Optimization of Water Injection Facilities in Mature Fields with Multiple Reservoirs

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Abstract

Produced Water reinjection is a serious proposition and is vital part of successful oil production operations. Constructing operating and maintaining water systems represent a substantial part of oil field facilities long term investments with huge capital and operational costs sunk into it. Therefore, it is very prudent to conduct thorough studies before embarking on any water injection system development. A typical oil field under water flooding, is swept under an IPR (injection/production ratio), ranging from 1.3-1.6. This requires constructing major facilities and handling huge volume of water for such oil fields. Produced water can be part of the water flooding program, the planning for this requires careful engineering.

Introduction

Handling water includes producing, treating, transporting and injecting the water at designated wells and at defined rates and wellhead pressure to maintain healthy reservoir production. The issue of developing an optimum water injection facility becomes even more complicated when addressing the injection demand of two distinct reservoirs of different characteristics in single field with one injection system. This paper discusses an optimization study conducted mainly to determine the best facilities approach to meet injection of two different formations within a single field. Three main study alternatives were developed and examined. The facilities requirement were defined the operational costs and flexibilities were integrated before selecting the optimum case. The cases were: 1) An integrated system: Expand the plant as a central injection plant for the two formations, 2) Two split systems: Dedicate plant to Formation A and build a new plant for Formation H and 3) Independent injection Units: Dedicate the existing plant for Formation A and build small injection stations for Formation H.

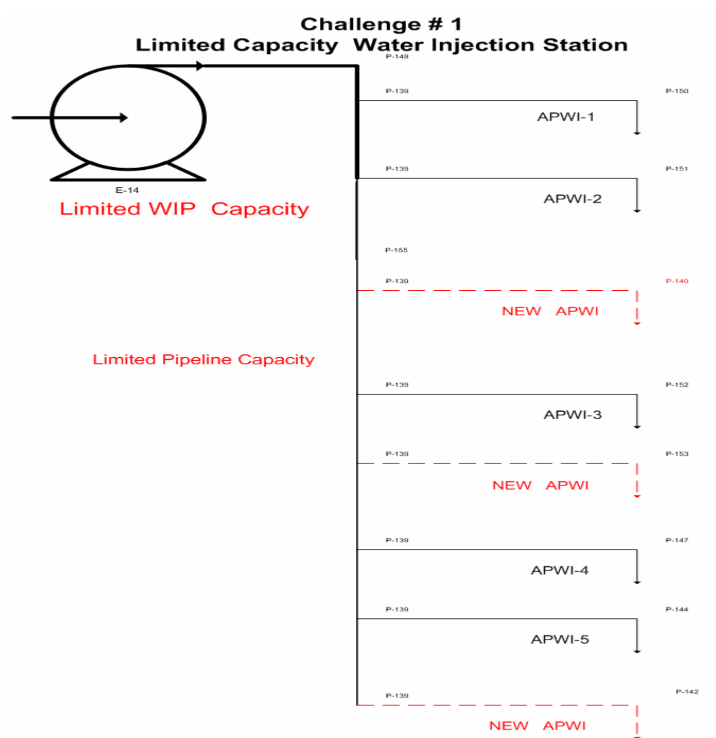
The study took into account the long term water injection demand, fluctuating formation parameters and the existing facilities conditions. The design of an injection systems required considering numerous factors ,mainly the formation static bottom hole pressure (SBHP), injectivity index (II), formation depth, well design & completion type , designated well rates and the well locations relative to the injection source. In this particular case, hydraulic evaluations and reservoir assessment showed that injection well head pressure (IWHP) of 600 PSIG is required for one formation, A versus 1600 PSIG for the other formation, H. This was due mainly to tighter formation, lower II and higher SBHP. The facilities requirement evaluation revealed that an integrated single injection system meant unnecessarily having to boost pressure to the higher end, around 1600 PSIG, resulting in substantial power waste. Investigations also showed handling the injection load with a single new system, requires investing a very large capital and sustaining significant operational costs in pumping and in maintaining longer pipelines. Moreover, it was determined that expanding and upgrading the existing injection plant, as it was originally designed for one reservoir injection requirement was cost prohibitive entailing completely modifying and replacing major parts. The study concluded that it was economically and operationally advantageous to go for option 3, building two split injection systems.

Discussion :

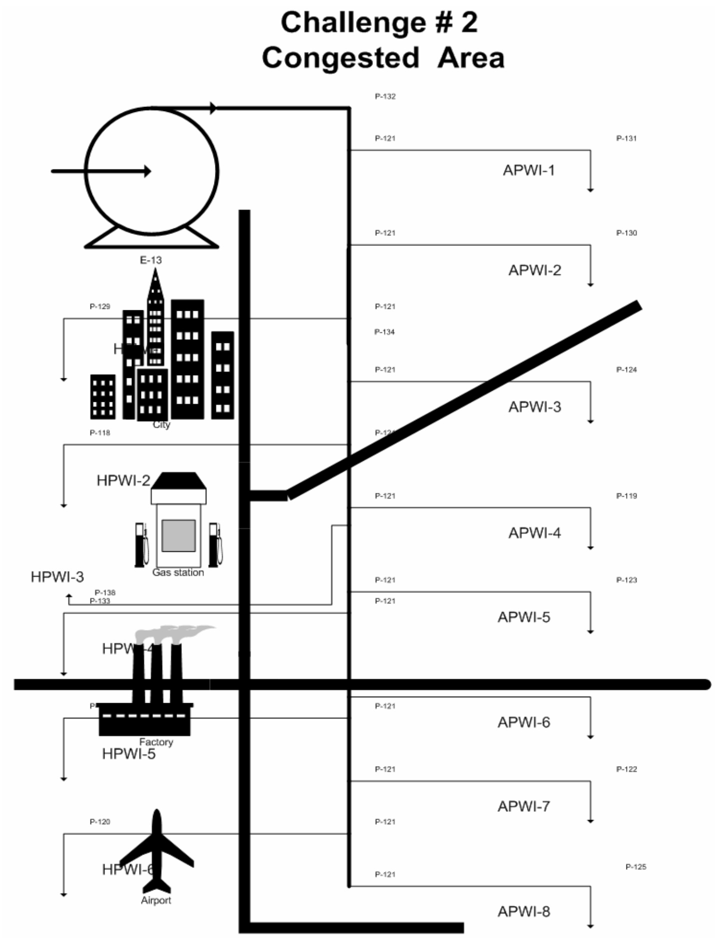
As the subject field matured, the water cut increased, requiring an all new water injection strategy. The strategy entailed drilling new PWI wells, converting some watered-out producers wells to disposal/reinjection wells, and upgrading the existing water injection facilities .The design of this included considering the required water injection/re-injection facilities for the new producing formation in the same field.

However, when the case was closely examined and all elements defined it was shown to require further considerations, such as the location of the proposed injectors of the formations and the injection parameters, the optimum set-up of the facilities had to be carefully thought out. Challenges to having a single system included the scattered well locations, different IWHP requirement and other complications such as the area urban development and congestion and the high power waste associated with the integrated system proposal. The challenges were as follows;

1- Limited Capacity of the existing plant



2-Congested Area: Due to urban development and the expansion of city road and power line networks, expanding or constructing a centralized single system an injection system .was not feasible.



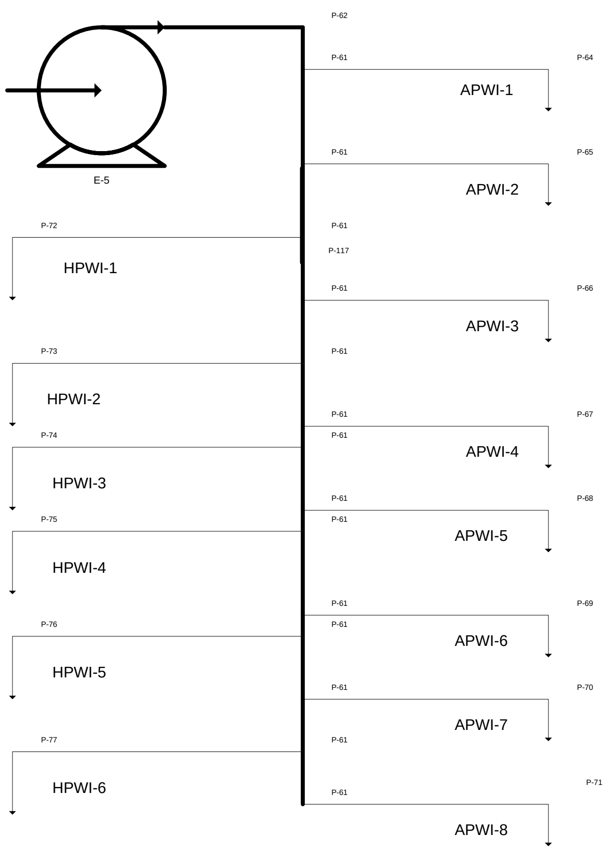
3- Different Formation Factors: Each formation has its own unique properties, leading to a different IWHP requirement. The data showed that the formation pressure and permeability of formation A, required less IWHP as that of formation H.

4- Changing water flooding program: Due to the consideration of the water reinjection a as an integral part of the flooding program, it has to meet rigorous reservoir management requirements .This entailed building a system with maximum flexibility.

For this, the following three alternatives were defined and evaluated:

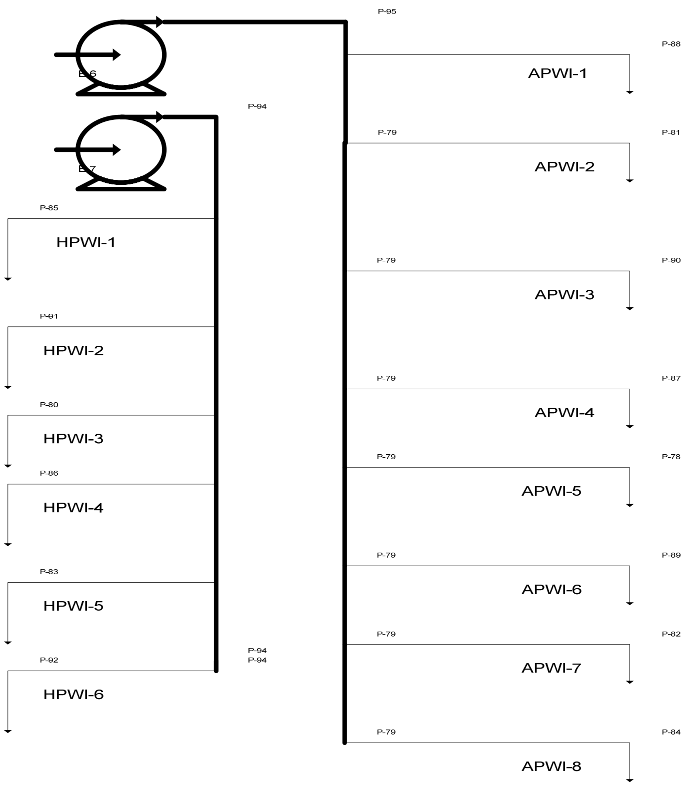
1- Expanding the existing water injection system to meet both formations injection requirements (A & H) with the high end discharge pressure (1600 psig). This required an overall less piping lengths but entailed higher piping rating for some segments, requiring replacing some pipe segments.

ALTERNATIVE 1
INTEGRATED WATER INJECTION STATION



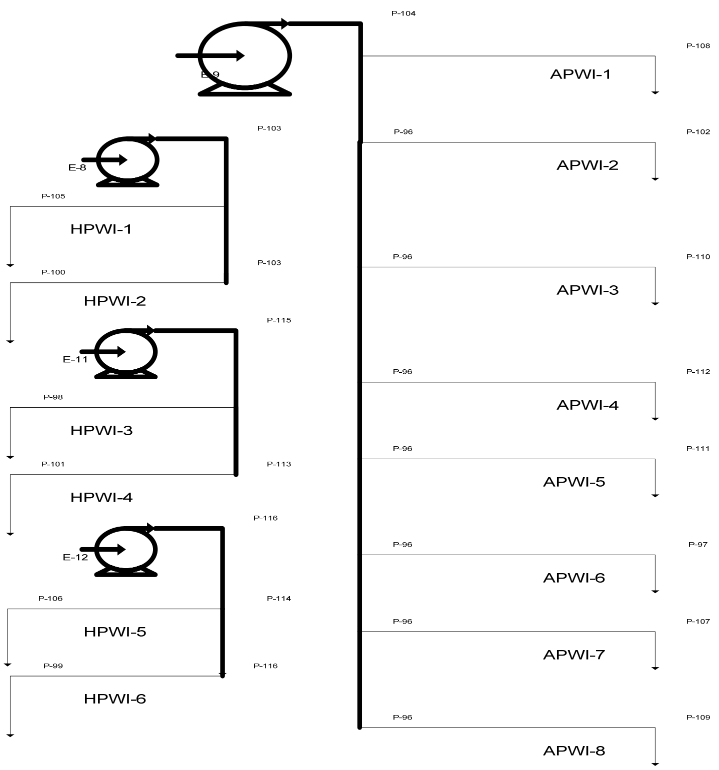
2- Building two split systems, one for each formation, a high (1600 psig) and low (600 psig) operating pressure. This required longer piping segments and running in and through existing developments and bypassing areas though running even longer pipes.

ALTERNATIVE 2
TWO SPLIT WATER INJECTION STATIONS



3- Dedicating the existing water injection system for formation A , retaining the system at low the low discharge pressure of 600 psig ,and custom-building independent smaller water injection stations in the congested area for formation H (1600 psig). This required far less piping and added operational flexibility.

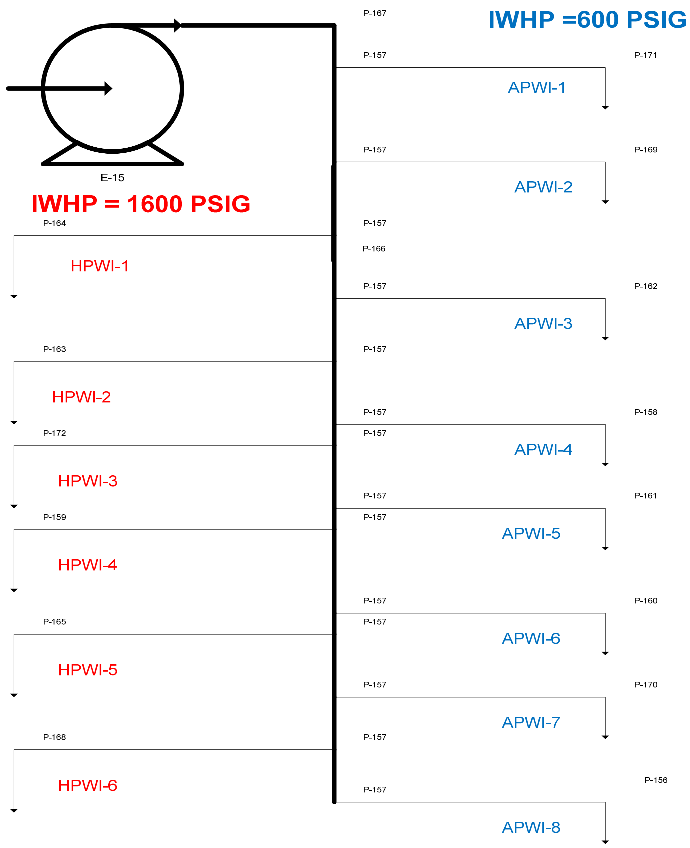
ALTERNATIVE 3
INDEPENDENT WATER INJECTION STATIONS



<u>IWHP Calculation And Power Requirement</u>

The injection wellhead pressure (IWHP) is determined by the well design, the formation parameters and the well rate. The formation parameters include the injectivity index , the static bottom hole pressure and formation depth .Due to these factors being different for the two formations, significantly less injection well head pressure is required to force water into formation A, as compared with of formation H. This translates to more pumps HP requirement   higher pipeline rating. Building a single injection system for the entire field to meet the two formation demand will result in significant power waste and construction costs.

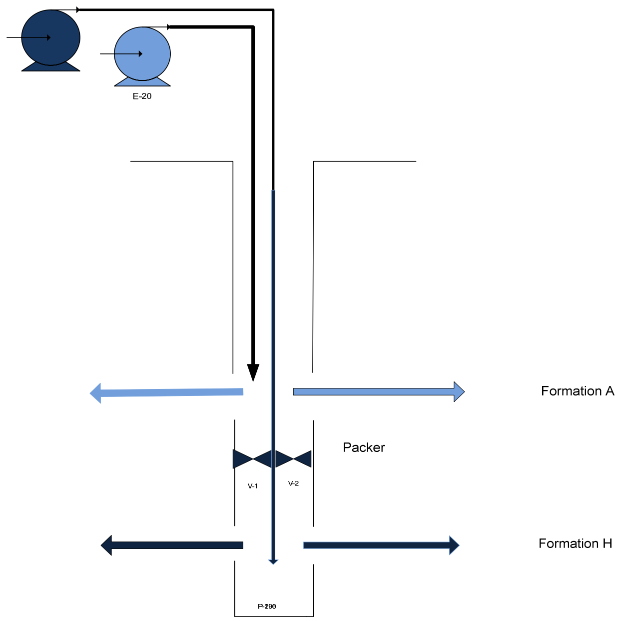
IWHP DIFFERENCE & POWER WASTE
DUE TO THIS DIFFERENCE POWER WASTE OF ROUGHLY
5000 KW-HR



Other Alternatives Examined:

Dual completion wells were also evaluated. Due to complexity associated with this approach such as the operational and limited injection capacity to smaller tubing sizes ,it was deemed undesirable .

Dual Completion Wells



Conclusions

Developing the optimum water injection system requires considering the long term water injection requirement and the field produced water forecast and understanding of the injection strategy of the field. In this specific case two formations of distinct characteristics and well locations were considered. Based on economics, operational flexibility and construction easiness, the 3rd alternative was selected.

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