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Integrated Production Surveillance and Reservoir Management (IPSRM)—How Petroleum Management Unit (PMU) Combines Data Management and Petroleum Engineering Desktop Solution to Achieve Production Operations and Surveillance (POS) Business Objectives

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Abstract

The role of managing PSC's (Production Sharing Contractor) performance as the main function of PETRONAS's Petroleum Management Unit (PMU) poses challenges for Production Operations and Surveillance (POS) engineers to efficiently perform technical review and monitor performance of the fields across all Malaysian PSCs.

In order to address these challenges, PMU has embarked on an Integrated Production Surveillance and Reservoir Management project to implement a system that integrate cross-domain data into end users engineering software with a pre-defined surveillance workflow, processes, procedures and techniques. The objectives is to provide POS engineers with the required data and workflow templates at their fingertips to enable them to make quick analysis, hence, accurate decisions.

IPSRM implementation consists of two components. The first component involves the Data Management team to build the Data Hub to consolidate cross-domain data from PSC Operators. The second component consists of setting up the workflow and techniques templates in engineering software with online interface to the Data Hub. A unique hybrid Petroleum Engineering tools that combines parametric, user-driven and data driven analysis capabilities are introduced to allow full surveillance capability.

IPSRM implementation has been in operation and provides an effective way for PMU engineers to perform day-to-day surveillance analysis across Malaysia fields. Some benefits and achievements from IPSRM implementation are as follows:

1. Reduced analysis cycle time of engineers by eliminating engineers' time in data preparation and processing
2. PMU engineers are provided with a full spectrum of analysis capabilities to perform study and analysis, covering from user-driven, parametric to data-driven applications
3. Some studies have successfully identified potential for recovery improvement
4. Neural Network applications have successfully identified potential for injection/production optimization

Introduction

The main objective of IPSRM implementation is to set up a solution to enable PMU engineers to perform field production review, reservoir management and surveillance analysis on all PSC fields in Malaysia.

Figure 1 depicts the conceptual architecture of IPSRM. The foundation of the integration between engineering tools and various domain-specific Data Management System within PMU is the Data Hub. Data Hub serves as the platform to gather required data from various sources into an easy-to-access structure and continuously feed into Reservoir Surveillance and Engineering software. The required data such as Production and Operation data, Petrophysical and Geological data, Pressure Survey, etc from PSCs are being submitted to PMU on a regular basis and managed in the respective domain-specific Data Management System in PMU.

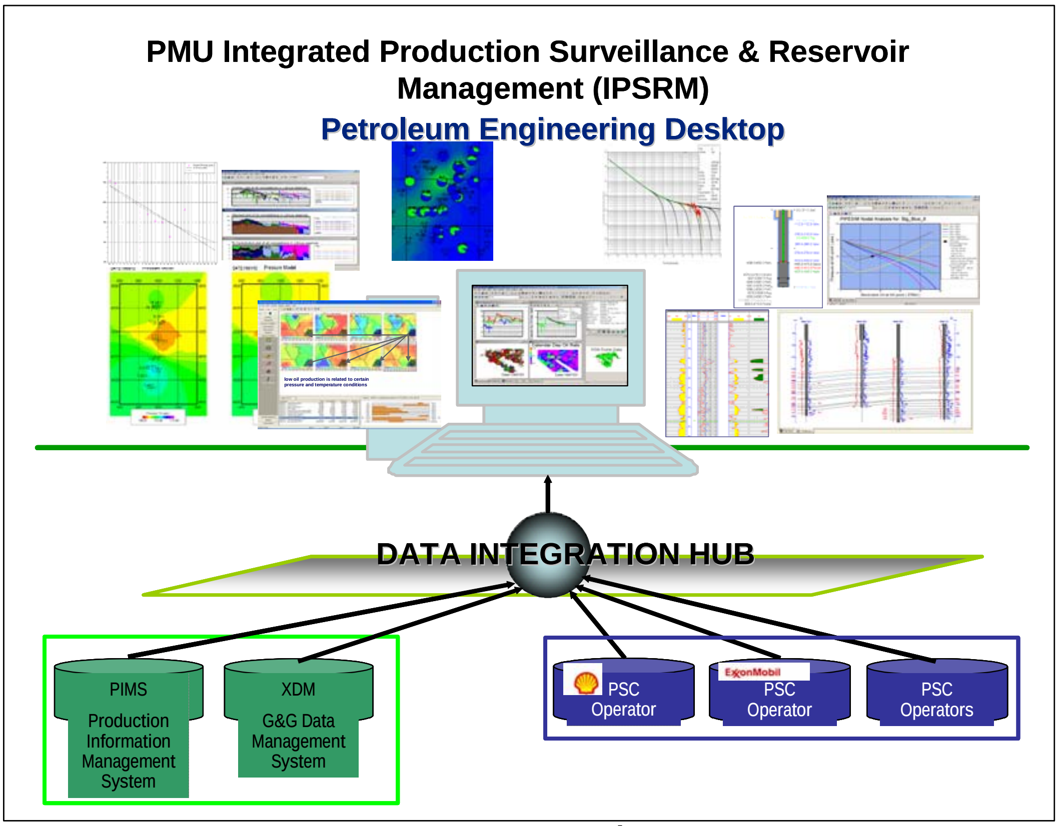

Figure 1: IPSRM Architecture

The Surveillance workflow, processes and techniques are pre-defined and established by using the Surveillance and Engineering software tools that are connected online to the Data Hub. With data available at fingertips, POS engineers in PMU are able to conduct field review, performance analysis and optimizations quickly and effectively across all Malaysian PSCs.

The team was formed with a combination expertise of E&P Data Management and Petroleum Engineering, as the system consists of two major scope of tasks. The first task is to establish the Data Hub for up-to-date data accessibility, while the second task involves setting up a set of Petroleum Engineering Desktop tools with predefined workflow, techniques and processes that enables PMU to efficiently conduct reservoir management, well performance analysis, field review and validation of PSC proposals.

Data Hub

The majority of the Surveillance and Petroleum Engineering tools in E&P industry are designed with Microsoft (MS) Access or spreadsheet as underlying database. The general practices of the industry are either by loading data explicitly into underlying database or using MS Open Database Connectivity (ODBC) mechanism to access multiple data repositories and database virtual tables. The past experiences and lessons learned highlighted that there were performance limitations and constraints in using MS Access or spreadsheet to manage large amount of data, as well as ODBC connections to multiple data sources via virtual tables and links.

In order to overcome these limitations, the Data Hub is designed with an easy-to-access structure, specifically fit for the purpose of data accessibility needs from Surveillance and Engineering tools. The data snapshot technique is adopted to integrate data from various domain-specific Data Management System in PMU, such as Production Information Management System (PIMS) and Finder Exploration Data Management System, into the Data Hub.

The data types listed below are integrated into IPSRM Data Hub:

- Well location and trajectory data
- Production data
- Injection data
- Welltest data
- Operation data

- Pressure data
- Event history data
- Petrophysical log and properties data
- Geological marker data

PMU receives official data submission from PSC operators on a regular basis. The data is loaded into various domain-specific Data Management System and managed by the PMU Data Management team. Data Hub serves as a platform to integrate various data from different sources through an automated data snapshot procedures. Three powerful features of Data Hub lies in:

1. Data integration and accessibility
2. Database scalability
3. Automation

The data structure in the Data Hub is designed with an easy-to-access format, basically to fit the data accessibility needs from Surveillance and Engineering applications. Oracle objects are used to establish multiple links and sourcing data from different domain-specific Data Management System. Oracle is selected to establish the Data Hub and hosted on a High Performance Computing (HPC) server to ensure the scalability and performance reliability of the Data Hub. These two features are particularly important as the Data Hub is intended to integrate cross-domain data from all Malaysia PSC operators.

Another powerful aspect of the Data Hub is its automation mechanism. Data snapshot procedures is scheduled to integrate data from different sources automatically into the Data Hub. The automated snapshot handles implicitly the complexity of multiple data links and integrations, and populates data into the Data Hub in an easy-to-access format and allows Surveillance and Engineering applications to source data on live connection basis. This architecture moves the complexity of performance overhead from MS Access to Oracle server which is running on a High Performance Computing environment, hence, eliminate the performance constraints and limitations caused by MS Access when using Surveillance and Engineering applications for analysis. As data snapshot procedure scheduler is set up to run automatically, the engineers do not need to spend time in data collection, formatting and loading.

Petroleum Engineering Desktop (PED)

Petroleum Engineering Desktop (PED) forms another part of IPSRM system as depicted in Figure 1 above. It is a hybrid analysis desktop that consists of parametric, user driven and data driven applications as depicted in Figure 2.

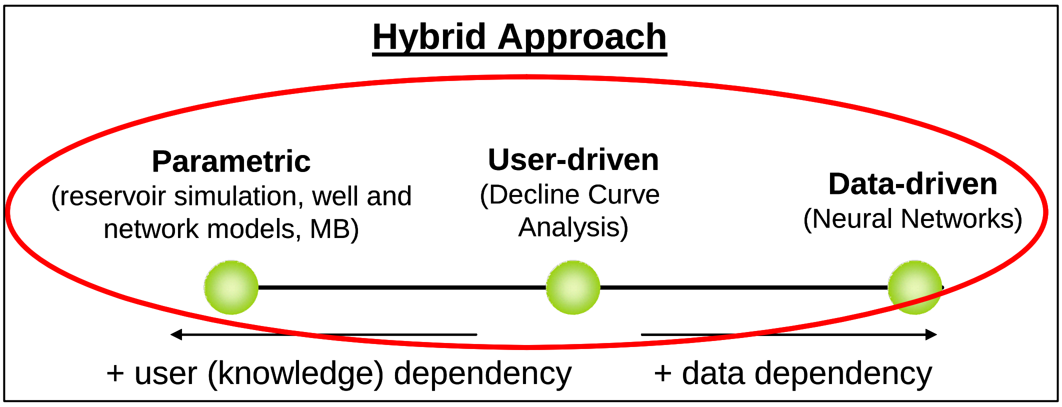

Figure 2: Hybrid Petroleum Engineering Desktop

User-Driven Approach

The user-driven application provides various visualization features such as plotting, reporting, mapping, cross sectional view and Decline Curve Analysis. This conventional approach is being widely used over the last decades in reservoir surveillance and management. This approach requires users to form various simple and complex data access and queries. The users must have an idea what they are looking for and define the data queries according to the idea.

The live data connection between user-driven application and Data Hub enables data to be always available to engineers. However, the data preprocessing steps like forming data queries, defining calculated variables and formatting data displays are time consuming and tend to increase the cycle time of analysis. The past experiences highlighted that most of these data preprocessing works are repeatable among engineers. The analysis cycle time can greatly improve by saving the data preprocessing setup as templates and shared across the projects and engineers. A template basically consists of the definition about data queries, variables and formatting. With respect to this concept, various templates have been defined and managed at a centralized server.

Engineers can then perform various analysis at their fingertips by accessing the predefined templates. This allows engineers to be able to spend high percentage of time on quality production surveillance work rather than querying, compiling and assembling syntax and data into formats or forms for review and analysis. Figure 3 depicts various analysis templates predefined in the user-driven application and examples such as field performance analysis template and cross sectional completion analysis template. Figure 4 showed the combination of various predefined templates for the workflow to track significant oil lost and identify the improvement opportunity. The solution provides significant benefits to PMU by shifting the old approach of relying on hardcopy reports from PSC operators to independent analysis and review of soft dataset.

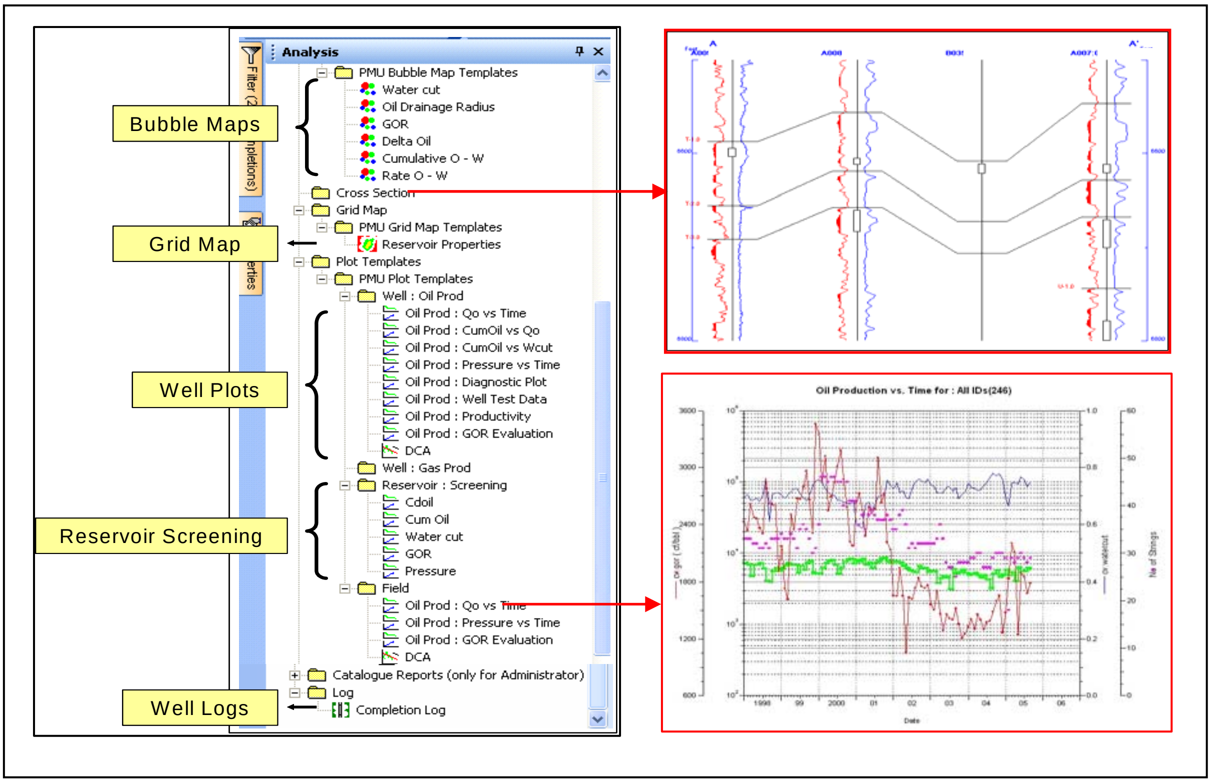

Figure 3: Pre-defined analysis templates

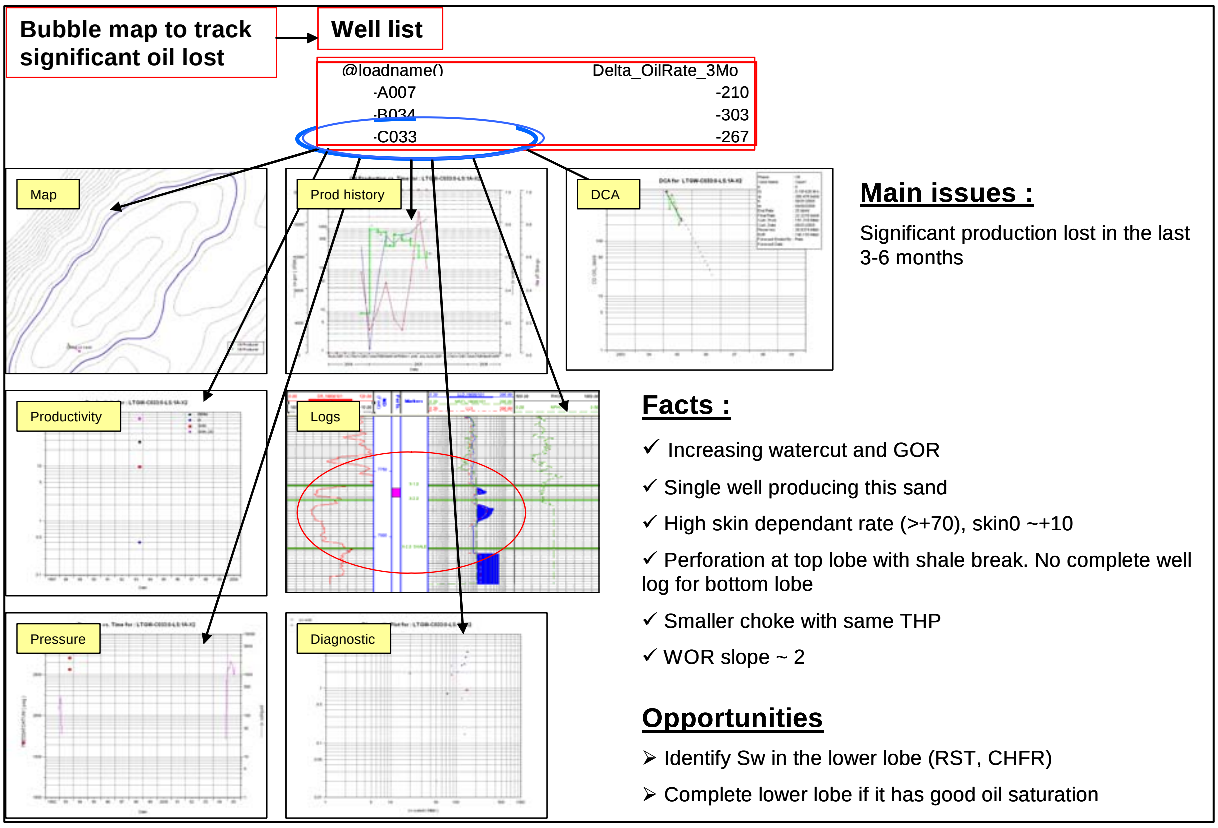

Figure 4: Surveillance case study combining different analysis templates

Parametric Approach

Parametric analysis such as well and network modeling and material balance is included as part of Petroleum Engineering Desktop tools to perform deterministic analysis. Figure 5 illustrates the combination analysis workflow of user-driven and parametric approaches. The surveillance analysis templates from user-driven application allow engineers to identify the under-performing and anomalous behaving candidates and parametric application is used to model the analysis for remedial treatments. In this case study (Figure 5), the surveillance templates from user-driven application identified the shut-in well with a high pressure profile. The well was then modeled using nodal analysis tool for various sensitivity analysis on treatment options. This case study showed different treatment scenarios like booster pump, acidizing and gas lifting as well as combined treatment to bring the well back to production.

Data integration is another powerful feature in this integration between user-driven and parametric approaches. For instance, the well completion and trajectory data are integrated into nodal analysis application when the engineers construct the physical well models. This reduces the modeling and analysis cycle time of the engineers. With both user-driven and parametric tools connected online to the Data Hub and together with the pre-defined surveillance templates, IPSRM system allows PMU engineers to perform the engineering analysis effectively for the production enhancement workflow.

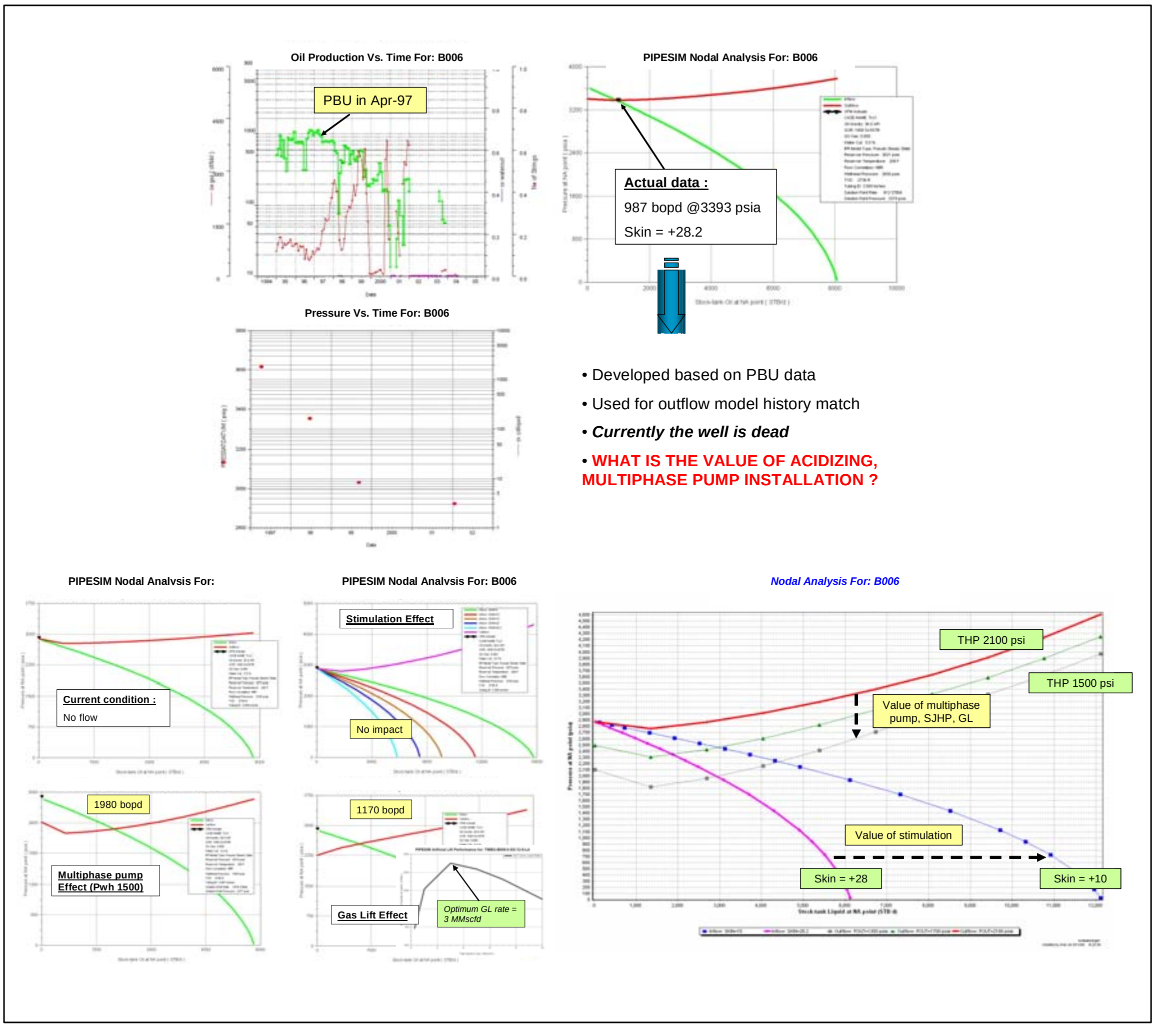

Figure 5: Integrated workflow from surveillance to well performance analysis

Data Driven Approach

Data driven application such as Neural Network is introduced as part of the Petroleum Engineering Desktop scope in addition to the parametric and deterministic approach to support engineers in reservoir surveillance and management.

Data Mining methods tend to be data-driven, which means that it is no longer necessary to know in advance what to look for, but the Data Mining tools (e.g. Artificial Intelligence methods like Neural Networks) find underlying, hidden patterns and relationships in the data. This way, “why” questions get a new dimension and can be answered with the knowledge gained.

There have been a number of published papers on its application in reservoir management with regard to injection-production ratio optimization. Figure 6 depicts the steps in preparing a Neural Network model in IPSRM. First, data from the Data Hub is fed into data driven application. The next step is the data preparation process to extract the pattern and configure the input and output Neurons. The Neural Network model is trained and fine-tuned to achieve a satisfactory match in this “training” process. Genetic Optimization process is then performed to optimize the outputs. Figure 7 illustrates the IPR surveillance case study performed on a water injection field. The Neural Network model highlighted the potential of production gain by optimizing the injection at southern part of the reservoir. The cautions for this approach are that the Neural Network model does not have reservoir-geological background; hence, the learning process is based on historical data behavior. Therefore, the understanding of the advantages and limitations of this application is important when using this approach.

Following are some factors to be considered for reliability of the Neural Network model:

1. Utilize the recent production-injection data to train the Neural Network to avoid significant reservoir condition change over the time frame
2. Eliminate the effect of non-reservoir factor which contributes to production change
3. Put appropriate constraints (surface, etc) to have more realistic prediction

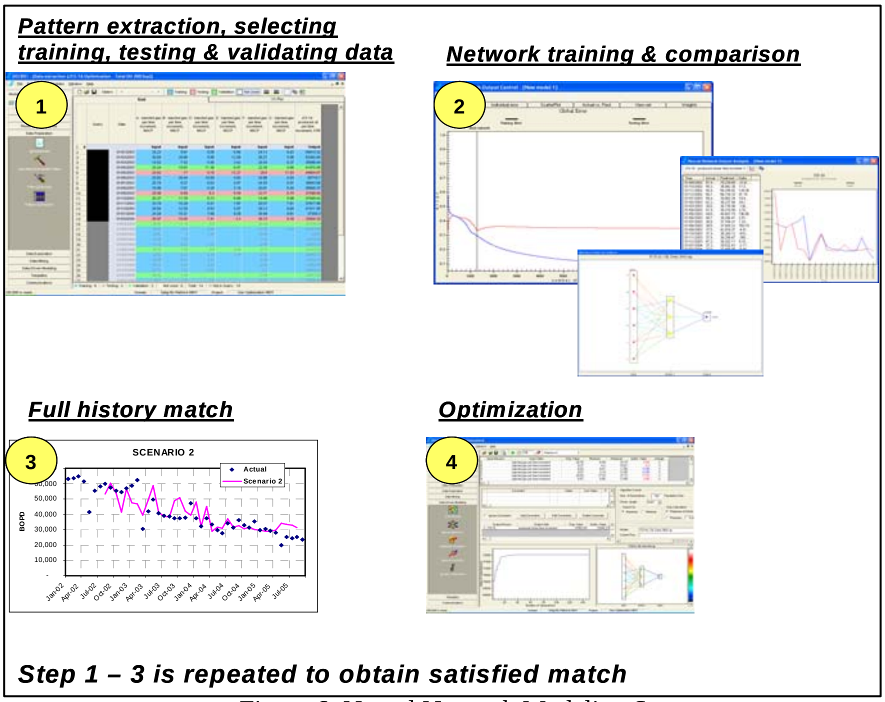

Figure 6: Neural Network Modeling Steps

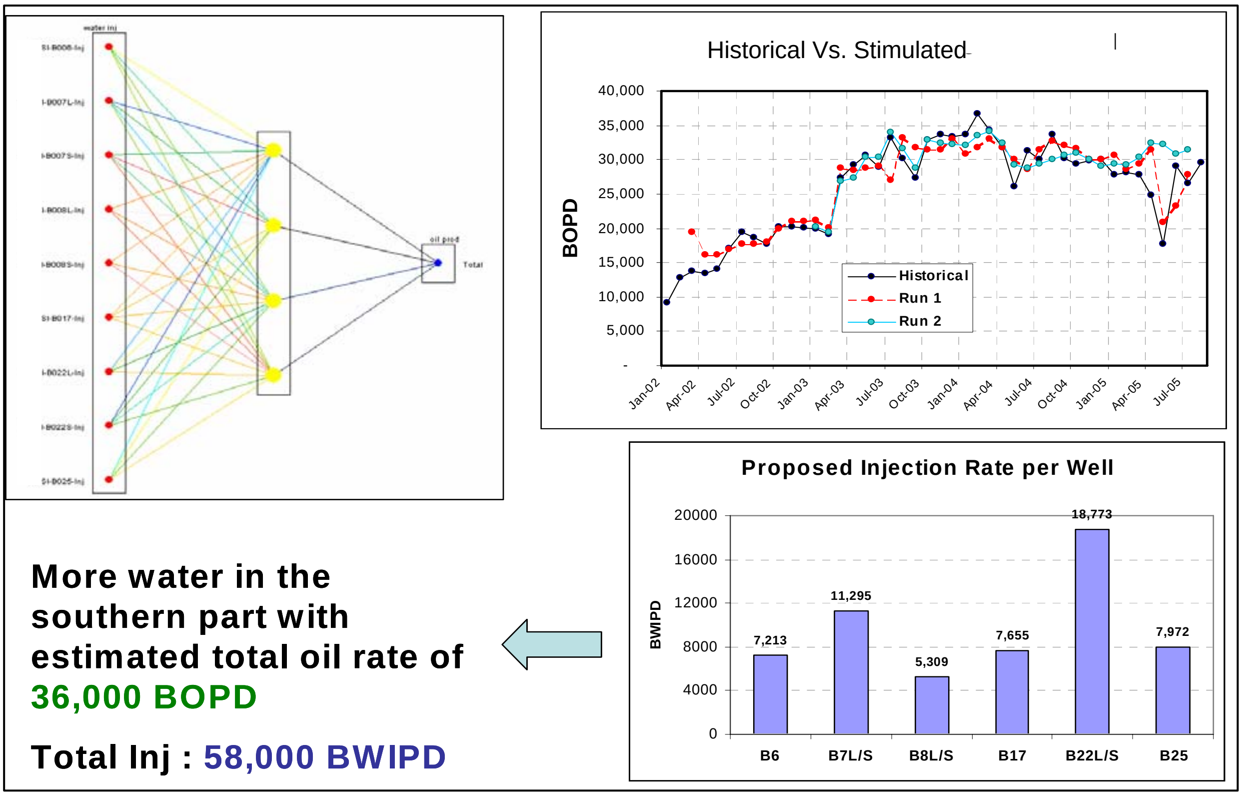

Figure 7: Injection-Production Ratio Surveillance

Surveillance Workflow

The role of PMU to monitor performance of all Malaysia fields requires IPSRM project to be implemented not only for the database and software tools but also for the workflow and processes. This is to ensure the surveillance study on all Malaysia fields can be performed in an effective manner.

Figure 8 illustrates the surveillance workflow that has been defined as part of ISPRM implementation. The workflow starts with screening at field level, and then followed by reservoir level and leading to basic and detail well level analysis. It also defines the criteria at each screening level to provide PMU engineers same guidelines whether to proceed into a more detail level of surveillance analysis. The Petroleum Engineering Desktop tools are used at various blocks in the workflow to perform the screening and analysis.

As described in the previous section, templates are designed to improve the analysis cycle time. These templates are identified and defined to perform different levels of screening and analysis at various blocks in the workflow processes. The definition of the workflow together with the standardization of analysis templates provides a consistent approach for PMU engineers to perform surveillance analysis in an effective manner. Figure 3 above shows the diagram on how the predefined analysis templates with association to workflow are configured and listed in the panel that are shared and used across by PMU engineers.

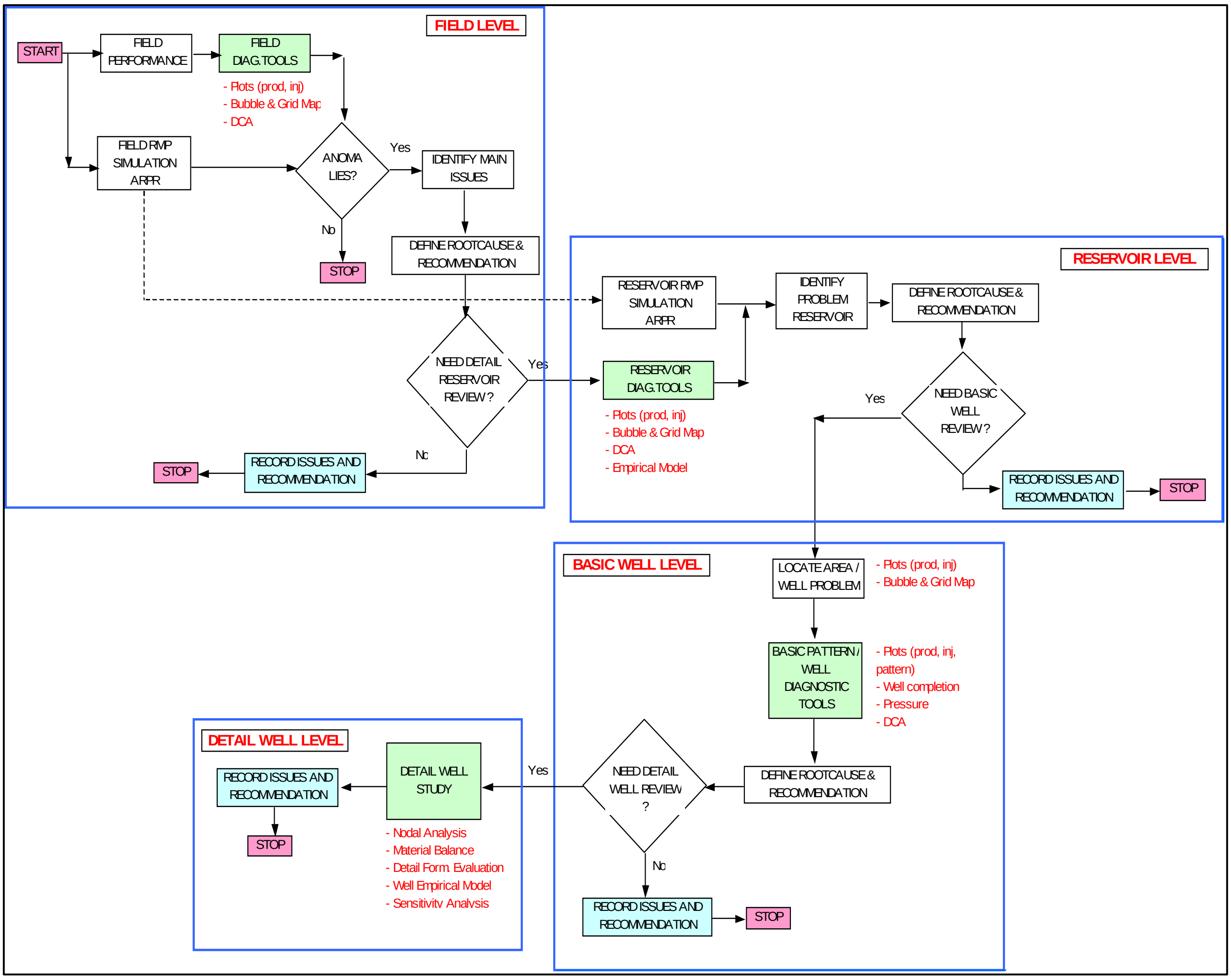

Figure 8: PMU Surveillance Workflow

Conclusions

IPSRM implementation has been in operation and provides an effective way for PMU engineers to perform day-to-day surveillance analysis across Malaysia fields. Some benefits and achievements from IPSRM implementation are as follows:

1. Reduced analysis cycle time of engineers by eliminating engineers' time in data preparation and processing
2. PMU engineers are provided with a full spectrum of analysis capabilities to perform study and analysis, covering from user-driven, parametric to data-driven applications
3. The system has enabled PMU engineers to perform studies effectively and have successfully identified potential for recovery improvement
4. Data driven applications have successfully identified potential for injection/production optimization

IPSRM solution shows how PMU meets the business challenges by using E&P data management practice to add value and better leverage country's natural resources.

References

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