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Assessing Aquifer Capacity for SAGD Development

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Summary

It has become of high interest in steam assisted gravity drainage (SAGD) to know how much water is an aquifer capable of producing and how dependable its production will be with time. Aquifer capacity is determined by Transmissivity (*T*) as derived from pumping tests. Although the aquifer testing theory provides analytical solutions to estimate *T*, data collected for interpretation may be negatively impacted by well efficiency, a quality-indicator of well completion. Thus, a close approximation of aquifer capacity – a reliable *T* – can only be derived by testing highly efficient wells. This assessment was initiated to investigate aquifer capability of delivering water for SAGD schemes. The results show that average geometric mean Transmissivity was 103 m^2/day, which is an indication of a prolific aquifer. Average Q_{20} rate was 619 m^3/day.

Introduction

Water production in a well is a function of aquifer capacity and well efficiency. Capacity is conventionally determined by Transmissivity (*T*). The higher the Transmissivity, the more prolific the aquifer, with less potential for depletion. While *T* is set by the bulk of aquifer properties and the hydrodynamic regime, well efficiency varies depending on individual well installations. Low efficiency resulting from poorly installed wells may negatively impact water production, lowering it below natural yield. Thus, a close approximation of aquifer capacity – a reliable *T* – can only be derived by testing highly efficient wells

Theory and Methods

Well efficiency is defined as the ratio of the theoretical drawdown in the aquifer to the actual drawdown in the well. The difference between the two is caused by head losses of the water as it moves from the formation to the surface. Well efficiency is calculated from step rate tests (SRT) data. The *Hantush (1964), Bierschenk (1964) and Todd (1980)* methods were used to estimate well efficiency.

$$Efficency = {BQ}/{S_{W_{THEOR}}} \qquad (3), \quad \text{Todd (1980)}$$

Where B represents the linear well loses coefficient, Q is the pumping rate and S_{wTHEO} is the theoretical drawdown. Specific capacity is calculated as SC = 1/B. Transmissivity from SRT data is calculated as T~1.4SC *and is* compared to values derived from constant rate tests (CRT) data. This comparison is useful to later assess heterogeneity.

A total of six water source wells (WSW) were installed and tested for the purpose of this assessment. Each WSW was installed using the telescopic screen method and coupled with an observation well. Aquifer testing consisted of SRT, each one with three to six pumping steps, 30 to 45 minutes long. Step rate tests were followed by long-term, 72-hour CRT.

Examples

Summary results from aquifer testing conducted on each WSW, including the sustainable rate Q_{20} assessment using the *Moell Method* (GoA 2011) are presented in Table 1. Testing results did not indicate presence of boundary conditions (recharge or impermeable barriers).

Table 1 – Summary results from aquifer testing

Well Id	Aquifer Thickness (m)	Available Head[1] (m)	Sustainable Rate-Q_{20} (m^3/day)	Step Rate Test -Q (m^2/day)	Constant Rate-Q (m^3/day)	Constant Rate -T (m^2/day)	Refined Specific Capacity[2] (m^3/day/m)	Well Efficiency % (Hi –Low)
PW-01	50.0	33.1	520	71.1	300	98.8	50.76	95-87
PW-02	46.0	33.3	605	64.5	850	76.9	46.08	93-88
PW-03	46.4	11.4	452	133.3	586	142.0	95.24	98-94
PW-04	62.0	20.3	1244	269.2	1500	190.0	192.31	85-80
PW-05	26.4	26.0	248	36.6	323	32.3	26.11	91-85
PW-06	61.0	24.9	1244	181.8	1000	179.1	129.87	97-91
Geometric Mean			619		611	103	73	

[1] *Above the top of the aquifer*
[2] *Calculated from step rate tests (SRT)*

Results of the well efficiency assessment are shown in Figure 1 and indicate that all wells were efficiently installed with efficiencies between 80% and 100%. Figure 2 shows that T values from SRT and CRT are close to a 1:1 ratio; therefore, T would closely represent the aquifer capacity at the given locations. As efficiency decreases, (e.g. well PW-04) T values are no longer close to a 1:1 ratio. Magnitude of the deviation depends directly on well efficiency – the lower the efficiency, the greater deviation. Thus, aquifer capacity in well PW-04 is expected to be higher when pumping out of more efficient wells (i.e. close to 269. m^2/day from SRT). Figure 2 also illustrates that the aquifer is quite homogeneous. In highly efficient wells, close correlation of T values from SRT and CRT suggest no boundary conditions, barriers, or major heterogeneities, for which T values will potentially deviate from a 1:1 ratio.

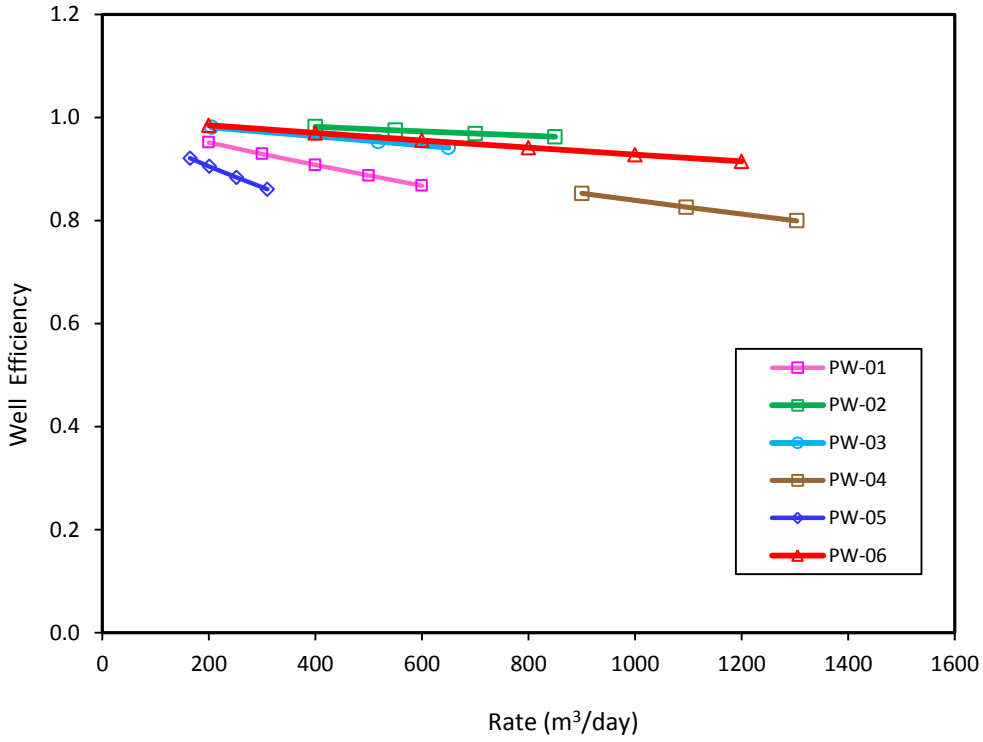

Figure 1 Well efficiency

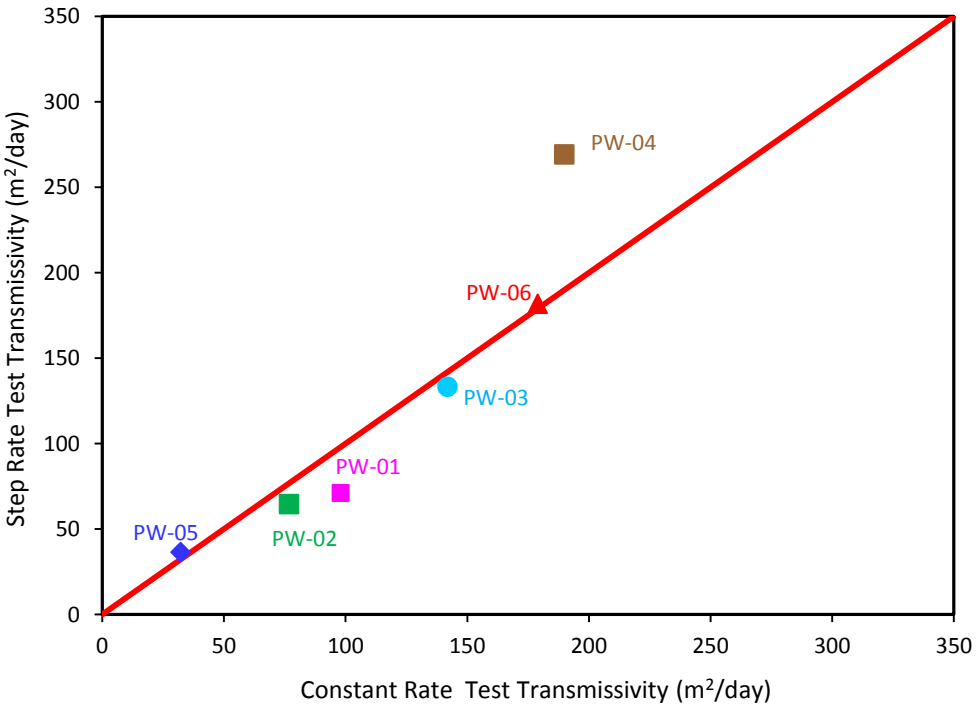

Figure 2 Transmissivity correlation

Conclusions

Results indicate that the assessed aquifer is prolific with enough capacity (*T*) of water supply for SAGD development. The geometric mean Transmissivity, approximately 103 m^2/day, is indicative of a prolific aquifer. Geometric mean for specific capacity of 73 m^3/day/m is also indicative of a prolific aquifer. The Geometric mean for Q_{20}, for single well pumping rates, is 619 m^3/day.

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