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Integrated Surveillance System for Decision-Making in Oil Production Scenarios

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Abstract. Numerous reservoir engineering, production engineering, and project management tasks require data to be selectively compiled, organized, cleaned and put in a database on a proper basis. In many oil companies, much of this data still resides on the older corporate mainframe systems often with inconsistent key field formats and clumsy sort options. In response to the advancement of the internet of things and data analytics, for the first time, this paper presents an innovative methodology to integrate operational data, production data, and surveillance information into a consistent database to use in conjunction with Oil Field Manager (OFM) Software from Schlumberger. The strategy of this approach is to provide technology, data management, rapid monitoring, and the use of a tool to work as a key decision-maker for future evaluations. The solution is delivered through a unified platform where daily operational datasheets with a big amount of data of surface and subsurface data will be organized, collected, cleaned, and processed to be transmitted to the main database and transferred to the main software for analysis.

INTRODUCTION

Numerous reservoir engineering, production engineering, and project management tasks involve high-frequency data captured and storage daily in a simple report, most of the time this data need to be selectively compiled, organized, cleaned, and put in a database on a proper basis, but this requires time and effort. This effort requires the use of hours to create a database by only one person, expending too much time in cleaning data, compile, organize and put in a proper format to be captured and processed by any software to analyse it for automated surveillance solutions [1-3].

In many oil companies, much of this data still resides on the older corporate mainframe systems often with inconsistent key field formats and clumsy sort options. Sometimes the data is reported in a simple daily excel sheet, captured, processed, and submitted to the interested parties, but it is just a report that cannot be analysed or stored in a proper database [4].

Once the data has been more than one month, one year, or several years, it is difficult to monitor any data or information by time, run evaluation or simply do surveillance of the Fields, for this reason, an Integrated Surveillance System is required, started capturing the data, stored in a database and use any tool available to run diagnostic curves to evaluate the behaviour of the fields and wells by time.

A large number of data, large years of production, a large number of wells, big amount of data in spreadsheets, implemented the surveillance plans relatively challenging to manage data and the creation of automated systems generated only for petroleum engineers, for this reason, is necessary the use of programming tools to expedite the process of data to clean, organize, storage, process and run diagnostic if the petroleum engineer does not know about data analytics or programming.

Besides that, the use of databases and data analysis tools to expedite the evaluations for the fields is challenging if the engineers do not have enough training or experience in surveillance analysis and interpretation [5, 6]. At the same time, many people in their daily work carry out repetitive tasks in front of their spreadsheets, wasting entire days making reports manually which, with a simple click of a button, would be done in a matter of seconds. For this reason, the use of Macros allows us to automate and perform complex tasks, increasing work efficiency and effectiveness [7].

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A macro is a Microsoft Excel function that allows automating tasks, this being an action that is recorded in the spreadsheet to be used at another time. Every day large and small companies are discovering the power of using macros together with Excel, companies require computer programs made "tailored" to their needs, to manage internal business processes automatically, quickly, and efficiently [8-10].

The use of Oil Field Manager (OFM), which is a powerful computerized application that develops an efficient method to visualize, relate and analyse the production, petrophysical and geological data, which allows for optimizing the drainage of reservoirs (oil and/or gas) throughout their production life cycle. It has been utilized and applied during all this time as alternatives, helping the Engineers to analyse a large amount of data, diagnostic, evaluation of the field behaviour and well performance, detect and identify surveillance problems in the field, and predictions that could help to make key decisions from the field production and performance [11].

The objective of this work is to generate added value for petroleum engineers with minor knowledge of programming for the first time, including database creation from daily Microsoft Excel reports, and surveillance analysis of the fields on daily basis.

METHODOLOGY

The methodology in this study includes reviewing the historical production information per well, in addition to compiling, ordering, and cleaning with macros in Microsoft Excel and transferring to the database to Microsoft Access and finally utilizing the software OFM.

The integrated Surveillance System is divided into three stages that are:

- Data Preparation (Microsoft Excel)
- Data Storage (Microsoft Access)
- Data Analytics (OFM)

The Integrated Surveillance System (ISS) is graphically explained in the following flowchart (see Figure 1).

FIGURE 1. Integrated Surveillance System (ISS)

The data preparation utilizing Microsoft Excel has a visual basic code that was arranged to compile, organize, and clean unnecessary data; and finally, prepare the information to be transmitted to the database platform in Access. In summary, the process is coded in a few steps, including data preparation, and the process to create the database for fields and wells. It is followed by the data storage in Access to store the processed data and prepare it to be read by the surveillance & analysis platform in the OFM.

Lastly, data analytics in OFM is a platform to do monitoring daily data and analyse trends (patterns, deviations, and changes) that require focus to generate decision-making to directly predict outcomes. Extra features are embedded in this platform by building a predictive surveillance analysis capability in response to the interpreted data. The final product is shown in Figure 2.

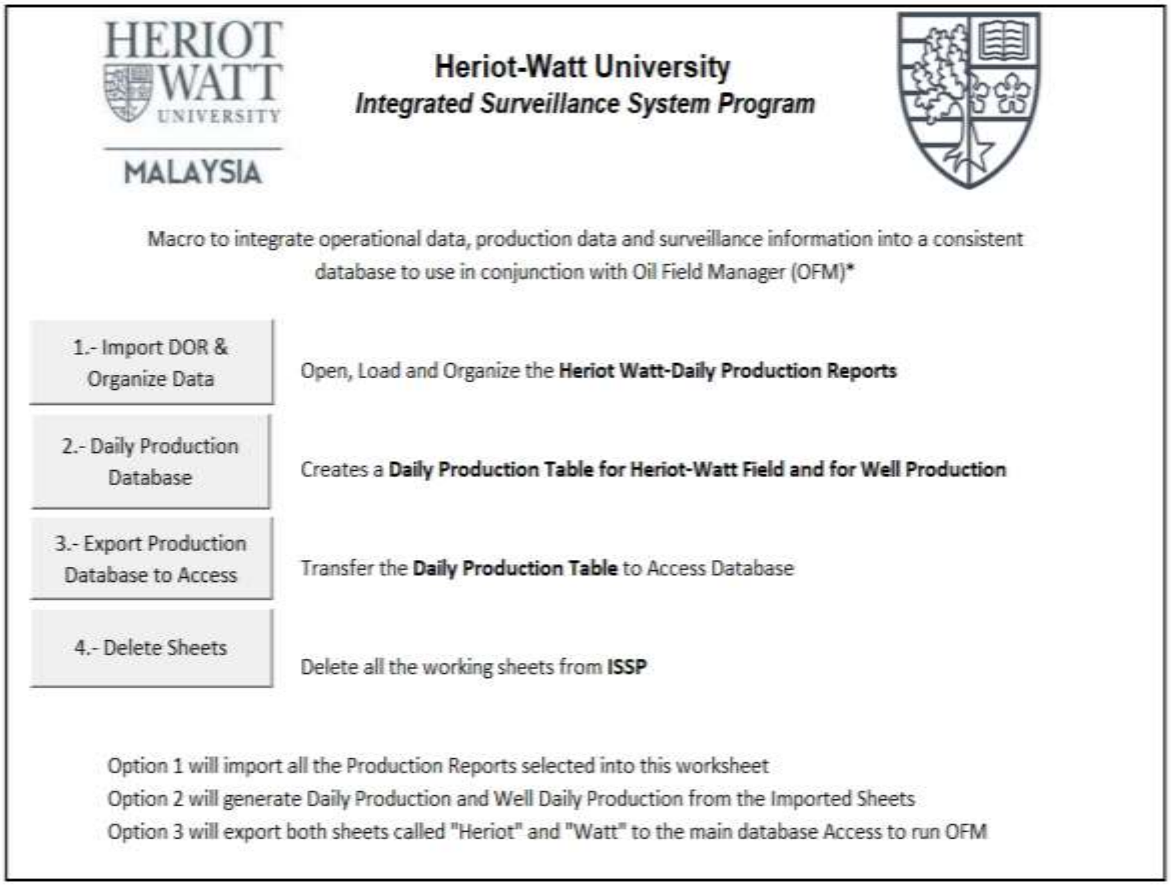

FIGURE 2. OFM predictive surveillance analysis

RESULTS AND DISCUSSIONS

The results will be presented in different diagnostic plots, trends, maps, and scatter plots, where procedures, trends, analogy, production behaviour, the relationship between wells, Cumulative production, diagnostic plots, decline analysis, and creation of equations to run all these diagnostics with the tools provided in OFM.

The first diagnostic plot introduced in which one introduces the concept of the Heterogeneity Index, this procedure that aims to study the behaviour of certain variables and classify the wells through their analogy with the behaviour of other wells that have already been analysed. The function is defined as the relationship between a given value of a population and the average value of that population minus the unit.

This index is very useful to establish the relative position of a given value in comparison to the average value of that variable and to know if it is above or below it. For example, it is possible, after calculating the monthly production average value of oil, water, and gas, to compare the production of these fluids from a particular well and determine if it is above or below the average. In other words, define if it is a good or a bad producer compared to the rest of the wells in the area under study. In analytical form it can be defined by the following equation:

$$HI = \frac{Q\ well}{Q\ avg.of\ wells} - 1 \tag{1}$$

This index is very useful to establish the relative position of a given value in comparison to the average value of that variable and to know if it is above or below it. Figure 3 shows the generated HI for the current study.

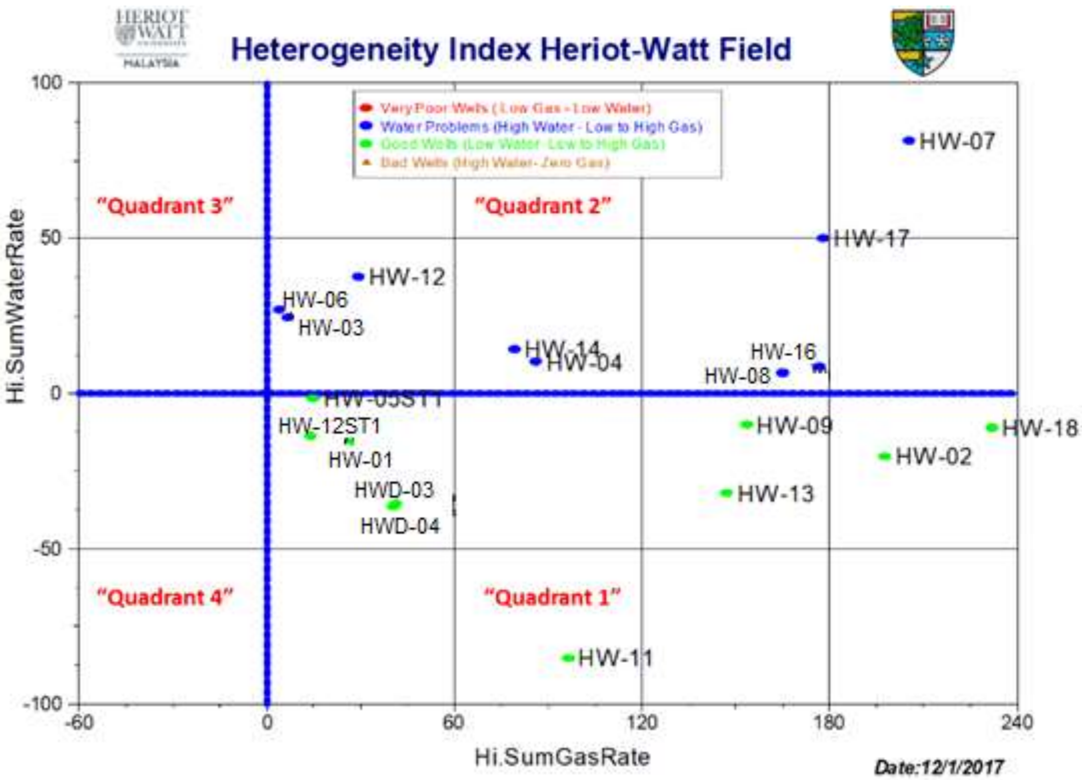

FIGURE 3. Heterogeneity Index Heriot-Watt Field example

The second diagnostic plot introduced is called After-Before-Compare (ABC) Plot. It is very helpful when we analyse a field with a high number of wells, identifying good performance but the end is quite challenging [12]. Besides this, the well-by-well review meetings always consume a lot of time and sometimes are very difficult to be always focused on. For this reason, the use of tools to do different approaches has been taken using the After-Before-Compare plot or ABC Plot, in which the plot utilizes the production data per well at different times or dates and compares the data from oil and water between those dates. The same dates will be used to compare all the wells in the field. The plot is composed of the ratio of the actual water production and the previous water production rate. It is shown in Figure 4 and it indicates wells without any change, wells with total liquid rate increase, wells with total liquid rate decrease, wells with water cut increase, and wells with water cut decrease. The result from this surveillance analysis shows that there is one well that falls below the 45 degrees slope line, there is one well that falls in the coordinate point (1,1) identified as a well without change, and there are a few Wells that fall above the 45 degrees slope line, and they practically respond to the water injection. The usefulness of this plot is hence proved by previous studies [13, 14].

The third diagnostic plot is called the "Formation Damage Index", this plot helps to detect if a well in the field has formation damage and its production rate will be low even though the formation has a higher storage capacity to deliver production. The formation damage index according to the equation must be lower to apply any stimulation job to reduce the skin, but it is very important to use extra information and data to support it, like well schematic diagrams, operative reports, reservoir information, open and cased hole logs, and other reasonable techniques. The known equation that represents the Formation Damage Index is shown below.

$$\boldsymbol{FDI = \frac{Q}{k.h} = \frac{0.007078*\Delta P}{\mu_o Bo\ Ln\left(\frac{r_e}{r_w} - 0.75 + Skin\right)}} \tag{2}$$

The numerator is the oil or gas production rate, which represents the capability of a well to produce. The denominator is the product of the permeability and the pay zone thickness or capacity of the reservoir to deliver production. It represents the storage capacity of the formation to deliver. If a well has formation damage problems, it will produce at a low rate even though the formation has a high storage capacity to deliver. The results from the interpretation of the Formation Damage Indicator in the plot where some Wells were identified with formation damage problems, will require any stimulation job to reduce the FDI and produce them again to the maximum potential. This will result in a low value of the formation damage index as shown in Figure 5.

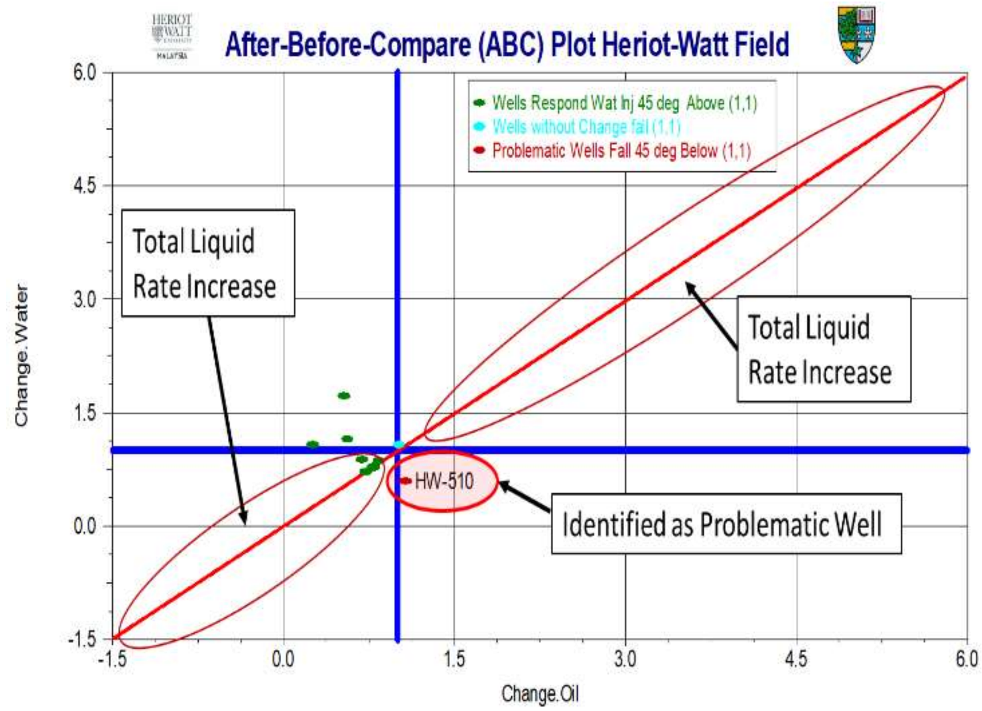

FIGURE 4. ABC Plot identifying the problematic Well in the Field

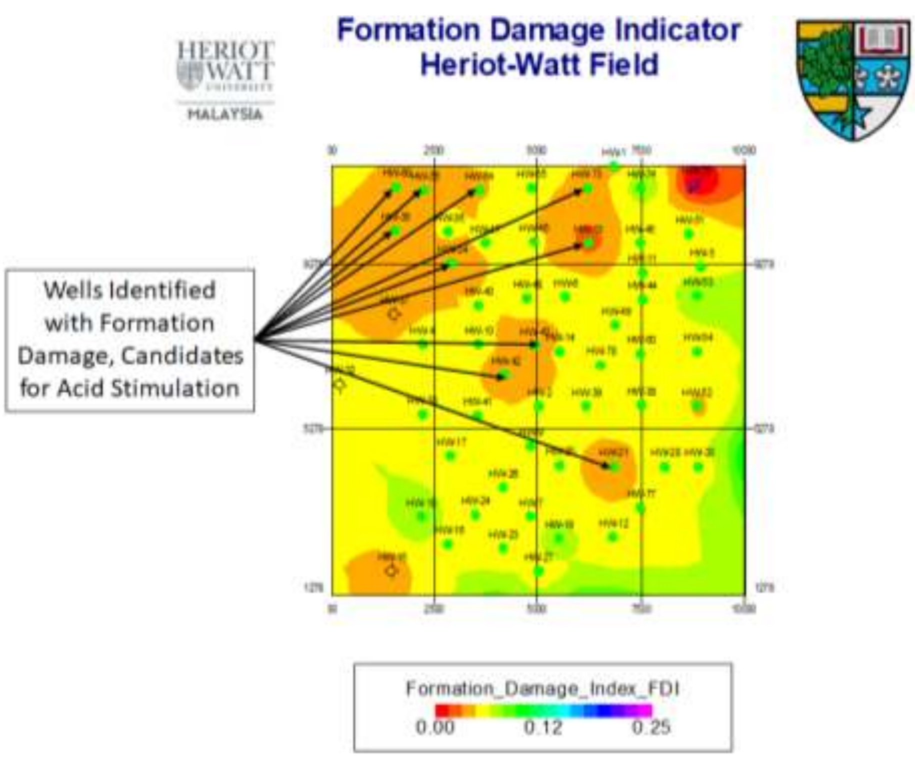

FIGURE 5. Formation Damage Index candidates for stimulation job

The fourth diagnostic plot is called "Drainage Radius", the drainage radius of a vertical well can be extremely useful information for the reservoir and production engineer. First, because it can give us an idea of the drainage area per well in the reservoir, and it represents the volumetric radius (rev), which is the volume occupied by the produced fluid at reservoir conditions, it assumes a uniform pressure reservoir.

The areas that have not been drained can be quickly identified visually through a drainage radius bubble map, this bubble map can help to identify undeveloped spots in the reservoir to propose infill wells for future development. The concept of drainage radius explained here should not be confused with the definition of drainage radius used in pressure testing and numerical reservoir simulation. The estimate of the drainage radius from the equation below is based on volumetric calculations and does not incorporate the compressibility of the reservoir fluids.

$$r_{ev} = \sqrt{\frac{5.615 \cdot N_p \cdot B_{oi}}{\pi \cdot h \cdot \varphi \cdot (1 - S_w - S_{or})}} \quad [ft] \tag{3}$$

The bubble map created with this equation shows the areas drained to date and not as in the case of pressure tests and simulations that are related to the areas that contribute to the flow. Therefore, this concept should not be used to detect well interference. The results for the drainage radius map show the areas not drained from the wells. There were identified undeveloped spots that could be potential areas to put more development wells in the future for the field. In Figure 6, the undeveloped spots are indicated.

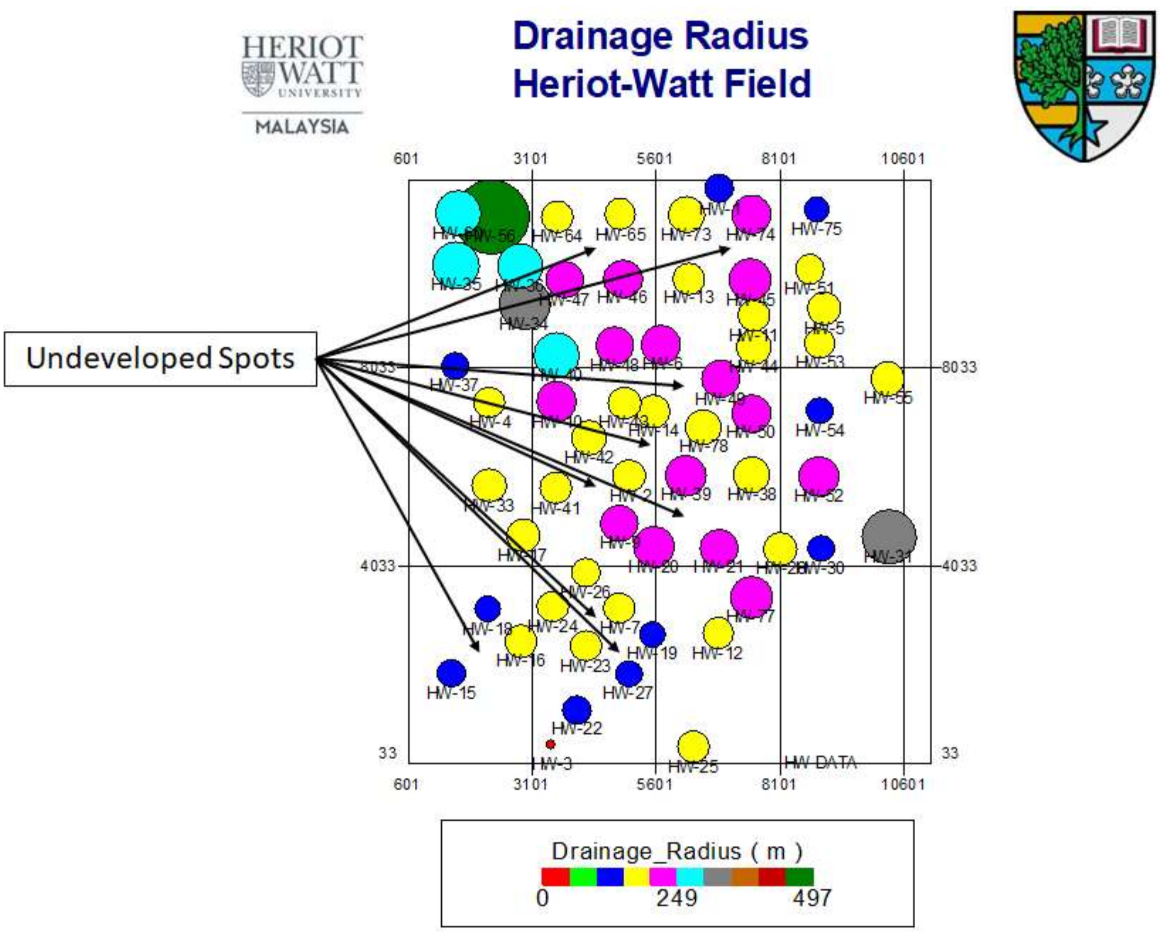

FIGURE 6. Drainage Radius bubble map

The next diagnostic plot is called the "Re-Perforation Plot" in which you can get a candidate well that needs a re-perforation workover, it can be caused by an unperforated pay zone or mechanical failure of the casing gun. Sometimes not all the wells in the fields have been perforated properly due to mechanical or performance with the guns used, the technique is based on the cumulative volume of hydrocarbons per perforated foot, and it is well represented in a bubble map. The next equation represents the cumulative gas per perforated foot in the field.

$$Gp\ per\ Perorated\ Foot = \frac{Gp\ (scf)}{Perforation\ Interval\ (ft)} \tag{4}$$

Once the bubble map is created, it is very important to look for the smallest values to detect the wells with inflow performance problems, after that it is important to compare it with the neighbours and select those wells that require a re-perforation job. Another reason could be if the cumulative liquid produced per perforation foot is low in case the well was perforated overbalance or perforation through tubing may not have good penetration into the formation. The results for the re-perforation plot in Figure 7 show the areas of the low value of the cumulative volume of hydrocarbon per perforated foot and select those wells for workover.

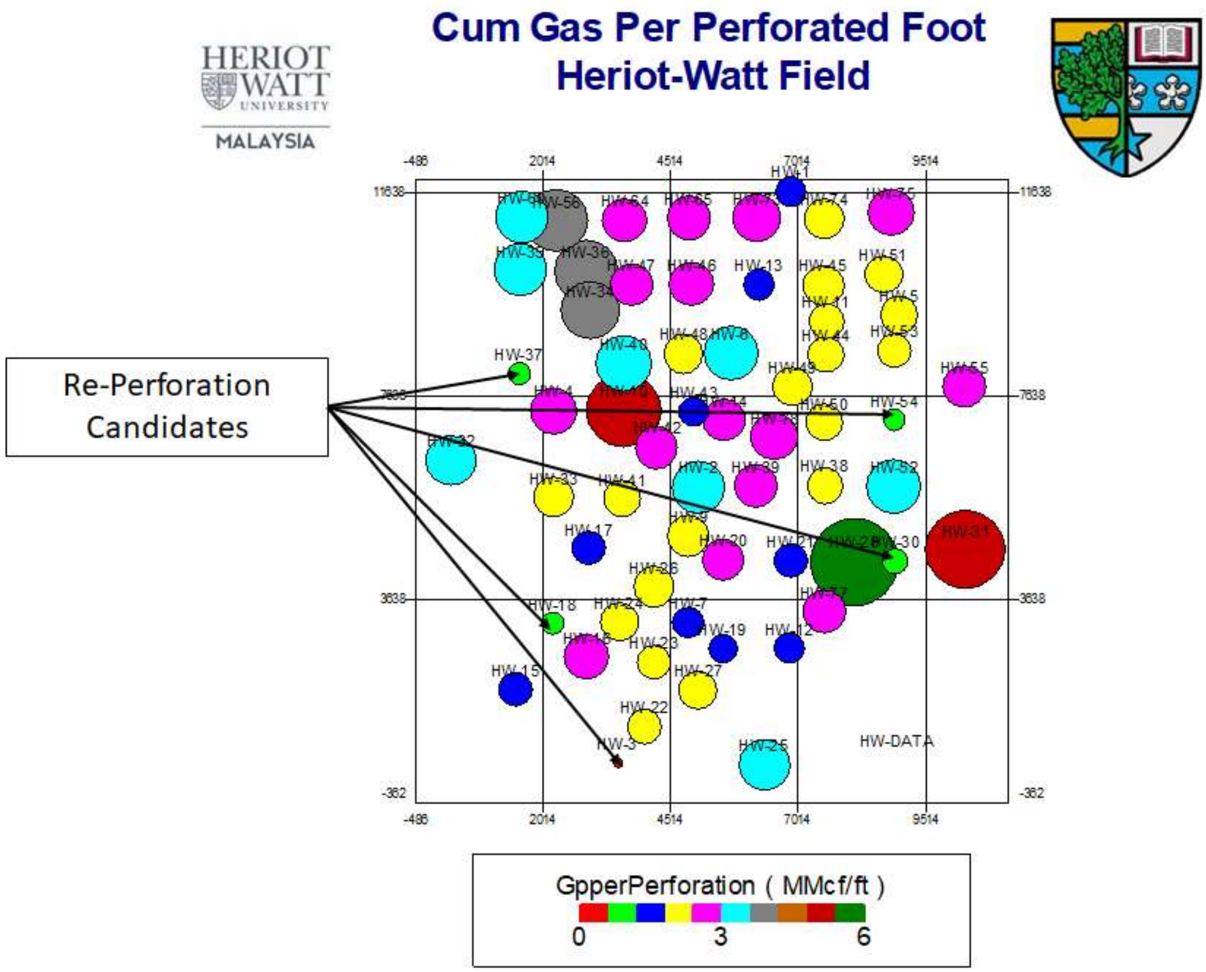

FIGURE 7. Re-Perforation Candidates

CONCLUSIONS

The main objective of this individual project was accomplished to propose a solution for performing production surveillance management by utilizing an integrated platform, which comprises of surveillance data management system, and production data analysis tool. The integrated surveillance system works to comply with the main objective, the development of the Macro in Excel (to organize, clean, extract, compile, optimize and automate a production database from the daily operation report) and to carry out analysis utilizing the generated database for production and reservoir surveillance, with the help of diagnostic plots, identified for the individual project the main surveillance problems, and finally propose tailored solutions, all this integration done by the Integrated Surveillance System.

The integration of VB Macros in Excel to carry out the analysis utilizing a generated DB for production and reservoir surveillance with the help of diagnostic plots, maps, and scatter plots to identify the main surveillance problems in the field. The benefits of the Integrated Surveillance System between Microsoft Excel, Microsoft Access, and OFM are the following:

- Time-saving, Reduction in time to prepare massive data by day, months, and years.
- A faster solution to organize, clean, and create a production and well-status database.
- Cost reduction for men hours.
- Cost-saving by avoiding expensive 3rd party software to create the databases.
- Reduction in processing time due to the integration of multiple applications.
- Integration, automation, and custom-made to our needs.

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