Muddy Waters: Iraq's Water Injection Needs

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Executive Summary

Iraq's current and continuing plans for major oil production growth require pressure support for reservoirs, which is likely to be provided mainly by water injection. This study covers the need for water injection, the progress made to date, and future plans, for central and southern Iraq. It does not consider the fields in the autonomous Kurdistan Region as they are managed separately, are a long way from the Gulf and are more likely to use gas than water injection.

Iraq is the world's fourth largest oil producer, after Russia, Saudi Arabia and the US, producing 4.56 million bpd in October 2016[1], before output was reduced to comply with OPEC targets, to 4.48 Mbpd (as reported by Iraq). This included about 0.6 million bpd from the autonomous Kurdistan region. Further ambitious plans for production expansion are continuing, primarily from the large southern fields around Basra. Currently estimated ultimate recovery factors average less than 30%, low by world standards, and indicating a need for improved recovery methods.

Iraq has a long history of using water injection on a relatively small scale, dating back to 1961. Water injection is the most appropriate recovery mechanism for most of the reservoirs in southern and central Iraq, would give the highest recovery factors and is technically relatively straightforward. Modern water injection following the fall of the Saddam Hussein regime has been applied by international oil companies developing fields in southern Iraq under technical service contracts. But widespread use of river water for injection has been discouraged because of the competing uses for agriculture and potable water, a continuing severe drought, and the reduction in water flow due to upstream dam construction in Turkey and Iran.

A comprehensive plan has been prepared from 2011 for a Common Seawater Supply Project (CSSP), initially managed by ExxonMobil, which would provide processed water from the Arabian Gulf for reinjection in the major fields. However the project has been repeatedly rethought and delayed and could not now be in operation before 2020 at the earliest. The CSSP plan as released by SOC has two phases, Phase 1 of 7.5 million barrels per day and Phase 2 adding 5 million bpd. However, in November 2016, the Ministry of Oil's released a scaled down scheme, for 5 million bpd of initial capacity.

The original CSSP was costed at $12 billion, later increased to $18 billion, while the Phase 1 (of 7.5 million bpd) was estimated by the Ministry of Oil to cost $5.6 billion.

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[1] OPEC Monthly Oil Market Report, November 2016, http://www.opec.org/opec_web/static_files_project/media/downloads/publications/MOMR%20November%202016.pdf

The CSSP, or some version of it, is highly economically attractive and delivers water (and therefore incremental oil production) at very moderate costs. Every year of delay, and the consequent loss of possible oil production, causes large losses to the Iraqi budget. The two main problems with implementation of the CSSP so far are project management; and financing.

Rather than a single megaproject, a series of logically integrated smaller steps may be easier to implement. A properly empowered team, reporting directly to the oil minister, could be established to drive the project forward. The CSSP should not be further complicated by bundling it with other projects, which has been proposed as part of the South Iraq Integrated Project. Instead of a direct government budget allocation, the CSSP could find alternative funding mechanisms underpinned by commitments from IOCs and national oil company-operated fields to use certain quantities of injection water.

Since the CSSP will at best not be operational for several years, interim solutions will be required, including alternative water sources, such as saline aquifers, river water where this is environmentally sustainable, waste-water, and smaller-scale projects using Gulf water.

The CSSP would ideally be part of an integrated national strategy for water, which would include the expected water supply from rivers and groundwater, and how much can be safely withdrawn; and the need for desalinated water. However, given the urgency and high value of the CSSP, and the potential delays and difficulties in coordinating with other ministries, it may be necessary to move ahead without a comprehensive plan.

Iraq Petroleum Background

Oil resources, production and plans

Iraq is a long-standing oil producer, with the first discovery having been made at Kirkuk in 1927. It is the world's third-largest holder of conventional oil reserves with 143.1 billion barrels, behind only Saudi Arabia and Iran[2]. It has an estimated 14-84 billion bbl of undiscovered additional oil resources[3]. The bulk of the known reserves are held in a number of supergiant fields in the south, around Basra, notably Rumaila, Zubair, West Qurna and Majnoon, and one supergiant in the north, Kirkuk.

There are numerous other large and medium-sized fields in the north, centre and south of the country. Up to the US-led invasion in 2003, 98 fields had been discovered. Several fields have subsequently been discovered in the autonomous Kurdistan region and a few in southern Iraq.

Iraq is the world's fourth largest oil producer, after Russia, Saudi Arabia and the US, producing 4.56 million bpd in October 2016[4], before output was reduced to comply with OPEC targets, to 4.48 Mbpd (as reported by Iraq). This included about 0.6 million bpd from the autonomous Kurdistan region. With domestic consumption modest at around 700 kbpd, Iraq is also the world's third largest oil exporter.

However, Iraq's oil production has historically fallen far short of its technical potential, due to political pressures, , war, sanctions and insecurity. Until recently, 90% of production came from just three fields: Kirkuk, Rumaila and Zubair. Output reached a high of 3.489 Mbpd in 1979, just before the Iran-Iraq War, but collapsed during that war and again following the invasion of Kuwait and First Gulf War. Following the removal of the Saddam Hussein regime by the 2003 US-led invasion, production recovered only slowly, until from 2011 onwards rapid growth was led by international oil companies. Output finally surpassed the 1979 level only in 2015. From mid-2014 onwards, several of the northern oil fields were damaged or captured during the fighting with Da'esh (ISIS), but the main ones were secured by the Peshmerga (Kurdish armed forces) and others have been recovered by the Iraqi military since. Despite the ISIS conflict, southern production continued to grow, leading overall output to the record levels mentioned above

[2] Venezuela claims 300.9 billion bbl, mostly extra-heavy crude of the Orinoco Belt. Its reserves were put at 99.4 billion bbl in 2007 before large upward revisions. BP Statistical Review of World Energy 2016.

[3] https://pubs.er.usgs.gov/publication/70026461

[4] OPEC Monthly Oil Market Report, November 2016, http://www.opec.org/opec_web/static_files_project/media/downloads/publications/MOMR%20November%202016.pdf

Figure 1 shows Iraq's main southern fields and export infrastructure. Most Iraqi oil is exported via terminals in the northern Arabian Gulf. Terminal capacity has been progressively expanded, with a project for a further Single Point Mooring (SPM) awarded in April 2017[5], but remains a constraint on exports and hence on production.

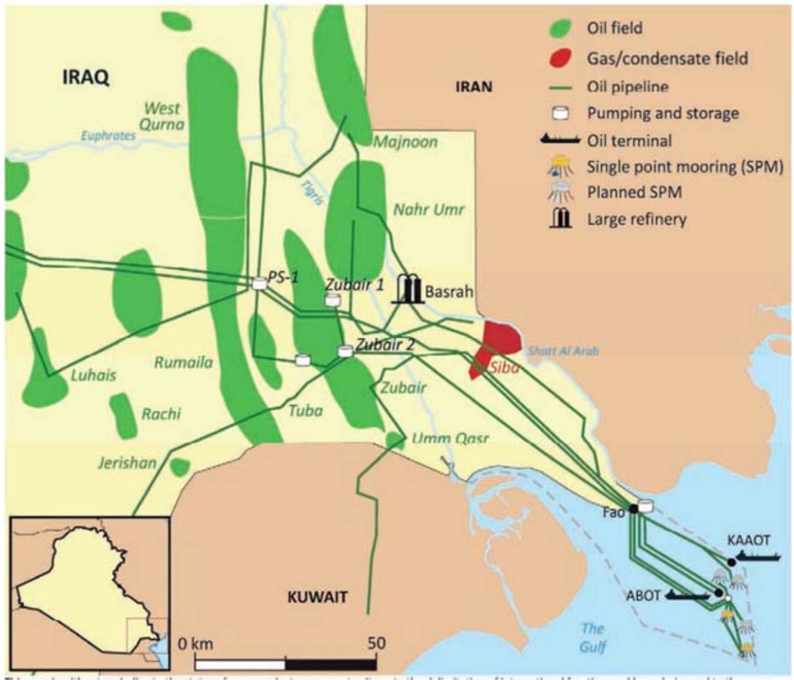


Figure 1 - Southern Iraq's oil & gas fields and related infrastructure[6] (ABOT is the Al Basra Oil Terminal, known as the Al Bakr Oil Terminal under the former regime)

The pervasive war, insecurity and sanctions had a damaging effect also on Iraqi energy infrastructure, and the level of technology applied to producing fields.

Of 28 producing fields, 22 have estimated ultimate recovery factors ranging from 15-42%, with an overall average of less than 30%, low by world standards. For comparison, Saudi Aramco seeks to raise its overall ultimate recovery factor, from rather similar reservoirs, from the current estimated 50%[7], to 70%[8].

Excluding the autonomous Kurdistan region, the Iraqi oil industry is controlled by the Ministry of Oil (MoO), headquartered in Baghdad. It controls a number of production subsidiaries, notably South Oil Company (SOC), North Oil Company (NOC), Midland Oil Company, Maisan Oil Company and others, as well as service, marketing and downstream subsidiaries.

[5] https://www.petrofac.com/en-gb/media/news/petrofac-enhances-iraq-presence-with-us-70-million-in-new-contracts/?IsFromNewsPage=true

[6] IEA, (2012) *World Energy Outlook 2012,* International Energy Agency

[7] http://www.oilandgasnewsworldwide.com/Article/33756/Abqaiq_recovery_rate_enhanced

[8] http://www.saudiaramco.com/en/home/news-media/news/wec2016.html

From 2009 onwards, a number of fields were offered for investment and development by international oil companies (IOCs), under Technical Service Agreements, as shown in Table 1. The TSAs (or Technical Service Contracts, TSCs) do not give ownership of reserves or production to the IOCs. Instead, they are compensated by recovering their costs (capital and operating costs), plus, after achieving a specified production level increase, a fixed fee per each barrel of oil increase over a set baseline production or, in the case of gas, per barrel of oil equivalent to the gas produced.

Table 1 Bid rounds

First Bid Round (June 2009)	Second Bid Round (December 2009)	Third Bid Round (October 2010)	Exploration Bid Round (May 2012)	Additional Bid Round (2018)	'National Effort' fields (or new bid rounds)
Ahdab[9]	Badra	Akkas (gas)	Block 8	Sindbad	Nahr Bin Umr
Rumaila	Gharraf	Siba (gas)	Block 9 (Faihaa discovery 2014)	Umm Qasr	Nassiriya[10]
Zubair	Halfaya	Mansuriya (gas)	Block 10 (Eridu discovery 2017)	Rachi	Tuba
West Qurna-1	Majnoon		Block 12	Abu Khaimah	Ratawi
Maisan Group (Buzurgan, Fauqi, Abu Ghirab)	Najmah		Blocks 1-7, 11 (not awarded)	Kumait	Rafidain
Kirkuk (not awarded)	Qaiyarah			Noor	East Baghdad
Bai Hassan (not awarded)	West Qurna-2			Amara	
	Diyala Group (not awarded)			Dima	
	East Baghdad (not awarded)			Dujaila	
	Euphrates Group (not awarded)			Euphrates Group (Marjan, Kifl, West Kifl)	

[9] Ahdab was awarded in 2008, prior to the First Bid Round

[10] Nassiriya has been extensively discussed with various companies as part of an integrated project including a refinery

This system was successful in attracting a number of the world's largest oil companies, notably Shell (Majnoon), ExxonMobil (West Qurna-1), Lukoil (West Qurna-2), ENI (Zubair), BP and CNPC (Rumaila), Petronas (Gharraf), CNPC (Halfaya) and others. However, some others have subsequently withdrawn from minority stakes, including Statoil and Occidental. The IOCs bid on the basis of their per-barrel fee, and the target plateau production rate. The total plateaux from the main fields bid added up to 11.4 Mbpd which, combined with smaller fields, those operated by MoO and the Kurdistan region, would have made Iraq the largest producer in the world.

The IOCs have complained of stringent terms which only permit a low return; bureaucratic delays in approvals; long delays in receiving reimbursement of their costs; and delays in the establishment of critical infrastructure. Such critical infrastructure includes export terminals, gas transmission and utilisation, and injection water supply.

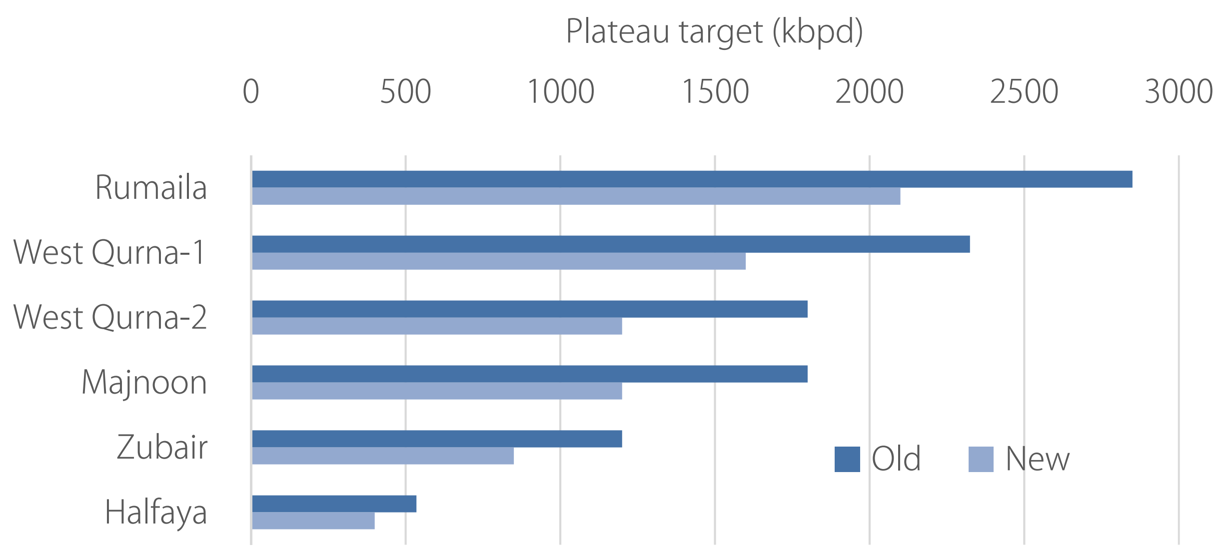


Figure 2 - Revised government plateau to meet downgraded production targets[11]

As a result of such problems, actual production, though registering significant increases, has fallen far short of the theoretical target. Negotiations were held through 2013 onwards to bring down the committed plateaux to more achievable levels, and to adjust the other terms of the contracts accordingly. The total production target from the main fields is now 8.25 Mbpd[12].

The MoO was responsible for delivering critical supporting infrastructure for the IOC field developments, whether through its subsidiaries such as SCOP (State Company for Oil Projects), or through other international partners or contractors. One of the key elements, the supply of water for reinjection, and specifically the Common Seawater Supply Project (CSSP), is discussed further below.

[11] Media reports

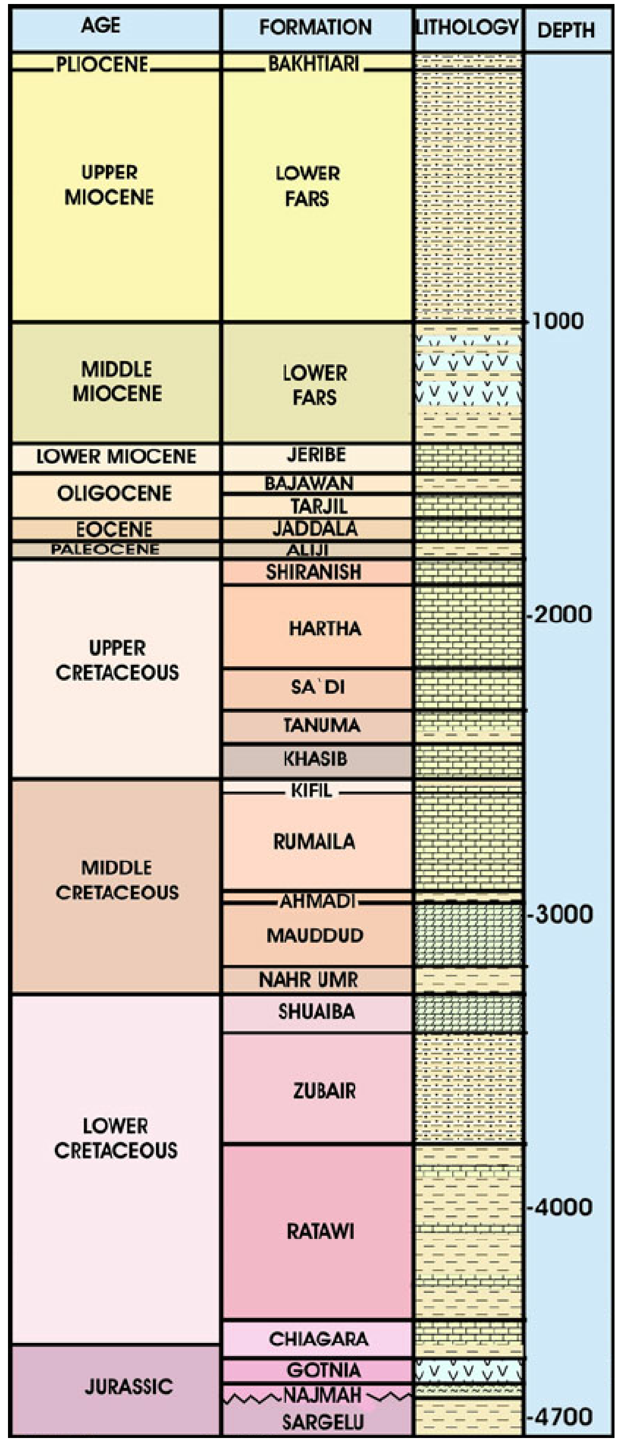
[12] Or may be slightly lower, since there is no public record of reduced targets from some of the smaller fields.

Water injection in Iraq

Secondary recovery

The large increases in production contemplated and in progress at the main southern Iraqi fields are quickly exceeding the levels that can be achieved by primary production alone (supported by reservoir compaction, fluid expansion, solution gas drive and any natural aquifer drive). Secondary recovery is essential to sustain and increase production rates while maintaining reservoir pressures at levels that ensure optimal recovery.

The chart below shows the stratigraphic column in the East Baghdad field. This is quite similar to that in the fields further south. The main hydrocarbon reservoirs discovered to date in southern Iraq lie in the Cretaceous, which as can be seen from the chart consists primarily of carbonates and shales, with sandstones, siltstones and shales of the Zubair and Nahr Umr formations (the proportion of sandstone in both formations being higher further south and to the west).



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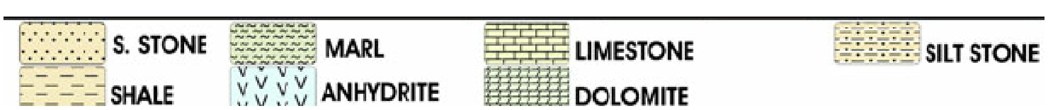

13 Al Ameri, T.K. and Al Obaydi, R.Y. (August 2011) 'Cretaceous petroleum system of the Khasib and Tannuma oil reservoir, East Baghdad oil field, Iraq' Arabian Journal of Geosciences 4(5):915-932

All four of the southern supergiant fields (Rumaila, West Qurna, Zubair and Majnoon) have reservoirs predominately distributed within the limestone Mishrif Formation and the sandstone Zubair Formation[14]. The Zubair Formation is composed primarily of sandstone and shale – the shale acts as a good barrier to impede the vertical flow of the hydrocarbons. The sandstone concentration in this formation is relatively high and using Rumaila as an example, the sandstone concentration increases towards the west and south to the extent that some areas in the west consist of almost 100% sandstone[15]. It fines upwards, so that water breakthrough occurs in permeable layers and isolates attic oil in poorer reservoir facies. The Zubair Formation (and Nahr Umr Formation) generally produces lighter oil (34-36° API) than the Mishrif Formation (24-28° API, or lower in some fields), and it has natural aquifer support, mainly from the west. The Mishrif consists of heterogenous reservoirs which produce at good initial rates from permeable rudist facies[16]. The Mishrif has little or no natural aquifer drive.

Overall southern Iraq has little surface structural expression. Anticlines and faults are prevalent due to structural growth and are very widely distributed[17]. However, without a high degree of tectonic deformation (unlike the Zagros Mountain Belt in Iran and the Kurdistan Region of Iraq), the reservoirs rely on primary porosity and permeability, with fracturing in the carbonate reservoirs only of secondary importance. The situation is different in Kirkuk which is highly fractured and extensively karstified[18].

Other reservoirs are being developed, varying by field, with the Nahr Umr (sandstone) and the Yamama (carbonate) being particularly important. (The Yamama is not shown on the stratigraphic chart above, but lies in the Lower Cretaceous below the Ratawi Formation, and usually contains light oil (37-44° API)). While the Nahr Umr is probably suitable for water injection, other reservoirs will have to be assessed case-by-case. The Yamama has only limited natural aquifer support.

To achieve such a large-scale increase in production, whilst maintaining reservoir pressure, the only practically viable options at this stage are gas or water injection. Currently, much gas produced is flared rather than being re-injected, and the government plans to harness the produced gas for electricity generation[19]. Even if the government accepted using the gas to enhance production, the amount required for injection to realise the targeted production rates would be very large, in excess of that available. Sandstone and most carbonate reservoirs give a better recovery factor under water drive as

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[14] IOF, (2012), *Iraq fields overview,* Iraq Oil Forum

[15] Jreou, G.N, (2012), Increasing of Oil Field Productivity by Implementation of Re-entry Horizontal Injection Well, Case study, International Journal of Engineering & Technology IJET-IJENS Vol: 12 No: 01

[16] http://www.iraqoilforum.com/wp-content/uploads/2010/12/Peter-Wells-Iraqs-Future-Oil-Production.pdf

[17] Ibrahim, M.W.I, (1978), *Petroleum Geology of South Iraq*, Imperial College London

[18] Al-Rawi, M., (2015), *Kirkuk. A Silent Giant* Oilfield, GeoExpro Vol:11 No: 6, http://www.geoexpro.com/articles/2015/02/kirkuk-a-silent-giant-oilfield

[19] Al-Khatteeb, L. and Istepanian, H., (2015), *Turn a Light On: Electricity Sector Reform in Iraq*, Brookings Doha Center, https://www.brookings.edu/wp-content/uploads/2016/06/Alkhatteeb-Istepanian-English-PDF.pdf

shown in Table 1. However, for now, fields with surplus gas could use it for reinjection while waiting for available injection water, if the reservoir conditions are suitable.

More advanced recovery methods are available, included Enhanced Oil Recovery methods, but these are unlikely to be appropriate or viable at the current stage of Iraq's field development. Some such as surfactant or polymer injection are combined with water-floods anyway. Carbon dioxide injection is a highly effective process but requires a large source of low-cost CO_2, not currently available in Iraq. Water-Alternating Gas (WAG) is a process that may be considered and applied in Iraq, but again it requires both water and gas to be available. One improved recovery approach that may be used is the low-salinity waterflood[20], which would require further processing of the injection water (either at the CSSP or at the field location), but which can improve recovery significantly under the right conditions.

As a general rule, to maintain reservoir pressure, 1.3-1.5 barrels of water should be injected for every barrel of oil extracted; however if the aim is to increase pressure, a greater ratio of water should be injected. Furthermore, water driven recovery achieves better recovery in the majority of sandstone and limestone reservoirs[21]. This is elaborated in Table 1 which shows the average recovery factor (RF) of a randomly selected group of fields with different reservoir specifications – water drive yields the highest recovery.

Table 2 - Recovery scenarios of various reservoirs[24]

Main drive	Fields	With support	Lithology	Recovery factor
Water	72		Sandstone	51%
Water	39		Limestone	44%
Gas cap	14		Mixed	33%
Solution gas	60	Yes	Sandstone	28%
Solution gas	21	Yes	Limestone	22%
Solution gas	77	Yes	Sandstone	21%
Solution gas	21	No	Limestone	18%
Gravity	10	No	Sandstone	57%

Whilst Table 1 highlights the general trend of sandstone and limestone reservoirs, these results may not apply exactly to Iraqi fields. A specific analysis of water injection in the Rumaila field is shown below, in Table 2, covering the effect of horizontal and vertical wells and increasing the injection and production rates. The optimum case yielding a recovery of 78.96%[22] was with vertical injectors and horizontal producers; however an increase in water injection saw an increase in the cumulative oil production regardless of the well configuration.

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[20] Alhuraishawy, A.K., Imqam, A., Wei, M. and Bai, B. (2016), Coupling Low Salinity Water Flooding and Preformed Particle Gel to Enhance Oil Recovery for Fractured Carbonate Reservoirs, Society of Petroleum Engineers SPE-180386-MS

[21] Arps., J. J., Brons, F., van Everdingen, A. F., Buchwald, R. W. and Smith, A. E.: "*A Statistical Study of Recovery Efficiency*" Bulletin 140, API, 1967

[22] Albeit this recovery factor is unrealistically high for a real reservoir

Table 3 - The effect of an increase in water injection on cumulative production on the Rumaila field[23]

Scenario	Cumulative oil production, 2011-2020 (MMbbl)	Incremental recovery over base scenario	Ultimate recovery factor
Base	1564		36.35%
1: Increased injection & production rates	1698	15.6	39.46%
2: As 1 but with horizontal injectors	2118	26.2	49.21%
3: As 1 but with new re-entry horizontal producers	3398	23.6	78.96%
4: As 2 but with new re-entry horizontal producers	3364	22.6	78.16%

The importance and success of water injection is therefore highlighted by the example of the Rumaila field. Water injection into its Zubair (sandstone) reservoir began in 1978 and the Mishrif (carbonate) reservoir saw water injections start in 2010[24]. Operators have suggested that without water injection, Rumaila's production would fall as much as 17% annually[25]. Figure 3 shows how the introduction of water injection has significantly increased the recovery factor of Rumaila, and maintained its reservoir pressure.

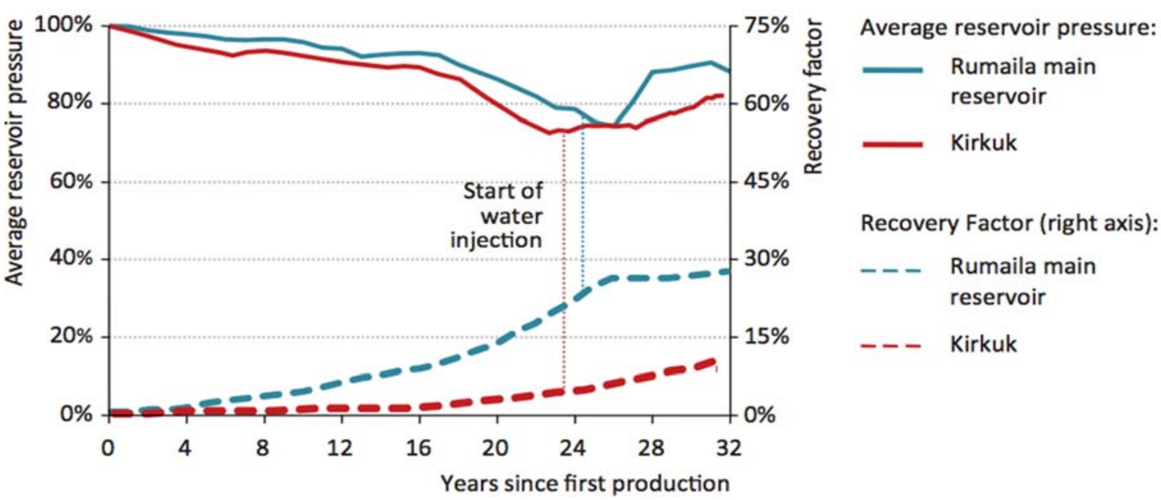


Figure 3 - Reservoir Pressure and Recovery Factor as a result of water injection in the Rumaila and Kirkuk Fields

[23] Jreou, G.N, (2012), Increasing of Oil Field Productivity by Implementation of Re-entry Horizontal Injection Well, Case study, International Journal of Engineering & Technology IJET-IJENS Vol: 12 No: 01

[24] Salim, B. et al. (2013), *Water Flood Management of the Mishrif Reservoir, Rumaila Field, Southern Iraq,* Second EAGE Workshop on Iraq

[25] Roopscmsr, (2016), *Water: vital for Rumaila's future,* Rumaila Operating Organization

Before its application by IOCs in recent years, Iraq had relatively little experience with water injection. Gas injection began in Kirkuk in 1954 and was followed by gravity-driven water injection into the Kirkuk Main Limestone in 1961, into the Amsha Saddle between the Baba and Avanah Domes, where the Lesser Zab River crosses the field on its way to the Tigris[26]. One injection well was required for every four producing wells. Many wells were lost to water breakthrough and the water left bypassed oil in the matrix, in this complex fractured carbonate reservoir.

In the small Ain Zalah field in northern Iraq, water injection began in 1970 into the fractured carbonates of the Lower Shiranish formation. This led to water breakthrough which was handled by processing facilities at the field.

Water injection began in the North and South parts of the Rumaila field into the Zubair reservoir (sandstone) in 1978 as noted above. The injected water was insufficient and below-specification, and not properly monitored. Many wells were lost to water breakthrough.

Estimated recovery factors for reservoirs in Iraq are relatively low by international standards, particularly for reservoirs with little or no production history (Figure 4). Even though higher-quality reservoirs have presumably been selected first for development, this chart does suggest that recovery factors from undeveloped reservoirs can be expected to rise substantially, given the application of suitable secondary recovery methods.

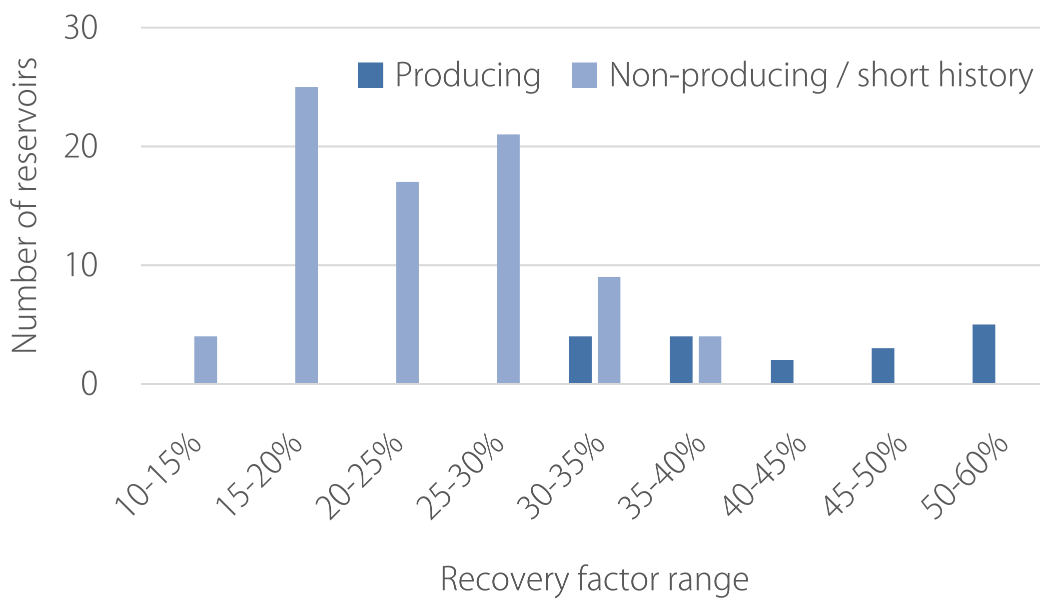
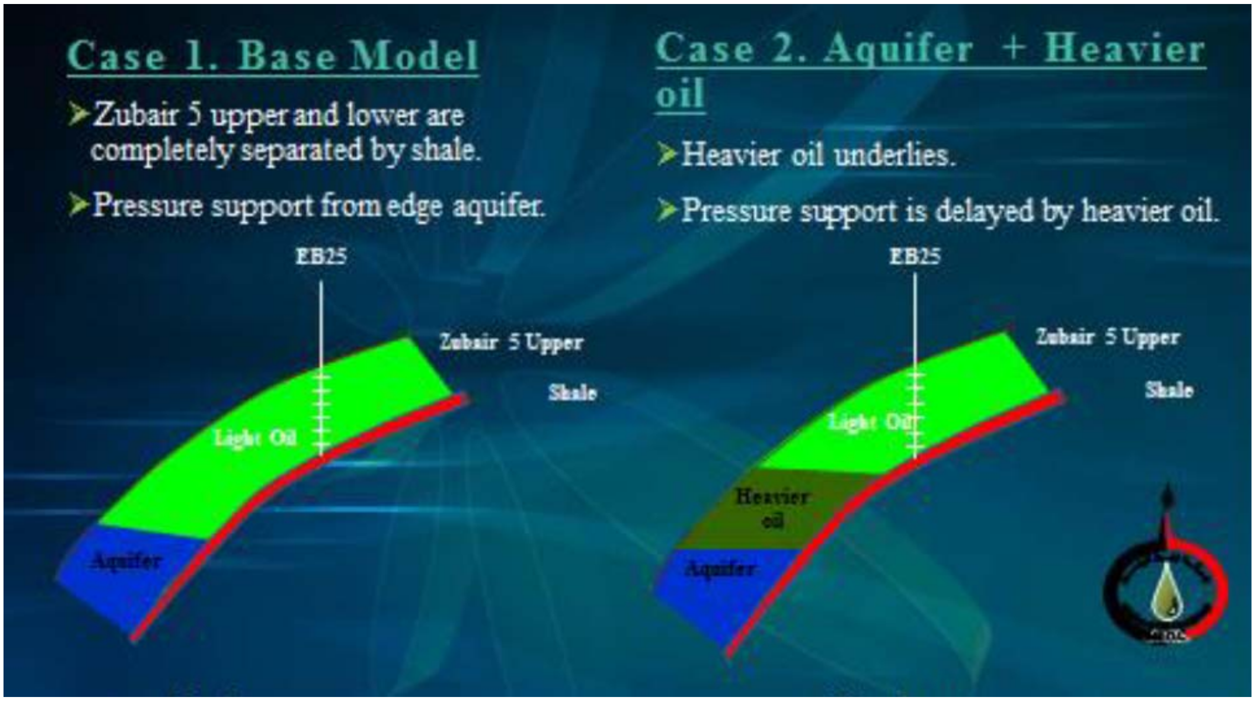


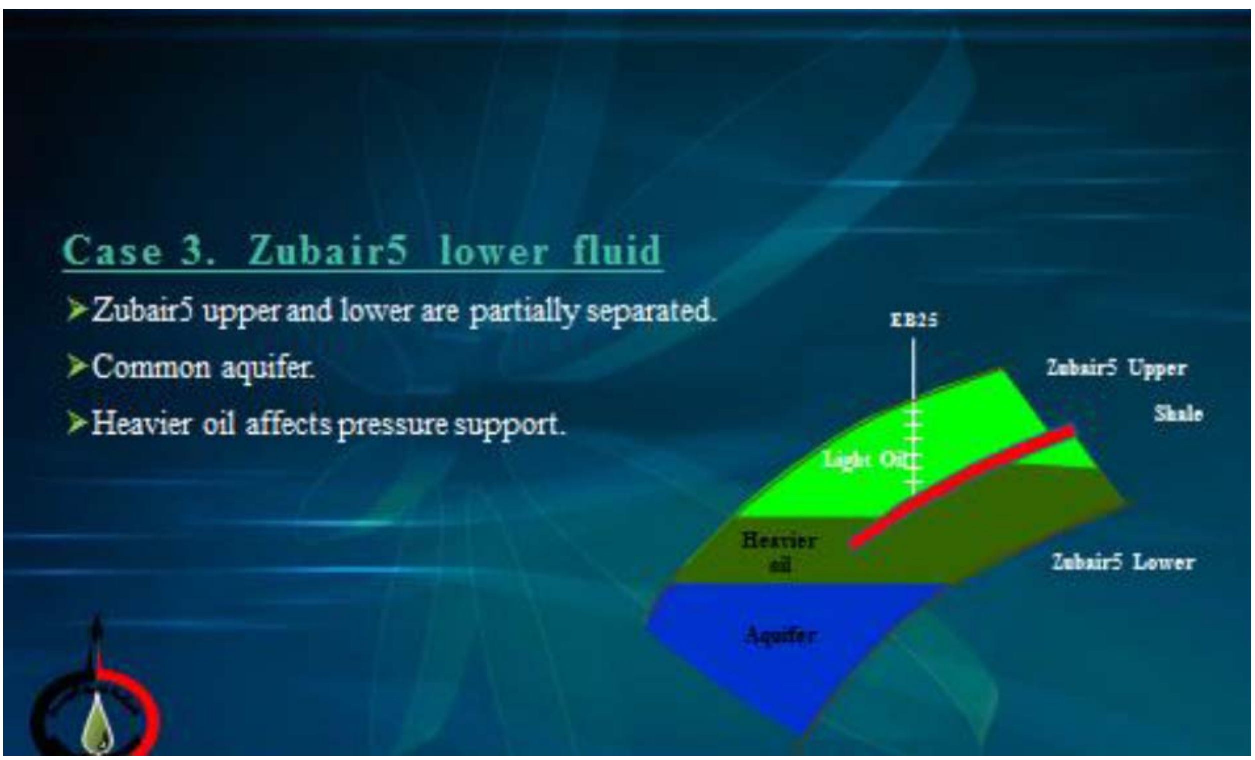
Figure 4 Estimated recovery factor for Iraqi reservoirs[27]

[26] (Saad Z. Jassim, 2008), p233

[27] Based on Uqaili, T. (18-20th May 2014) 'Iraq Common Seawater Supply Project (CSSP)' IEF Amman

The degree of natural pressure support also has an impact on the amount of water injection required.





Iraq could (and has) increased its production in the short term without injecting any water but this would not be sustainable. Water injection therefore appears as the most viable solution - it is the most common secondary recovery method in the world[28] and many southern Iraqi fields are already using it. The amount of water required is estimated to be 9-11 million barrels per day to boost production to the target amount and as Figure 5 shows, the current water use is minor in comparison at around 1 million barrels per day.

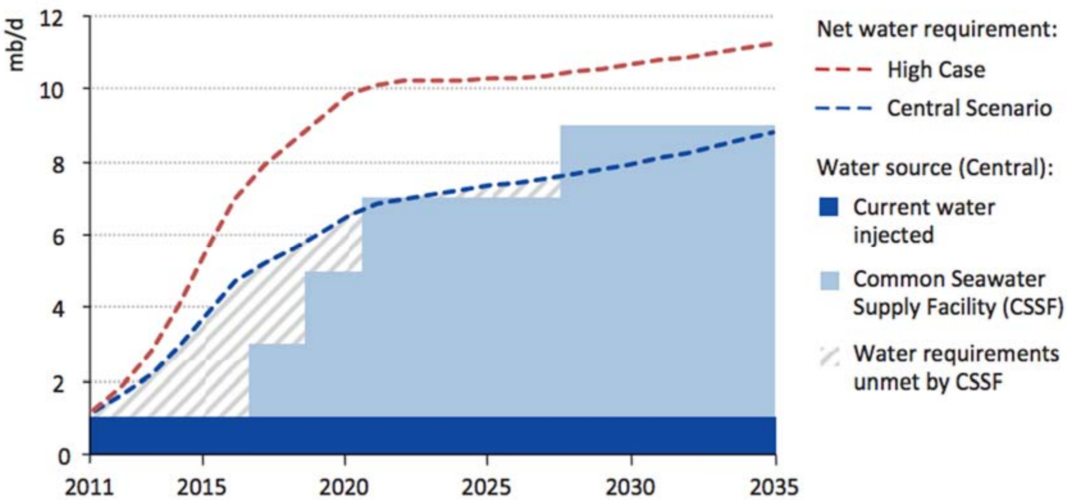


Figure 5 - Net water requirement for injection in Southern Iraq

[28] Aminshahidy, B. et al. (2013), Comparison Between Gas Injection and Water Flooding , in Aspect of Secondary Recovery in One of Iranian Oil Reservoirs, Global Journal of Science, Engineering and Technology

Water sources and availability

Iraq experiences very little rainfall and is reliant on the rivers Euphrates and Tigris for almost all of its water needs[29]. Climate change has exacerbated droughts across the Middle East, and the Iraqi problem is worsened by lower rainfall, increased evaporation in higher temperatures, decreased water discharges by the Euphrates and Tigris, increased Iraqi population and outdated water policies within the country[30]. Many farmers have been forced out of the industry due to lack of water for their crops, and digging wells to revive the situation has proved futile as many wells have either turned out to be dry or to produce water not fit for irrigation[31]. A country that was agriculturally self-sufficient in the 1950s[32] now relies on importing foods that were once exported. Indeed, Iraqi Kurdistan reports that almost 90% of its food is now imported: a lack of water is cited as the main reason behind this[33].

This water situation seems likely to worsen further rather than improving. Studies show that the temperature is to increase in Iraq by 1°C over the next thirty years, and by almost 3.5°C by the end of the century, inevitably increasing the rate of evaporation, which currently stands at 15 mm daily in some regions in the summer months. An increase in temperature by 3.5°C will increase the evaporation to more than 8.9 billion m^3. The UN predicts the winter rainfall (September-November) will decrease by 10-20%, and upstream along the Euphrates expects the snow coverage will decrease from 170,000 km^2 to 33,000 km^2. This would reduce the precipitation by 100 mm a year at the end of the century, equating to a 22% fall in the Euphrates' discharge[30].

Water security has been an integral issue for Iraq, and the advent of Da'esh (ISIS) has made matters worse. Da'esh's strategic capture of dams across Iraq aggravated the short-term water shortage problem, but the long-term consequences seem direr. Their partial closure of the Ramadi dam results in more water exiting the Euphrates and entering into the Habaniyah Lake, which Iraqi officials have labelled as an *"environment catastrophe";* contributing to the drainage of the southern Iraq marshes[34].

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[29] Schwartzstein, P, (2014), *Amid Terror Attacks, Iraq Faces Water Crisis*, National Geographic

[30] Alzaidi, M, (2014), *The Iraqi Water Resources, Availability and Management,* Iraq Future Energy Amman 18-20 May 2014, IEI Library

[31] Al-Obaidi A (2015) Iraq facing crisis as water supplies dry up, *The New Arab*

[32] Helen Chapin Metz, (1988), ed. *Iraq: A Country Study*. Washington: GPO for the Library of Congress

[33] Ekurd Daily,(2015), Iraqi Kurdistan imports over 90% of its food: ministry, Ekurd Daily

[34] Paraszczuk, J,(2015), ISIS is waging a 'water war' in Southern Iraq, Business Insider

Rivers

The River Euphrates and Tigris cross Iraq from north to south, and whilst 54% of the Tigris and 46% of the Euphrates lies within Iraq, they are affected by Syria, Turkey and Iran who are building dams upriver. The Tigris is joined within Iraq by the Greater Zab, Lesser Zab and Diyala Rivers. Turkey has blocked 22 out of 42 waterways leading to Iraq[35], and built approximately 140 dams upstream leading to a loss of 60% by the Tigris and 80% by the Euphrates of discharge into Iraq. Iran built two dams on the Diyala tributaries, reducing the discharge into the Tigris in Iraq by 20%[36]. The Kurdistan Region of Iraq is also planning a number of dams[37] although these have made little progress to date due to financing constraints. The continuing Syrian civil war also makes it impossible to incorporate Syria, which supplies 9% of the flow of the Euphrates and a considerable portion of its water storage and withdrawals, within rational regional water management.

This makes it difficult for Iraq, a downstream country, to manage its water resources when the discharge of the rivers is almost entirely manipulated by upstream riparian countries, who are executing their own water management projects without entertaining any water-sharing agreements[38]. Iraq's own political weakness and dysfunction puts it in a weak bargaining position against the two regional powers Turkey and Iran.

As shown in Figure 6, Iraq is located downriver – this holds an additional geographical disadvantage whereby rivers evaporate downstream resulting in Iraq's soil having increased salinity, rendering it infertile. Iraq's relatively flat terrain does not serve as an advantage either because it hampers the environment's ability to drain silt naturally, and does not provide many optimum locations to build dams[39]. Therefore even if water was taken from these rivers, they would only be able to supply 10% of the quantities required by the southern oil fields[40]. The water quality in the Tigris is significantly better than that in the Euphrates, which reaches a salinity of 2000-3500 ppm near its confluence with the Tigris[41].

[35] Schwartzstein, P, (2014), *Amid Terror Attacks, Iraq Faces Water Crisis*, National Geographic

[36] Alzaidi, M, (2014), *The Iraqi Water Resources, Availability and Management,* Iraq Future Energy Amman 18-20 May 2014, IEI Library

[37] Rudaw (19th March 2017), *Twenty new dams to offset shortage of water in Kurdistan, minister says*, http://www.rudaw.net/english/business/19032017

[38] Ambassador Janabi, H,(2013), *Water Security in Iraq*, Iraqi Economists, Letter from Permanent Representative of Iraq To the UN Food and Agriculture Organization (FAO) And other Rome-based UN Agencies

[39] Helen Chapin Metz, (1988), ed. *Iraq: A Country Study - Agriculture*. Washington: GPO for the Library of Congress

[40] Walk, T, (2015), CSSP – enabling one of the world's top oil producing regions, ILF Engineers

[41] http://www.harcresearch.org/sites/default/files/Project_Documents/Reports1-EuphratesTigris.pdf . Normal seawater is 35000 ppm, while the Gulf reaches 40000-45000 ppm.

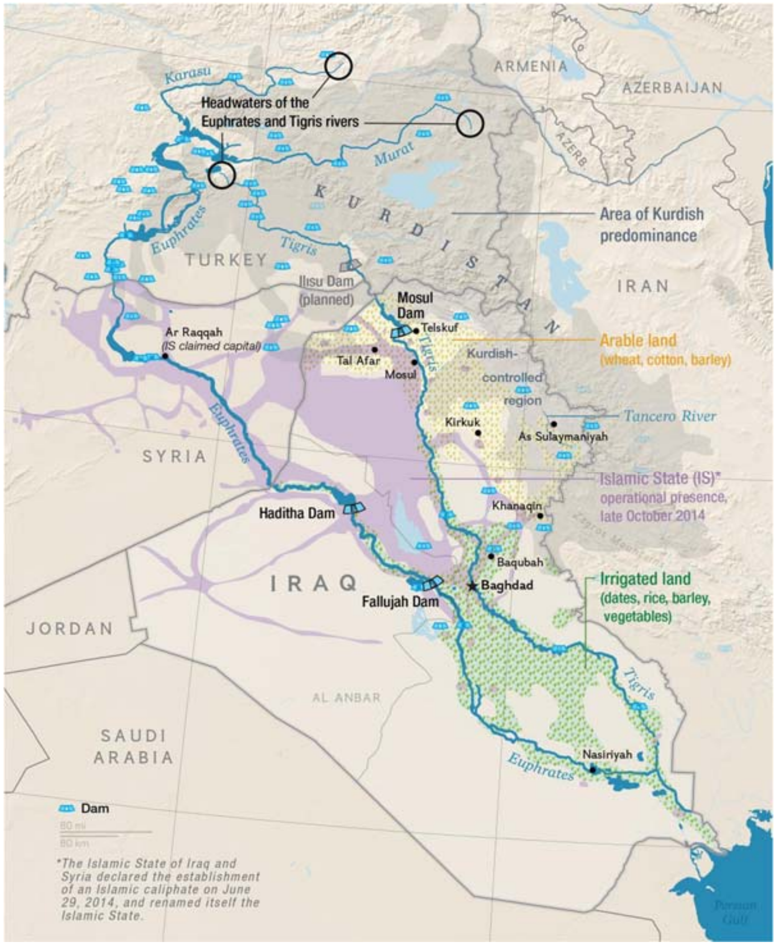

Figure 6 – Map of the water situation in Iraq[42]

Qarmat Ali water treatment plant

Rumaila, West Qurna-1 and West Qurna-2 are currently fed by water from the Qarmat Ali and Shatt Al Arab Waterway Facilities. The Qarmat Ali plant was built in 1970, but was looted and damaged following the US-led invasion[43]. It was repaired in 2004 but suffered repeated breakdowns[44]. It uses industrial-grade water which is not fit for human consumption and whilst this is a very helpful source of water to support oil production, the amount these facilities can deliver is insufficient. Even after the extension was completed in 2016, it can treat 1.3 million bpd of water[45], 10% of what is required for the southern fields.

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[42] Schwartzstein, P, (2014), *Amid Terror Attacks, Iraq Faces Water Crisis*, National Geographic

[43] http://www.gasandoil.com/news/2004/05/cnm42034

[44] https://books.google.ae/books?id=OjM3DTks4ekC&pg=PA181&lpg=PA181&dq=qarmat+ali+water&source=bl&ots=hSKKKl-Cuf&sig=iSwOsiRZngUFBX0_P1eF4Xlru5k&hl=en&sa=X&ved=0ahUKEwi12L_B_NvSAhVLL8AKHSc6C284ChDoAQhBMAk#v=onepage&q=qarmat%20ali%20water&f=false

[45] http://www.veolia.com/middleeast/our-services/achievements/industries/oil-gas/bp-iraq

BP and CNPC increased water injection from Qarmat Ali at Rumaila from 60 kbpd in March 2013 to 900 kbpd by October 2016[46].

Groundwater

Another potential source of water for injection is saline (non-potable) groundwater produced from wells. Saline aquifers with water not usable for agriculture, having salinity of 10 000 ppm or greater, appear to be widespread in southern Iraq[47]. Such water would have to be assessed to ensure it is not suitable for drinking or agriculture, and treated to remove solids or salts which would precipitate in the reservoir. The existence of sufficient volumes of such water at reasonable flow rates from saline aquifers for long-term field development would have to be assured. This option may be more applicable for inland fields which otherwise require long pipelines from the Gulf. The economics of water source wells and treatment facilities would have to be weighed against the cost of water supply via the CSSP.

The attraction of using groundwater for field operators, particularly those remote from the initial phases of the CSSP, is that they would not be dependent on the progress of projects operated by others. They would permit water injection to begin at limited rates while waiting for the CSSP.

Individual facilities

If an integrated system is not ready in time, individual field operators may construct their own systems. For instance, in 2011 ExxonMobil was evaluating interim water sources beginning at 100 000 barrels per day and scaling up to 1.5-2 million bpd, for West Qurna-1 before the CSSP comes online[48]. ExxonMobil, Lukoil (West Qurna-2) and ENI (Zubair) have submitted schemes to use water, on the scale of 100-250 kbpd each, from Iraq's Third River, an artificial system which runs roughly between the southern courses of the Euphrates and Tigris into the Shatt Al Basra. In 2014, Petronas filed plans to use the Gharraf canal, which links the Tigris and Euphrates, to supply fresh water for its Gharraf field development[49]. In July 2016, Drake & Scull was awarded a $61.5 million engineering, procurement and construction (EPC) contract for a water injection project at the Zubair field[50].

Meanwhile fields closer to the Gulf, such as Zubair, could in principle construct their own seawater schemes.

Such local approaches have the advantage of being simpler to manage, potentially faster, and under the control of the IOCs responsible. This way forward could also be more resilient as it would not be vulnerable to failure at a single point. However, it has the following disadvantages:

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[46] http://www.jwnenergy.com/article/2016/12/new-technologies-immense-water-injection-program-rejuvenates-old-iraqi-oilfield/

[47] http://file.scirp.org/pdf/JWARP_2014090413490170.pdf , p1079

[48] http://www.iraqoilreport.com/news/qa-exxons-iraq-chief-james-adams-5763/

[49] http://www.platts.com/latest-news/oil/amman/oil-companies-seek-independent-water-facilities-27788170

[50] http://www.oilreviewmiddleeast.com/industry/drake-scull-wins-iraq-water-injection-installation-contract

- Volumes of river-water are insufficient for full-scale production from the large fields, particularly when considering the competing uses (agriculture, potable water)
- Individual schemes using seawater are only really practical for fields near the Gulf. More distant fields (Badra, East Baghdad), particularly the smaller ones, would not be able to bear the expense of constructing their own long-distance seawater supply systems;
- Costs would be considerably higher due to duplication (design, project management, rights of way, etc.) and lack of economies of scale;
- Multiple intake facilities would be required, crowding the limited waterfront at Fao;
- Interoperability of the systems may be lost, particularly if different design specifications are used;
- Other value-added options such as the production of desalinated water would be lost;
- The systems would not be easily expanded/extended to cover new fields;
- Recovery of their costs by the IOCs for these systems may be difficult with the MoO;
- The potential for a single financing package would be lost.

Common Seawater Supply Project (CSSP)

History

The Common Seawater Supply Project (CSSP) was conceived in 2010 when it was awarded to ExxonMobil, who was to carry out the design, implementation and operation of the project. ExxonMobil was then excluded from the project in February 2012 by the government who cited poor economics and lack of coordination with the Oil Ministry. It also appears that ExxonMobil's exclusion may have been a reaction to its signing an independent deal with the Kurdish government in October 2011, rather than going through the central authorities[51].

The project was then given in 2012 to Iraq's South Oil Company (SOC), a unit of the Ministry of Oil, who contracted CH2M Hill to provide project management consultancy services, including procurement support for long-lead items, and together they have put forward the overall design and time schedule. In June 2014, ILP Consulting Engineers were awarded the detailed Front End Engineering Design (FEED) contract for the pipeline[40]; FEED for processing facilities was awarded to Parsons in February 2015, and the two FEEDs are therefore currently in progress. PetrolInvest was awarded the contract for high-priority site surveys and Coffey for the environmental, health and safety assessment. Meanwhile, a formal tender request has been issued and the government is waiting for tenders to put forward their bids and proposals to lead the project; without a lead company, the project cannot start[52].

Until now, the government has only allocated in the region of $170 million for the project, distributed as follows:

- $120 million for the services of CH2M Hill, of which $30 million has been paid;
- $30 million dollars for the cost of designs, processing units, tanks and pumps by Parsons as part of the FEED design;
- $20 million for the cost of the design of the pipeline by ILF Consulting Engineers; it is suggested they have already been paid the full amount.

Overall, the government lacks the experience and capacity to deal with such a large contract, and so administrative delays are expected. Bureaucracy has also added to the delays; disputes between the Iraqi Oil Ministry and Ministry of Finance over who should shoulder the cost are blamed. The Oil Ministry has

[51] Wing, J, (2012), Problems With Iraq's Southern Oil Fields' Common Seawater Supply Project, MusingsOnIraq

[52] Walji, M, (2016), *Interview with Hamza Jawahari,* IEI Library

been pushing for the lowest price: initial estimations by IOCs were in the region of $3 billion to build phase 1 (when the planned phase 1 water production was 4 million bpd instead of the current 7.5 million bpd) , but even then the Oil Ministry had requested to put forward a lower price[53]. The government have a price in mind based on international construction prices which takes into account pipe specification, the length of pipe required and the facility costs; however it is argued that calculations based on these standards underestimates the true cost. Based on their own calculations, the government feels that IOCs have been presenting exaggerated prices; initial estimates by ExxonMobil were $12 billion, which was then increased to $18 billion. If these prices were to be accepted, then the overall cost of production would rise significantly – the government feels these costs are already high as they stand due to exaggerated prices of other facilities currently in use by IOCs[52].

It has been suggested that lack of accounting control within the government is the source of a lot of the delayed expenditure. It is said the government only started planning their financial obligations with regards to the project after ExxonMobil signed the contract in 2010; before that there was no clear plan in place. Even then, they had allocated future estimated revenue to cover the financial cost - had a fund been set up with money in place and reserved for this project, there would be no financial problems.

Furthermore, delays were caused by a number of changes within the project design. The output capacity of the first phase was initially set at 5.2 million bpd of water, which was then increased to 7.5 million bpd. This was also the case with the pipeline length, which was increased to 430 km from 120 km. These changes have inevitably led to an increase in the projected cost of the project. This was then followed by the collapse in the oil price in the second half of 2014, which saw a decline in the government budget by over 60%, compounded by the fighting against Da'esh which captured Mosul in June 2014. The Ministry of Finance could therefore not maintain payments to the contractors, who reduced the staff working on the project from 20 to 10 engineers, causing an additional delay.

Presently, even if the designs are complete and a tender comes forward, the government lacks the capital to fund this project due to the fall in oil price, and their subsequent budget deficit. In a letter dated September 6th 2015, the government warned IOCs that energy sector cuts should be expected in 2016, which would shake the confidence of prospective tenders particularly as the government owe in excess of $8 billion to the IOCs as part of their Technical Service Contract (TSC) remuneration[54]. However, for the CSSP, the government has also proposed that the costs are paid in oil to avoid delays and increase confidence of prospective tenders.

Furthermore, to attract more tenders, the project has now been made into an investment project whereby companies can build the facilities at their own expense and then sell the water per barrel[52]. Alternatively, if they want to cooperate with the original government plans, then the Oil Ministry would grant the winning tender access to the undeveloped Nahr Bin Omar field which has an estimated 6.5 billion bbl in reserves[54]. In November 2015, the Ministry of Oil was in negotiations with ExxonMobil and

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[53] Jones, D, (2011), Iraq and IOCs to Build Oil Field Water Injection Plant, Iraq Business News

[54] Bradley, M, (2015), Stalled Oil Field Project Adds to Iraq's Woes, The Wall Street Journal

PetroChina to fund the CSSP in return for being given access to develop Nahr Bin Omar and the Ratawi field (2.47 billion bbl reserves). This was developed into the South Iraq Integrated Project (SIIP), which included the CSSP, the development of the two fields, and development of oil export facilities onshore and offshore, and gas treatment for 1000 MMscf/day.

In November 2016, oil minister Jabbar Al Lueibi instructed SOC to begin with the CSSP at a capacity of 5 million bpd[55], significantly scaled down from the original Phase 1 of 7.5 million bpd (see below).

Plan

The CSSP targets International Oil Companies (IOCs) to provide water to the southern oil fields to maintain their reservoir pressure and maximize oil recovery. Seawater will be used as it is viable in terms of cost and long term supply; it will be taken from the Arabian Gulf via the Khor Al Zubair estuary through an open channel that will be cut to have an intake capacity of 12.5 million bpd.

The project incorporates filtration and treatment facilities to account for the oxygen and solid content of seawater, and the project takes into account the pipeline specifications, reservoir injection specifications and control of the amount of biological growth, scale and corrosion. This includes addressing the breeding cycle of microorganisms, especially copepodes, which occur during March-September with a peak in June, and can form a colloidal mixture which plugs the filters[56].

Figure 7 highlights the facilities required - there will be a pipeline of at least 430 km connecting all the facilities and the fields and as a minimum, the project will include seawater intake and outfall structures, seawater filtration and deoxygenating sections, transportation pumps, power generation facilities and the necessary infrastructure to support, monitor and provide security to the project[57].

Figure 7 - CSSP Facilities Design[58]

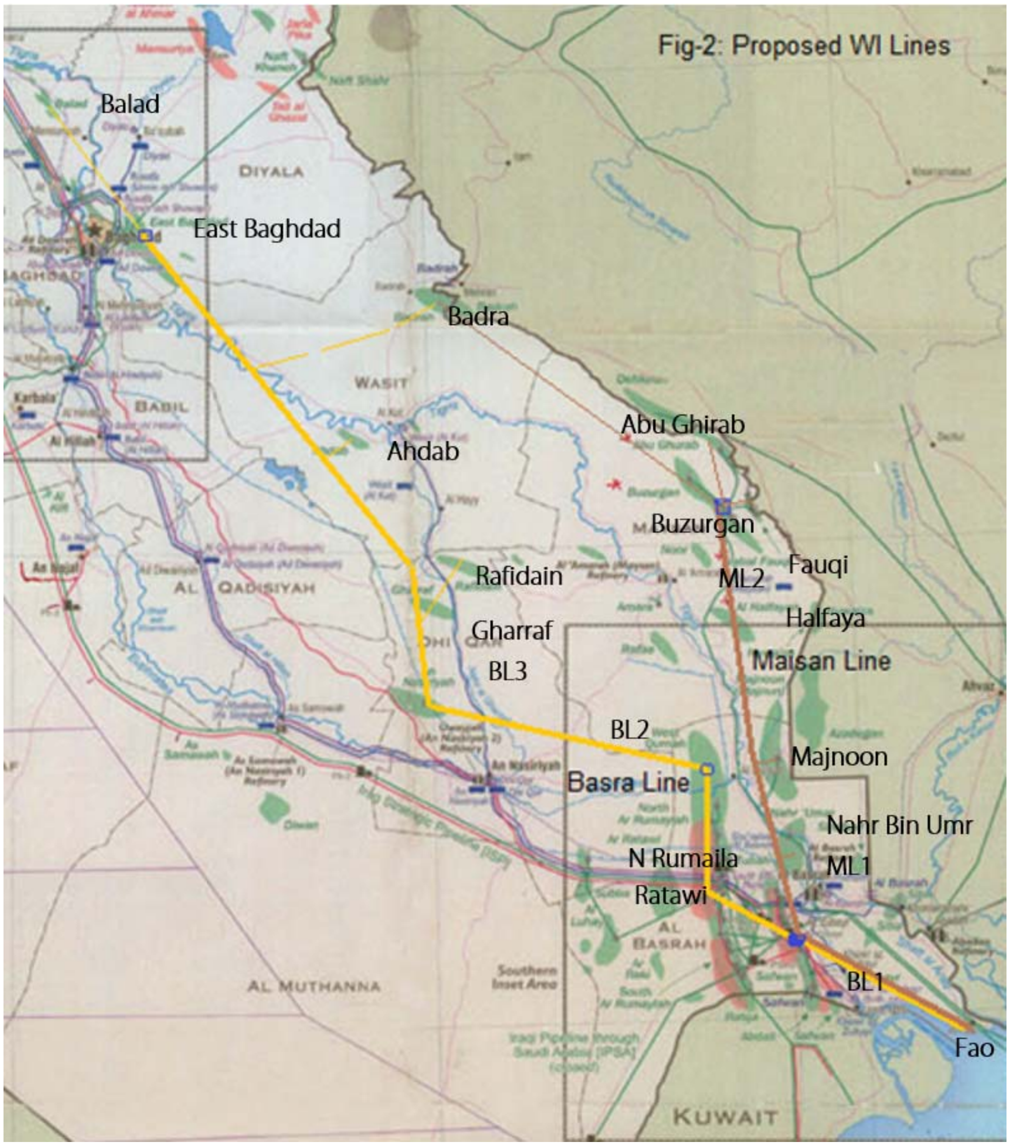
[55] http://www.iraqoilreport.com/news/iraq-pursues-scaled-water-injection-project-20271/

[56] Uqaili, T. (18-20th May 2014) 'Iraq Common Seawater Supply Project (CSSP)' IEF Amman

[57] Ghadban, T, (2010), *CSSP Tender invitation by Iraqi government,* Government Archives, IEI Library

[58] SOC/CSSP (17th January 2015) 'Common Seawater Supply Project' Presentation, Baghdad

The project consists of 2 phases: the first phase will provide water to the oilfields West Qurna-1, West Qurna-2, Rumaila and Zubair; and thereafter Majnoon, Gharraf, Maisan and Halfaya will be incorporated in the second phase. The first phase will have capacity to provide 7.5 million bpd of water, whilst the second phase will provide 12.5 million bpd, however these amounts are subject to change based on negotiations of contracts[59]. Phase 1 was initially set to be completed in 2015, whilst Phase 2 would be completed in 2020. These dates are now, of course, substantially delayed.



[59] SOC, (2015), Common Seawater Supply Project, IEI Library

Field	Plateau target (MoO)[60]	CSSP water injection plan	Possible plateau[61]	Water injection required
Rumaila	2850 → 2100	1000	1470-2285	2100-3300
West Qurna 1	2325 → 1600	1500	2760-4317	4000-6200
West Qurna-2	1800 → 1200	1500		
Zubair	1200 → 850	1200	505-739	730-1100
Majnoon	1800 → 1200	1000	1601-2288	2300-3300
Nahr Bin Umr			903-1355	1250-1800
Ratawi		200[62]	367-551	500-750
Tuba			282-390	380-550
Miscellaneous		50		
Halfaya	535 → 400	750	619-928	850-1300
Maisan Group (Fauqi, Buzurgan, Abu Ghirab)	450	300	450	650
Gharraf	230		140-210	200-300
Ahdab	220		165-254	250-350
Badra	170		90-140	125-200
Nassiriya			430-640	600-900
Rafidain			135-200	190-280
East Baghdad			1510-2160	2100-3000
Balad			445-635	600-900

The CSSP plan as released by SOC has two phases. Phase 1 includes the main fields around Basra (Rumaila, Zubair, West Qurna, and others), with an eastern line up to Majnoon, Halfaya and the Maisan group (Buzurgan, Abu Ghirab, Fauqi), and a western extension to Nassiriya. Its total capacity is 7.5 million barrels of water per day, delivered in three-month intervals as follows: 2 MMbpd to Zubair and Rumaila, 2 MMbpd to West Qurna-1 and West Qurna-2, 2 MMbpd to Tuba and Majnoon, and finally 1.5 MMbpd to Halfaya and Maisan. Phase 2 expands the capacity to 12.5 million bpd though its scope is not spelt out in detail[63].

[60] Original bid and the revisions made after renegotiation from 2013 onwards

[61] Uqaili, T. (18-20th May 2014) 'Iraq Common Seawater Supply Project (CSSP)' IEF Amman

[62] Including Nassiriya

[63] SOC/CSSP (17th January 2015) 'Common Seawater Supply Project' Presentation, Baghdad

However, it is not clear how the Ministry of Oil's latest scaled down scheme, for 5 million bpd of initial capacity, is allocated between the different fields and pipelines.

Further extensions may be needed to cover the smaller fields discussed for development in 2016-17, some of which (such as Kifl, West Kifl and Marjan between Najaf and Karbala, are a long way from the sea and from other parts of the planned system). Additional fields are also being discovered, such as Faihaa in Block 9 between the Majnoon and Nahr Bin Umr fields (2014), and the Eridu discovery made in Block 10 by Lukoil in February 2017, south-west of Nassiriya.

The outline water injection scheme prepared by Dr Thamer Uqaili is somewhat different:
The stages of the project are envisioned as follows:

Phase 1: Basra Line (9.13-13.9 Mbpd)

- BL1 – Fao to Rumaila (3 x 48")
- BL2 – North Rumaila to Nassiriya (2 x 48")
- BL3 – Nassiriya to Manifold 1 to Gharraf and Rafidain (24")

Phase 2: Maisan Line (1.5-1.9 Mbpd)

- ML1 – Fao to Nahr Bin Umr to Halfaya (48")
- ML2 – Halfaya to Buzurgan (28")
- Branches to Majnoon, Fauqi, Abu Ghirab, Badra

Phase 3: Branch from North Rumaila to Tuba and Ratawi (2.13-3.1 Mbpd)

Phase 3/4: Extension lines (1.365-2.03 Mbpd to fields in Dhi Qar and Wasit, 2.75-3.9 Mbpd to East Baghdad and Balad)

- Nassiriya to Ahdab to East Baghdad (48")
- East Baghdad to Balad (16")

Total: 16.875-24.83 Mbpd

It can be seen that the system proposed by Dr Uqaili is considerably larger than Phase 1 and Phase 2 of SOC's CSSP plan. It also explicitly covers a number of 'National Effort' fields, including those such as East Baghdad which are a long way inland. However, once the scope is adjusted down allowing for the reductions in the field plateau targets in recent years, and for further inevitable delays in field development, the difference is not so large. This does emphasise, though, the need for the CSSP to be scaleable and flexible.

The plant can be adapted to produce desalinated water in addition. Indeed the plan revealed by SOC includes an (apparently small) reverse osmosis unit. The cost of desalinated water depends on the energy cost (low in Iraq if natural gas is available), the salinity of the water (rather high in the Gulf), and the method chosen (reverse osmosis and multi-stage flash are the commonest methods). However, very roughly, the cost may be in the range $0.1-0.3 per barrel of water[64]. Producing potable water for use in Basra and the surrounding region would take advantage of the economies of scale of the plant, gain public support, and could be eligible for international financial assistance.

Analogous projects

Saudi Arabia uses large volumes of seawater for injection in its fields. From Qurrayah on the Gulf, the QUAD-2 pipeline brings injection water to Ain Dar in the northern part of the giant Ghawar field and runs on to the Khurais field, while the QUU-4 pipeline takes water to the Uthmaniyah, Hawiyah and Haradh sectors of Ghawar. The system appears to deliver about 9 million bpd of water (consistent with known production of about 6 Mbpd from Khurais and Ghawar, at a 1.5 bbl water:1 bbl oil ratio). With the Khurais pipeline being at least 200 km long, the scale of the system is similar to that of the CSSP. It came into operation in 1978 at 4.2 million bpd and has been expanded since.

Saudi Arabia currently has 50% of its drinking water produced from desalination plants[65], many of which were designed by the same designers of the CSSP, ILP Consulting Engineers[66]. The Saline Water Conversion Corporation (SWCC) manages the Saudi Arabia's water desalination operations and is the biggest such entity in the world. Their plants produce almost 4.6 million m^3 of water per day (27.05 million bpd) through 5,390km of pipeline and 46 pumping stations[67]. One of its recent additions was the Ras Al Khair desalination plant on the Arabian Gulf which after completion in 2014 costing $7.2 billion, produced 1.025 million m^3 of water per day (6.45 million bpd)[68]. This particular plant is more elaborate than the CSSP designs as it incorporates hybrid technology, but the $7 billion price tag should give the Iraqi government of how much such projects should cost. The Ras Al Khair desalination plant, currently the biggest plant of its type in the world, is an adequate comparison to the CSSP; the distance between Ras Al Khair and Khor Al Zubair (where water will be taken for the CSSP) is under 500 km and it produces similar amounts of water to that required from the phase 1 CSSP programme.

Another example is the Esperanza Sea Water Supply System in Chile which specifically caters for the mining industry to avoid water conflict with other users. Similarly to Iraq's dependence on the energy sector, more than 50% of Chilean exports are accounted for by mined copper[69]. The $2.6 billion project involves delivering seawater from the Pacific Ocean, through four pumping stations to the mine site 147 km away and 2300 metres above sea level[70].

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[64] International Renewable Energy Agency (March 2012), *Water Desalination Using Renewable* Energy, https://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20I12%20Water-Desalination.pdf

[65] Saudi Government, (2016), *Shoaiba, Saudi Arabia,* Water Technology Forum

[66] Wrench, (2014*), 2014: IMPLEMENTATION REPORT,* Wrench Smart Project

[67] QWI, (2016), Saudi fires starting gun for SWCC privatization, Global Water Intel

[68] Almashabi, D, (2014), Saudis Start Production at World's Biggest Desalination Plant, Bloomberg

[69] Antofagasta, (2013), *Mining in Chile, Copper Solution,* The Economist

[70] WOMP, (2008), ITT to Supply Seawater Pumps for Esperanza, WOMP Magazine

Economics

The economics of the Phase 1 development at its original scale (7.5 Mbpd) have been calculated under the following assumptions:

- 10% discount rate
- Average operations at 90% of maximum capacity (in practice actual oil production might not be at these levels initially)
- Capital costs of $5.6 billion spread according to SOC estimates ($262 million in Year 1, $1318 million in Year 2, $1916 million in Year 3, $2119 million in Year 4)
- Annual operating costs at 3% of cumulative capex ($168 million per year)
- Operating lifetime of 30 years
- Operations begin in Year 5 (in practice the system might be able to operate at reduced capacity earlier, improving the economics)
- 1.5 barrels of water required per barrel of oil produced

With these figures, the discounted cost of water supplied is $0.33 per barrel, giving an incremental production cost of $0.50/bbl of oil (this does not include the required in-field injection facilities – wells and water-handling). Even allowing for some extra costs and ramp-up time, this still suggests the CSSP is a highly attractive investment yielding very low incremental production costs.

At an oil price of $50 per barrel, 4.5 million bpd of production (the amount supported by Phase 1 of the CSSP) yields $82 billion in revenues per year. Even if a large portion of this could have been produced without the CSSP, it still implies that the system could pay off the Iraqi government within a year. In fact, incremental production of 370 kbpd for the first year of operations, sold at $50 per barrel, would be sufficient to pay off the investment costs plus a 10% annual return on capital.

These very attractive economics imply that:

- There should be no problem in financing the project, as long as properly structured and managed;
- Further delays are very harmful to the Iraqi budget, particularly as oil production growth is hampered by shortages of injection water.

Barriers and challenges

The delivery of solutions to Iraq's water injection requirements, whether the CSSP or other approaches, faces a number of major challenges. Some are the same problems that afflict the Iraqi oil industry and economy in general; others relate specifically to water.

Security

Security is well-known to be a long-running problem in Iraq. Insecurity has prevented a number of oil and gas projects from going ahead entirely, notably in Anbar, Ninewa, Salahaddin and Diyala governorates. The presence of Da'esh, which has lost ground steadily through 2016 and 2017, is not the only security concern that would deter investment into Iraq. There have been physical threats to oil fields and workers in the north[71]. In southern Iraq, where most of the field development projects are underway, problems have included labour protests, kidnapping and extortion. These are dealt with via heavy security but this raises costs. Business development and negotiations in Baghdad are cumbersome and expensive because of the required security, which makes it hard for smaller companies in particular to participate.

Whilst it is almost impossible to paint a rosy picture of the security situation in Iraq, an analysis put forward by the Global Terrorism Database (Figure 8) highlights that only a few scattered attacks had occurred in the south between 2012-2014; the majority lay in the North where the Da'esh stronghold lies. The southern region has generally been securely under control of government forces (though with the influence of militias and criminal gangs), and it has seen few recent attacks on oil fields due to the tight security around producing facilities.

[71] Collins, G, (2015), How ISIS Is Undermining Iraq's Oil Production Potential, OilPro

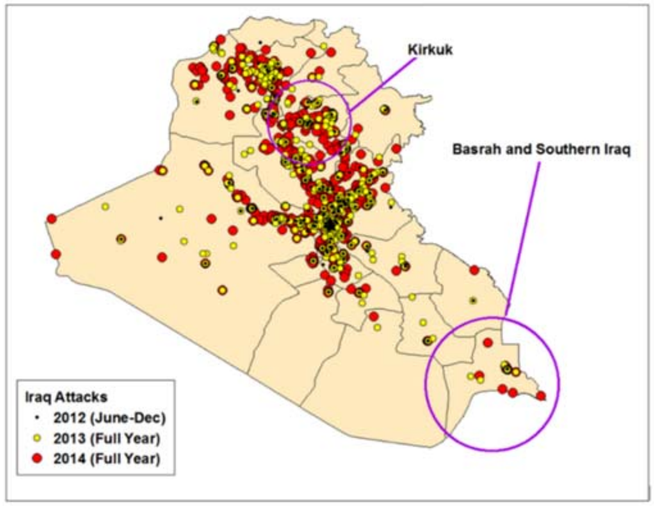

Figure 8 - The location of attacks in Iraq between 2012-2014[72]

For the government, a secure south is by no means a reason to be complacent. This may be advantageous in the short term as it prevents disruptions in productions from its core producing facilities, but lack of security on an aggregate scale brings with it investor fear, the consequences of which are seen in the long term. Investor fear brings with it lack of foreign investment, and sectarian violence distracts the government and prevents internal investment into infrastructure projects like the CSSP[71]. Sectarian differences also bring with them a greater north/south divide. A further divide is between the Arab population of Iraq and the predominantly Kurdish population of the Kurdistan Region, resulting in the Kurdish government not complying with the central government, and selling its oil independently, as it has been doing so recently via Turkey.

A further issue affecting the water injection project is that of unexploded ordnance (UXO) along the pipeline routes, particularly the eastern one up through Majnoon. This can be dealt with by site surveys and UXO clearance but increases costs and the risk of delays.

Bureaucracy

The lengthy bureaucratic process deters many foreign investors from entering into Iraq, delaying decision making which brings with it unnecessary costs and uncertainty. The Oil Minister himself is legally only allowed to authorise projects under $100 million; any project with a value greater than this has to then be referred to the Council of Ministers and there is no fixed timeframe in which they have to respond[73]. There also lies a flaw in the manner in which the government goes about accepting bids for projects; the project is advertised online and in local newspapers and any contact with firms beforehand is strictly forbidden by the ministry. Thereafter, in the interest of competition, a minimum of 3 bids needs to be submitted or else the project is reopened for bidding.

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[72] Author's Analysis, Global Terrorism Database, GADM

[73] Bogan, J, (2009), Iraq's Baby Oil Bureaucracy, Forbes

Policies such as these that directly influence megaprojects like the CSSP; few companies can manage such large projects and therefore having a minimum requirement of at least 3 bids may be unrealistic. Also governments should reach out to companies to encourage them to bid for these projects, rather than expecting them to show up, especially since if companies approach the government, the bureaucratic process may prevent them from ever getting a response.

MoO and SOC have also tended to push for the lowest possible price for work being done, not just on the CSSP but on other projects[74]. While of course Iraq should seek to procure competitively-priced EPC contracts, and there is pressure from anti-corruption agencies to prefer the lowest bid, the authorities also have to bear in mind the quality of work being procured; the capability of the company chosen to deliver; and the fact that when it comes to a vital project such as the CSSP, long negotiations cost far more in the value of deferred or lost oil production than they might gain in cost reductions.

When contracts are finally accepted, the lack of co-operation from the central government means that it can take significant periods of time before work can actually commence. An example is Weatherford who won a contract to drill 20 wells in the southern Buzurgan field in May 2009, but it was not until August 2010 that the first well was drilled. This was due to red tape surrounding expatriate visas and customs clearance on equipment[75]. It therefore comes as no surprise that The World Bank's annual Doing Business Report has consistently placed Iraq towards the bottom of their list over the last few years[76].

Corruption continues to be a serious problem in Iraq. Anti-corruption laws are weakly and selectively enforced and corruption is an integral part of the governing system. Corruption is present on both grand and petty scales. Public procurement and customs are particularly badly affected and of concern to international oil and EPC companies trying to execute projects in the country. Cumbersome anti-corruption procedures, however necessary, further slow down business[77]. Transparency International's 2016 ranking placed Iraq at 166 of 176 countries for the severity of corruption (176 being the most corrupt)[78].

Skills

Iraq faces a lack of skilled labour within the industry which prevents projects from progressing[79]. Current oil contracts stipulate that IOCs must have an 85% local workforce which is difficult to acquire. For comparison, 86% of workers in the Middle East are from abroad[80]. It is estimated that for Iraq to reach its future target of 12 million bpd of oil once the CSSP project is completed, it would require a local force of

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[74] http://musingsoniraq.blogspot.ae/2012/11/problems-with-iraqs-southern-oil-fields.html

[75] Tollast, R, (2013), An Iraqi oil executive's perspective on bureaucracy and paranoia, Your Middle East

[76] World Bank, (2016), Doing Business 2016 - Measuring Regulatory Quality and Efficiency, World Bank Washington DC, 13th Edition

[77] http://www.business-anti-corruption.com/country-profiles/iraq

[78] http://www.transparency.org/news/feature/corruption_perceptions_index_2016

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[80] Dupre, R, (2013), Iraq in Need of Skilled Workers to Finish Existing Developments, Rigzone

at least 5,000-10,000 per million bpd produced[81]. Currently oil exports account for 93% of the government's revenue but only 1% of Iraqis are employed by the oil sector, a number which should be increased by ramping up training facilities for locals[82]. It needs to be recognised that, even with increased employment of Iraqis in the oil sector, it will only provide a small number of direct jobs relative to the total workforce. The improving but still poor security situation, and the continuing flow of refugees and emigrants from the country currently, may take with it qualified personnel that are vitally required to deliver southern oil exports.

Finance

Projects such as the CSSP require much capital, and therefore tenderers need to have the confidence that their costs will be recovered. Iraq has not maintained IOC confidence in its financial management; in 2015 it owed $8 billion to IOCs for 2014 and $18 billion for 2015[83], and whilst around $9 billion of that sum was paid in 2015, $3.679 billion still remained by end-June 2016[84]. However, Iraq understands the importance of settling these financial accounts and has been looking at alternative sources of financing. One of the proposed methods to settle the accounts in oil rather than cash, whilst another proposition is to pay in local currency bonds. China has agreed to underwrite $50 billion of these bonds which would have a 1 year yield of 10% and 3 year yield of 14%, or they could be used as collateral for bank loans or cashed in at a discounted rate[85].

Production planning

The delivery of water for injection depends closely on the planned production levels per field, and on the reservoirs which deliver this (given that different reservoirs may require different ratios of water injection). However, it is difficult for both government and companies to predict future production levels, given the major delays and changes of plan that have affected all the IOC development projects.

Increasing production does not depend only on individual field development plans and the delivery of water injection, but also the infrastructure capacity of the southern region. Its export facilities have been renovated by adding three Single Point Moorings (SPM) to the ports in the south, with a design capacity of only 900,000 bpd. A fourth was installed in 2015 but is not live, being planned to be operational in mid-2017, and a fifth was scheduled for 2016. Storage facilities are also limited, with the Basra terminal having a capacity to store 10.5 million barrels, under a week's production. Plans to build storage facilities to cater for another 5 million barrels are under way but a large-scale expansion of storage, transport and export capacity is required to facilitate the anticipated production rise.

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Conclusions and recommendations

The CSSP, or some version of it, is highly economically attractive and delivers water (and therefore incremental oil production) at very moderate costs. Every year of delay, and the consequent loss of possible oil production, causes large losses to the Iraqi budget.

However, since the CSSP has made limited progress in realisation since 2011, further delays are likely. Even if construction started now, it would not be fully operational until 2020. Delays are due to changes of lead party; changes of approach on the scope and business model; and to lack of financing through the budget, causing more complicated financing schemes to be proposed.

The two main problems with implementation of the CSSP so far are project management; and financing. There are several solutions for appropriate project management. However, Iraq's management of large projects (oil export terminals, gas gathering, power, etc.) in general in the post-2003 period has been very weak. One solution could be a properly empowered team, including members from the project management contractor (CH2M Hill or other), reporting directly to the minister. Rather than a single megaproject, a series of logically integrated smaller steps may be easier to implement.

For financing, the project is, as noted, highly economically attractive, with the right structure. Given the difficulties in funding it through direct government budget allocation, it could be funded by a consortium of international financial institutions, commercial banks, export credit agencies and state development funds (e.g. Chinese, Japanese), with the commercial proposition secured by commitments by IOCs to use certain amounts of water at a given price. The IOCs would recoup their operating costs for the water in the normal way under their TSAs, with the incremental oil production from water injection providing the Iraqi government with the required funds for reimbursement. Given the interest of several large Asian oil companies, notably those from China and Japan, in Iraqi oil developments, and their national objective to secure future oil imports, they could be appropriate backers.

Recommendations

- The CSSP, or some version of it, needs to be implemented without further delay to ensure continued oil production growth. However, plans have to be realistic and consider that, even if begun today, it will take several years to deliver the first water to fields, and hence interim solutions are also required.
- A properly empowered team, including the PMC, reporting directly to the oil minister, could be established to drive the CSSP project forward without further delay.

- Since the project will take several years anyway to start delivering water, interim solutions are required, including the following steps:
    - Water injection availability should be considered when preparing production forecasts and development plans, prioritising the development of fields with easy access to water (particularly those near the Gulf)
    - The production potential of all fields in production and development or on the priority list for development should evaluated, comparing water injection at optimal levels with that from limited water injection (local sources only). This includes National Effort fields as well as IOC-operated fields.
    - Alternative secondary recovery methods, and alternative water sources including saline aquifers, should be evaluated for all fields on the priority list. It could be considered whether re-injection of produced gas should be made mandatory for fields without a sales outlet (to prevent flaring and maintain reservoir pressure).
- The CSSP project can be broken down into a number of separately-implementable, smaller projects. While this may increase final total cost, it would be easier to finance and implement, and would bring forward the date when at least some water is delivered for injection (and hence when incremental oil production begins).
- Financing approaches should be investigated that do not rely on allocations from the government budget, but that are backed by appropriate international lenders and underpinned by guarantees to use the water provided at a certain price, repaid by the incremental oil production.
- The SIIP is overly complicated. The CSSP itself is already a large and complicated (though technically not particularly difficult) project. Bundling it with field developments, gas and export facilities further increases the risk of delays and obscures the underlying economics of the separate projects. The CSSP is sufficiently economically attractive that it should be able to be tendered as a standalone project. Field developments, if attractive, can be offered on their own terms.
- The CSSP would ideally be part of an integrated national strategy for water, which would include the expected water supply from rivers and groundwater, and how much can be safely withdrawn; and the need for desalinated water. However, given the urgency and high value of the CSSP, and the potential delays and difficulties in coordinating with other ministries, it may be necessary to move ahead without a comprehensive plan.

Iraq Energy Institute

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