



Intro to Satellite Sleuthing 101: Finding Haradh III

Posted by [JoulesBurn](#) on February 29, 2008 - 11:10am

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Everybody talks about the Saudi Arabian Oil Miracle, but most seem to be saying the same things. And those things usually consist of quotes or statistics provided by Saudi Aramco. This presents us with the following dilemma: if we believe what they say, why don't we just quit worrying about whether or not their oil will continue to flow? Or, if we don't believe what they say, why do we bother making future oil supply projections based on "production capacity" figures by them -- figures which can never be verified because their production levels always remain below capacity? What we need is some independent verification of the things they tell us. Hence the birth of Saudi Satellite Sleuthing using Google Earth. Following a brief introduction, I will show how Google Earth can be used to shed some light on the Haradh III Megaproject brought onstream in 2006.

This project began early last year with a crude effort to map out Saudi oil fields using Google Maps. I soon discovered that recent releases of Google Earth facilitated this at a much higher level. After being inspired by the work of Stuart Staniford, Euan Mearns, and other TOD contributors on Ghawar, I persisted and was soon sucked in beyond the point of no return. This finally resulted in the creation of [Satellite o'er the Desert](#) where I will try to relieve the backlog of what I have learned (and am continuing to learn). It is planned that many articles will be posted here as well for discussion.

Getting Started

The first few entries at SOTD present an introduction to using Google Earth to study oil fields. Rather than repeat all of that here, I will just suggest reading the following:

- [Using Google Earth](#)
- [Well, What Can You See?](#)
- [Types of Wells](#)

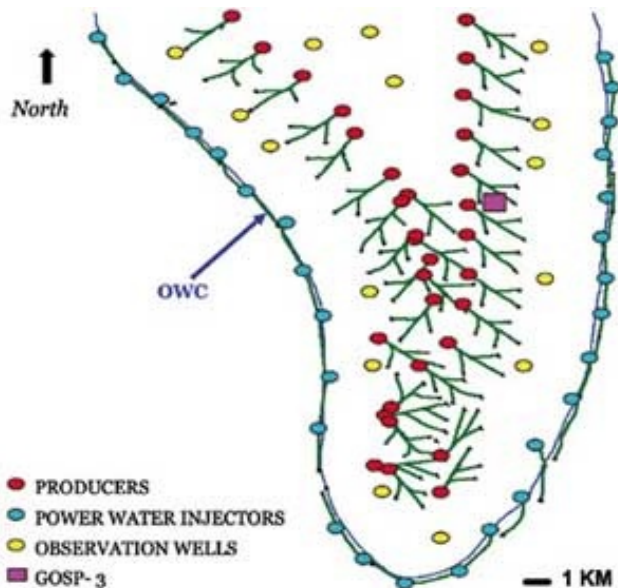
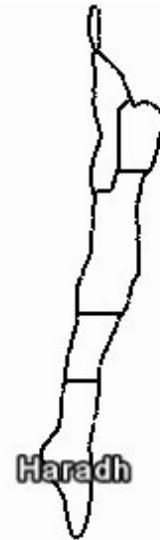
- [Dating Google Earth Imagery](#)

Some people (such as my niece) like to work on 500+ piece jigsaw puzzles where you know what the end result will look like and the pieces almost all look the same. I can only take so much of that, but the Saudi oil is very much a puzzle with hints scattered across the internet. I don't think that many (even at Saudi Aramco) know what the picture really looks like. So, on with the fun!

Finding Haradh III

Haradh is the southernmost operational area of the Ghawar oil field, and Increment III represents the development of the bottom third of the area. This project was completed and production brought online in early 2006, although the field wasn't producing at the planned output capacity of 300,000 barrels of oil per day until mid year. The infrastructure put in place includes 32 maximum reservoir contact (MRC) wells (each with multiple horizontal laterals), 28 horizontal water injector wells, 12 observation wells, and a new gas-oil separation plant (GOSP).

What does Haradh III look like? There were some rather crude renditions being used in Saudi Aramco presentations for awhile, but they eventually decided to come clean with the article [Haradh III: A Milestone for Smart Fields](#) which included the following image:



This seems to be a fairly definitive representation. To see if this reflects how the field was actually laid out, we will use Google Earth to overlay this image over the satellite imagery for the tip of Haradh. Unfortunately, the imagery for most of that area was taken between May through November of 2004 as the project was just getting started. Fortunately, the water injectors on the east side lie in an area photographed in May 2006 and so we have an initial point of reference. Also, the Haradh III GOSP construction was far enough along in November 2004 that its location is clear as well. There are also low resolution DigitalGlobe preview images available dating to 2006-2007 which cover parts of Haradh. While it is not possible to make apriori identifications using these, they can be used for spotting changes indicative of new development by comparison with older high resolution images covering the same area.

Finding Putative Haradh III Wells

Another complication is that the area encompassed by this project is already full of wells, as shown in the left figure below. The field boundary is drawn based on its location relative to the wells in the paper by Stenger et. al. *Assessing the Oil Water Contact in Haradh Arab-D* ([SPE 71339](#)). Upon closer inspection, it is determined that over 80 of these are gas wells drilled down into the Khuff formation deep beneath the Arab-D oil reservoir. These can be clearly distinguished from oil wells as discussed [here](#). Shown below right are identified gas wells along with the network of manifolds and pipelines which feed the gas into the Haradh Gas Plant.



All visible lower Haradh wells (left) and identified gas wells, pipelines, and manifolds (right).

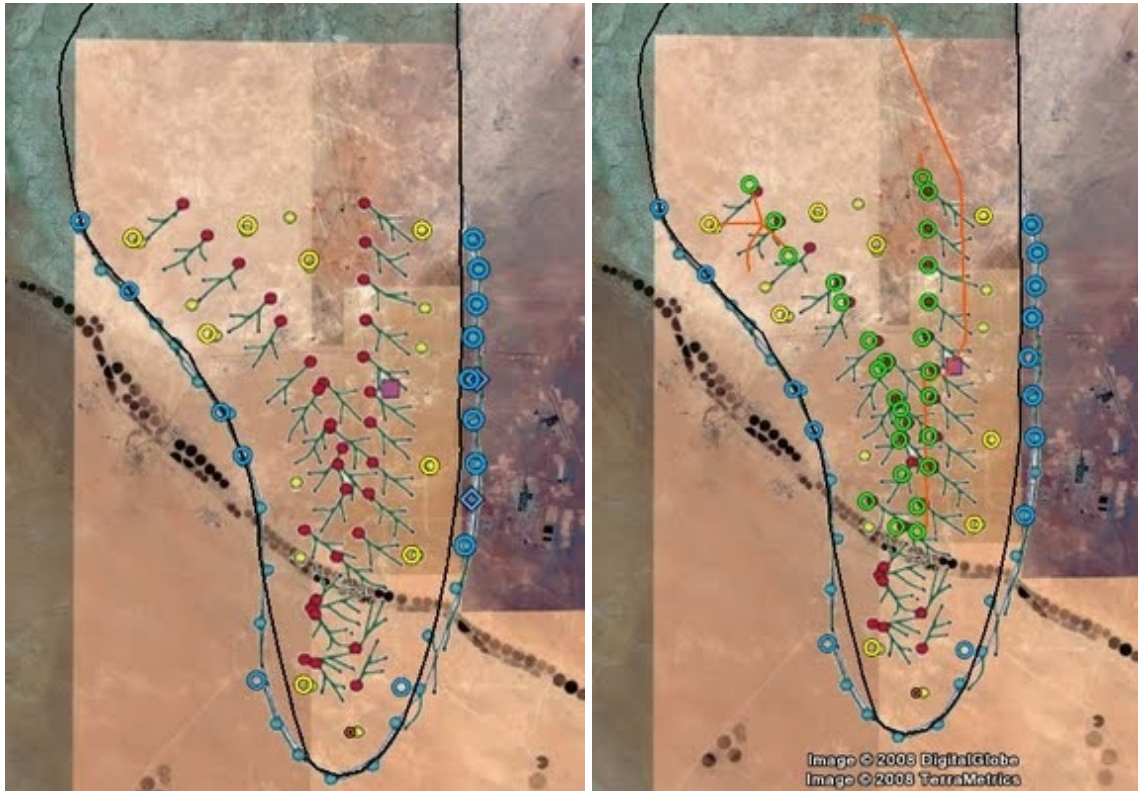
One other curious observation regarding the gas wells is that they are almost invariably oriented as shown below (north is towards the top), even when it results in a rather contorted path for the pipeline.



It Seems To Fit

With the gas wells identified, it becomes easier to ignore these while adjusting the dimensions and position of the overlay to match putative Haradh III wells. The the result of this process is shown

below at left. The published image was found to be stretched horizontally by about 22% from the true aspect. Existing wells or well sites are identified with large circles (blue for injectors, yellow for observation wells). Two drilling rigs are observed (May 2006) at injector sites on the eastern flank. It is clear that several wells present in 2004 were either targeted for or reused as observation wells for Haradh III. Also, six water injection wells were seemingly present by mid 2004. This conflicts with [this report](#) which indicates that development didn't start until Feb. 2005. However, an earlier well layout map shown in a Feb. 2004 CSIS presentation by Nansen Saleri (former reservoir czar for Saudi Aramco) suggests that several wells around the periphery were put in place by then and that these were distinct from the 28 planned for 2005-2006.

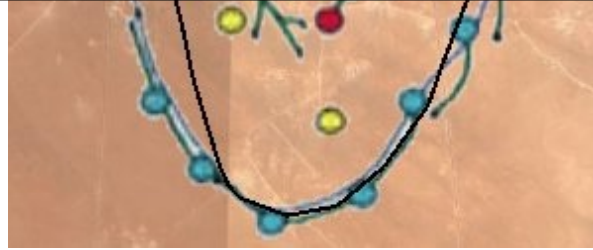


Using low-resolution DigitalGlobe preview images as overlays as described earlier, we can try to confirm locations for the Haradh III producers. Tentative confirmations (how's that for a hedge) are indicated with green circles in the figure above at right. 26 of the 32 producers were accounted for. Recent imagery covering those at the southern tip was not available. Also shown (with red lines) are some new pipelines that were found, including a connection line from the new GOSP III to GOSP II (located just up into the low resolution coverage area). This is most likely used to transport water for injection in Haradh III. An additional well was identified at the right top, although a pipeline also visible in the low resolution 2006 photo shows that this connects with a manifold for the Haradh II increment. This highlights the point that, while boundaries can be drawn on a map separating development increments, there is really no geological boundary between them.

It is curious that the May 2006 drilling date for the two water injectors comes several months after production completion was announced. Also, there is [this report](#) which describes MRC well Haradh-1425 being drilled in April 2006. Its orientation and relative lateral positions suggests a good match with one of the southernmost Haradh III producers, as shown at right. Additional evidence comes from the well id (HRDH-1425). A complete



synopsis of the well numbering scheme in Haradh will be forthcoming in a separate article, but for now I will just assert, based on evidence from the Saleri presentation mentioned above, that the 32 Haradh MRC producers have ID values from 1400-1431. I have also found a report of the drilling dates for other Haradh producers: HRDH-1417 , from October 1 to November 17 of 2005, and HRDH-1406 from December 1, 2005 to January 3, 2006.



Actually, Just Getting Started

In summary, Google Earth is a useful tool for correlating the various fragments of information out there on Ghawar and other Saudi oil fields with what is actually found there by looking from above. In the midst of a lot of misinformation and sloppy reporting, it is hoped that this type of analysis can inject some independent and objective data into the discussion.



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