Optimization Selection Research of Chemical EOR Pilot Project Site for Umm Niqqa Oilfield in Kuwait

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Abstract. The Low Fars of Umm Niqqa oilfield in northern Kuwait is a carbonate formation. After many years of primary and secondary oil recovery, Kuwait Oil Company has started to use chemical EOR flooding technology to increase recovery in this reservoir in recent years, and plans to carry out chemical EOR Pilot project. Due to the dense well pattern and surface facilities in the oil field, the site selection of the pilot project has become a problem. This essay focuses on the optimization method of the pilot project site, underground influencing factors, surface influencing factors, and analysis of the preferred site. Therefore, several important conclusions for selecting the site of the pilot project are summarized: simplifying the site design, combining local geological conditions and construction experience of similar projects, will greatly reduce investment and improve the efficiency of the chemical flooding pilot project. The successful pilot site selection of Umm Niqqa water and polymer flooding pilot projects based on underground design and surface foundation includes well site selection and water source selection. Reserve the surrounding site in advance, drill new wells in this area, install and connect the corresponding water injection pipelines and manifolds to ensure the successful implementation of the chemical flooding pilot project.

Keywords: Umm Niqqa, EOR, Pilot, Site, Subsurface, Surface.

1. Introduction

Kuwait has one of the largest recoverable oil reserves in the world and most, if not all, of its production is still due to primary forces. The primary and secondary forces are expected to recover approximately 45% of the oil in place [1, 2]. The huge volume of unrecoverable oil will be the target of enhanced oil recovery techniques that have become attractive because of the higher oil prices. If the heavy oil sands of Alberta can become economically attractive, then the much lighter oil in Kuwait oil reservoirs will certainly present a more attractive target for enhanced oil recovery processes.

Due to the large current production capacity of Kuwait oil fields, no published study has been undertaken previously to investigate the Enhanced Oil Recovery (EOR) potential in Kuwait, as the capacity due to primary and secondary techniques is more than enough to meet the daily production requirements.

Recent years, Kuwait Oil Company set chemical EOR as one of goal of 2040 strategy, Umm Niqqa oil field as one of the most important area which use chemical EOR technology. Through many

laboratory experiments and polymer flooding was identified as the most suitable EOR method for Umm Niqqa Lower Fars (UN-LF). Laboratory experiments were conducted on core plugs taken from UN-LF and were flooded with most suitable chemicals for enhanced oil recovery and the recorded results are promising. Now Kuwait Oil Company (KOC) plan to perform a larger test in the field by conducting a pilot project.

The scope of the pilot project is to conduct a successful turnkey normal 5-spot polymer flooding pilot [four (4) injectors, one (1) main producer well within an area of approximately 1 (1) acre] in UN-LF in north Kuwait with minimal impact on the existing field operations. Need Contractor with relevant chemical mixing and injection experience shall due diligently perform detailed engineering, construction, installation, and operation of a fit-for-purpose plant by the specified target date. The findings of this pilot will be instrumental to assess the techno-commercial feasibility of polymer-flooding for the Umm Niqqa oilfield in accordance with KOC's 2040 strategy [3].

2. Optimization Method of Site Selection

Like any new high-cost technology project, a pilot was considered essential to de-risk the application of ASP technology to Umm Niqqa Lower Fars (UN-LF) reservoir. After nearly 5 years of studies and pre-planning the ASP pilot was initiated in 2018.The selected location and coordinates of the water injection facilities (water injection bulk-like, injection manifold and injection flowlines) for pilot trials, as required for Urban Planning, surveying and for a land allocation request for the water flood pilot infrastructure. The request is to reserve the land space required to run the new 3" water injection bulk-like from the existing EPF15 facility to the water injection area located around UN-0036 producer well, which requires a 200 x 200 meters plot enclosing the producer / injection wells in which the injection manifold, metering station and injection flowlines will be installed.

Please note that this revision includes a description of the land requirements for the water injection bulk-like as well as a revision to the required plot space area to accommodate the water injection facilities in and around UN0036 area, which has been reduced from 400 x 400 meters to 200 x 200 meters after confirmation with Urban Planning of the space requirements, the resizing of the injection manifold and inclusion of the metering station within the fenced area of UN0036.

There are oil wells, water injection wells, gas wells, gathering centers, water injection stations, brackish water stations, fire stations and other facilities in the oilfield. And many directional or horizontal wells under the ground. So how to choose a EOR pilot location is a very difficult task, above mentioned fixed facility and unseen underground limited the selection of location.

Preferred method of location selection is to communicate the selected coordinates and proposed land reservation of the Umm Niqqa Lower Fars water and polymer flood project, consideration from both subsurface and surface side. Integration Study to ensure compatibility with the existing surface infrastructure, assigned pilot location, wells, source water supply and main production facilities with minimal impact on existing operations [4].

3. Subsurface Selection of The Pilot

In March 2018 the subsurface design of the Umm Niqqa Lower Fars water & polymer flooding pilot has been completed .The previous pilot study has resulted in the following concept selections related to location:

3.1 Four vertical injectors will be drilled in a normal, symmetric 5-spot pattern around the central producer, which is the existing producer UN-0036. The pattern orientation is 45 degrees with respect to the North- South axis of Umm Niqqa, see Figure 1 Umm Niqqa pilot wells location. The injector to injector spacing is 63m, corresponding to a pattern size is about 1 acre.

3.2 The targeted start date of the pilot is currently scheduled for April 2019. Source water for the Water Flood pilot is Umm Niqqa produced water from EPF15 (120k ppm TDS), for the Polymer Flood pilot this is assumed to be seawater (50k ppm TDS), however the utilization of produced water will be evaluated in the lab. Water Flood will last 12-24 months, Polymer Flood 12 -18 months after water injection period.

3.3 Producers in the vicinity of the pilot can have an impact on the current fluid flow and saturation distribution in the pilot area and could also be affected by the pilot once in operation. From simulations it has been shown that the majority of the injected water (or polymer containing water) will flow to the central producer UN-0036, which is closest to the injectors, but a certain percentage could flow outwards to the neighboring producers. The nearest wells are UN-0042, 74, 83, 86, 89, 115, 128, see Figure 2 [5].

Figure 1. Umm Niqqa pilot wells location.

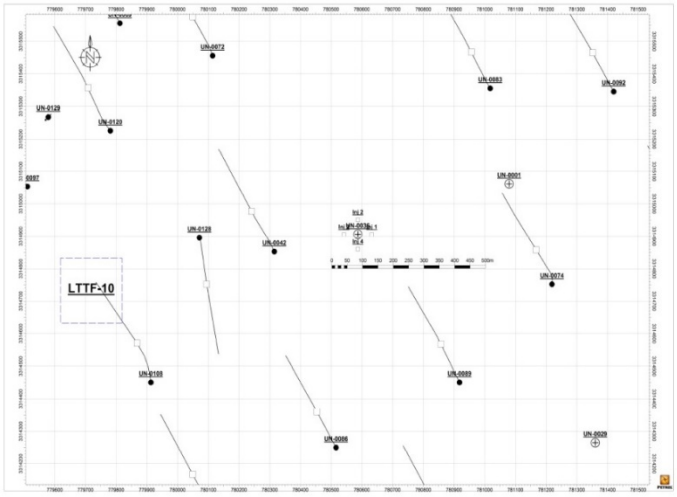

Figure 2. Top view of the pilot pattern with nearby wells, on 100x100m grid. The solid circles indicate the surface location and the squares in each trajectory indicate the intersection of deviated wells with the top reservoir.

4. Surface Selection of The Pilot

4.1. Description of Existing Facilities

The wells currently on production feed into two Early Production Facilities (EPF15 @ 15 MBOPD) for separation and treatment prior to export to South Tank Farm (STF) in Al Ahmadi. Power requirement for these two facilities is met from diesel and natural gas fuelled generators located at the individual facility. The local power needs at the existing operating wells are met by small rental wellsite diesel generators. The crude oil export is through a network of pipelines which ties into the South Ratqa new 24" SR-LFHO Transit Line.

The base case for the water source to support the water injection schedule is the produced water from the Umm Niqqa field originating from EPF15. For an Umm Niqqa map with facilities see Figure 3[6-8].

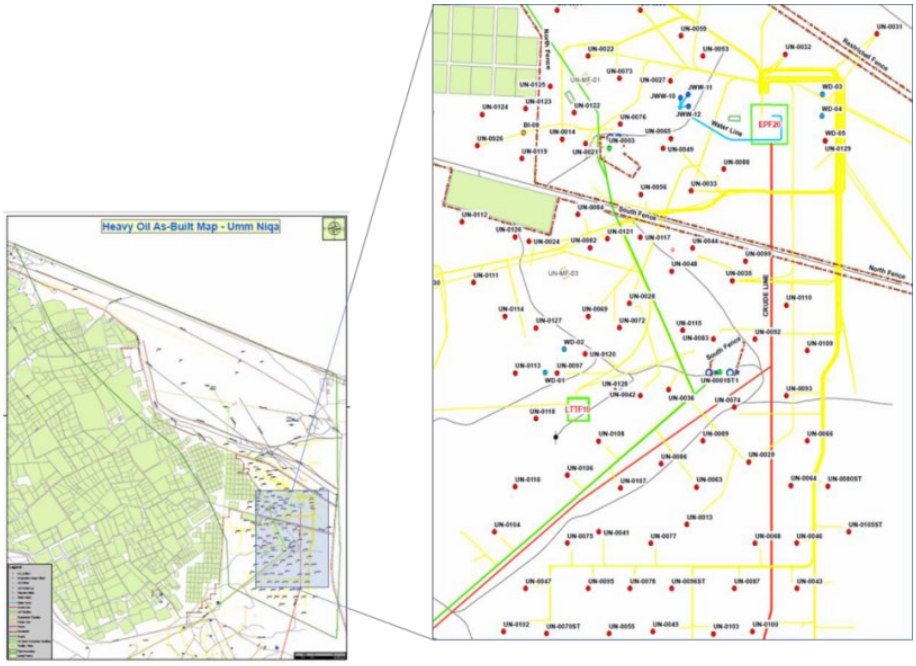

Figure 3. Umm Niqa Map and Location of LTTF10 (dismantled) and EPF15 (green squares).

4.2. General Site Information of Umm Niqqa Pilot Area

The key features of the pilot site are as below:

- UN-0036 well is located 3.5kms from EPF15 facility.
- Access road to existing EPF15 facility is just north of the pilot location.
- Access road to new injectors will be via temporary rig roads.
- There are existing producers /flowlines /oil lines in the area near UN0036.
- Extensive farming area approx. 3.3 km East of the proposed pilot location.
- Existing pipeline corridors enter the pilot area.
- There are a number of miscellaneous tracks.
- There are existing Burn pits and Mud pits from existing wells.

4.3. Water Injection Pilot Well Coordinates

The four new injector wells are located on centers approximately 63 m apart with existing well UN-0036 in a central position. There is an existing track giving access to the UN-0036 well. The well coordinates are specified in Table 1 below.

Table 1. Pilot well names, indicators and coordinates.

Well ID	Type	East Co-ordinate	North Co-ordinate
UN-0036	Producer (Central)	780587	3314906
UN-0387 (141-GD-03)	Water Injector (South East)	780632	3314906
UN-0388 (142-GE-02)	Water Injector (South West)	780587	3314951
UN-0385 (141-GD-01)	Water Injector (North West)	780542	3314906
UN-0386 (142-GD-02)	Water Injector (North East)	780587	3314951

4.4. Proposed Water Injection Manifold Key Plan

The water flood pilot will require a water injection manifold to be built in the pilot area. This is depicted in Figure 4. The water injection manifold will be located inside a reserved plot space of 200 m x 200 m in close proximity to UN-0036 and injection wells.

A metering station will be located within the reserved area. The multi-phase flow meter will be located inside the UN-0036 fenced area and most likely the test separator will be located adjacent to the fence.

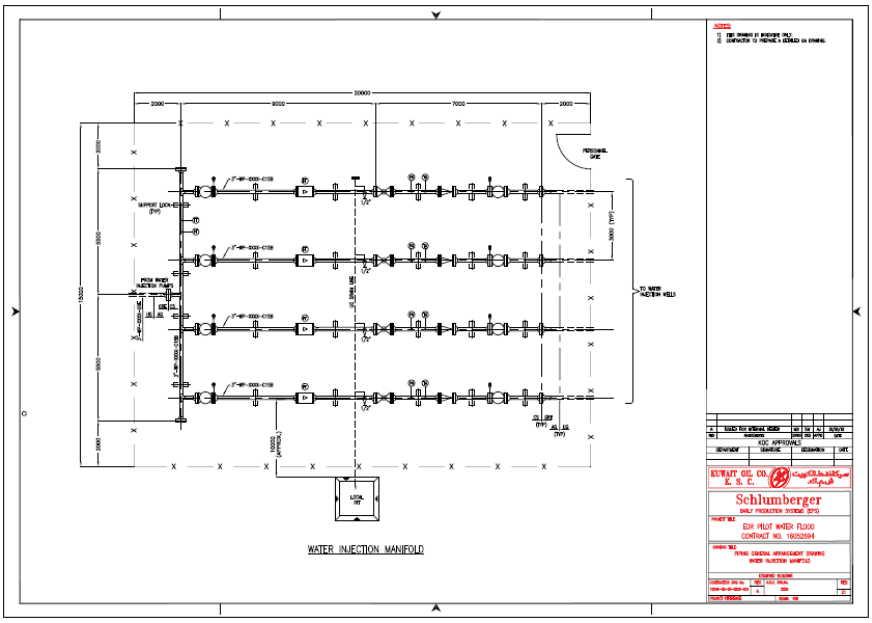

Figure 4. Water Injection Manifold Key Plan.

4.5. EPF15 Plot Plan

The source water will come from EPF15 to the water injection manifold .The location of EPF15 is approx. North 3301692 and East 766785.

Key Features:

Local control room located in northwest corner of the plant.

Inlet production manifold is located at the north part of the plant.

Incinerator and LP flare are located in a fenced of area northeast of the plot. See Figure 5 for a plan of the EPF15 plot.

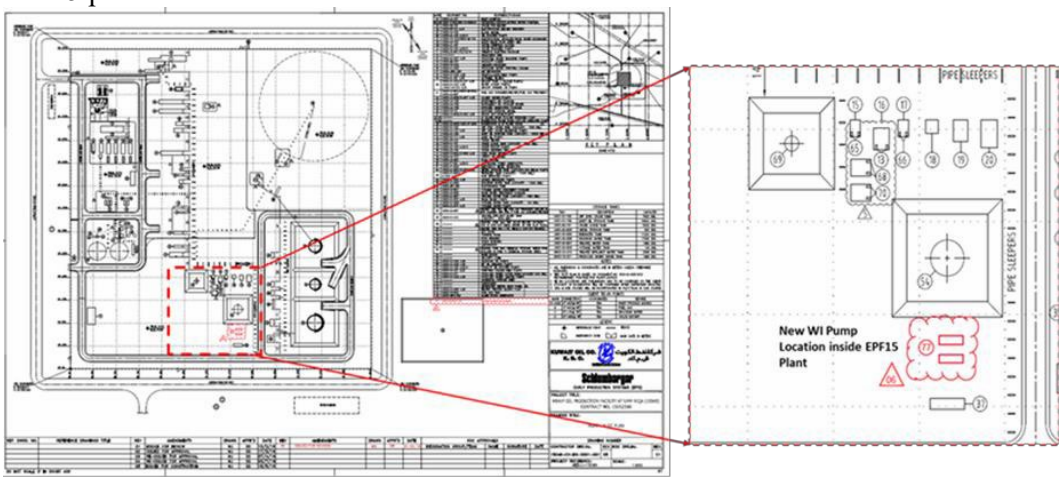

Figure 5. EPF15 plot plan and proposed location for the water injection pumps.

4.6. Proposed Produced Water Supply Tie-in

The project will provide a new produced water system to route the water from the EPF15 produced water line to the water injection facilities. Produced water will be drawn from the produced water piping routed to the Treated Produced Water Tank (UN01-D-210) through the Produced Water Injection Pumps and on to the Injection Wells, see Figure 6. Provision of seawater to the site for the polymer phase of the pilot will be decided at a later stage [9-11].

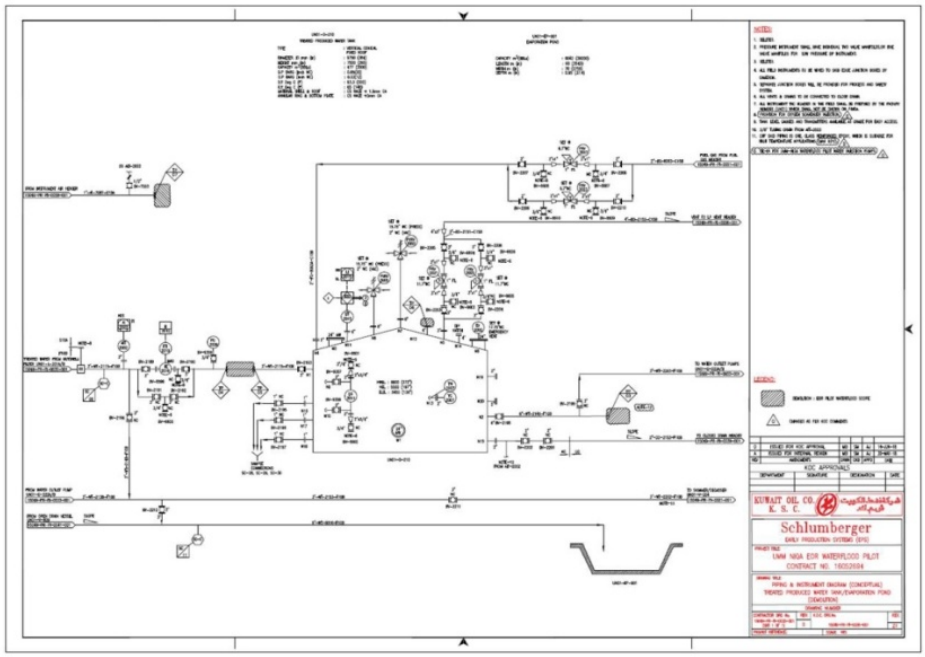

Figure 6. Proposed Produced water Supply Tie-in.

5. Analysis Selected Site and Reservation for The Pilot Facilities

The EOR pilot project is currently in the early test stage in Kuwait. If the pilot test can be successful, this ultra-small well spacing test cannot be immediately promoted in Kuwait on a large scale. However, as a technical reserve for long-term technological evolution, it is necessary and an effective means to increase the ultimate recovery of the reservoir. In this process, the contractor needs to have strong EOR chemical flooding construction and operation experience to help KOC analyze and deal with various unexpected technical problems [12-14].

All equipment in pilot location uses skid-mounted equipment, and the injection pump skid, mixing valve block and other skid blocks can be placed in the location. The process piping, electrical and communication interfaces should adopt unified specifications as can as possible to meet the requirements of simple and quick installation on site. The short-distance process between pump skids can be laid on the ground, and the high-pressure single-well pipelines are laid on the ground with aerial + shield + soil. Consider the anti-shock problem of high-pressure injection equipment. All equipment and facilities shall be prepared with detailed equipment installation procedures, pre-drills for installation and commissioning of equipment and facilities shall be conducted in OEM. Considering that there are many on-site technological processes and equipment facilities on the pilot location, involving multiple process nodes such as seawater softening, powder engineering, mixed injection, crude oil dehydration, sewage treatment, etc., the on-site automation design must as high as possible, and all the equipment operating parameters are taken to ensure injection quality, improve on-site operating efficiency [15-17].

To accommodate the water injection bulk-line, the injection manifold and injection flow lines, land needs to be allocated and reserved as indicated in Figures 7 and 8. Figure 8 shows the pipeline routing from EPF15 facilities to the pilot area (located at the bottom). Figure 8 shows the proposed location of the water injection area around exiting UN0036 well.

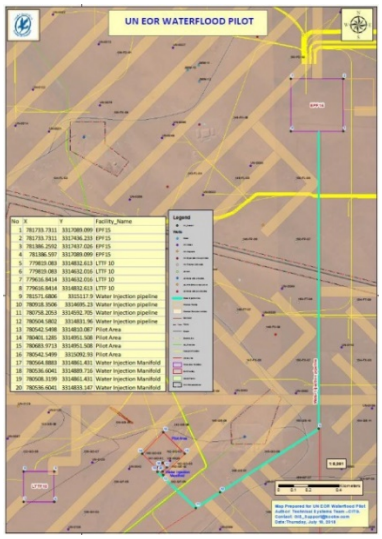

Figure 7. Pipeline routing from the EOR pilot area (at the bottom part of the graph) to EPF15. The main part of the pipeline (781571.7 Easting) runs about 785 m East of the East side of the pilot land plot indicated in the red square in Figure 8.

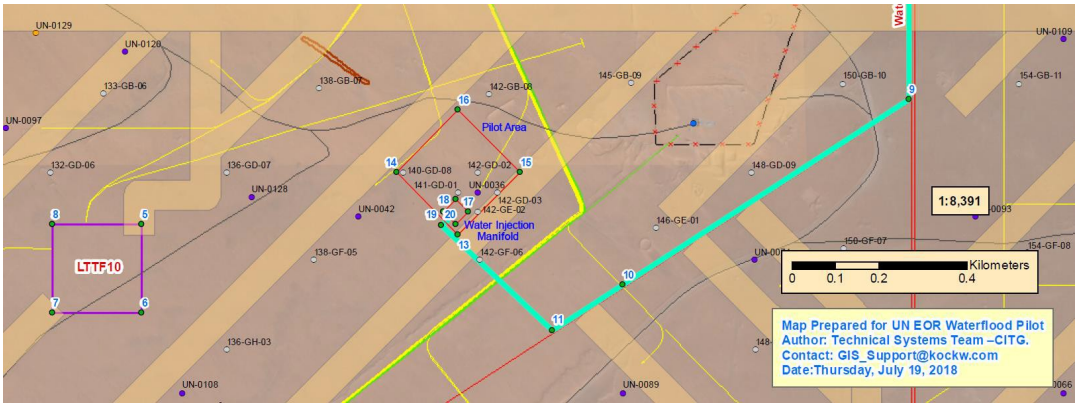

Figure 8. Land reservation plot and coordinates. The red square indicates the 200x200m area requested for the land reservation. Coordinates of the corner points are indicated. The water injection manifold (small red square) is discussed in section 0. The tie-in coordinates of the water line to the manifold are also indicated on the plot.

6. Conclusions

Simplify the design of location, combine local geological conditions and construction experience of similar projects, it will reduce investment and improve chemical EOR pilot project efficiency.

The location selection ,including well location selection and water source selection for Umm Niqqa Lower Fars water flood and polymer flood pilot based on the subsurface design and the surface basis .As a result, the decision for a surface plot for the Umm Niqqa pilot can now be made and this has been selected in the above mentioned.

The plot for the land reservation is presented in Figure 8. In this area new wells will be drilled, a water injection manifold will be installed and flowlines will be laid. Next step is for the Urban Planning team to initiate surveying the land and for the selected contractor to confirm the routing and then prepare the detailed drawings.

Acknowledgment
We would like to extend our thanks to Kuwait Oil Company for allowing us to study this important work, and the entire KOC team who made the work possible. We strongly feel their commitment to share EOR pilot site selection studies is of major benefit to the industry as a whole.

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