-01B	E-01		E-01	G-03	
16		RK_G-02	D-5	D-02	E-01B	E-01		E-09	E-01A		E-01A		
17		RK_G-03	E-01	D-02_B	E-09	E-01A		E-12	E-01B		E-01B		
18			E-01A	D-05	E-12	E-01B		F-01A	E-09		E-09		
19			E-01B	D-05_B	F-01A	E-09			E-12		E-12		
20			E-09	E-01	F-01B	E-12			F-01		F-01A		
21			E-12	E-01A	F_01C	F-01A							
22			F-05	E-09	F_01D	F-01B							
23			F-06	E-12	F-04	F-01C							
24			F-07			F_01D							

LEGEND	
	Gas
	Oil
	Water



Objectives of the Subsurface Data Acquisition

- Validate the identified oil and gas development opportunities for well intervention in OML-55.
- It is also for well reservoir management (WRM) and to satisfy other statutory requirements.
- Acquired data will be used to update static and dynamic reservoir models and to support ongoing subsurface studies
- Data to be acquired includes, but is not limited to:
  - CO logs using Reservoir Saturation Tool (RST) to identify current fluid contacts
  - Static Bottom Hole Pressure (SBHP) survey for all OML55 sands
  - Cement Bond Log with Variable Density Display (CBL - VDL)

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OML-55 Value Chain

Exploration

- OML-55, areal size of about **852 sqkm**, spatially covered by seismic data.
- Only about 40% covered by seismic data.
- The quality of the current seismic **data deteriorates** with depth, below 3000 msec.
- Area characterized by **Fault shadow Imaging** problem.
- OML-55 reserves **rapidly depleting** as its ageing.
- **15 Prospects and Leads** to be matured.

ACQUISITION

- Terrain – Swamp and Shallow water.
- SOW – circa 1300 sq km
- Fold Multiplicity = 180

Year	2019	2020	2021	2022	2023
Planned Volume (sqkm)	300	300	300	300	100

Appraisal

Jokka field, a field with one (1) exploration which was converted to a producing well to develop the field.

- Actual value of Jokka field yet unknown.
- Aggressive **appraisal** activities currently ongoing to ascertain the extent of the pool.
- Planned appraisal well to target the **deep opportunities** in this field.

Inda and **Idama** Fields.

Planned ongoing to appraise the deep opportunities in the two(2) fields by drilling deep appraisal wells.

Development

- Aggressively close out all outstanding OML-55 subsurface **data acquisition** to:

✓ **Validate the identified oil and gas** development opportunities for well intervention.

✓ Also **for well reservoir management (WRM)** and to satisfy other statutory requirements

- **Development drilling** post subsurface data acquisition interpretation.
- Progress with planned OML-55 field wide **water shut-off** campaign activities.
- Close out the Robertkiri **Gaslift** project.
- **Gas cap blowdown** and NAG development with associate condensate.
- Produced water handling

Gas Development

Robertkiri Gas Development Project:

- To unlock the Associated (AG) & Non-Associated Gas (NAG) potential in this gas field. The greatest potential of Robertkiri field is inherent in the gas field development.
- **120 MMSCFD** of gas to be delivered into the domestic market 2021.

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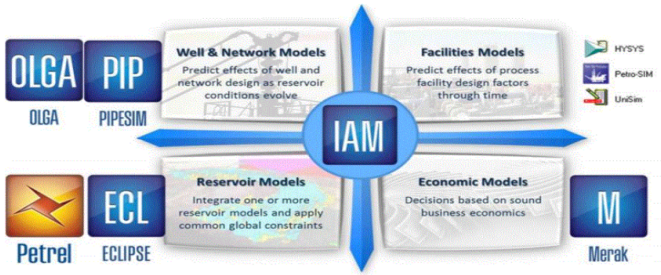
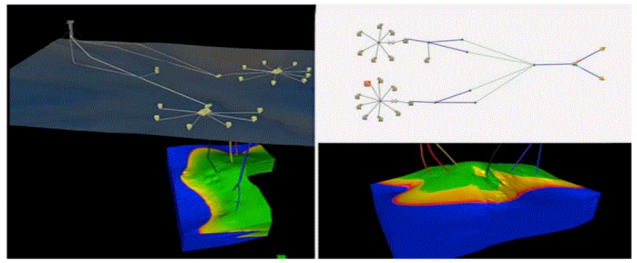
Integrated Workflow Utilizing Schlumberger Cutting Edge Technology





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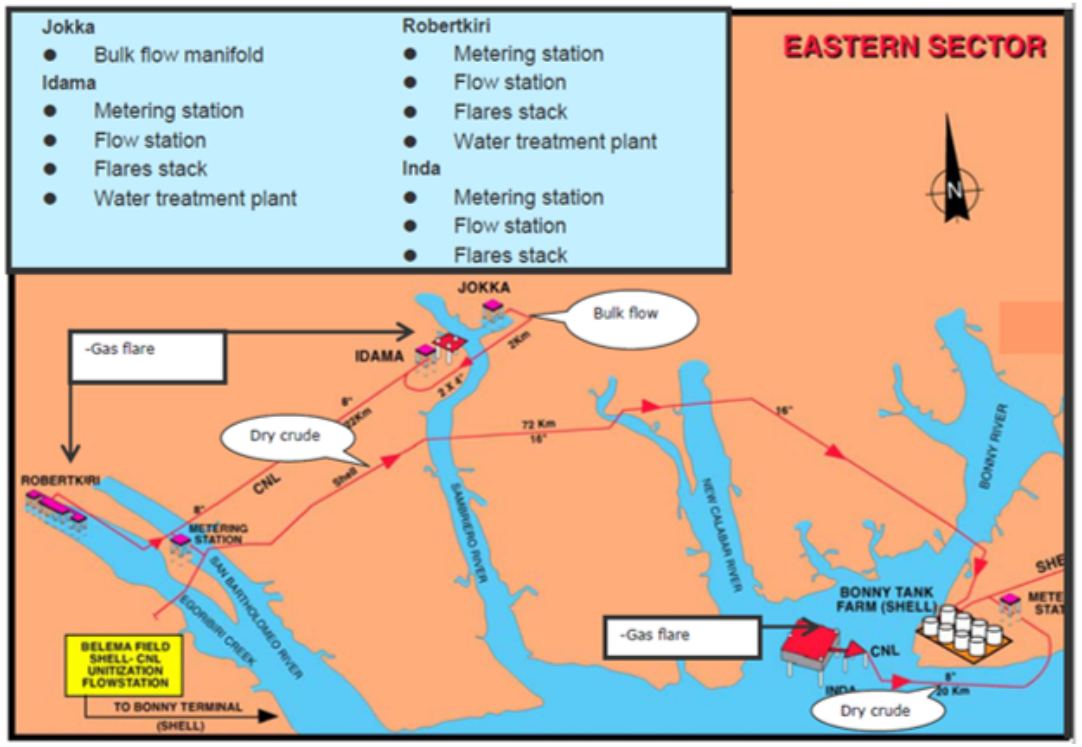

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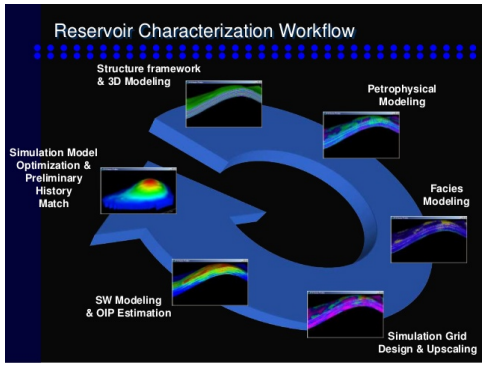
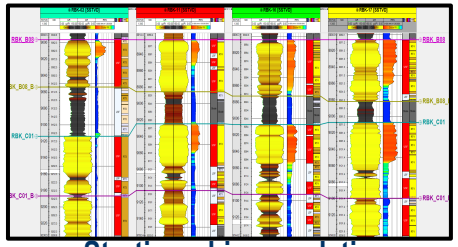
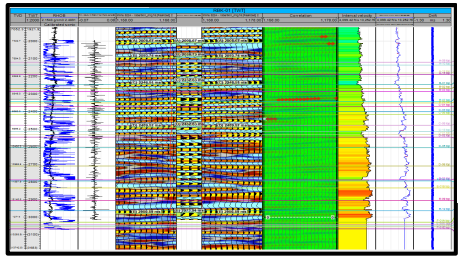
Reservoir Characterization

Workflow

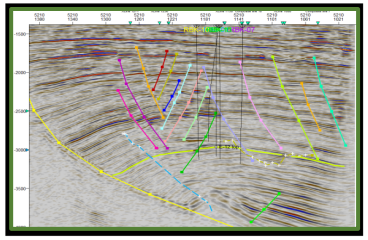


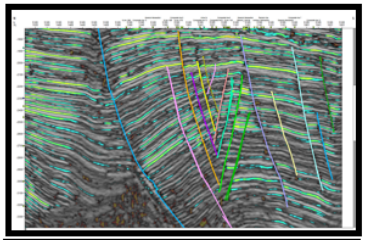


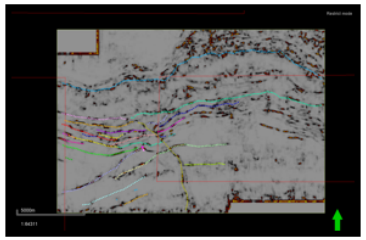
Stratigraphic correlation

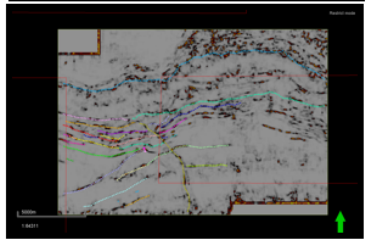


Seismic – Well Tie

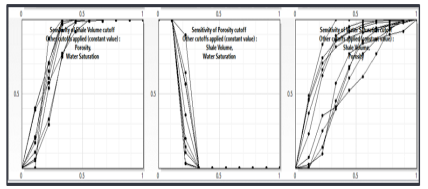






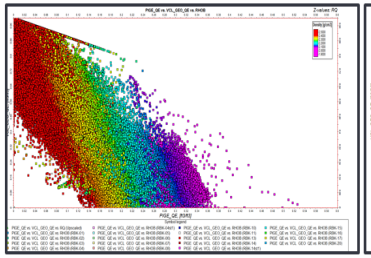


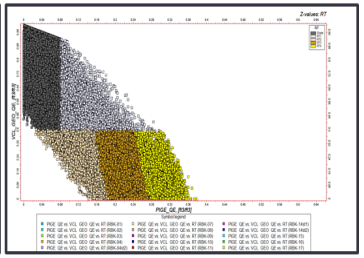
Seismic Interpretation; Ant tracking, Enhanced Fault delineation



Reservoir summation Sensitivity

Petrophysical Evaluation: Rock typing





Integrated Technology enabled robust G&G workflows that accurately links structural complexity of this field , depo-facies and updated in-place volumes to improved field-wide Dynamic Behavior and Production Optimization

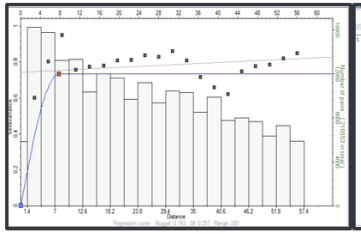
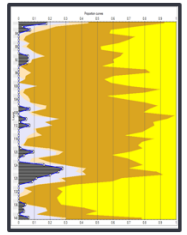


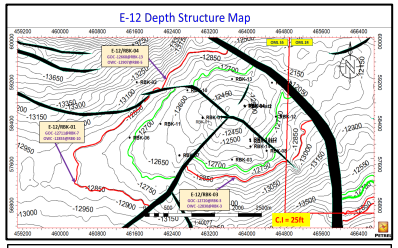
Figure Shows C08 Vertical Variogram

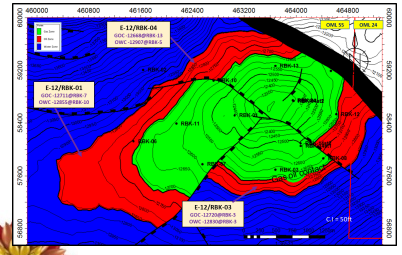
Histogram comparison for shallow reservoirs

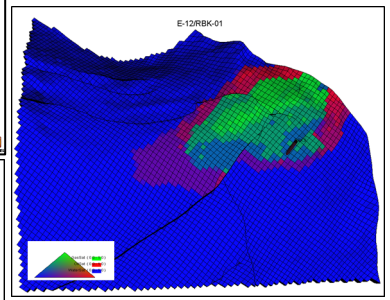


Vertical Proportion Curve

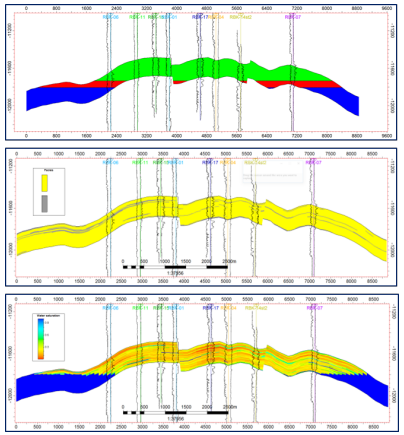
Capturing Heterogeneity



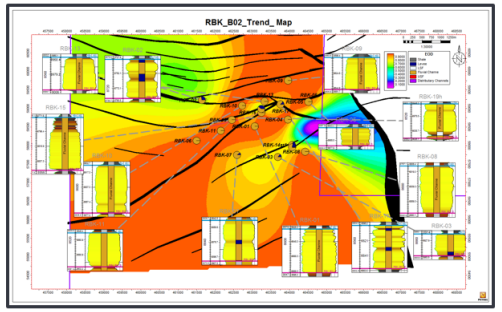


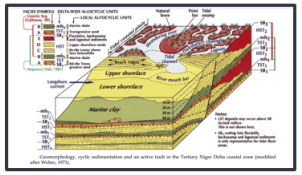


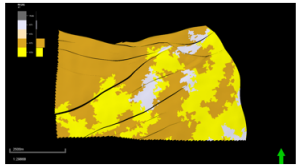
Hydrocarbon –in place Computation



Conceptual Model, Environment of Deposition, Model replication







- *The EOD probability map shows the channels trend Northeast-South West generally*
- *The variogram, VPC and probability maps guided the Rock type distribution .*
- *Similarly, for other reservoir levels, the EOD probability maps were used to trend the facies distribution*

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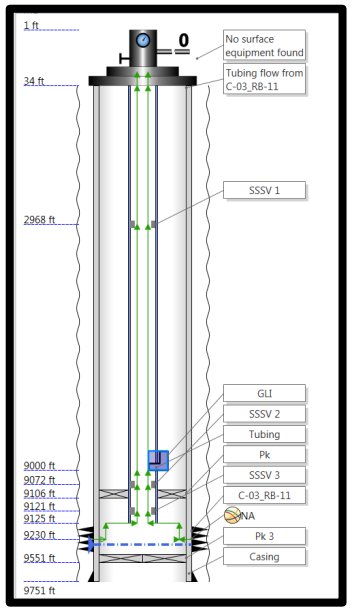
Production Optimization



Well Model Creation

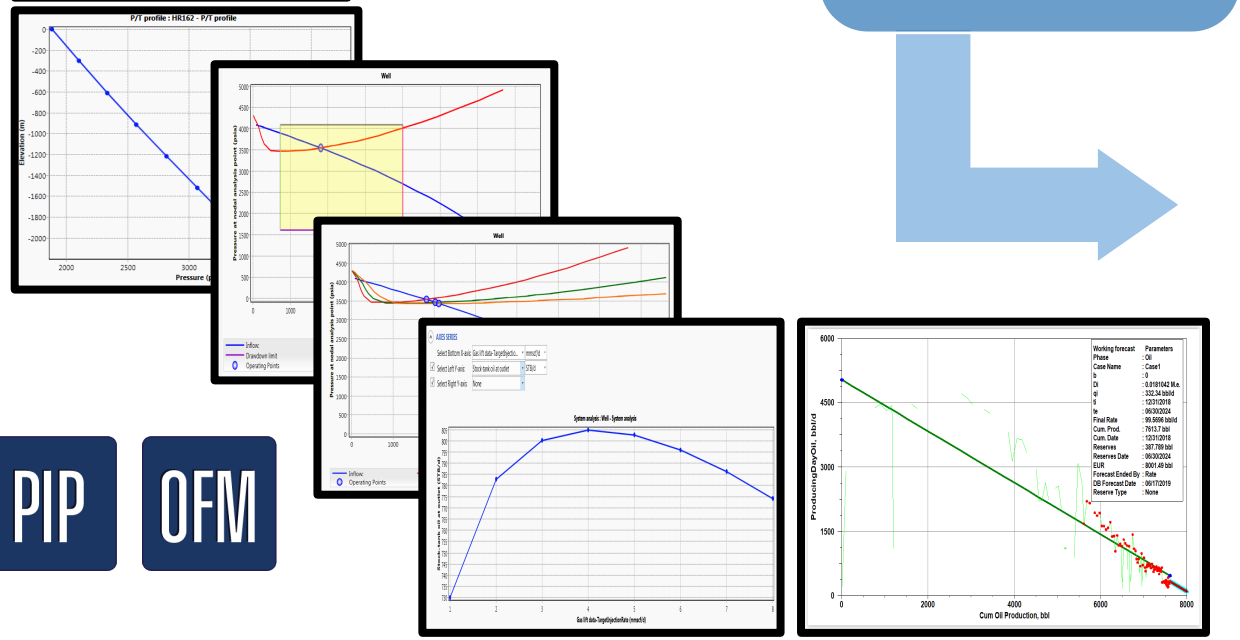
- Completion
- Production Test History
- Static Pressure History
- Well Head Pressure

Well Model Calibration

- Flow Correlation Data Matching
- Hold up and friction factor tuning
- Nodal Analysis
- Gas Lift Optimization
- Tubing size selection
- Decline Curve Analysis

Well Screening/VFP Table

- Workover Candidate Well selection
- VFP Table Creation



PIP OFM

The well performance study has been beneficial in determining the impact of various options to increase production so that an economic assessment can be made for various workover options

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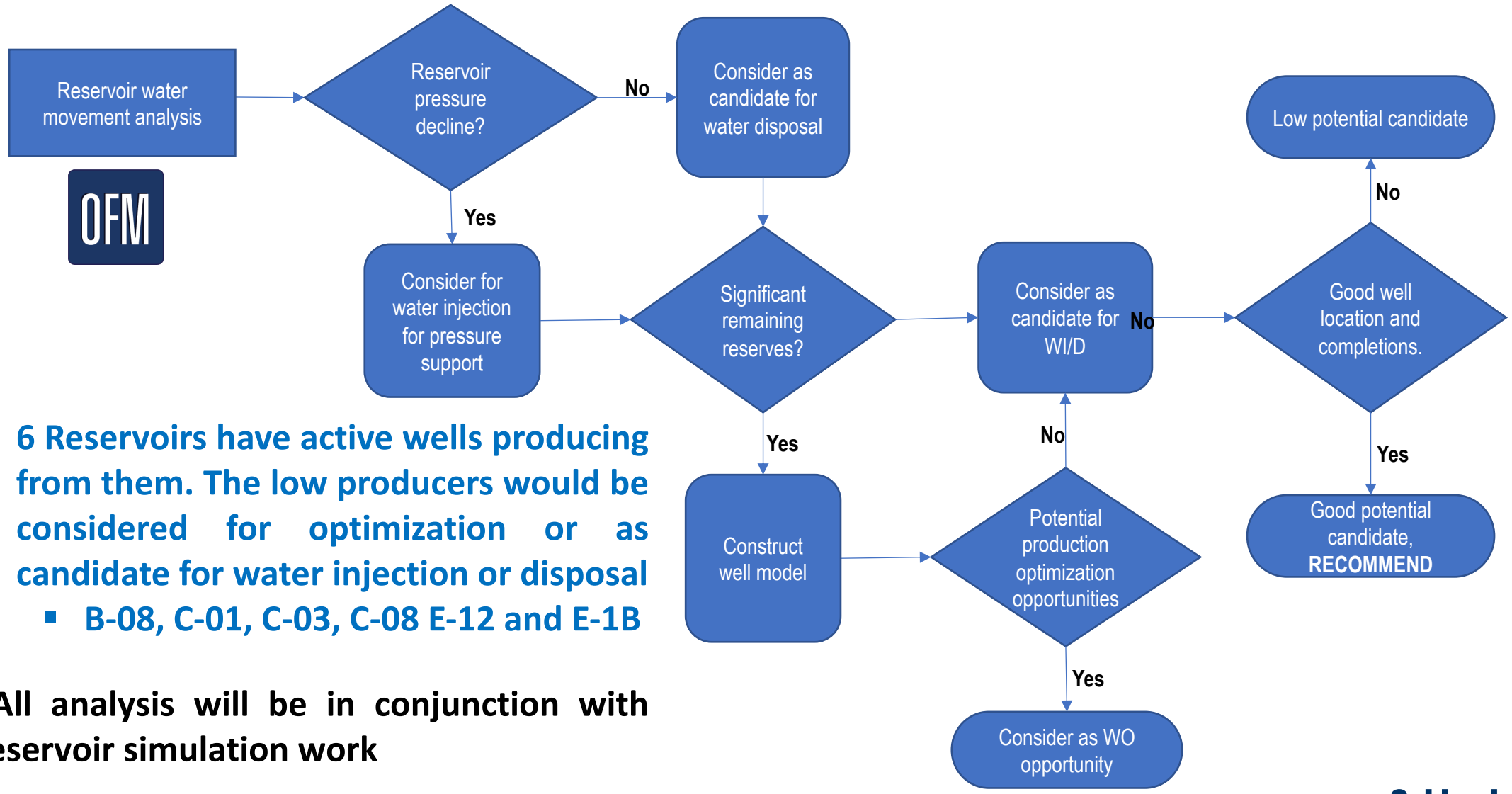
Candidate Screening for water injection



- 6 Reservoirs have active wells producing from them. The low producers would be considered for optimization or as candidate for water injection or disposal
  - B-08, C-01, C-03, C-08 E-12 and E-1B

*All analysis will be in conjunction with reservoir simulation work

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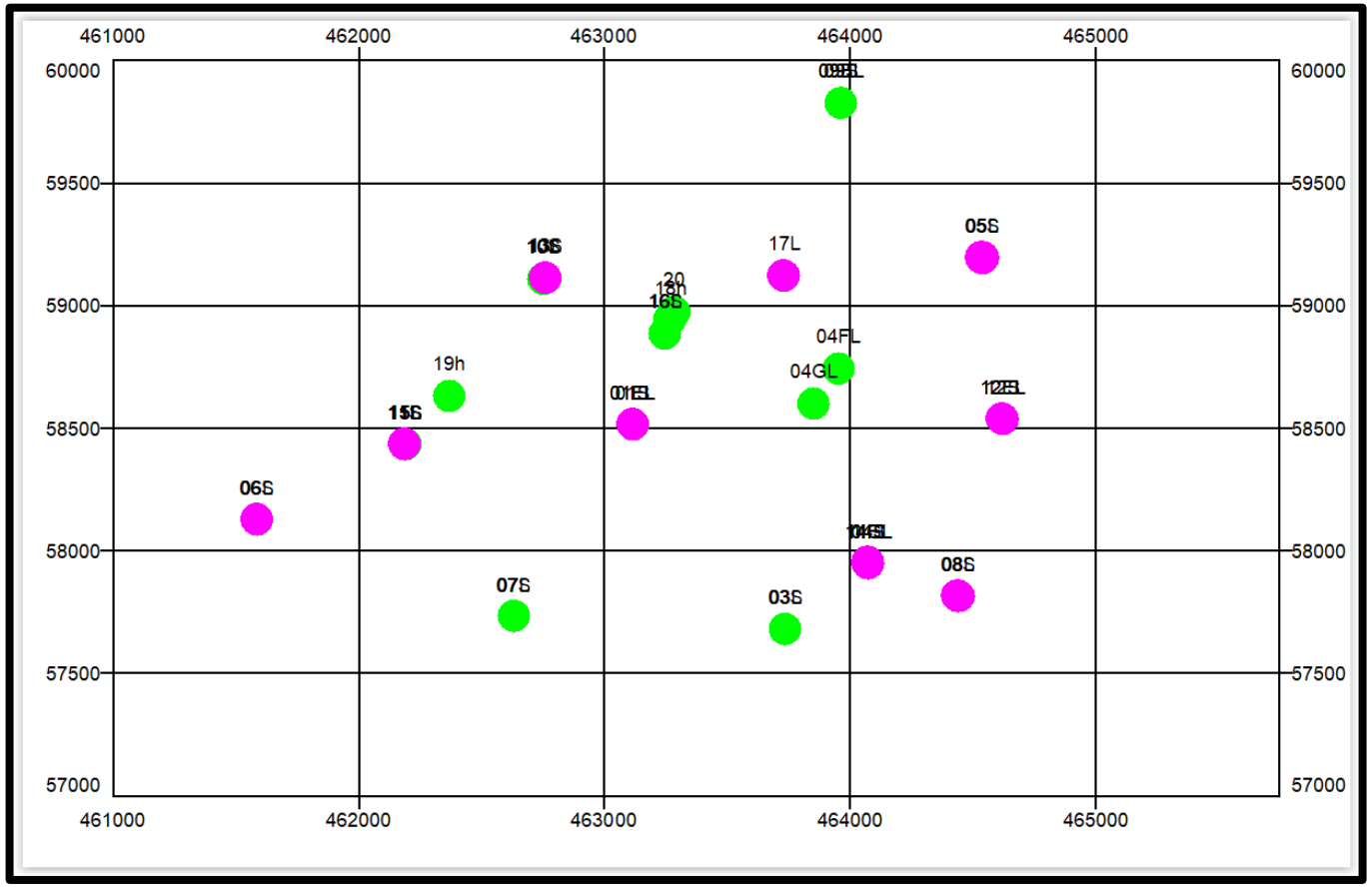
Candidate Screening for Water Injection



- * denotes potential wells that may be re-entered to produce remaining reserves and then converted to water injection/disposal wells.
- 14 candidate strings for WI/D
- 18 candidates for WO
  - 6 drainage points for re-entry
  - 4 drainage points for GL optimization
  - 4 drainage points (2wells) replace wellhead
  - 4 drainage points require AL installation

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Potential wells for intervention/NFA

Potential wells for water injection/disposal

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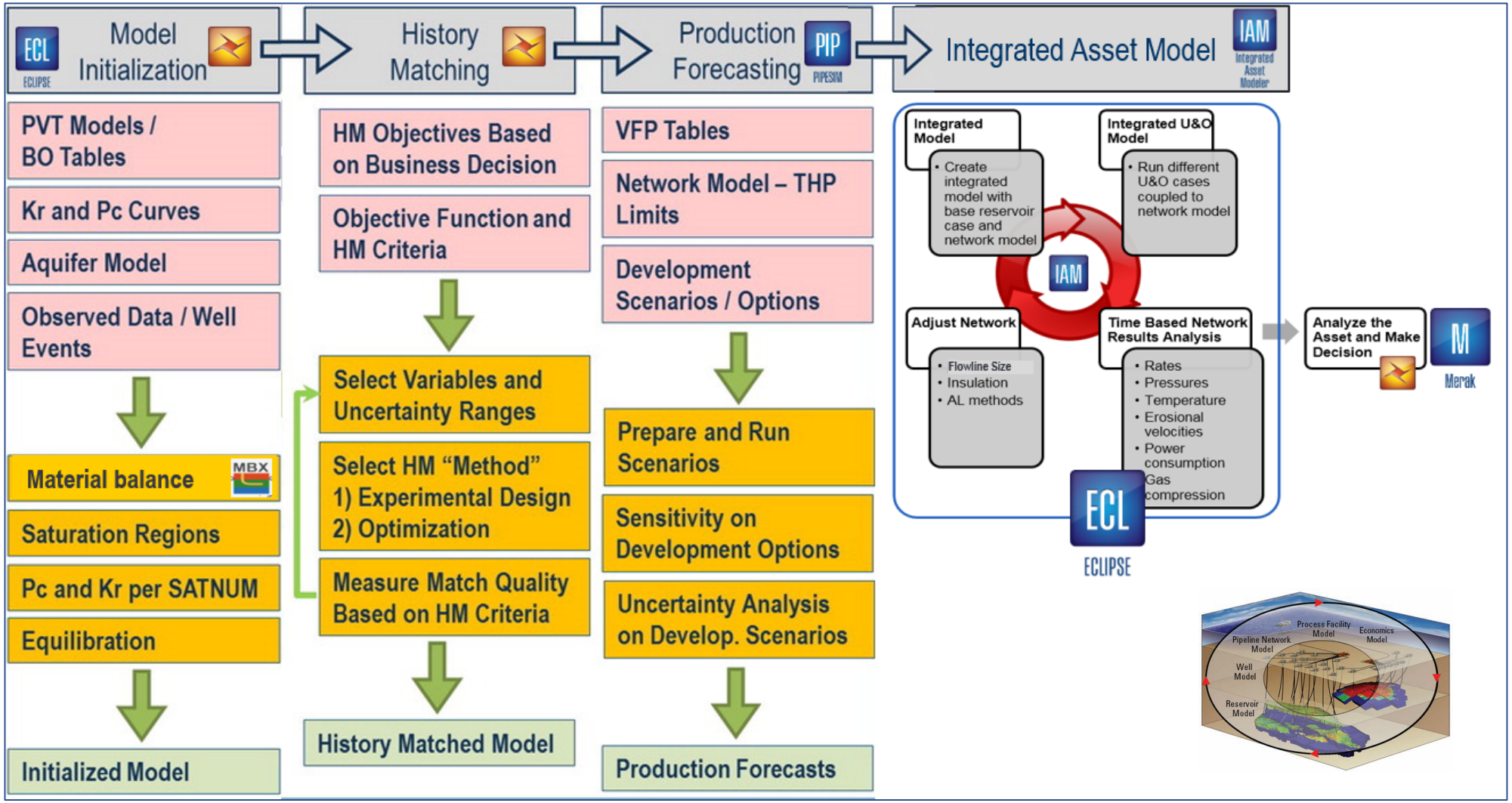
Reservoir Engineering



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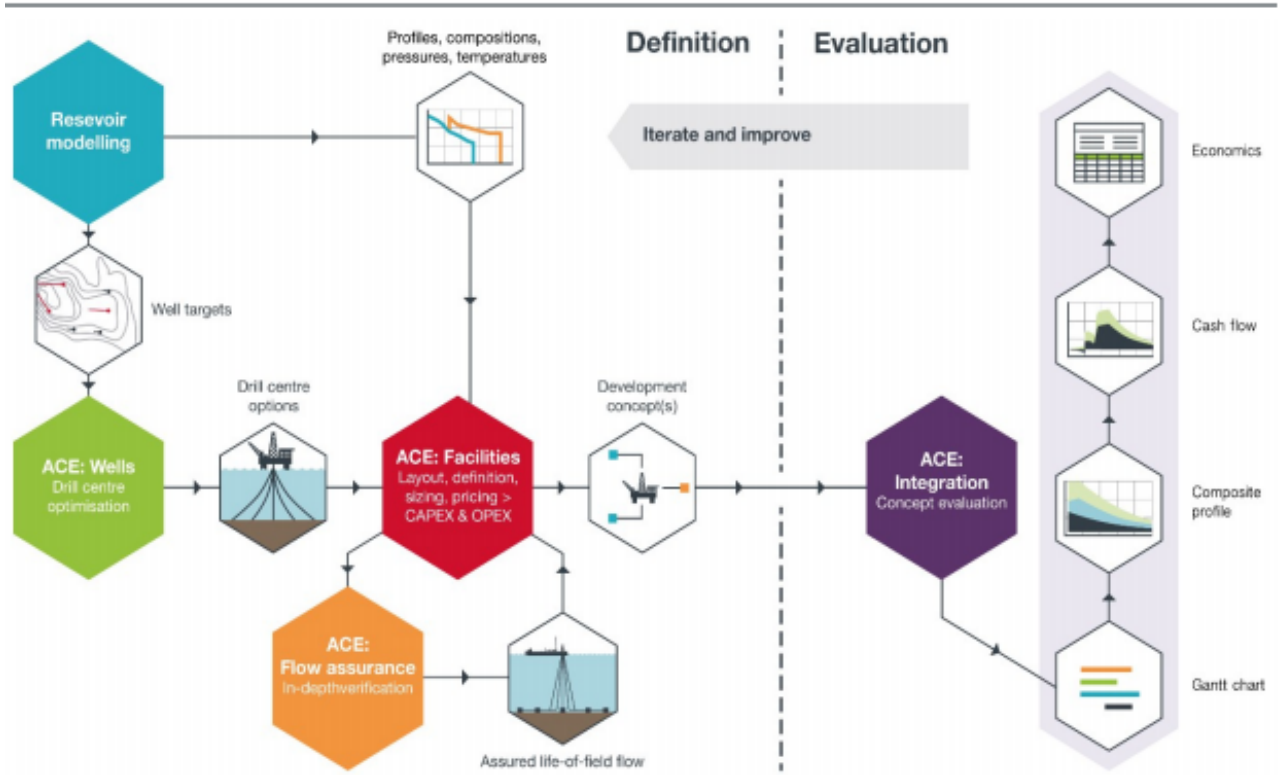
Facilities Concept Design – Way Forward



- Description of Facilities Concept plus rationale for concept selection
- Development schematic, PFDs & H&MB
- Preliminary equipment sizing
- Equipment and utility load estimates
- Capex estimates and estimating basis
- High level OPEX estimate
- CAPEX estimation for new facilities. AACE Class 3/4

- Review available data from field and neighboring assets
- Review reservoir modeling output
- Review and agree an initial basis of design
- Setup FDP layout in Accelerated Conceptual Engineering (ACE)
- Build required surface production systems model
- Review process inputs, run cases and amend the input
- Review and finalize equipment for new facilities
  - Extract Long Lead Items list
    - Build CAPEX and Abandonment cost model.
    - Develop high level OPEX model for each concept
    - Benchmark costs

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Economics- way forward

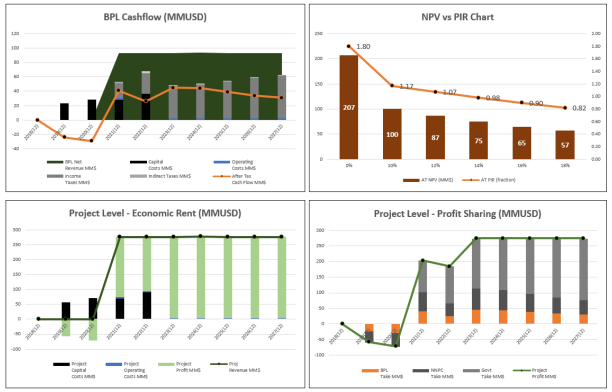
Fiscal Assumptions: Nigeria Royalty Tax 2000

Fiscal Regime Type	Royalty Tax.
Governing Legislation	• Petroleum Act of 1969, Petroleum Profits Tax Act of 1990, and Companies Income Tax Act of 1979
State Participation	NNPC: 60% and Belemaoil:40%
Niger Delta Development Commission (NDDC)	• NDDC Levy is incurred on annual costs (Opex + Capex excluding Abandonment + Community Development Expenses) • NDDC Levy Rate: 3%
Gas Flare Penalty	• There is a 10 Naira/mcf penalty charged for Flaring Gas. • This is modeled as a 0.0838/m³ charge against [Gas Flare Volume]
Royalty	Product / Terrain / Royalty Rate (%) Crude & Condensate / Onshore / 20.0 Gas / Onshore / 7.0
Education Tax	• Tax Rate: 2% based on Assessable Profit levied on Oil and Gas separately • Assessable Profit Oil = Sales Revenue Oil – Royalties Oil – Op Costs Oil – Exploration Costs – Intangible Development Costs – Abandonment Costs – Community Development Costs – (VAT on Opex) • Assessable Profit Gas = Sales Revenue Gas – Royalty Gas – Operating Costs Gas

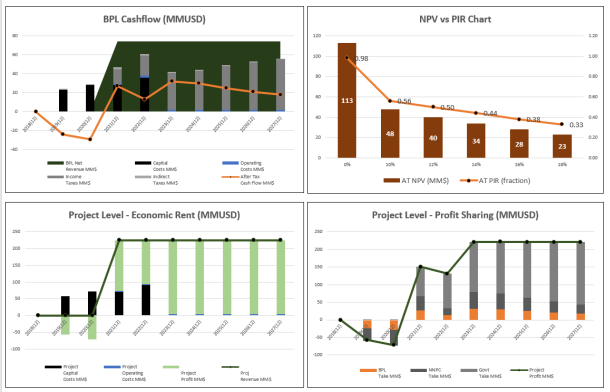
Investment Tax Allowance (ITA)	• Investment Tax Allowance (ITA)
	  • It is a % of Tangible Development & Exploration Costs, and is deductible in the current period
	  • 10 % Onshore and 5 % Offshore

Petroleum Profit Tax (PPT)	**Applies only to Oil profits, CITA used for Gas profits** • Tax Rate: 85% • **Chargeable Profit** = Assessable Profit – Education Tax – Allowable Deduction Amount – Investment Tax Allowance (ITA) • **Assessable Tax** = Chargeable Profit * Tax Rate • **Chargeable Tax** = Assessable Tax • Un-used ITA are carried forward to subsequent years • PPT Losses can be carried forward indefinitely. • Tangible Development & Exploration Costs are depreciated upon production start with the custom schedule – 20%, 20%, 20%, 20%, 19%. This depreciation is Capital Allowance. • **Allowable Deduction** Amount is the minimum between (a) and (b); where; a) The aggregate amount computed as capital allowance b) 85% (Assessable Profits) – 170% (Investment Tax Credit)
CITA	• Applies only to Gas profits, PPT used for Oil profits • Tax Rate: 30% • Revenue basis: Gas Sales Revenue • Deductions: Royalty + Education Tax Gas + Operating Costs Gas • Loss can be carried forward indefinitely. • (AGFA terms applicable, hence Gas Capex is treated as Oil Capex and serves as a deduction in calculating PPT)

Project Economics Graphs - Base Case (Integrated Gas FDP) @ $2/Mscf



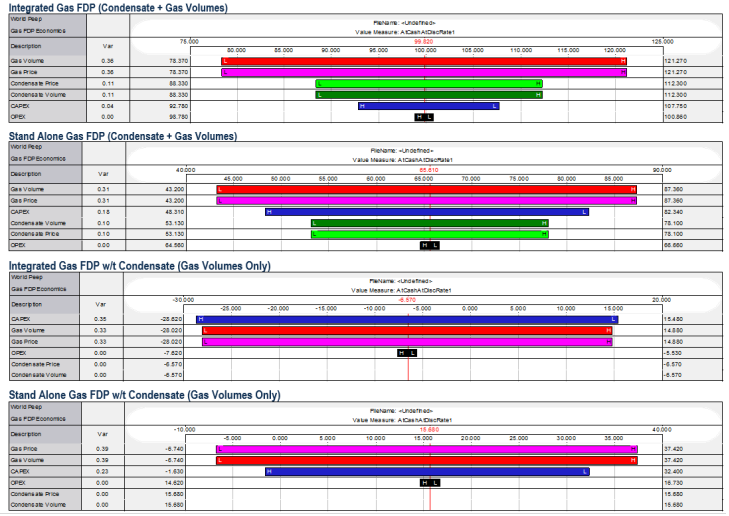
Project Economics Graphs - Base Case (Integrated Gas FDP) @ $0.8/Mscf



Expected economic analysis to ascertain the commercial implication of all technical input and data required to guide critical business decisions and implementation of the Field Development Plan such as :

- **Cashflow Analysis**
- **Fiscal Analysis (Contractor Vs Government Take)**
- **Economic Indicators**
- **Uncertainty Analysis**

Project Economics - Sensitivity Analysis



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Conclusion

Integrated workflow is expected to achieve the following:

- Production Enhancement
- Reservoir Management
- Multidisciplinary Integration
- Results/Field Development

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