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Äspö Hard Rock Laboratory

Prototype Repository

Hydraulic tests and deformation measurements during operation phase

Test campaign 7

Single hole test

Torbjörn Forsmark
SWECO VIAK

March 2007

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

Äspö Hard Rock Laboratory

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Author	Date
Torbjörn Forsmark	2007-03-05
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Ingvar Rhén	2007-03-05
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Abstract

The Prototype Repository Test is focused on testing and demonstrating the function of the SKB deep repository system. Activities aimed at contributing to development and testing of the practical, engineering measures required to rationally perform the steps of a deposition sequence are also included in the project but are also part of other projects.

The objective of the single-hole tests is to estimate the transmissivity of the Hydro Mechanical (HM) test sections equipped with deformation sensors.

Single hole tests are done in 8 boreholes of the Prototype Repository tunnel. In some of the holes several tests are made. The pressure change (dp_p) is limited to approximately 100 metres of water, 200 metres of water and finally a maximum possible pressure change (i.e open the flow control valves entirely) respectively.

There are two HM sections in KA3544G01 and KA3550G01, which however could not be tested due to packer system failure. In the G-tunnel there is a hole with a HM-equipped section used as a reference hole. The results are shown in the table below.

An alternative evaluation method (Dougherty, Babu, 1984), is used using the software AQTESOLV and detailed in the appendices. All data from the earlier test campaigns 1–6 have been re-evaluated and are considered as the results that should prevail from now on. The result from test campaign 7 using the alternative method is shown in the table below.

Table 1. Results from the test campaign 7. (1) Indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	HM section	dp_p (m)	Specific capacity (m^2/s)	T_{MOYE} (m^2/s)	T_{eval} (Jacob's) (m^2/s)	Skin factor (Jacob's) (-)	T_{eval} (Dougherty & Babu) (m^2/s)	Skin factor (Dougherty & Babu) (-)
KA3550G01:2	X	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	X	max	$1.2 \cdot 10^{-9}$	$8.0 \cdot 10^{-10}$	$4.6 \cdot 10^{-10}$	-1.6	$8.0 \cdot 10^{-10}$	-0.2
KA3554G01:2	X	~100	$1.1 \cdot 10^{-7}$	$7.1 \cdot 10^{-8}$	$4.5 \cdot 10^{-7}$	17	$5.3 \cdot 10^{-7}$	20
KA3554G01:2	X	~200	$9.3 \cdot 10^{-8}$	$6.0 \cdot 10^{-8}$	$4.0 \cdot 10^{-7}$	19	$4.6 \cdot 10^{-7}$	22
KA3554G01:2	X	max	$8.1 \cdot 10^{-8}$	$5.2 \cdot 10^{-8}$	$3.7 \cdot 10^{-7}$	22	$4.4 \cdot 10^{-7}$	26
KA3554G02:4	X	~100	$1.3 \cdot 10^{-9}$	$8.6 \cdot 10^{-10}$	$1.1 \cdot 10^{-8}$	47	$1.1 \cdot 10^{-8}$	50
KA3554G02:4	X	max	$1.8 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-8}$	35	$1.1 \cdot 10^{-8}$	35
KA3548A01:3	X	~100	$1.0 \cdot 10^{-7}$	$6.8 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	-2.0	$8.0 \cdot 10^{-8}$	-2.5
KA3548A01:3	X	~200	$9.3 \cdot 10^{-8}$	$6.3 \cdot 10^{-8}$	$9.5 \cdot 10^{-8}$	-1.5	$8.3 \cdot 10^{-8}$	-1.8
KA3548A01:3	X	max	$8.8 \cdot 10^{-8}$	$5.9 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	-0.9	$8.6 \cdot 10^{-8}$	-1.3
KA3542G01:3	X	~100	$5.2 \cdot 10^{-8}$	$3.4 \cdot 10^{-8}$	$3.4 \cdot 10^{-8}$	-2.0	$4.7 \cdot 10^{-8}$	-1.5
KA3542G01:3	X	~200	$5.0 \cdot 10^{-8}$	$3.3 \cdot 10^{-8}$	$3.3 \cdot 10^{-8}$	-1.6	$4.0 \cdot 10^{-8}$	-1.5
KA3542G01:3	X	max	$4.6 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	-0.2	$3.8 \cdot 10^{-8}$	-0.7
KA3544G01:2	X	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	X	~100	$9.5 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$4.2 \cdot 10^{-10}$	-1.5	$9.0 \cdot 10^{-10}$	0.6
KA3542G02:2	X	max	$1.1 \cdot 10^{-9}$	$6.8 \cdot 10^{-10}$	$5.1 \cdot 10^{-10}$	-1.5	$4.6 \cdot 10^{-10}$	-1.1
KA3563G:4	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3546G01:2	X	max	$5.2 \cdot 10^{-10}$	$3.3 \cdot 10^{-10}$	-	-	-	-
KA3566G01:2	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3572G01:2	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3574G01:3	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3539G:2	X	~100	$1.9 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	$4.7 \cdot 10^{-7}$	-2.3	$6.3 \cdot 10^{-7}$	-1.5
KA3539G:2	X	max	$1.7 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$5.5 \cdot 10^{-7}$	-1.6	$7.2 \cdot 10^{-7}$	-0.8

Sammanfattning

Huvudsyftet med prototypförvaret är att testa och demonstrera funktionen av en del av SKB:s djupförvarssystem. Aktiviteter som syftar till utveckling och försök av praktiska och ingenjörsmässiga lösningar, som krävs för att på ett rationellt sätt kunna stegvis utföra deponeringen av kapslar med kärnbränsle, är inkluderade i projektet för prototypförvaret men även i andra projekt.

Målsättningen med enhålstesterna är att få en uppskattning av transmissiviteten hos de hydromekaniska testsektionerna, (HM), som är utrustade med sprickdeformationssensorer.

Enhålstester gjordes i totalt 8 stycken borrhål. Ett nionde och tionde borrhål är utrustad med HM sensorer men har ej kunnat testas på grund av läckageproblem med de hydrauliska manschetterna. I G-tunneln finns ytterligare ett borrhål med en HM sensor installerad. Det hålet används som referenshål. Resultaten från denna testomgång presenteras i tabellen nedan.

En alternativ metod (Dougherty, Babu, 1984), har använts i samband med utvärderingen av denna testkampanj. Programvaran AQTESOLV har använts vid denna utvärdering. Resultat för testomgång 7 presenteras i tabellen nedan. I appendixdelarna har alla testomgångar 1 – 6 även utvärderats med den alternativa metodiken. Resultaten från utvärderingen enligt Dougherty & Babu anses vara de som skall gälla framöver.

Tabell 1. Resultat från testomgång 7. (1) indikerar läckageproblem med manschetterna, "- " indikerar att inget värde kunnat beräknas med valt utvärderingsmetod. (2) indikerar att ingen test gjordes i detta borrhål denna testkampanj

Sektion	HM sektion	dp_p (m)	Specifik kapacitet ($m^3/s \cdot m$)	T_{MOYE} (m^2/s)	T_{eval} (Jacob's) (m^2/s)	Skin faktor (Jacob's) (-)	T_{eval} (Dougherty & Babu) (m^2/s)	Skinfaktor (Dougherty & Babu) (-)
KA3550G01:2	X	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	X	max	$1.2 \cdot 10^{-9}$	$8.0 \cdot 10^{-10}$	$4.6 \cdot 10^{-10}$	-1.6	$8.0 \cdot 10^{-10}$	-0.2
KA3554G01:2	X	~100	$1.1 \cdot 10^{-7}$	$7.1 \cdot 10^{-8}$	$4.5 \cdot 10^{-7}$	17	$5.3 \cdot 10^{-7}$	20
KA3554G01:2	X	~200	$9.3 \cdot 10^{-8}$	$6.0 \cdot 10^{-8}$	$4.0 \cdot 10^{-7}$	19	$4.6 \cdot 10^{-7}$	22
KA3554G01:2	X	max	$8.1 \cdot 10^{-8}$	$5.2 \cdot 10^{-8}$	$3.7 \cdot 10^{-7}$	22	$4.4 \cdot 10^{-7}$	26
KA3554G02:4	X	~100	$1.3 \cdot 10^{-9}$	$8.6 \cdot 10^{-10}$	$1.1 \cdot 10^{-8}$	47	$1.1 \cdot 10^{-8}$	50
KA3554G02:4	X	max	$1.8 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-8}$	35	$1.1 \cdot 10^{-8}$	35
KA3548A01:3	X	~100	$1.0 \cdot 10^{-7}$	$6.8 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	-2.0	$8.0 \cdot 10^{-8}$	-2.5
KA3548A01:3	X	~200	$9.3 \cdot 10^{-8}$	$6.3 \cdot 10^{-8}$	$9.5 \cdot 10^{-8}$	-1.5	$8.3 \cdot 10^{-8}$	-1.8
KA3548A01:3	X	max	$8.8 \cdot 10^{-8}$	$5.9 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	-0.9	$8.6 \cdot 10^{-8}$	-1.3
KA3542G01:3	X	~100	$5.2 \cdot 10^{-8}$	$3.4 \cdot 10^{-8}$	$3.4 \cdot 10^{-8}$	-2.0	$4.7 \cdot 10^{-8}$	-1.5
KA3542G01:3	X	~200	$5.0 \cdot 10^{-8}$	$3.3 \cdot 10^{-8}$	$3.3 \cdot 10^{-8}$	-1.6	$4.0 \cdot 10^{-8}$	-1.5
KA3542G01:3	X	max	$4.6 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	-0.2	$3.8 \cdot 10^{-8}$	-0.7
KA3544G01:2	X	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	X	~100	$9.5 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$4.2 \cdot 10^{-10}$	-1.5	$9.0 \cdot 10^{-10}$	0.6
KA3542G02:2	X	max	$1.1 \cdot 10^{-9}$	$6.8 \cdot 10^{-10}$	$5.1 \cdot 10^{-10}$	-1.5	$4.6 \cdot 10^{-10}$	-1.1
KA3563G:4	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3546G01:2	X	max	$5.2 \cdot 10^{-10}$	$3.3 \cdot 10^{-10}$	-	-	-	-
KA3566G01:2	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3572G01:2	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3574G01:3	-	max	(2)	(2)	(2)	(2)	(2)	(2)
KA3539G:2	X	~100	$1.9 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	$4.7 \cdot 10^{-7}$	-2.3	$6.3 \cdot 10^{-7}$	-1.5
KA3539G:2	X	max	$1.7 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$5.5 \cdot 10^{-7}$	-1.6	$7.2 \cdot 10^{-7}$	-0.8

Executive Summary

In Tables 1 to 4 below is a summary of the test results of the single hole tests so far. In the heading of each test campaign column is indicated the number of days since the heaters in canister hole 5 (DA3551G01) were turned on.

An alternative evaluation method (Dougherty, Babu, 1984), is used using the software AQTESOLV and detailed in the appendices. All data from the earlier test campaigns 1–6 have been re-evaluated using Dougherty & Babu model and are considered as the results that should prevail from now on.

Table 1. Specific capacity. For each test campaign is indicated the number of days since starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	dp_p (m)	Test campaign 1 (-0 days) ($m^3/s \cdot m$)	Test campaign 2 (-166 days) ($m^3/s \cdot m$)	Test campaign 3 (-270 days) ($m^3/s \cdot m$)	Test campaign 4 (-461 days) ($m^3/s \cdot m$)	Test campaign 5 (-622 days) ($m^3/s \cdot m$)	Test campaign 6 (-935 days) ($m^3/s \cdot m$)	Test campaign 7 (-1236 days) ($m^3/s \cdot m$)
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	$9.4 \cdot 10^{-9}$	$1.6 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$5.8 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$1.5 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$
KA3554G01:2	~100	(2)	(2)	(2)	$1.0 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$9.7 \cdot 10^{-8}$	$1.1 \cdot 10^{-7}$
KA3554G01:2	~200	(2)	(2)	(2)	$8.8 \cdot 10^{-8}$	$8.9 \cdot 10^{-8}$	$8.4 \cdot 10^{-8}$	$9.3 \cdot 10^{-8}$
KA3554G01:2	max	$8.2 \cdot 10^{-8}$	$8.3 \cdot 10^{-8}$	$7.8 \cdot 10^{-8}$	$7.9 \cdot 10^{-8}$	$7.7 \cdot 10^{-8}$	$7.7 \cdot 10^{-8}$	$8.1 \cdot 10^{-8}$
KA3554G02:4	~100	(2)	(2)	(2)	$1.2 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$
KA3554G02:4	max	$1.3 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$1.8 \cdot 10^{-9}$
KA3548A01:3	~100	(2)	(2)	(2)	(2)	$1.1 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$
KA3548A01:3	~200	(2)	(2)	(2)	(2)	$1.1 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$9.3 \cdot 10^{-8}$
KA3548A01:3	max	$1.1 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$9.8 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	$9.3 \cdot 10^{-8}$	$8.8 \cdot 10^{-8}$
KA3542G01:3	~100	(2)	(2)	(2)	$5.8 \cdot 10^{-8}$	$5.9 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$5.2 \cdot 10^{-8}$
KA3542G01:3	~200	(2)	(2)	(2)	$4.9 \cdot 10^{-8}$	$5.4 \cdot 10^{-8}$	$5.4 \cdot 10^{-8}$	$5.0 \cdot 10^{-8}$
KA3542G01:3	max	$5.4 \cdot 10^{-8}$	$4.9 \cdot 10^{-8}$	$4.7 \cdot 10^{-8}$	$4.5 \cdot 10^{-8}$	$4.7 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	$4.6 \cdot 10^{-8}$
KA3544G01:2	(1)	$7.8 \cdot 10^{-10}$	$5.9 \cdot 10^{-10}$	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	$9.5 \cdot 10^{-10}$	$9.5 \cdot 10^{-10}$	$9.5 \cdot 10^{-10}$
KA3542G02:2	max	$5.4 \cdot 10^{-10}$	$4.9 \cdot 10^{-10}$	$1.0 \cdot 10^{-9}$	$9.8 \cdot 10^{-10}$	$9.9 \cdot 10^{-10}$	$9.7 \cdot 10^{-10}$	$1.1 \cdot 10^{-9}$
KA3563G:4	max	$1.7 \cdot 10^{-8}$	(2)	(2)	(2)	$9.3 \cdot 10^{-9}$	(2)	(2)
KA3546G01:2	max	$6.1 \cdot 10^{-10}$	$6.0 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$5.7 \cdot 10^{-10}$	$5.9 \cdot 10^{-11}$	$5.1 \cdot 10^{-10}$	$5.2 \cdot 10^{-10}$
KA3566G01:2	max	$6.8 \cdot 10^{-10}$	(2)	(2)	(2)	$6.4 \cdot 10^{-11}$	(2)	(2)
KA3572G01:2	max	$1.9 \cdot 10^{-10}$	(2)	(2)	(2)	$2.3 \cdot 10^{-10}$	(2)	(2)
KA3574G01:3	max	$8.7 \cdot 10^{-10}$	(2)	(2)	(2)	$1.9 \cdot 10^{-10}$	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	$2.3 \cdot 10^{-7}$	$2.2 \cdot 10^{-7}$	$2.1 \cdot 10^{-7}$	$1.9 \cdot 10^{-7}$
KA3539G:2	max	$1.9 \cdot 10^{-7}$	$3.0 \cdot 10^{-7}$	$2.2 \cdot 10^{-7}$	$2.3 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$	$1.9 \cdot 10^{-7}$	$1.7 \cdot 10^{-7}$

Table 2. T_{MOYE} . For each test campaign is indicated the number of days since the starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	**dp_p (m)**	**Test campaign 1 (-0 days) (m^2/s)**	**Test campaign 2 (-166 days) (m^2/s)**	**Test campaign 3 (-270 days) (m^2/s)**	**Test campaign 4 (-461 days) (m^2/s)**	**Test campaign 5 (-622 days) (m^2/s)**	**Test campaign 6 (-935 days) (m^2/s)**	**Test campaign 7 (-1236 days) (m^2/s)**
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	$8.8 \cdot 10^{-9}$	$1.0 \cdot 10^{-9}$	$8.8 \cdot 10^{-10}$	$3.8 \cdot 10^{-9}$	$8.9 \cdot 10^{-10}$	$9.9 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$
KA3554G01:2	~100	(2)	(2)	(2)	$6.5 \cdot 10^{-8}$	$7.2 \cdot 10^{-8}$	$6.2 \cdot 10^{-8}$	$7.1 \cdot 10^{-8}$
KA3554G01:2	~200	(2)	(2)	(2)	$5.6 \cdot 10^{-8}$	$5.7 \cdot 10^{-8}$	$5.4 \cdot 10^{-8}$	$6.0 \cdot 10^{-8}$
KA3554G01:2	max	$5.2 \cdot 10^{-8}$	$5.3 \cdot 10^{-8}$	$5.0 \cdot 10^{-8}$	$5.1 \cdot 10^{-8}$	$4.9 \cdot 10^{-8}$	$4.9 \cdot 10^{-8}$	$5.2 \cdot 10^{-8}$
KA3554G02:4	~100	(2)	(2)	(2)	$8.2 \cdot 10^{-10}$	$8.2 \cdot 10^{-10}$	$7.5 \cdot 10^{-10}$	$8.6 \cdot 10^{-10}$
KA3554G02:4	max	$8.2 \cdot 10^{-10}$	$7.9 \cdot 10^{-10}$	$7.9 \cdot 10^{-10}$	$7.5 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$	$9.1 \cdot 10^{-10}$	$1.2 \cdot 10^{-9}$
KA3548A01:3	~100	(2)	(2)	(2)	(2)	$7.4 \cdot 10^{-8}$	$7.5 \cdot 10^{-8}$	$6.8 \cdot 10^{-8}$
KA3548A01:3	~200	(2)	(2)	(2)	(2)	$7.7 \cdot 10^{-8}$	$6.8 \cdot 10^{-8}$	$6.3 \cdot 10^{-8}$
KA3548A01:3	max	$7.1 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$6.3 \cdot 10^{-8}$	$5.9 \cdot 10^{-8}$
KA3542G01:3	~100	(2)	(2)	(2)	$3.8 \cdot 10^{-8}$	$3.9 \cdot 10^{-8}$	$4.5 \cdot 10^{-8}$	$3.4 \cdot 10^{-8}$
KA3542G01:3	~200	(2)	(2)	(2)	$3.3 \cdot 10^{-8}$	$3.5 \cdot 10^{-8}$	$3.5 \cdot 10^{-8}$	$3.3 \cdot 10^{-8}$
KA3542G01:3	max	$3.6 \cdot 10^{-8}$	$3.2 \cdot 10^{-8}$	$3.1 \cdot 10^{-8}$	$3.1 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$2.9 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$
KA3544G01:2	(1)	$5.1 \cdot 10^{-10}$	$3.6 \cdot 10^{-10}$	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	$6.1 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$
KA3542G02:2	max	$3.5 \cdot 10^{-10}$	$3.1 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$6.3 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$6.2 \cdot 10^{-10}$	$6.8 \cdot 10^{-10}$
KA3563G:4	max	$5.6 \cdot 10^{-9}$	(2)	(2)	(2)	$5.9 \cdot 10^{-9}$	(2)	(2)
KA3546G01:2	max	$3.9 \cdot 10^{-10}$	$3.9 \cdot 10^{-10}$	$4.1 \cdot 10^{-10}$	$3.6 \cdot 10^{-10}$	$3.6 \cdot 10^{-11}$	$3.3 \cdot 10^{-10}$	$3.3 \cdot 10^{-10}$
KA3566G01:2	max	$4.4 \cdot 10^{-10}$	(2)	(2)	(2)	$4.1 \cdot 10^{-11}$	(2)	(2)
KA3572G01:2	max	$1.3 \cdot 10^{-10}$	(2)	(2)	(2)	$1.6 \cdot 10^{-10}$	(2)	(2)
KA3574G01:3	max	$6.1 \cdot 10^{-10}$	(2)	(2)	(2)	$1.4 \cdot 10^{-10}$	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	$1.5 \cdot 10^{-7}$	$1.4 \cdot 10^{-7}$	$1.4 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$
KA3539G:2	max	$1.3 \cdot 10^{-7}$	$2.0 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$

Table 3. Transmissivity – transient evaluation according to (Dougherty, Babu, 1984). For each test campaign is indicated the number of days since the starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	dp_p (m)	Test campaign 1 (-0 days) (m^2/s)	Test campaign 2 (-166 days) (m^2/s)	Test campaign 3 (-270 days) (m^2/s)	Test campaign 4 (-461 days) (m^2/s)	Test campaign 5 (-622 days) (m^2/s)	Test campaign 6 (-935 days) (m^2/s)	Test campaign 7 (-1236 days) (m^2/s)
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	$4.2 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$	$9.5 \cdot 10^{-10}$	$8.1 \cdot 10^{-10}$	$7.4 \cdot 10^{-10}$	$4.5 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$
KA3554G01:2	~100	(2)	(2)	(2)	$5.7 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$
KA3554G01:2	~200	(2)	(2)	(2)	$5.3 \cdot 10^{-7}$	$4.9 \cdot 10^{-7}$	$4.8 \cdot 10^{-7}$	$4.6 \cdot 10^{-7}$
KA3554G01:2	max	$6.4 \cdot 10^{-7}$	$6.4 \cdot 10^{-7}$	$5.8 \cdot 10^{-7}$	$4.9 \cdot 10^{-7}$	$4.6 \cdot 10^{-7}$	$4.5 \cdot 10^{-7}$	$4.4 \cdot 10^{-7}$
KA3554G02:4	~100	(2)	(2)	(2)	$7.0 \cdot 10^{-9}$	$9.0 \cdot 10^{-9}$	$1.7 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$
KA3554G02:4	max	$2.1 \cdot 10^{-8}$	$2.0 \cdot 10^{-8}$	$1.9 \cdot 10^{-8}$	$1.2 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$	$1.7 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$
KA3548A01:3	~100	(2)	(2)	(2)	(2)	$1.0 \cdot 10^{-7}$	$9.0 \cdot 10^{-8}$	$8.0 \cdot 10^{-8}$
KA3548A01:3	~200	(2)	(2)	(2)	(2)	$1.2 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	$8.3 \cdot 10^{-8}$
KA3548A01:3	max	$1.1 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$9.1 \cdot 10^{-8}$	$8.6 \cdot 10^{-8}$
KA3542G01:3	~100	(2)	(2)	(2)	$4.4 \cdot 10^{-8}$	$5.8 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$	$4.7 \cdot 10^{-8}$
KA3542G01:3	~200	(2)	(2)	(2)	$4.8 \cdot 10^{-8}$	$4.2 \cdot 10^{-8}$	$6.5 \cdot 10^{-8}$	$4.0 \cdot 10^{-8}$
KA3542G01:3	max	$4.5 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$5.5 \cdot 10^{-8}$	$3.1 \cdot 10^{-8}$	$3.5 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	$3.8 \cdot 10^{-8}$
KA3544G01:2	(1)	$1.1 \cdot 10^{-8}$	$7.4 \cdot 10^{-9}$	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	$1.0 \cdot 10^{-9}$	$9.6 \cdot 10^{-10}$	$9.0 \cdot 10^{-10}$
KA3542G02:2	max	$3.6 \cdot 10^{-10}$	$2.7 \cdot 10^{-10}$	$9.3 \cdot 10^{-10}$	$8.7 \cdot 10^{-10}$	$8.6 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$4.6 \cdot 10^{-10}$
KA3563G:4	max	$1.7 \cdot 10^{-7}$	(2)	(2)	(2)	$5.1 \cdot 10^{-8}$	(2)	(2)
KA3546G01:2	max	$6.8 \cdot 10^{-10}$	$1.4 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.1 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$9.6 \cdot 10^{-10}$
KA3566G01:2	max	*$1.3 \cdot 10^{-10}$*	(2)	(2)	(2)	*$3.3 \cdot 10^{-10}$*	(2)	(2)
KA3572G01:2	max	*$3.5 \cdot 10^{-9}$*	(2)	(2)	(2)	*$1.4 \cdot 10^{-8}$*	(2)	(2)
KA3574G01:3	max	-	(2)	(2)	(2)	-	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	$1.1 \cdot 10^{-6}$	$1.2 \cdot 10^{-6}$	$8.8 \cdot 10^{-7}$	$6.3 \cdot 10^{-7}$
KA3539G:2	max	$1.3 \cdot 10^{-6}$	$1.5 \cdot 10^{-6}$	$1.1 \cdot 10^{-6}$	$1.0 \cdot 10^{-6}$	$9.8 \cdot 10^{-7}$	$9.6 \cdot 10^{-7}$	$7.2 \cdot 10^{-7}$

Table 4. Skin factor – according to (Dougherty, Babu, 1984). For each test campaign is indicated the number of days since the starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	dp_p (m)	Test campaign 1 (-0 days) (-)	Test campaign 2 (-166 days) (-)	Test campaign 3 (-270 days) (-)	Test campaign 4 (-461 days) (-)	Test campaign 5 (-622 days) (-)	Test campaign 6 (-935 days) (-)	Test campaign 7 (-1236 days) (-)
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	1.1	-0.5	-0.7	-0.9	-0.4	-1.9	-0.2
KA3554G01:2	~100	(2)	(2)	(2)	26	24	25	20
KA3554G01:2	~200	(2)	(2)	(2)	30	28	28	22
KA3554G01:2	max	43	42	39	32	30	29	26
KA3554G02:4	~100	(2)	(2)	(2)	30	38	90	50
KA3554G02:4	max	100	95	94	58	73	68	35
KA3548A01:3	~100	(2)	(2)	(2)	(2)	-1.4	-2.1	-2.5
KA3548A01:3	~200	(2)	(2)	(2)	(2)	-1.1	-0.6	-1.8
KA3548A01:3	max	0.2	1.1	-1.2	-0.1	-0.4	-1	-1.3
KA3542G01:3	~100	(2)	(2)	(2)	-1	-0.1	-1	-1.5
KA3542G01:3	~200	(2)	(2)	(2)	0.3	-0.9	1.1	-1.5
KA3542G01:3	max	0.1	-1	1.5	-0.9	-0.7	0.2	-0.7
KA3544G01:2	(1)	90	100	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	0.8	-0.1	0.6
KA3542G02:2	max	0.4	-0.5	0.1	0.1	-0.1	-0.9	-1.1
KA3563G:4	max	-	(2)	(2)	(2)	31	(2)	(2)
KA3546G01:2	max	6	10	7	8	9	11	8
KA3566G01:2	max	-	(2)	(2)	(2)	0.1	(2)	(2)
KA3572G01:2	max	-	(2)	(2)	(2)	-	(2)	(2)
KA3574G01:3	max	-	(2)	(2)	(2)	-	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	1.8	2.1	-0.6	-1.5
KA3539G:2	max	3.6	5.7	2.7	1.7	1	0.7	-0.8

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Appendices

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1 Background

1.1 Äspö Hard Rock Laboratory

In order to prepare for the siting and licensing of a spent fuel repository SKB has constructed an underground research laboratory.

In the autumn of 1990, SKB began the construction of Äspö Hard Rock Laboratory (Äspö HRL), see Figure 1-1, near Oskarshamn in the southeastern part of Sweden. A 3.6 km long tunnel was excavated in crystalline rock down to a depth of approximately 460 m.

The laboratory was completed in 1995 and research concerning the disposal of nuclear waste in crystalline rock has since then been carried out.

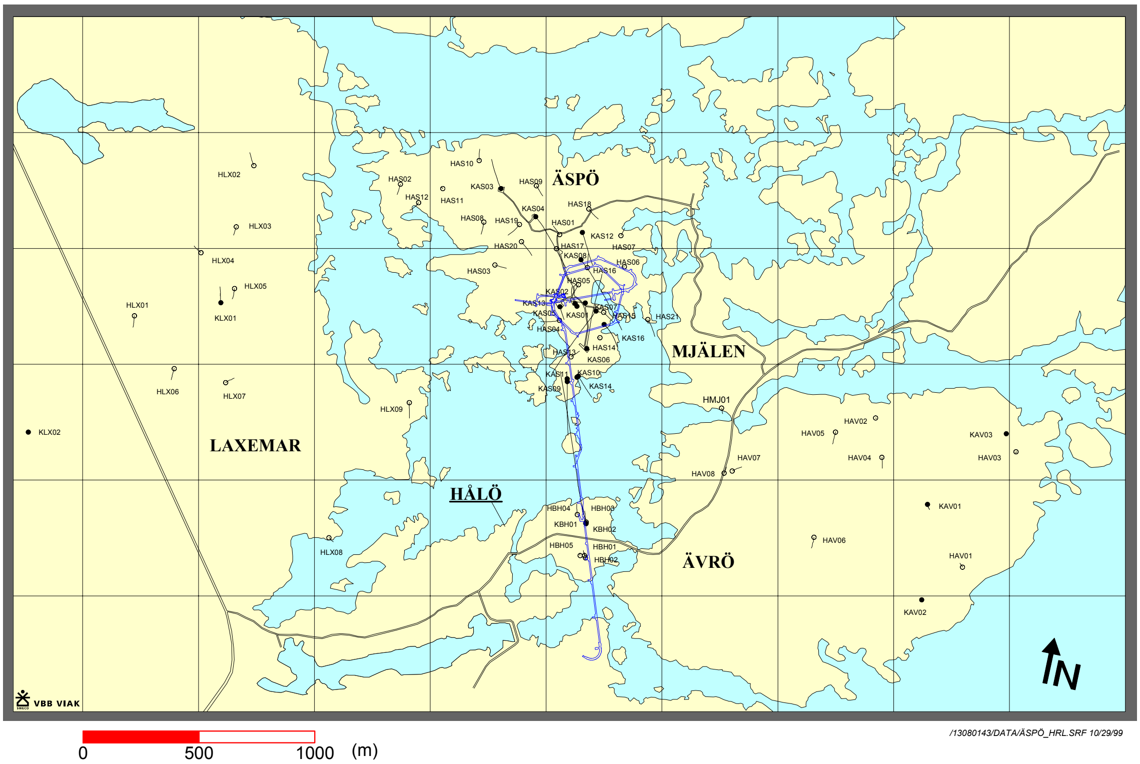


Figure 1-1. *Äspö Hard Rock Laboratory.*

1.2 Prototype Repository

The Äspö Hard Rock Laboratory is an essential part of the research, development, and demonstration work performed by SKB in preparation for construction and operation of the deep repository for spent fuel. Within the scope of the SKB program for RD&D 1995, SKB has decided to carry out a project with the designation "Prototype Repository Test". The aim of the project is to test important components in the SKB deep repository system in full scale and in a realistic environment.

The Prototype Repository Test is focused on testing and demonstrating the function of the SKB deep repository system. Activities aimed at contributing to development and testing of the practical, engineering measures required to rationally perform the steps of a deposition sequence are also included. However, efforts in this direction are limited, since these matters are addressed in the Demonstration of Repository Technology project and to some extent in the Backfill and Plug Test.

1.2.1 General objectives

The Prototype Repository should simulate as many aspects as possible a real repository, for example regarding geometry, materials, and rock environment. The Prototype Repository is a demonstration of the integrated function of the repository components. Results will be compared with models and assumptions to their validity.

The major objectives for the Prototype Repository are:

- To test and demonstrate the integrated function of the repository components under realistic conditions in full scale and to compare results with models and assumptions.
- To develop, test and demonstrate appropriate engineering standards and quality assurance methods.
- To simulate appropriate parts of the repository design and construction process.

The objective for the operation phase program is:

- To monitor processes and properties in the canister, buffer material, backfill and near-field rock mass

2 Objective

The objective of the single-hole tests is to estimate the transmissivity of the Hydro Mechanical (HM) test sections equipped with deformation sensors, *(Alm et al, 2005)*.

3 Scope

Single hole tests are done in 8 boreholes of the Prototype Repository tunnel. There are two more HM sections in KA3544G01 and KA3550G01, which however could not be tested due to packer system failure. In the G-tunnel there is a hole with a HM-equipped section to be used as a reference hole. The tested intervals and basic test data are listed in Table 3-1. The first figure in the test number indicates this being the seventh single hole test campaign, while the second number indicates the chronological order of the single hole tests. The same numbering of the tests as used during test campaign 1 to 6 is used *(Forsmark et al, 2004), (Forsmark, Rhén, 2004a, 2004b, 2004c, 2005a, 2005b, 2005c),(Forsmark,2006)*. Also indicated in the table are the sections where Hydro Mechanical (HM) measurements are done. In chapter 6 the results of the tests are presented.

In some of the holes several tests are made. The pressure change (dp_p) is limited to approximately 100 metres of water, approximately 200 metres of water and finally a maximum possible pressure change (i.e open the flow control valves entirely) respectively.

Table 3-1. Single hole tests during the campaign in September 2006. (1) indicates packer system failure, "X" indicates that section is equipped with HM sensors. (2) indicates no test is done in this campaign

Bore hole	Section (m)	HM section	Single hole test no.	Date of test	Start of test	Flow start	Flow stop	Test stop
KA3550G01:2(1)	5.20-7.30	X	- (1)	-	-	-	-	-
KA3552G01:2	4.35-6.05	X	7:1	2006-09-28	08:00:00	09:00:00	11:00:00	12:00:00
KA3554G01:2	22.60-24.15	X	7:2a	2006-09-25	12:00:00	13:00:00	15:00:00	17:00:00
KA3554G01:2	22.60-24.15	X	7:2b	2006-09-26	09:00:00	10:00:00	12:00:00	13:00:00
KA3554G01:2	22.60-24.15	X	7:2c	2006-09-27	08:00:00	09:00:00	11:00:00	12:00:00
KA3554G02:4	10.50-12.20	X	7:3a	2006-09-26	06:00:00	07:00:00	09:00:00	10:00:00
KA3554G02:4	10.50-12.20	X	7:3b	2006-09-28	11:00:00	12:00:00	14:00:00	15:00:00
KA3548A01:3	8.80-10.75	X	7:4a	2006-09-26	14:00:00	15:00:00	16:00:00	17:00:00
KA3548A01:3	8.80-10.75	X	7:4b	2006-09-27	06:00:00	07:00:00	08:00:00	09:00:00
KA3548A01:3	8.80-10.75	X	7:4c	2006-09-28	06:00:00	07:00:00	08:00:00	09:00:00
KA3542G01:3	18.60-20.30	X	7:5a	2006-09-25	17:00:00	18:00:00	19:00:00	21:00:00
KA3542G01:3	18.60-20.30	X	7:5b	2006-09-26	16:00:00	17:00:00	18:00:00	20:00:00
KA3542G01:3	18.60-20.30	X	7:5c	2006-09-27	16:00:00	17:00:00	18:00:00	20:00:00
KA3544G01:2(1)	8.90-10.65	X	- (1)	-	-	-	-	-
KA3542G02:2	25.60-27.20	X	7:7a	2006-09-28	14:00:00	15:00:00	18:00:00	20:00:00
KA3542G02:2	25.60-27.20	X	7:7b	2006-09-29	04:30:00	05:30:00	08:30:00	10:30:00
KA3563G:4	1.50-3.00	-	- (2)	-	-	-	-	-
KA3546G01:2	6.75-8.30	X	7:9	2006-09-27	11:00:00	12:00:00	15:00:00	17:00:00
KA3566G01:2	20.00-21.50	-	- (2)	-	-	-	-	-
KA3572G01:2	2.70-5.30	-	- (2)	-	-	-	-	-
KA3574G01:3	1.80-4.10	-	- (2)	-	-	-	-	-
KA3539G:2	15.85-17.60	X	7:13a	2006-09-25	15:00:00	16:00:00	17:00:00	18:00:00
KA3539G:2	15.85-17.60	X	7:13b	2006-09-26	12:00:00	13:00:00	14:00:00	15:00:00

4 Equipment

4.1 Description of equipment

A large number of boreholes are instrumented with one or several packers. In all packed-off sections, the water pressure is measured. Each borehole section is connected to a tube of polyamide that via lead-through holes ends in the G-tunnel. All pressure transducers are placed in the G-tunnel to facilitate easy calibration and exchange of transducers that are out of order. The transducers are connected to the HMS system at Äspö Laboratory and it is a flexible system for changing the sampling frequency, see Figure 4-1. The maximum scan frequency is every third second. During periods with no hydraulic tests, the sampling (storing a value in the data base) frequency will be every second hour with an automatic increase of the sampling frequency if the pressure change since last registration is larger than 2kPa. During hydraulic tests, the sampling frequency may be up to every third second.

Figure 4-1. *All pressure transducers are connected to the HMS system. In the G-tunnel there is a computer in the HMS system where logging frequencies easily can be changed.*

4.2 Pressure sensors

The pressure in a borehole is transmitted via a plastic tube directly to a pressure transducer, *see* Figure 4-2.

The pressure transducers are either of the type DRUCK PTX 500 series or DRUCK PTX 600 series with a pressure range of 0 – 50 bar (absolute).

According to the manufacturer the uncertainty for these transducers is +/-0.2 % (type 500) and +/-0.08 % (type 600) of full scale (F.S) for the best straight line (B.S.L.). For the 600 series types the time drift is given to max. 0.05 % F.S., while no figure is given for the 500 series types. Normally, a pressure value is scanned once every third second. If the change since the latest stored value exceeds a "change value" of approximately 2 kPa the newly scanned value is stored. A value is always stored once every second hour, regardless of any changes.

Figure 4-2. *Pressure transducers connections.*

4.3 Flowmeter equipment

A new kind of flowmeter, see Figure 4-3, is used in order to obtain continously flow measurements during the tests. The equipment system used was originally developed by Micro Motion, Inc. in USA, and is comprised of a sensor and a signal processing transmitter. It is called a Coriolis mass flowmeter and measures mass flow directly. The volume flow can be obtained when knowing the temperature, the pressure and finally the density of the fluid (water).

The fluid enters the sensor and travels through the sensor´s flow tubes, which vibrate and twist. The twisting characteristic is called the Coriolis effect. According to Newton's Second Law of Motion, the amount of sensor tube twist is directly proportional to the mass flow rate of the fluid flowing through the tube.

The equipment unit consist of two flowmeters with different measurement ranges. The measurement range for the large flowmeter is 0 to appr. 36 kg/min and for the small flowmeter is 0 to approx. 1.8 kg/min.

Figure 4-3. *The equipment for flowrate measurement with Micro Motion Coriolis mass flowmeter system.*

4.4 Deformation measurements

During storage of nuclear waste in the rock mass the temperature will increase due to the heat loss from the canisters with spent fuel. This will increase the rock stresses and the fractures will generally close, but may locally open due to the stress situation (*Alm et al, 2005).*

It is of interest to investigate the magnitude of this effect on the fracture transmissivity since the fracture transmissivity is essential of two reasons. First, enough transmissivity is needed to provide the bentonite buffer with water if no artificial moistening of the buffer is arranged. Secondly, the transmissivity should be as low as possible in order to minimise the hydraulic contact with the canisters. The increased temperature will decrease the transmissivity, which in principal is positive in perspective of Safety Assessment. The last effect is however limited in time and may not be of any greater importance in Safety Assessment.

Displacement measurements are done continuously. Hydraulic tests will be made a number of times during the operation period for the ten measurement sections. An extra section is also equipped with hydromechanical measurements equipment and is used as a reference hole (KG0010B01). Most tests have been planned to be made during the first years of operation when the largest displacements are expected to occur. This report details the interference results from the fifth test campaign. They are done in order to provide hydrogeological data useful for setting up a hydrogeological model of the rock volume around the TBM tunnel.

In order to investigate the hydro mechanical response of the fractures as a result of the increased thermal load, two different approaches are considered.

The first approach is to measure the change of the fracture width as function of temperature and time. The displacement is both measured for the intact rock as for a section with one or more fractures.

The second approach implies that the mechanical response is evaluated indirect by using the results from hydraulic tests. Single hole hydro tests is performed in the same sections as the mechanical measurements are made (*Forsmark, Rhén, 2004a, 2004b, 2004c, 2005a and 2005c*), *(Forsmark,2006)*.

All results from the hydromechanical measurements will be documented in separate documents.

4.4.1 Measurement equipment

In order to measure the fracture deformation (and to separate the fracture deformation from the deformation of the intact rock) due to the increased temperature a measurement equipment has been developed.

The equipment consists of two hydraulic packers, which hydraulically isolate the test section. Between the packers three anchors are placed. These anchors are fixed to the borehole wall and in the sections between the anchors sensors (strain gage) are mounted. These sections are called mechanical measurement sections. The sensors will register any relative movement between the anchors; see Figure 4-4 and 4-5. The temperature is also measured in each sensor by a thermistor.

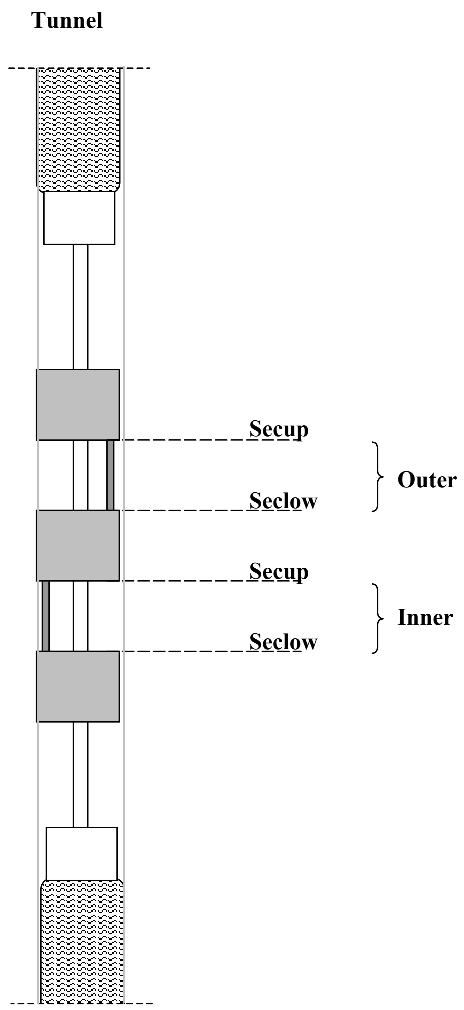


Figure 4-4. *A schematic figure that shows the different parts of the test equipment and also the definitions of the terms outer and inner.*

The deformation is measured in two sections in each borehole. One mechanical measurement section is placed over a fracture (or fractures) and the other mechanical measurement section is placed over intact rock. That makes it possible to separate the fracture deformation from the deformation of the intact rock.

Of all boreholes in the prototype tunnel, ten are equipped as described above. Five of the measurement sections are placed over a single fracture and the rest are placed over two to six fractures, see Table 4-1.

Since hydraulic packers isolate the test sections and the test sections have contact with the tunnel (atmospheric pressure) via tubes and valves it is possible to perform hydraulic tests in the sections.

Table 4-1. Data of the deformation measurement sections (sensors, length, number of fractures etc)

Label	Cable mark	Sensor S/N	Position	Secup	Seclow	Section length (m)	Number of fractures
KA3539G-2-1	HRA 1121	3511	Inner	16.77	16.97	0.20	2
KA3539G-2-2	HRA 1122	3510	Outer	16.47	16.67	0.20	0
KA3542G01-3-1	HRA 1231	3513	Inner	19.47	19.67	0.20	0
KA3542G01-3-2	HRA 1232	3512	Outer	19.17	19.37	0.20	1
KA3542G02-2-1	HRA 1321	3515	Inner	26.50	26.70	0.20	1
KA3542G02-2-2	HRA 1322	3514	Outer	26.20	26.40	0.20	0
KA3544G01-2-1	HRA 1621	3509	Inner	9.82	10.02	0.20	1
KA3544G01-2-2	HRA 1622	3508	Outer	9.52	9.72	0.20	0
KA3546G01-2-1	HRA 1721	3517	Inner	7.67	7.87	0.20	1
KA3546G01-2-2	HRA 1722	3516	Outer	7.37	7.57	0.20	0
KA3548A01-3-1	HRA 1831	3526	Inner	9.70	10.15	0.45	2
KA3548A01-3-2	HRA 1832	3518	Outer	9.40	9.60	0.20	0
KA3550G01-2-1	HRA 2121	3527	Inner	6.10	6.70	0.60	6
KA3550G01-2-2	HRA 2122	3519	Outer	5.80	6.00	0.20	0
KA3552G01-2-1	HRA 2521	3521	Inner	5.25	5.45	0.20	0
KA3552G01-2-2	HRA 2522	3520	Outer	4.95	5.15	0.20	2
KA3554G01-2-1	HRA 2821	3525	Inner	23.54	23.80	0.26	2
KA3554G01-2-2	HRA 2822	3522	Outer	23.24	23.44	0.20	0
KA3554G02-4-1	HRA 2941	3524	Inner	11.40	11.60	0.20	0
KA3554G02-4-2	HRA 2942	3523	Outer	11.10	11.30	0.20	1
KG0010B01-1-1	-	3238	Inner	3.66	3.86	0.20	-
KG0010B01-1-2	-	3507	Outer	3.36	3.56	0.20	-

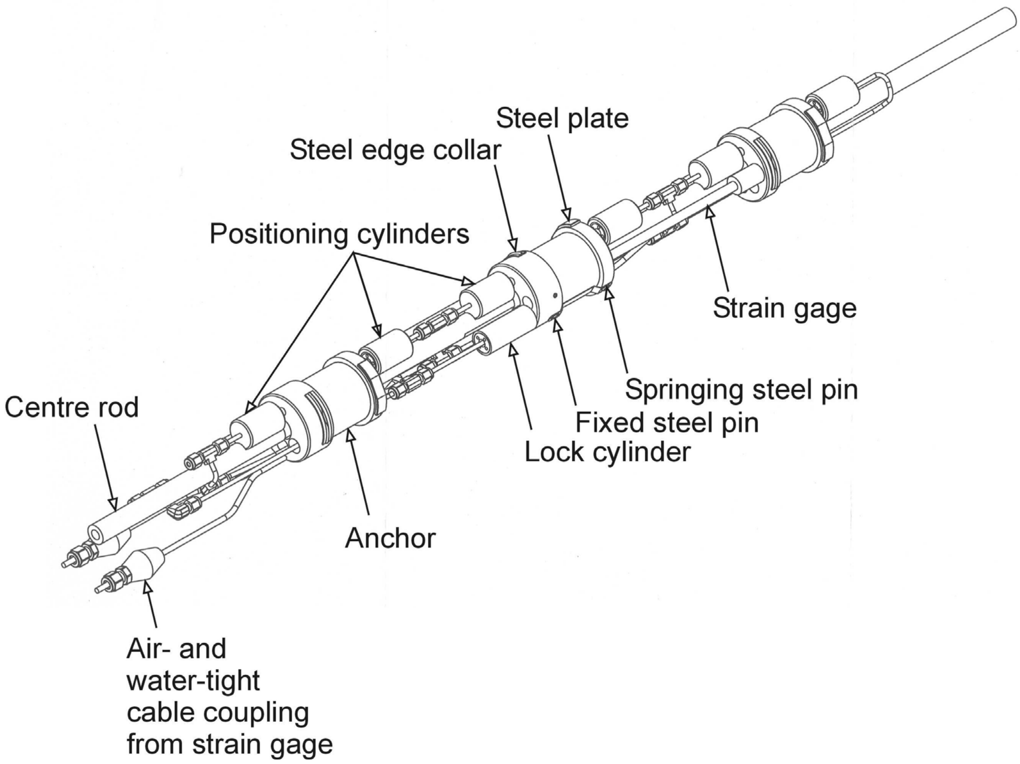


Figure 4-5. *A detailed figure of the three anchors, sensors (strain gage), positioning cylinder etc.*

5 Execution

5.1 Preparations

Planning is an important step in the preparation stage. No other activities, which may cause pressure responses, must occur in the neighbourhood of the test area. Such activities include drilling, blasting and flowing of boreholes.

Preparations also include checking of equipment to be used in the tests. The equipment included

- measuring glasses of various sizes
- synchronizing watches with the HMS system (only normal time)
- protocols for flow measurements
- water sampling bottles
- hand calculator
- flow rate measurement equipment with Micro Motion flowmeter system

5.2 Execution of tests/measurements

5.2.1 Test principle

The main purpose of a single hole pressure build-up test is to do a test, which makes it possible to evaluate the hydraulic properties of the bedrock around the tested borehole section.

5.2.2 Test procedure

The following measurement cycle is used:

- Initialising of the HMS system 30 minutes before flow start with logging interval of 5 minutes
- A couple of minutes before flow start and until 5 minutes after flow start the highest logging interval of 3 seconds are used. Thereafter the logging interval is 30 seconds which is used until 30 minutes after flow start and a logging interval of 5 minutes is then used once again
- The flow is measured manually 2-3 times the first 5 minutes after flow start, 2-3 times the following 60 minutes and 3 times shortly before flow stop
- From shortly before flow stop until 5 minutes after flow stop the highest logging interval of 3 seconds are used. Thereafter the logging frequency is 30 seconds which is used until 30 minutes after flow start and a logging frequency of 5 minutes is then used
- The valve shutting is done as swiftly as possible

5.3 Data handling

The test operator is keeping a diary during the test period. Data from the hydro tests includes:

- Daily logs in accordance with Äspö Hard Rock Laboratory routines
- Protocols from flow measurements

The project coordinator collected all data and delivered it to the data handling responsible person at Äspö for further SICADA handling.

5.4 Analyses and interpretation

5.4.1 Single hole tests

The following description applies to the analysis in this report. The analysis done is for the recovery phase only.

The specific capacity is as mentioned above, Q/s, where Q is the calculated average water flow before shutting the valve and s is the maximum change of pressure, in metres, during the test.

The Moye formula can be used for interpretation of stationary tests in order to get an estimate of the transmissivity

$T_{Moye} = Q \cdot (1 + \ln(L/(2 \cdot r_w))) / (2 \cdot \pi \cdot \Delta h)$ where

$\Delta h = (p_0 - p_p) / (\rho_w \cdot g)$ [m]

L = test section length [m]

r_w = borehole radius [m]

p_0 = absolute pressure in test section before start of flow period [Pa]

p_p = absolute pressure in test section before stop of flow period [Pa]

ρ_w = water density [kg/m^3]

g = acceleration of gravity [m/s^2]

When the skin factor, ξ, is determined, use is made of the fact that the increase in pressure change, Δp, due to the skin effect is constant during the test, *(Blomquist et al, 1985)*. When the straight portion of the recovery curve displayed in a semi-logarithmic diagram is extrapolated to the zero line, this is cut at time t_0 (in minutes). If the skin effect would not exist the same line would cut the zero line at time t_{0f}. This time can be calculated as

$t_{0f} = (S^* \cdot r_w^2) / (135 \cdot T)$ where [min]

S^* = estimated rock storativity (10^{-6} is used in this area) [-]

r_w = borehole radius [m]

T = evaluated transmissivity [m^2/s]

Finally the skin factor is calculated such as

$\xi = 1.15 \cdot \log (t_{0f} / t_0)$ [-]

While plotting the data, three different kinds of graphs are produced. The first plot is made in a linear scale. The time, date and hours is indicated on the horizontal axis. The pressure (p), expressed in bar or metres of water head is indicated on the vertical axis. The second plot is made in a semi-logarithmic diagram, where the pressure change, Δp, is plotted versus the equivalent time, dt_e, in minutes. The equivalent time, dt_e, (*Spane, Wurstner, 1993*) is defined as

$dt_e = (t_p \cdot dt) / (t_p + dt)$ where

t_p = the flowing time of the borehole before shutting the valve

dt = the time after shutting the valve

The pressure change Δp is calculated as

Δp = $p(dt) - p(t_p)$

p(dt) = measured pressure at time dt after shutting the valve

$p(t_p)$ = measured pressure just before shutting the valve

The third plot is made in a logarithmic diagram, where the change of pressure, Δp, is plotted versus the equivalent time, dt_e, in minutes. The derivative of the pressure is also plotted in this diagram.

The pressure normally is signed using the p and a change of pressure using a Δp. In the diagrams the pressure can be expressed in bar, kPa or in metres of water head. In the formulas below however the praxis is to use the s for the change of water head and Δs for the difference of pressure over one decade in a logarithmic diagram. The s or Δs values shall be expressed in metres before used in the formulas.

Hydrologic test analysis based on the derivative of pressure (i.e., rate of pressure change) with respect to the natural logarithm of time has been shown to significantly improve the diagnostic and quantitative analysis of slug and constant-rate discharge tests (i.e., pumping tests) (*Spane, Wurstner, 1993*). The improvement in hydrologic test analysis is attributed to the sensitivity of the derivative response to small variations in the rate of pressure change that occurs during testing, which would otherwise be less obvious with standard pressure change versus time analysis techniques. The sensitivity of pressure derivatives to pressure change responses facilitates their use in identifying the presence of wellbore storage, boundaries, and establishment of flow conditions, as e.g. radial flow, within the test data record. Specifically, pressure derivative analysis can be used to:

- diagnostically determine formation response (homogeneous vs. heterogeneous) and boundary conditions (impermeable or constant head) that are evident during the test,
- determine when radial flow conditions are established and, therefore, when straight-line solution analysis of drawdown data is valid, and
- assist in log-log type-curve matching to determine hydraulic properties for test data exhibiting wellbore storage and/or leakage effects.

The software DERIV, (*Spane, Wurstner, 1993*), is used to produce the derivative. DERIV is a software for converting slug and constant-rate discharge test data and type curves to derivative format. The software has features that permit the smoothing of noisy test data, accounts for pressure derivative end-effects, and can be used to convert slug test data to equivalent constant-rate test responses.

To evaluate the transmissivity, T, the following methodology should be used:

The flow regime can be estimated from the logarithmic plot. In most cases the flow can be said to be radial to the borehole approximately 1.0-1.5 decades after the time the curve has left the 1:1 curve. The 1:1 curve indicates the well bore storage, WBS. The transmissivity is then calculated with Jacob's semi logarithmic approximation of Theis well function

$T = 0.183 \cdot Q / \Delta s$

Q = the average flow rate before shutting the valve (m^3/s)

Δs = the pressure change in metres during a decade along the straight line (radial flow period) in the semi logarithmic diagram.

Sometimes both the logarithmic and the semi logarithmic diagrams indicate a more complicated flow regime than described above (WBS, transition, radial flow, linear flow) and in these cases it is necessary to decide what part of the curve and what evaluation method that is appropriate for estimating the hydraulic properties.

In a fracture, different flow regimes may be observed at different times, *(Horne, 1995)*. At very early time only a linear flow regime occur within the fracture. At early time, there is linear flow within the fracture and linear flow into the fracture from the rock formation. The combination of these two linear flows gives rise to a bilinear flow period. This part of the pressure response is charcterized by a straight line with slope 1:4 at early time on a log-log plot of pressure drop against time. Following the bilinear flow period, finite conductivity fracture responses generally enter a transition after bilinear flow, but reach radial flow before ever achieving linear flow, recognizeable by the upward bending of the pressure response curve towards a 1:2 slope on the log-log plot. In practice, the 1:2 slope is rarely seen except in fractures where the conductivity is infinite. The above described methodology is used in chapter 6.

The tests are also evaluated using the software AQTESOLV ver. 4.01, and results are reported in Appendix 1 – 19 and in the executive summary. AQTESOLV is the all-in-one software package for the design and analysis of aquifer tests including pumping tests, step-drawdown tests, variable-rate tests, recovery tests, single-well tests, slug tests and constant-head tests. The software is developed by HydroSOLVE, Inc., USA.

Test campaign 1 – 7 have been evaluated using this software and the results are considered somewhat more reliable than using DERIV as the matching of data to models is more integrated using AQTESOLV, *see Appendices* for results. The solution used in these analysis is the Dougherty-Babu model for a pumping test in a confined aquifer (Dougherty, Babu, 1984). The model assumes radial flow in a porous medium. AQTESOLV uses the principle of superposition in time to simulate variable-rate tests including recovery with the solution. The result consist of

- Transmissivity, T (m^2/s)
- Skinfactor, Sw (-)

It is of uttermost importance when evaluation the hydraulic tests within the scope of this report that all tests are evaluated using the <u>same approach</u> between the test campaigns. This is important to be able to evaluate the <u>relative difference</u> of the transmissivity from one test campaign to another.

It is however important as well to observe any significant changes of the pressure plot from on time to another. If changes have occurred another matching of the data to a chosen model may be necessary.

6 Results

6.1 Single hole tests

6.1.1 KA3552G01:2, test No 7:1

General test data for the pressure build-up test in the interval 4.35-6.05 m of borehole KA3552G01 are presented in Table 6-1.

Table 6-1. General test data for the pressure build-up test in section 4.35-6.05 m of borehole KA3552G01

General test data			
Borehole section	KA3552G01:2		
Test No	7:1		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp$_p$ = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	4.35
Test section- seclow	Seclow	m	6.05
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060928 08:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060928 09:00:00
Stop of flow period		yymmdd hh:mm:ss	20060928 11:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060928 12:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	738.1	
Absolute pressure in test section before stop of flow	p_p	kPa	98.3	
Absolute pressure in test section at stop of recovery period	p_f	kPa	677.4	
Maximal pressure change during flow period	dp_p	kPa	639.8	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$7.84 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$9.40 \cdot 10^{-8}$
Total volume discharged during flow period	V_p	m^3	$6.77 \cdot 10^{-4}$

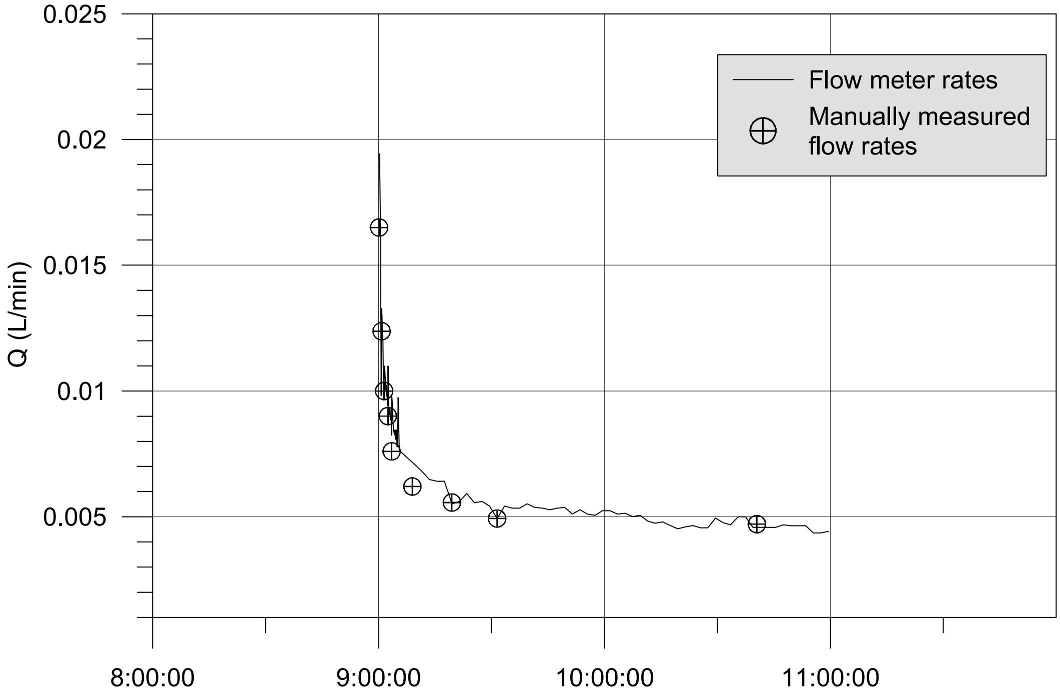


Figure 6-1. *Flow rates during draw down in KA3552G01:2.*

Comments to the test

Interpreted flow regimes

0 – 2	minutes	Well Bore Storage (WBS)
2 – 30	minutes	Transition period
30 –	minutes	Radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

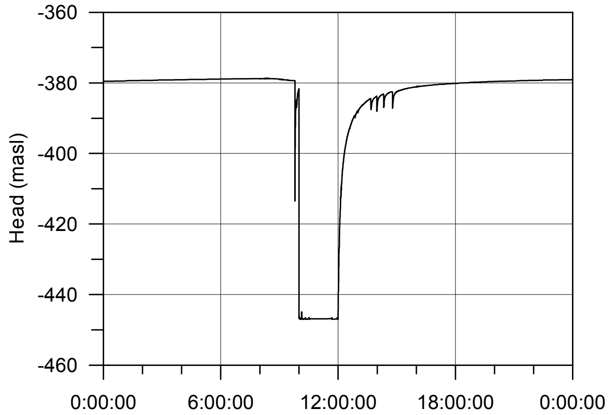
Selected representative parameters

The selected representative parameters from the test in the interval 4.35-6.05 m in KA3552G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

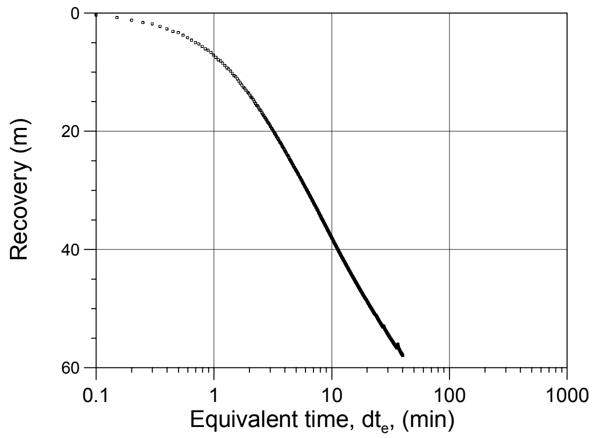
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:1
Borehole ID:	KA3552G01	Test start:	2006-09-28 08:00
Test section (m):	4.35-6.05	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



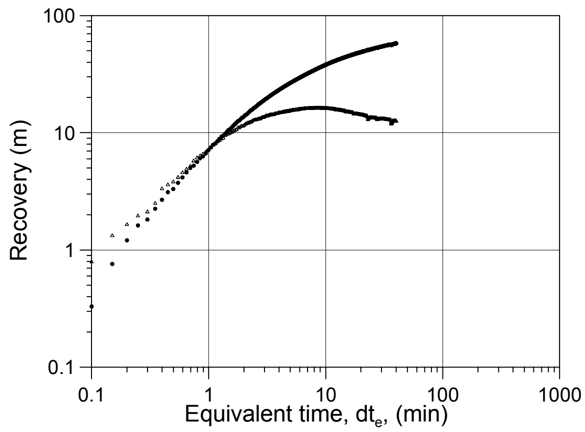
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	738.1		
p_i (kPa)			
p_p(kPa)	98.3	p_F (kPa)	677.4
Q_p (m^3/s)	$7.84 \cdot 10^{-8}$		
tp (min)	120	t_F (min)	120
S*	$1 \cdot 10^{-6}$	S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.2 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$8.0 \cdot 10^{-10}$	dt_{e1} (min)	30
Flow regime:		dt_{e2} (min)	38
dt_1 (min)		T (m^2/s)	$4.6 \cdot 10^{-10}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-1.6
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	30	C_D (-)	
dt_2 (min)	38	ξ (-)	-1.6
T_T (m^2/s)	$4.6 \cdot 10^{-10}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments:

6.1.2 KA3554G01:2 , test No 7:2a

General test data for the pressure build-up test in the interval 22.60-24.15 m of borehole KA3554G01 are presented in Table 6-2.

Table 6-2. General test data for the pressure build-up test in section 22.60-24.15 m of borehole KA3554G01

General test data			
Borehole section	KA3554G01:2		
Test No	7:2a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp$_p$ = approx. 100 m)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	22.60
Test section- seclow	Seclow	m	24.15
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060925 12:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060925 13:00:00
Stop of flow period		yymmdd hh:mm:ss	20060925 15:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060925 17:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2737.3	
Absolute pressure in test section before stop of flow	p_p	kPa	2081.2	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2723.8	
Maximal pressure change during flow period	dp_p	kPa	656.1	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$7.33 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$7.37 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.05305

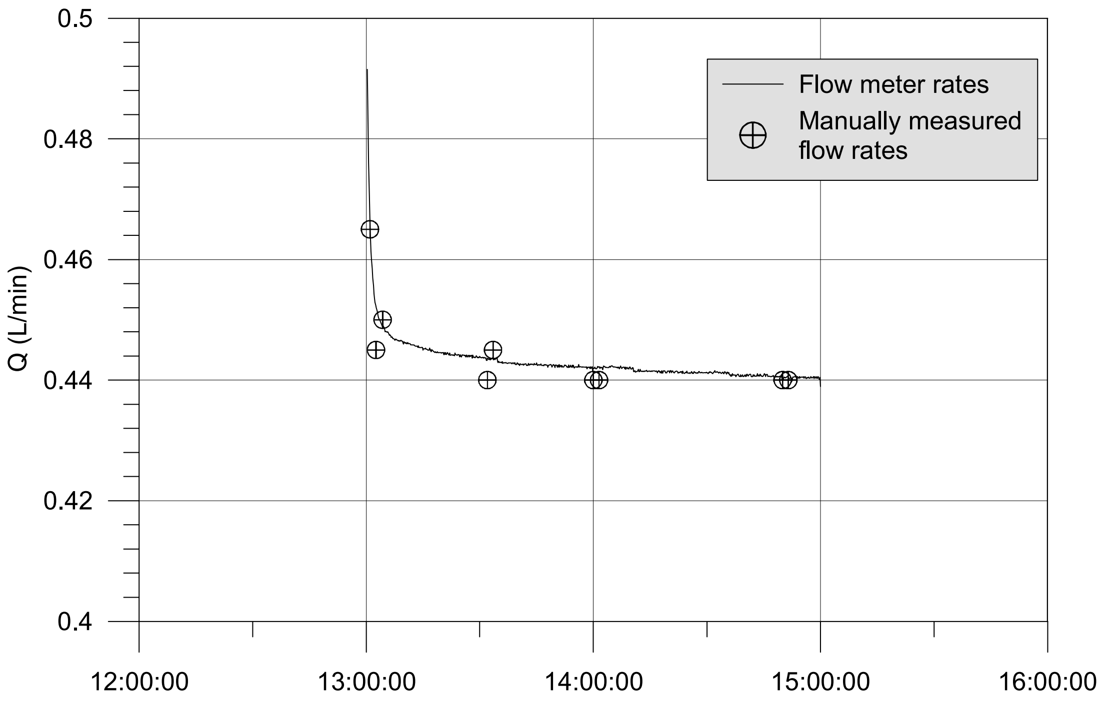


Figure 6-2. *Flow rates during draw down in KA3554G01:2.*

Comments to the test

The test is successful in regard to pressure response.

Interpreted flow regimes

0 – 0.3	minutes	Well Bore Storage (WBS)
0.3 – 5	minutes	Transition period
5 – 10	minutes	Radial flow period
10 – 30	minutes	Transition period
30 –		Possible larger scale radial flow

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

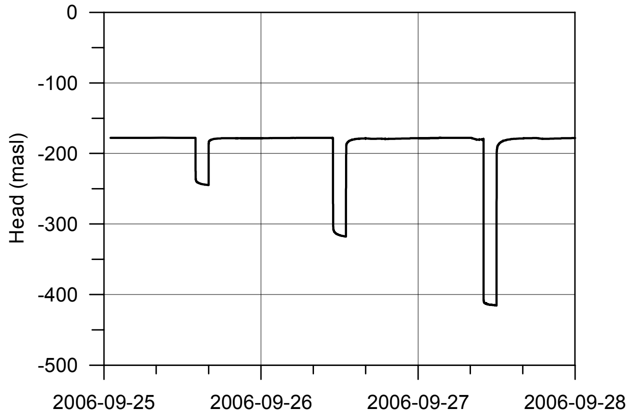
Selected representative parameters

The selected representative parameters from the test in the interval 22.60-24.15 m in KA3554G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

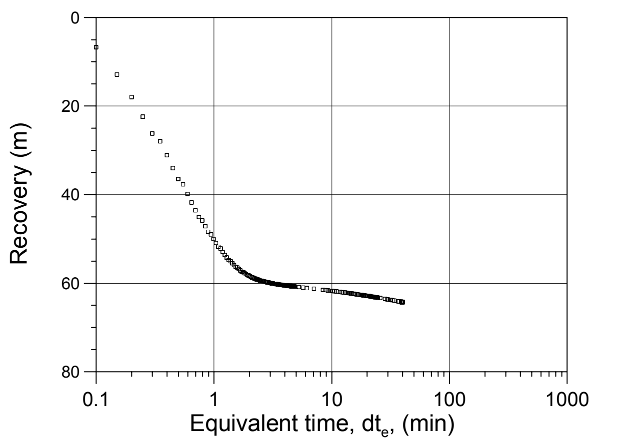
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:2a
Borehole ID:	KA3554G01	Test start:	2006-09-25 12:00
Test section (m):	22.60-24.15	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



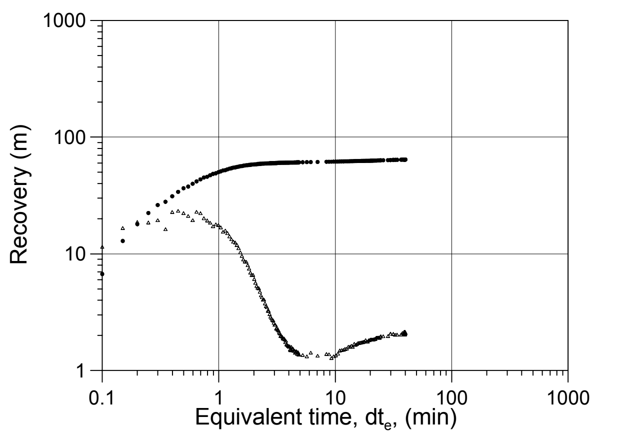
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	2737.3		
p_i (kPa)			
p_p(kPa)	2081.2	p_F (kPa)	2723.8
Q_p (m^3/s)	$7.33 \cdot 10^{-6}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.1 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$7.1 \cdot 10^{-8}$	dt_{e1} (min)	5
Flow regime:		dt_{e2} (min)	10
dt_1 (min)		T (m^2/s)	$4.5 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	17
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	5	C_D (-)	
dt_2 (min)	10	ξ (-)	17
T_T (m^2/s)	$4.5 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The test is successful in regard to pressure response.

6.1.3 KA3554G01:2 , test No 7:2b

General test data for the pressure build-up test in the interval 22.60-24.15 m of borehole KA3554G01 are presented in Table 6-3.

Table 6-3. General test data for the pressure build-up test in section 22.60-24.15 m of borehole KA3554G01

General test data			
Borehole section	KA3554G01:2		
Test No	7:2b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 200 m)		
	Nomencl ature	Unit	Value
Test section- secup	Secup	m	22.60
Test section- seclow	Seclow	m	24.15
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060926 09:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060926 10:00:00
Stop of flow period		yymmdd hh:mm:ss	20060926 12:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060926 13:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2736.3	
Absolute pressure in test section before stop of flow	p_p	kPa	1366.1	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2712.5	
Maximal pressure change during flow period	dp_p	kPa	1370.2	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.28 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.32 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.09552

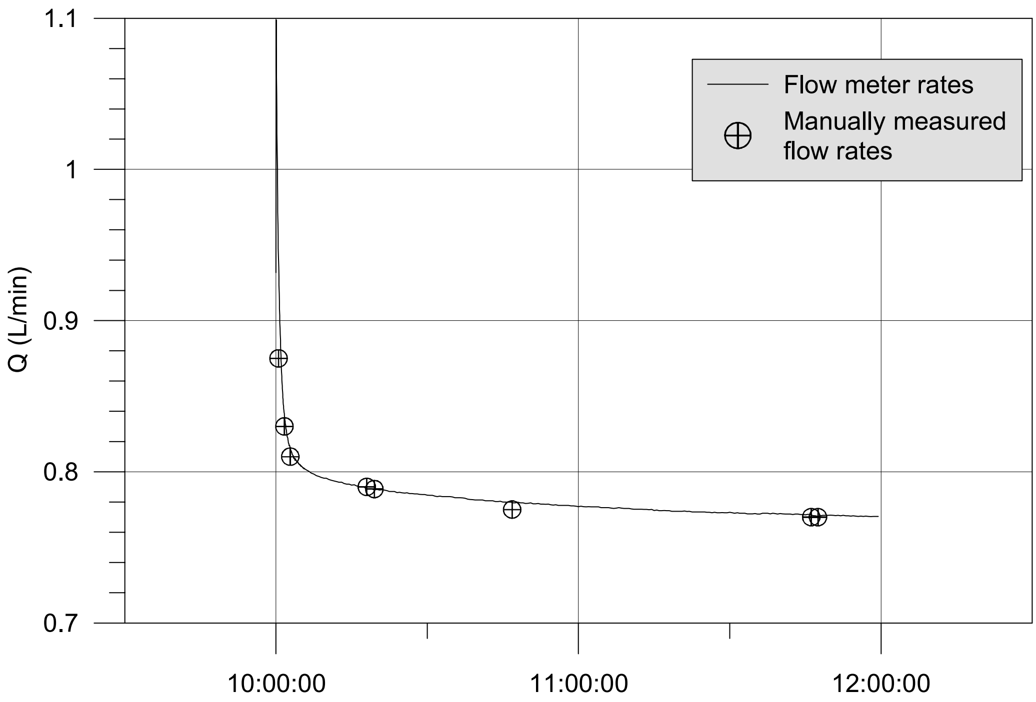


Figure 6-3. *Flow rates during draw down in KA3554G01:2.*

Comments to the test

The test is successful in regard to pressure response.

Interpreted flow regimes

0 – 0.2	minutes	Well Bore Storage (WBS)
0.2 – 7	minutes	Transition period
7 – 9	minutes	Radial flow period
9 – 30	minutes	Transition period
30 –		Possible larger scale radial flow

Calculated parameters

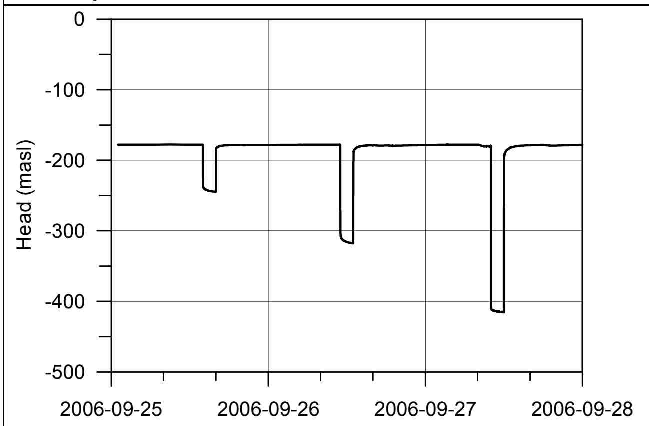
Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

Selected representative parameters

The selected representative parameters from the test in the interval 22.60-24.15 m in KA3554G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

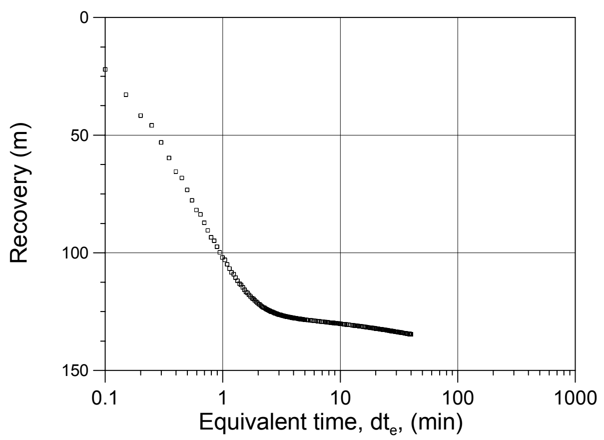
Test Summary Sheet			
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:2b
Borehole ID:	KA3554G01	Test start:	2006-09-26 09:00
Test section (m):	22.60-24.15	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



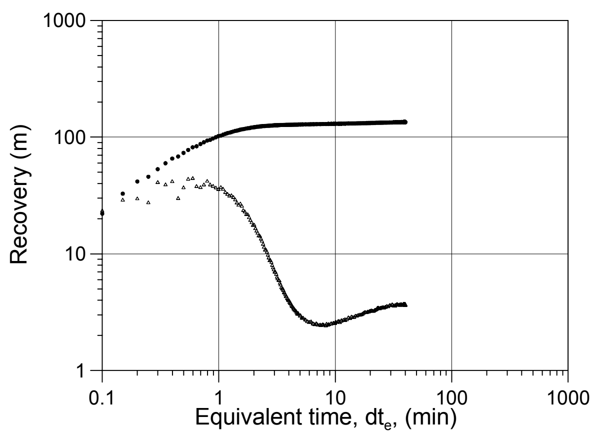
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	2736.3		
p_i (kPa)			
p_p(kPa)	1366.1	p_F (kPa)	2712.5
Q_p (m^3/s)	$1.28 \cdot 10^{-5}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$9.3 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$6.0 \cdot 10^{-8}$	dt_{e1} (min)	7
Flow regime:		dt_{e2} (min)	9
dt_1 (min)		T (m^2/s)	$4.0 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	19
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	7	C_D (-)	
dt_2 (min)	9	ξ (-)	19
T_T (m^2/s)	$4.0 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The test is successful in regard to pressure response.

6.1.4 KA3554G01:2 , test No 7:2c

General test data for the pressure build-up test in the interval 22.60-24.15 m of borehole KA3554G01 are presented in Table 6-4.

Table 6-4. General test data for the pressure build-up test in section 22.60-24.15 m of borehole KA3554G01

General test data			
Borehole section	KA3554G01:2		
Test No	7:2c		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	22.60
Test section- seclow	Seclow	m	24.15
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060927 08:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060927 09:00:00
Stop of flow period		yymmdd hh:mm:ss	20060927 11:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060927 12:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2718.7	
Absolute pressure in test section before stop of flow	p_p	kPa	408.2	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2693.3	
Maximal pressure change during flow period	dp_p	kPa	2310.5	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.87 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.94 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.1396

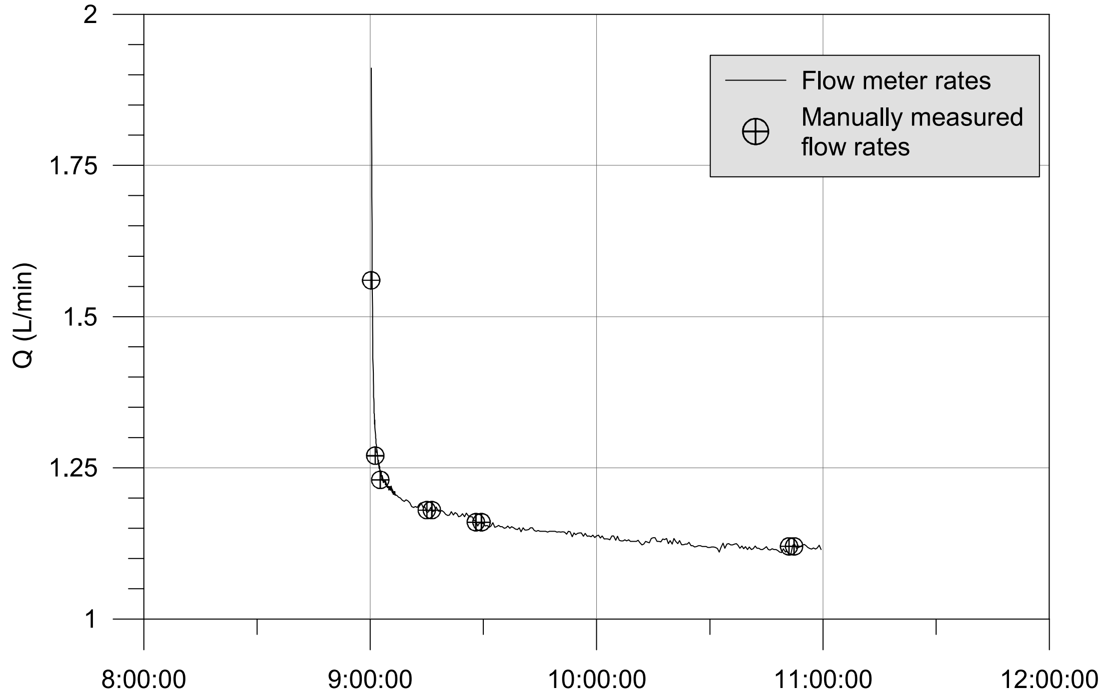


Figure 6-4. *Flow rates during draw down in KA3554G01:2.*

Comments to the test

The test is successful in regard to pressure response.

Interpreted flow regimes

0 – 0.3	minutes	Well Bore Storage (WBS)
0.3 – 7	minutes	Transition period
7 – 9	minutes	Radial flow period
9 – 30	minutes	Transition period
30 –		Possible larger scale radial flow

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

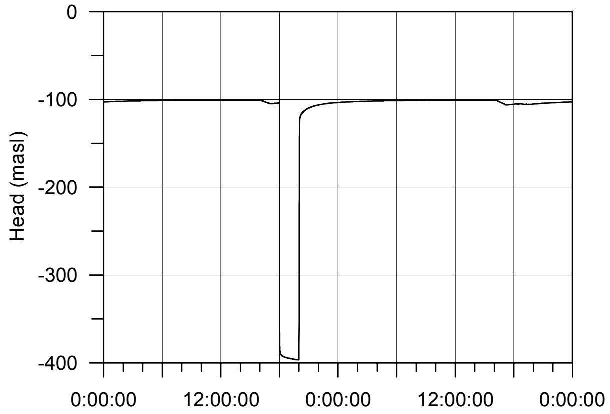
Selected representative parameters

The selected representative parameters from the test in the interval 22.60-24.15 m in KA3554G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

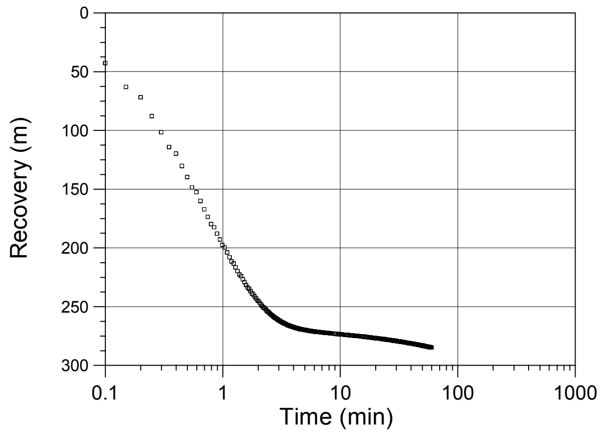
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:2c
Borehole ID:	KA3554G01	Test start:	2006-09-27 08:00
Test section (m):	22.60-24.15	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



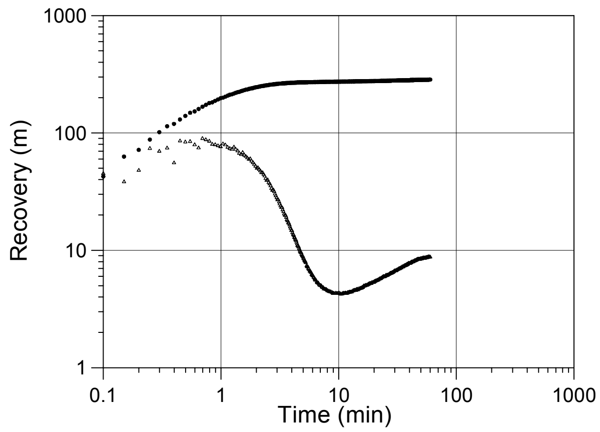
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	2718.7		
p_i (kPa)			
p_p(kPa)	408.2	p_F (kPa)	2693.3
Q_p (m^3/s)	$1.87 \cdot 10^{-5}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$8.1 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$5.2 \cdot 10^{-8}$	dt_{e1} (min)	7
Flow regime:		dt_{e2} (min)	9
dt_1 (min)		T (m^2/s)	$3.7 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	22
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	7	C_D (-)	
dt_2 (min)	9	ξ (-)	22
T_T (m^2/s)	$3.7 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The test is successful in regard to pressure response.

6.1.5 KA3554G02:4, test No 7:3a

General test data for the pressure build-up test in the interval 10.50-12.20 m of borehole KA3554G02 are presented in Table 6-5.

Table 6-5. General test data for the pressure build-up test in section 10.50-12.20 m of borehole KA3554G02

General test data			
Borehole section	KA3554G02:4		
Test No	7:3a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	10.50
Test section- seclow	Seclow	m	12.20
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060926 06:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060926 07:00:00
Stop of flow period		yymmdd hh:mm:ss	20060926 09:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060926 11:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1329.3	
Absolute pressure in test section before stop of flow	p_p	kPa	710.6	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1343.1	
Maximal pressure change during flow period	dp_p	kPa	618.7	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$8.14 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$8.83 \cdot 10^{-8}$
Total volume discharged during flow period	V_p	m^3	$6.37 \cdot 10^{-4}$

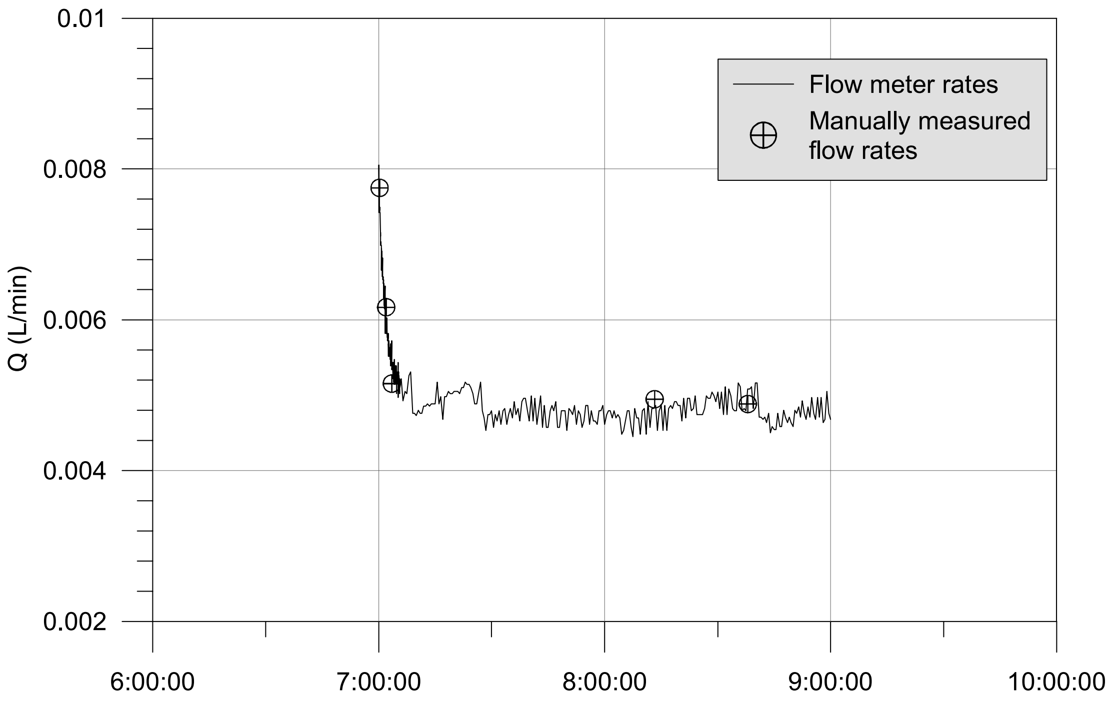


Figure 6-5. *Flow rates during draw down in KA3554G02:4.*

Comments to the test

The test is successful in regard to pressure response. The radial flow period is uncertain.

Interpreted flow regimes

0 – 1	minutes	Well Bore Storage (WBS)
1 – 30	minutes	Transition period
30 –	minutes	Probable radial flow period

Calculated parameters

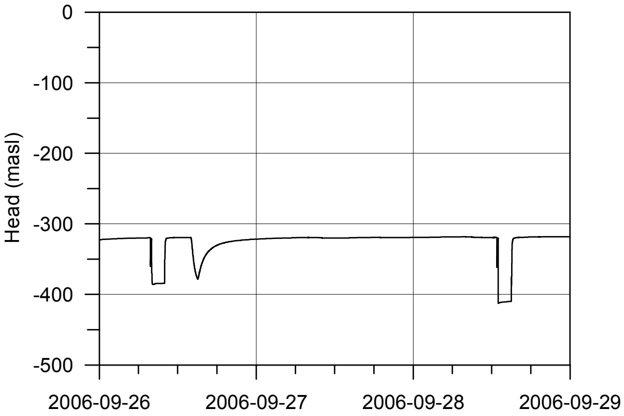
Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

Selected representative parameters

The selected representative parameters from the test in the interval 10.50-12.20 m in KA3554G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

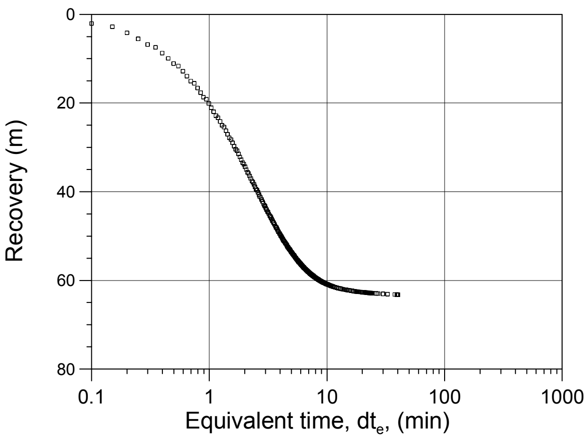
Test Summary Sheet			
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:3a
Borehole ID:	KA3554G02	Test start:	2006-09-26 06:00
Test section (m):	10.50-12.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



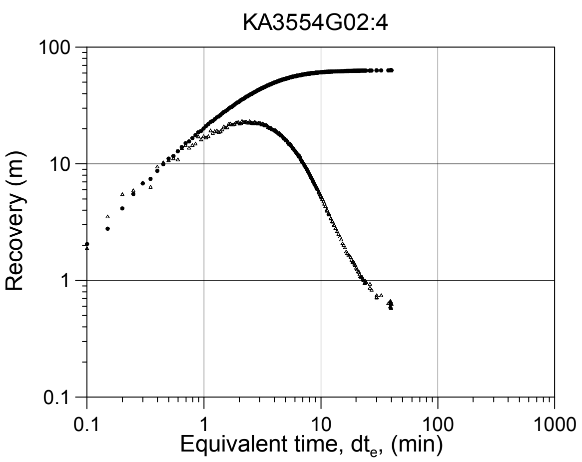
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1329.3		
p_i (kPa)			
p_p(kPa)	710.6	p_F (kPa)	1343.1
Q_p (m^3/s)	$8.14 \cdot 10^{-8}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		Results	
Q/s (m^2/s)	$1.3 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$8.6 \cdot 10^{-10}$	dt_{e1} (min)	30
Flow regime:		dt_{e2} (min)	40
dt_1 (min)		T (m^2/s)	$1.1 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	47
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	30	C_D (-)	
dt_2 (min)	40	ξ (-)	47
T_T (m^2/s)	$1.1 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments:

6.1.6 KA3554G02:4 , test No 7:3b

General test data for the pressure build-up test in the interval 10.50-12.20 m of borehole KA3554G02 are presented in Table 6-6.

Table 6-6. General test data for the pressure build-up test in section 10.50-12.20 m of borehole KA3554G02

General test data			
Borehole section	KA3554G02:4		
Test No	7:3b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomencl ature	Unit	Value
Test section- secup	Secup	m	10.50
Test section- seclow	Seclow	m	12.20
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060928 11:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060928 12:00:00
Stop of flow period		yymmdd hh:mm:ss	20060928 14:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060928 15:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1336.5	
Absolute pressure in test section before stop of flow	p_p	kPa	458.8	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1345.9	
Maximal pressure change during flow period	dp_p	kPa	877.7	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.58 \cdot 10^{-7}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.67 \cdot 10^{-7}$
Total volume discharged during flow period	V_p	m^3	$1.25 \cdot 10^{-3}$

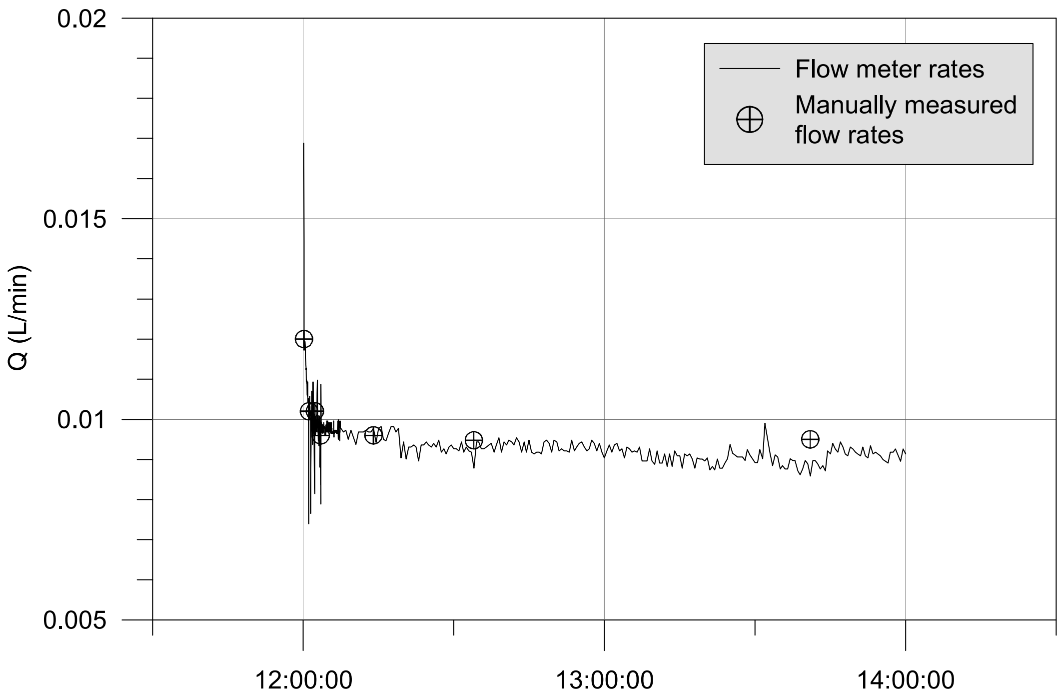


***Figure 6-6.** Flow rates during draw down in KA3554G02:4.*

Comments to the test

The test is successful in regard to pressure response. The radial flow period is uncertain.

Interpreted flow regimes

0 – 1	minutes	Well Bore Storage (WBS)
1? – 30	minutes	Transition period
30 –	minutes	Probable radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

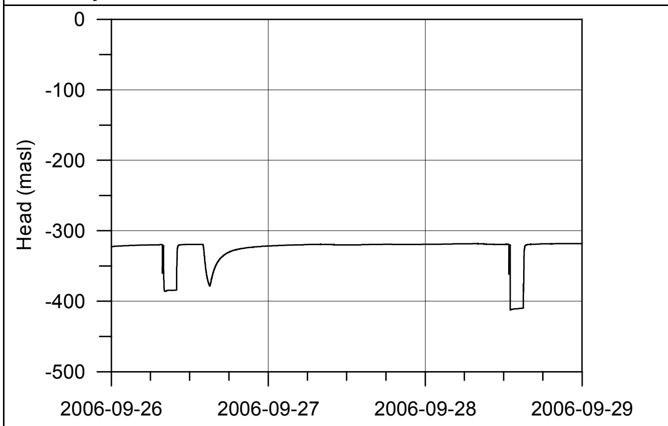
Selected representative parameters

The selected representative parameters from the test in the interval 10.50-12.20 m in KA3554G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

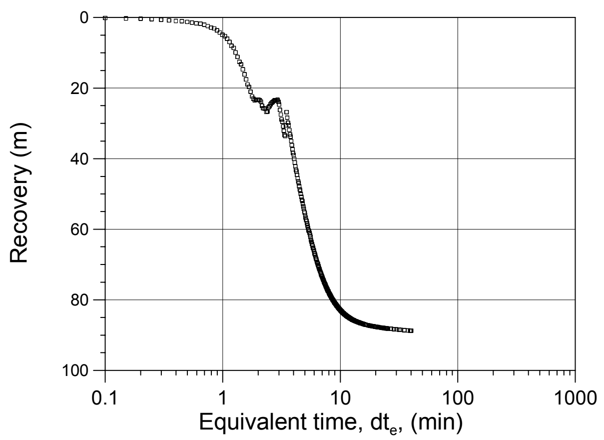
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:3b
Borehole ID:	KA3554G02	Test start:	2006-09-28 11:00
Test section (m):	10.50-12.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



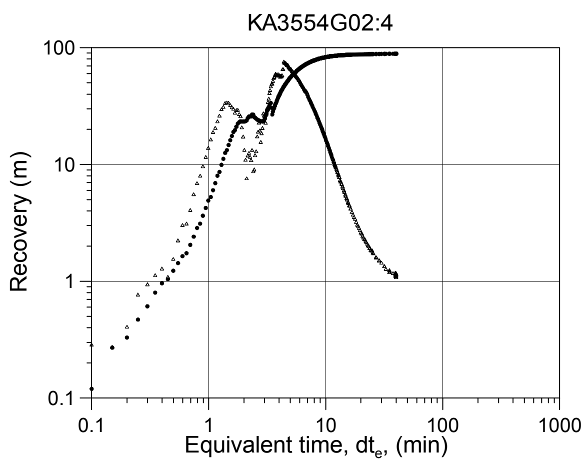
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	1336.5		
p_i (kPa)			
p_p(kPa)	458.8	p_F (kPa)	1345.9
Q_p (m^3/s)	$1.58 \cdot 10^{-7}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.8 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.2 \cdot 10^{-9}$	dt_{e1} (min)	30
Flow regime:		dt_{e2} (min)	40
dt_1 (min)		T (m^2/s)	$1.2 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	35
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	30	C_D (-)	
dt_2 (min)	40	ξ (-)	35
T_T (m^2/s)	$1.2 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The reason to the pressure disturbance during recovery is not known. However, the later part of the recovery is considered as reliable.

6.1.7 KA3548A01:3 , test No 7:4a

General test data for the pressure build-up test in the interval 8.80-10.75 m of borehole KA3548A01 are presented in Table 6-7.

Table 6-7. General test data for the pressure build-up test in section 8.80-10.75 m of borehole KA3548A01

General test data			
Borehole section	KA3548A01:3		
Test No	7:4a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomencl ature	Unit	Value
Test section- secup	Secup	m	8.80
Test section- seclow	Seclow	m	10.75
Test section length	L_w	m	1.95
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060926 14:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060926 15:00:00
Stop of flow period		yymmdd hh:mm:ss	20060926 16:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060926 17:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2442.7	
Absolute pressure in test section before stop of flow	p_p	kPa	1794.8	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2365.6	
Maximal pressure change during flow period	dp_p	kPa	647.9	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$6.50 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$7.29 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.0262

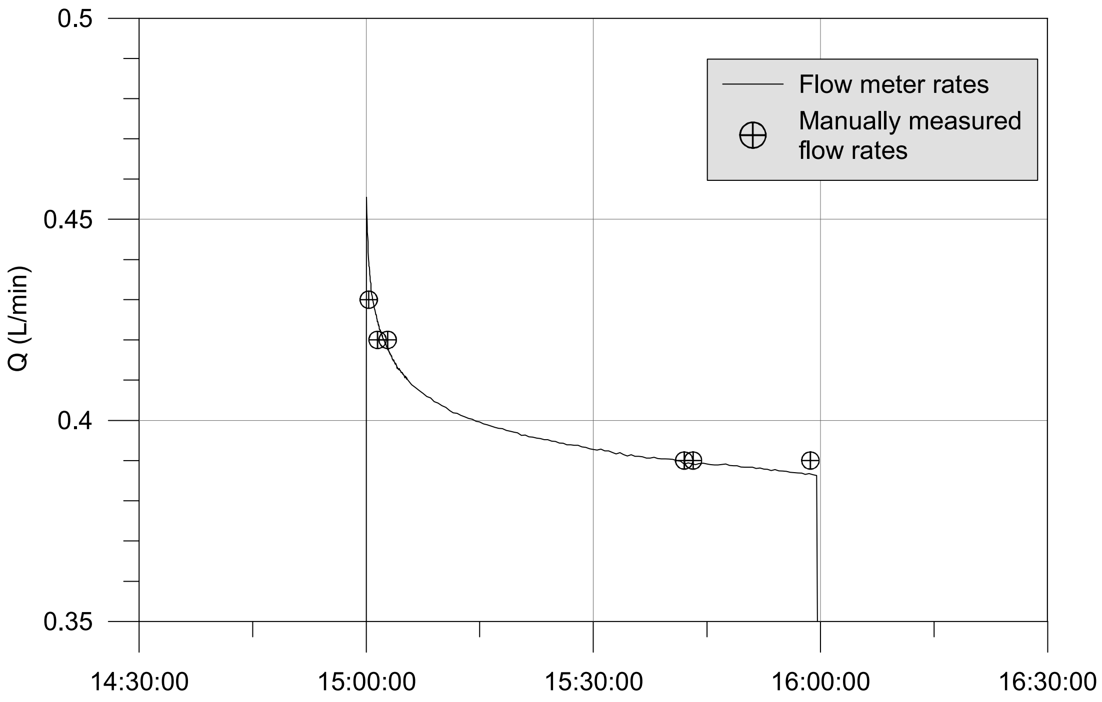


Figure 6-7. *Flow rates during draw down in KA3548A01:3.*

Comments to the test

The test is successful in regard to pressure response. The radial flow period occurs very early in the test.

Interpreted flow regimes

0 – 0.1	minutes	Well Bore Storage (WBS)
0.1 – 0.2	minutes	Transition period
0.2 – 0.5	minutes	Radial flow period
0.5 – 15	minutes	Transition period
15 –	minutes	Possible larger scale radial flow

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

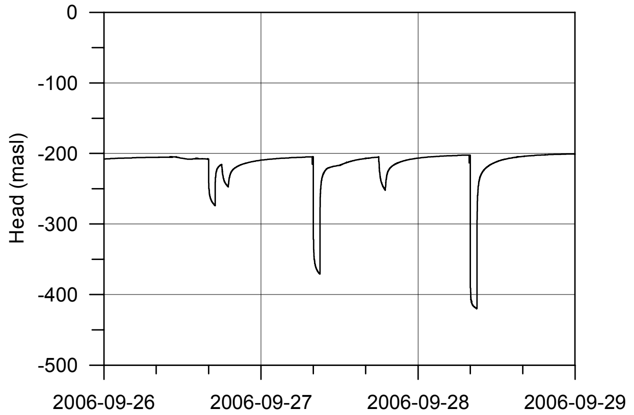
Selected representative parameters

The selected representative parameters from the test in the interval 8.80-10.75 m in KA3548A01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

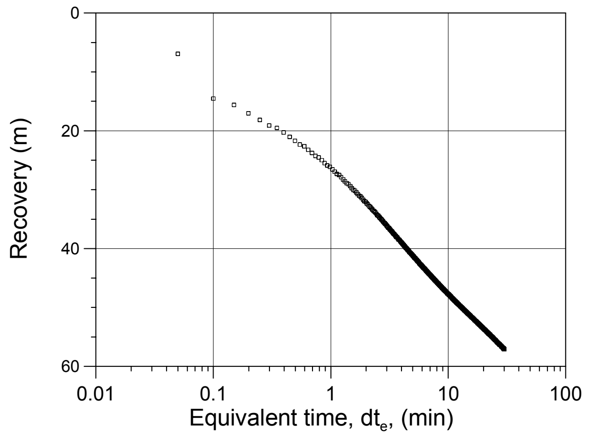
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:4a
Borehole ID:	KA3548A01	Test start:	2006-09-26 14:00
Test section (m):	8.80-10.75	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



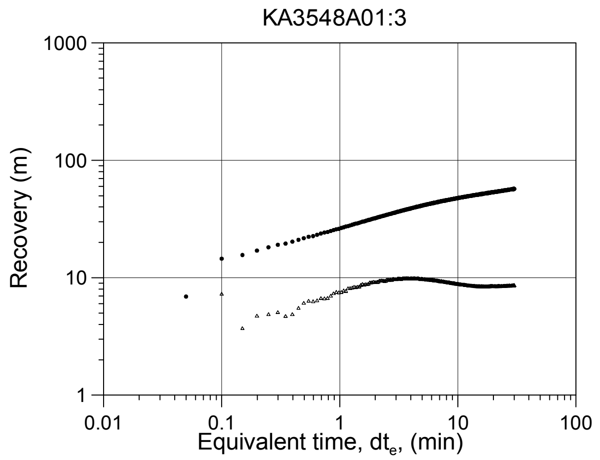
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	2442.7		
p_i (kPa)			
p_p(kPa)	1794.8	p_F (kPa)	2365.6
Q_p (m^3/s)	$6.50 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.0 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$6.8 \cdot 10^{-8}$	dt_{e1} (min)	0.2
Flow regime:		dt_{e2} (min)	0.5
dt_1 (min)		T (m^2/s)	$1.0 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-2.0
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.2	C_D (-)	
dt_2 (min)	0.5	ξ (-)	-2.0
T_T (m^2/s)	$1.0 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A successful test.

6.1.8 KA3548A01:3 , test No 7:4b

General test data for the pressure build-up test in the interval 8.80-10.75 m of borehole KA3548A01 are presented in Table 6-8.

Table 6-8. General test data for the pressure build-up test in section 8.80-10.75 m of borehole KA3548A01

General test data			
Borehole section	KA3548A01:3		
Test No	7:4b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approximate 200 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	8.80
Test section- seclow	Seclow	m	10.75
Test section length	L_w	m	1.95
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060927 06:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060927 07:00:00
Stop of flow period		yymmdd hh:mm:ss	20060927 08:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060927 09:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2471.1	
Absolute pressure in test section before stop of flow	p_p	kPa	842.4	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2300.0	
Maximal pressure change during flow period	dp_p	kPa	1628.7	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.51 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.60 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.05754

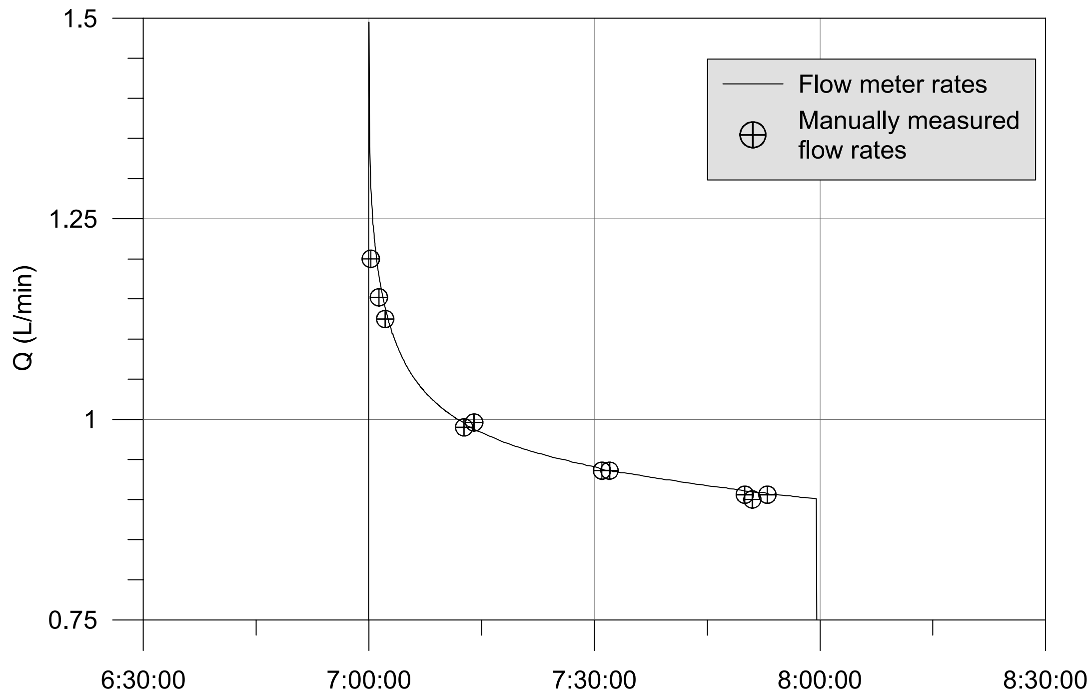


Figure 6-8. *Flow rates during draw down in KA3548A01:3.*

Comments to the test

The test is successful in regard to pressure response. The radial flow period occurs very early in the test.

Interpreted flow regimes

0 – 0.07	minutes	Well Bore Storage (WBS)
0.07 – 0.15	minutes	Transition period
0.15 – 0.7	minutes	Radial flow period
0.7 – 15	minutes	Transition period
15 –	minutes	Possible larger scale radial flow

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

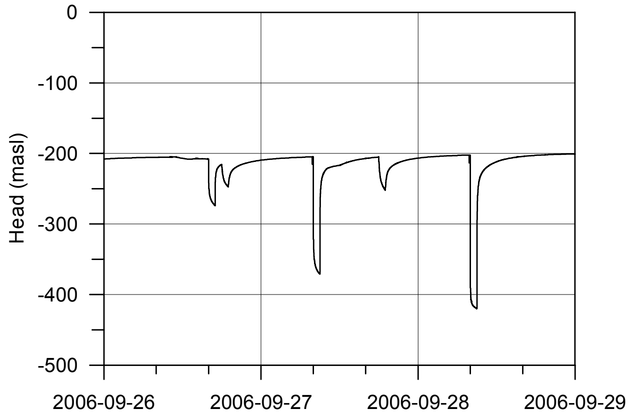
Selected representative parameters

The selected representative parameters from the test in the interval 8.80-10.75 m in KA3548A01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

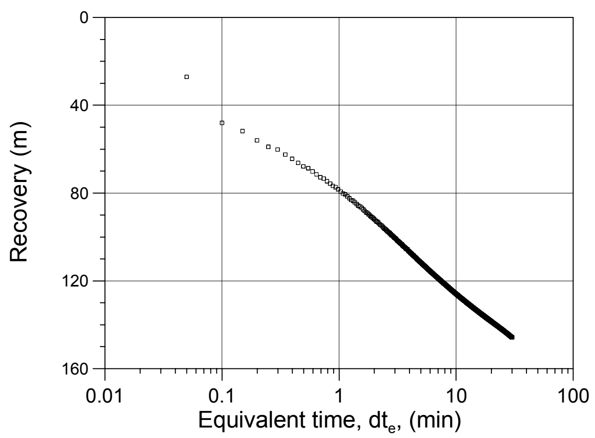
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:4b
Borehole ID:	KA3548A01	Test start:	2006-09-27 06:00
Test section (m):	8.80-10.75	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



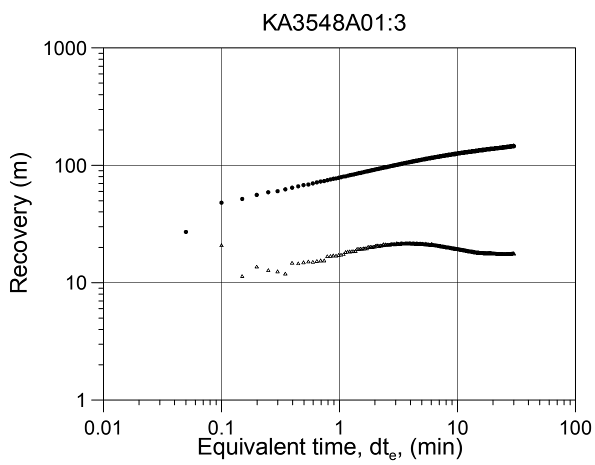
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	2471.1		
p_i (kPa)			
p_p(kPa)	842.4	p_F (kPa)	2300.0
Q_p (m^3/s)	$1.51 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$9.3 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$6.3 \cdot 10^{-8}$	dt_{e1} (min)	0.15
Flow regime:		dt_{e2} (min)	0.7
dt_1 (min)		T (m^2/s)	$9.5 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-1.5
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.15	C_D (-)	
dt_2 (min)	0.7	ξ (-)	-1.5
T_T (m^2/s)	$9.5 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A successful test.

6.1.9 KA3548A01:3 , test No 7:4c

General test data for the pressure build-up test in the interval 8.80-10.75 m of borehole KA3548A01 are presented in Table 6-9.

Table 6-9. General test data for the pressure build-up test in section 8.80-10.75 m of borehole KA3548A01

General test data			
Borehole section	KA3548A01:3		
Test No	7:4c		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp$_p$ = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	8.80
Test section- seclow	Seclow	m	10.75
Test section length	L_w	m	1.95
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060928 06:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060928 07:00:00
Stop of flow period		yymmdd hh:mm:ss	20060928 08:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060928 09:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2496.1	
Absolute pressure in test section before stop of flow	p_p	kPa	364.0	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2279.4	
Maximal pressure change during flow period	dp_p	kPa	2132.1	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.87 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$2.04 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.07363

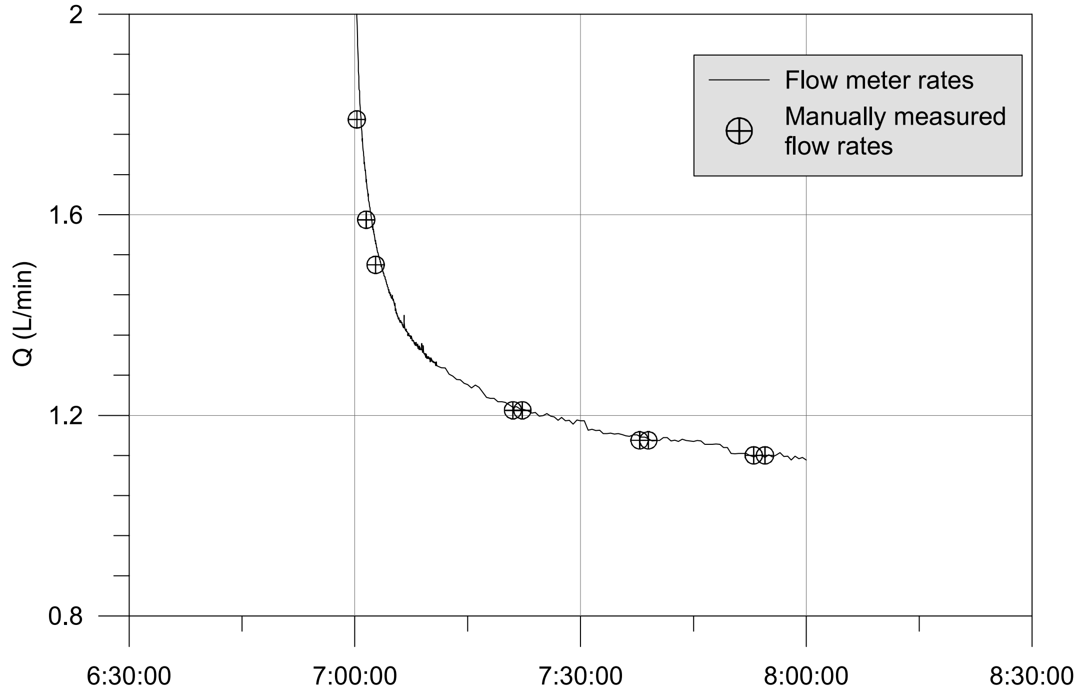


Figure 6-9. *Flow rates during draw down in KA3548A01:3.*

Comments to the test

The test is successful in regard to pressure response. The evaluated radial flow period occurs early in the test.

Interpreted flow regimes

0 – 0.07	minutes	Well Bore Storage (WBS)
0.07 – 0.15	minutes	Transition period
0.15 – 0.5	minutes	Radial flow period
0.5 – 15	minutes	Transition period
15 –	minutes	Possible larger scale radial flow

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log and log-log diagrams according to the methods described in Section 5.4.1.

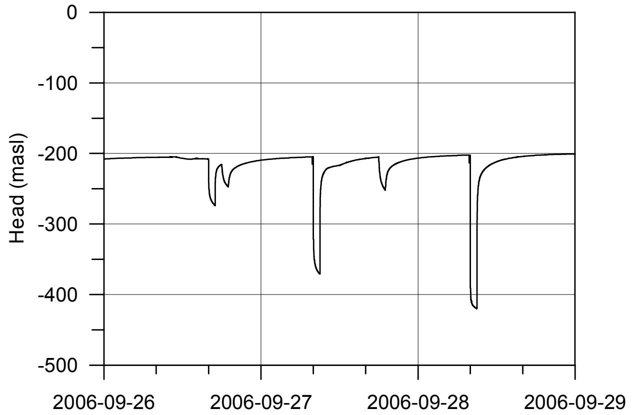
Selected representative parameters

The selected representative parameters from the test in the interval 8.80-10.75 m in KA3548A01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

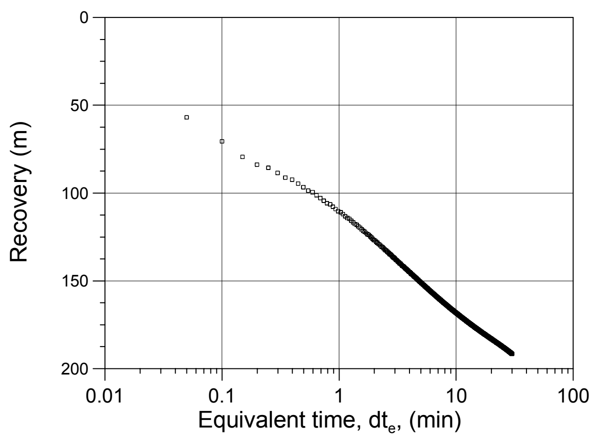
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:4c
Borehole ID:	KA3548A01	Test start:	2006-09-28 06:00
Test section (m):	8.80-10.75	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



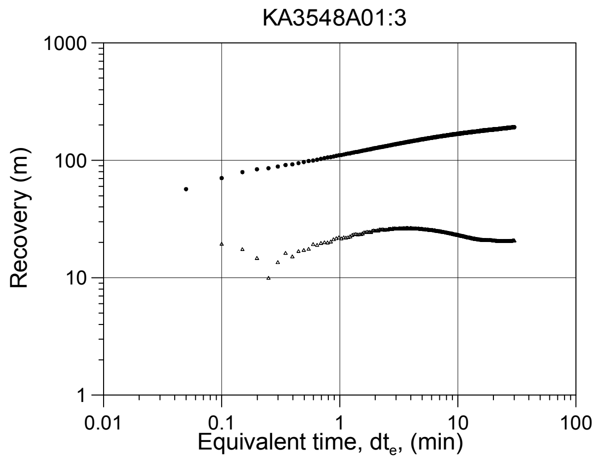
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	2496.1		
p_i (kPa)			
p_p(kPa)	364.0	p_F (kPa)	2279.4
Q_p (m^3/s)	$1.87 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		Results	
Q/s (m^2/s)	$8.8 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$5.9 \cdot 10^{-8}$	dt_{e1} (min)	0.15
Flow regime:		dt_{e2} (min)	0.5
dt_1 (min)		T (m^2/s)	$1.0 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-0.9
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.15	C_D (-)	
dt_2 (min)	0.5	ξ (-)	-0.9
T_T (m^2/s)	$1.0 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A successful test.

6.1.10 KA3542G01:3 , test No 7:5a

General test data for the pressure build-up test in the interval 18.60-20.30 m of borehole KA3542G01 are presented in Table 6-10.

Table 6-10. General test data for the pressure build-up test in section 18.60-20.30 m of borehole KA3542G01

General test data			
Borehole section	KA3542G01:3		
Test No	7:5a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	18.60
Test section- seclow	Seclow	m	20.30
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060925 17:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060925 18:00:00
Stop of flow period		yymmdd hh:mm:ss	20060925 19:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060925 21:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2410.2	
Absolute pressure in test section before stop of flow	p_p	kPa	1781.9	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2376.8	
Maximal pressure change during flow period	dp_p	kPa	628.3	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$3.28 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$3.33 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.01199

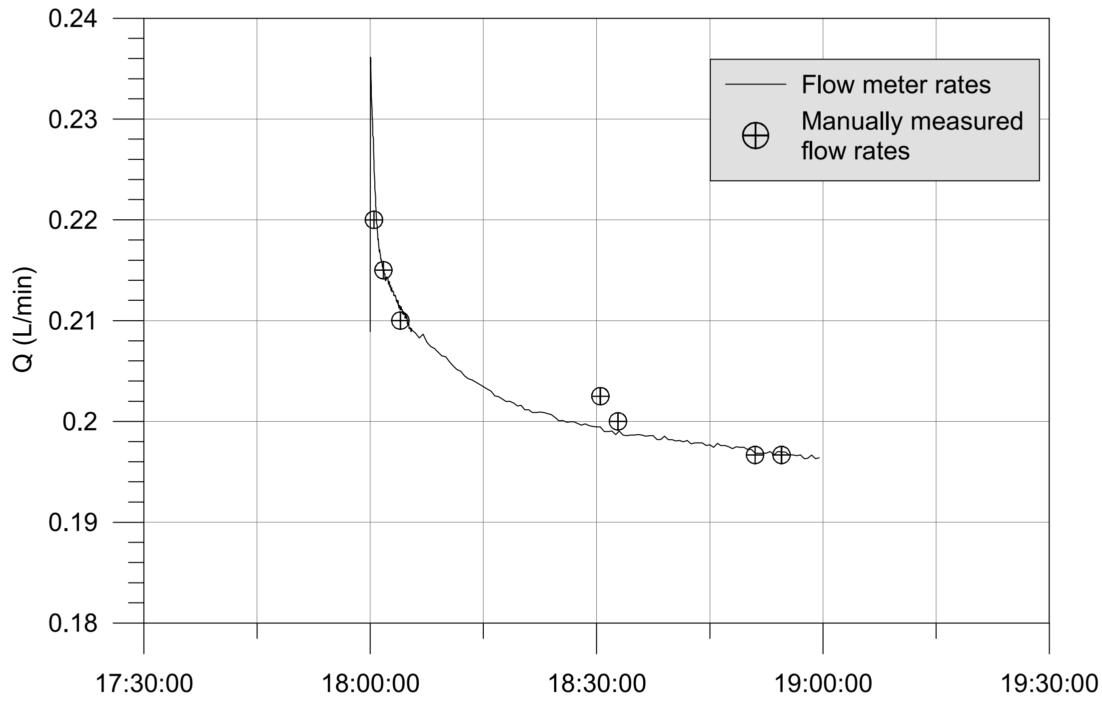


Figure 6-10. *Flow rate during draw down in KA3542G01:3.*

Comments to the test

A successful test. During the earlier test campaigns the rather flat shape of the derivative curve for the period 0.3 – 2 min was not as apparent as now. This may be an indication of an earler radial flow period than that is presented below. However, the late radial flow period is used to estimate the transmissivity to give a fairer comparison with results from earlier test campaigns.

Interpreted flow regimes

0 – 0.1	minutes	Well Bore Storage (WBS)
0.1 – 0.3	minutes	Transition period
0.3 – 2	minutes	Radial flow period
2 – 30	minutes	Transition period
30 –	minutes	Radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

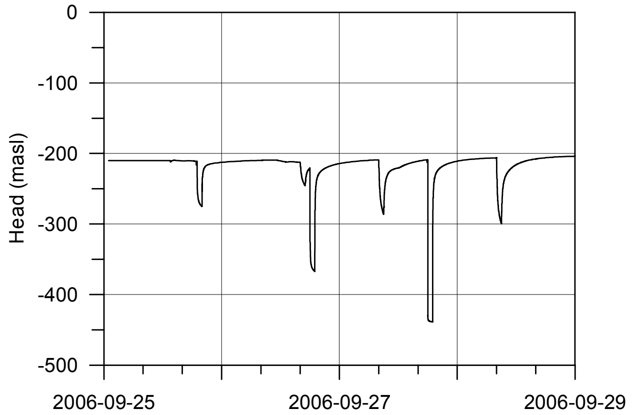
Selected representative parameters

The selected representative parameters from the test in the interval 18.60-20.30 m in KA3542G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

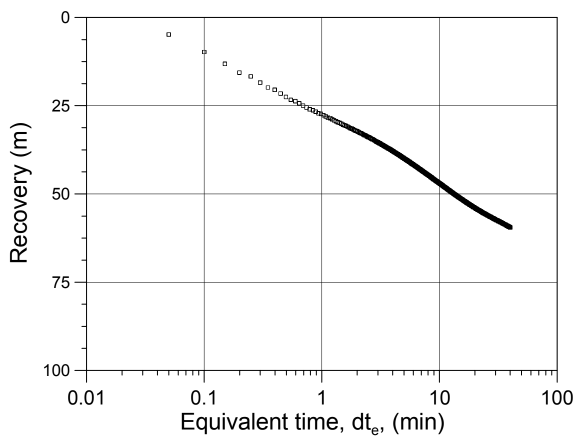
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:5a
Borehole ID:	KA3542G01	Test start:	2006-09-25 17:00
Test section (m):	18.60-20.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



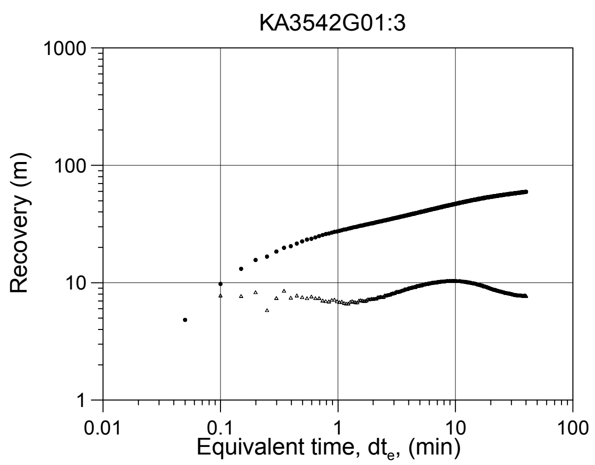
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	2410.2		
p_i (kPa)			
p_p(kPa)	1781.9	p_F (kPa)	2376.8
Q_p (m^3/s)	$2.49 \cdot 10^{-6}$		
tp (min)	60	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$5.2 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$3.4 \cdot 10^{-8}$	dt_{e1} (min)	30
Flow regime:		dt_{e2} (min)	35
dt_1 (min)		T (m^2/s)	$3.4 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-2.0
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	30	C_D (-)	
dt_2 (min)	35	ξ (-)	-2.0
T_T (m^2/s)	$3.4 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A successful test. During the earlier test campaigns the rather flat shape of the derivative curve for the period 0.3 – 2 min was not as apparent as now. This may be an indication of an earler radial flow period that is presented above. The transmissivity for this period is T = $3.8 \cdot 10^{-8}$ m^2/s. However, the late radial flow period is used to estimate the transmissivity to give a fairer comparison with results from earlier test campaigns.

6.1.11 KA3542G01:3 , test No 7:5b

General test data for the pressure build-up test in the interval 18.60-20.30 m of borehole KA3542G01 are presented in Table 6-11.

Table 6-11. General test data for the pressure build-up test in section 18.60-20.30 m of borehole KA3542G01

General test data			
Borehole section	KA3542G01:3		
Test No	7:5b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 200 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	18.60
Test section- seclow	Seclow	m	20.30
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060926 16:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060926 17:00:00
Stop of flow period		yymmdd hh:mm:ss	20060926 18:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060926 20:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2315.0	
Absolute pressure in test section before stop of flow	p_p	kPa	878.9	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2310.6	
Maximal pressure change during flow period	dp_p	kPa	1436.1	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$7.17 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$7.43 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.02675

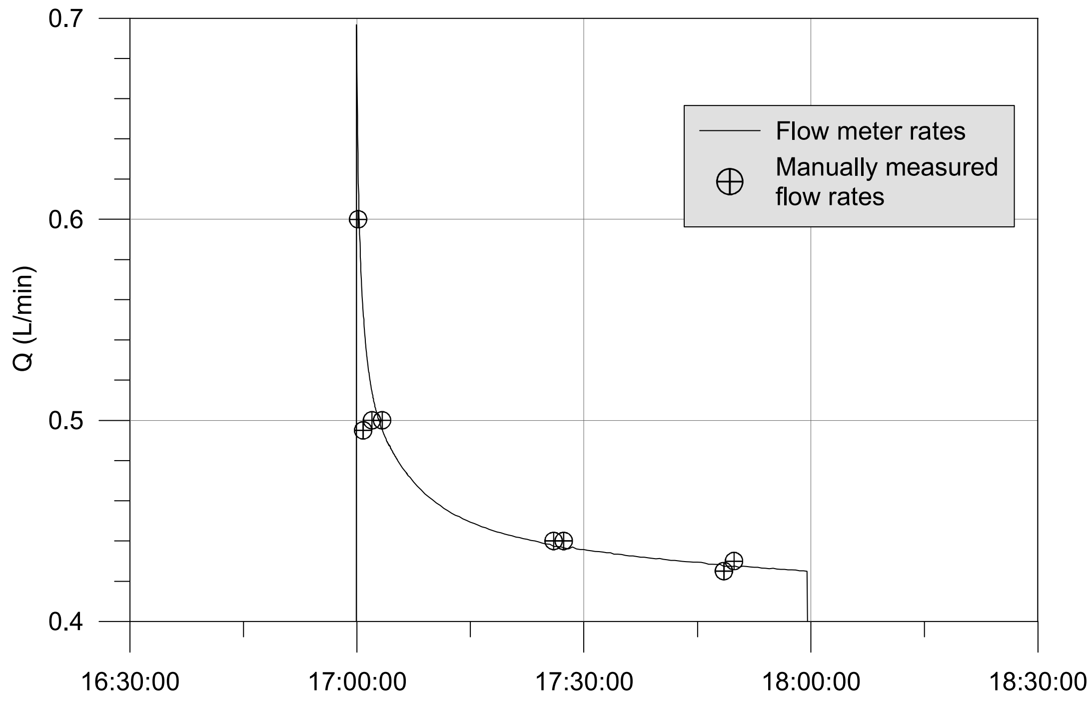


Figure 6-11. Flow rate during draw down in KA3542G01:3.

Comments to the test

A successful test. During the earlier test campaigns the rather flat shape of the derivative curve for the period 1.7 – 3 min was not as apparent as now. This may be an indication of an earler radial flow period than that is presented below. However, the late radial flow period is used to estimate the transmissivity to give a fairer comparison with results from earlier test campaigns.

Interpreted flow regimes

0 – 0.1	minutes	Well Bore Storage (WBS)
0.1 – 0.3	minutes	Transition period
1.7 – 3	minutes	Radial flow period
3 – 20	minutes	Transition period
20 – 30	minutes	Radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

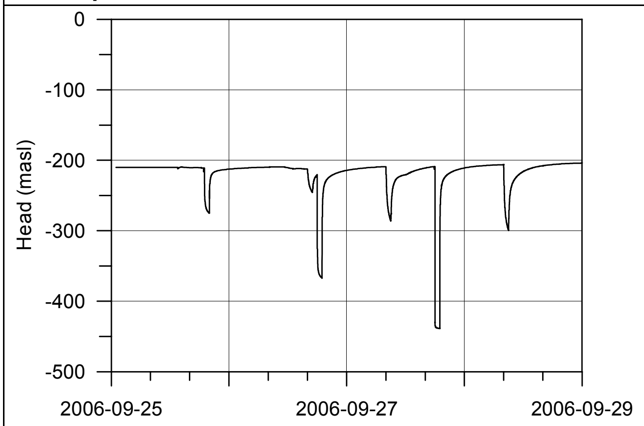
Selected representative parameters

The selected representative parameters from the test in the interval 18.60-20.30 m in KA3542G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

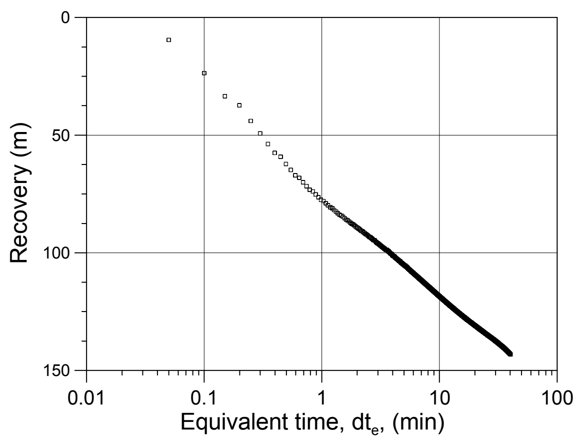
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:5b
Borehole ID:	KA3542G01	Test start:	2006-09-26 16:00
Test section (m):	18.60-20.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



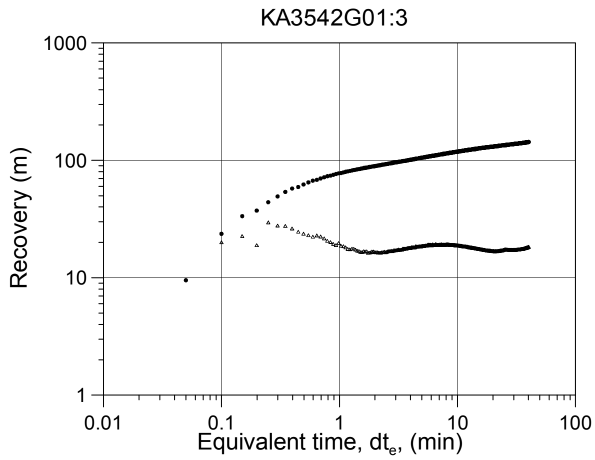
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	2315.0		
p_i (kPa)			
p_p(kPa)	878.9	p_F (kPa)	2310.6
Q_p (m^3/s)	$7.17 \cdot 10^{-6}$		
tp (min)	60	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$5.0 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$3.3 \cdot 10^{-8}$	dt_{e1} (min)	20
Flow regime:		dt_{e2} (min)	30
dt_1 (min)		T (m^2/s)	$3.3 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-1.6
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	20	C_D (-)	
dt_2 (min)	30	ξ (-)	-1.6
T_T (m^2/s)	$3.3 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A successful test. During the earlier test campaigns the rather flat shape of the derivative curve for the period 1.7 – 3 min was not as apparent as now. This may be an indication of an earler radial flow period that is presented above. The transmissivity for this period is $T = 3.3 \cdot 10^{-8}$ m^2/s. However, the late radial flow period is used to estimate the transmissivity to give a fairer comparison with results from earlier test campaigns.

6.1.12 KA3542G01:3 , test No 7:5c

General test data for the pressure build-up test in the interval 18.60-20.30 m of borehole KA3542G01 are presented in Table 6-12.

Table 6-12. General test data for the pressure build-up test in section 18.60-20.30 m of borehole KA3542G01

General test data			
Borehole section	KA3542G01:3		
Test No	7:5c		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	18.60
Test section- seclow	Seclow	m	20.30
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060927 16:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060927 17:00:00
Stop of flow period		yymmdd hh:mm:ss	20060927 18:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060927 20:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	2430.6	
Absolute pressure in test section before stop of flow	p_p	kPa	176.8	
Absolute pressure in test section at stop of recovery period	p_f	kPa	2341.7	
Maximal pressure change during flow period	dp_p	kPa	2253.8	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.03 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.15 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.04128

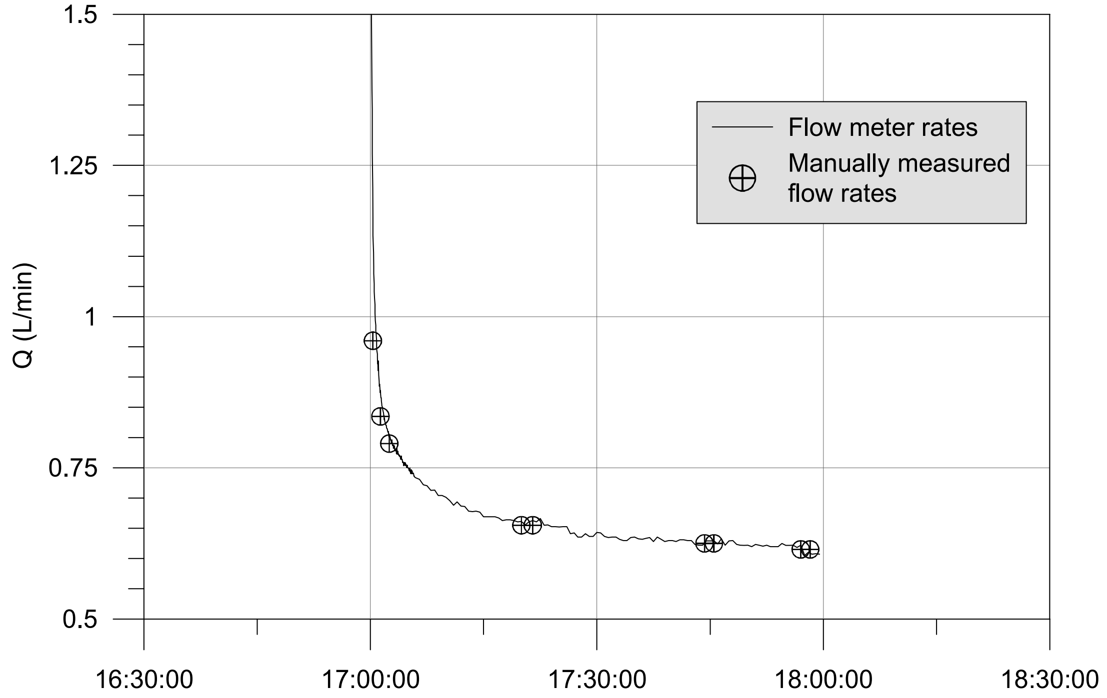


Figure 6-12. *Flow rate during draw down in KA3542G01:3.*

Comments to the test

A successful test. During the earlier test campaigns the rather flat shape of the derivative curve for the period 2 – 8 min was not as apparent as now. This may be an indication of an earler radial flow period than that is presented below. However, the late radial flow period is used to estimate the transmissivity to give a fairer comparison with results from earlier test campaigns.

Interpreted flow regimes

0 – 0.1	minutes	Well Bore Storage (WBS)
0.1 – 2	minutes	Transition period
2 – 8	minutes	Radial flow period
8 – 20	minutes	Transition period
20 – 40	minutes	Radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log and log-log diagrams according to the methods described in Section 5.4.1.

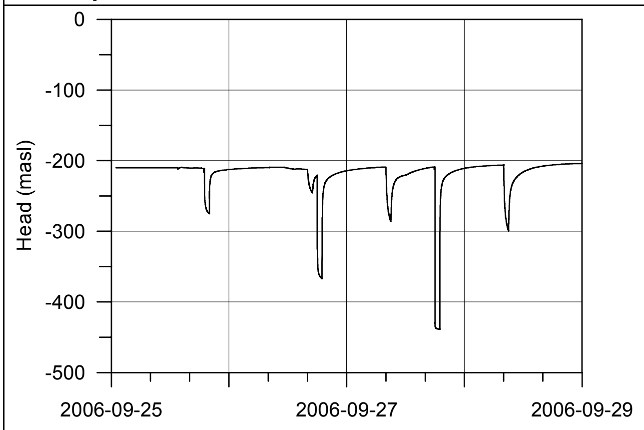
Selected representative parameters

The selected representative parameters from the test in the interval 18.60-20.30 m in KA3542G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

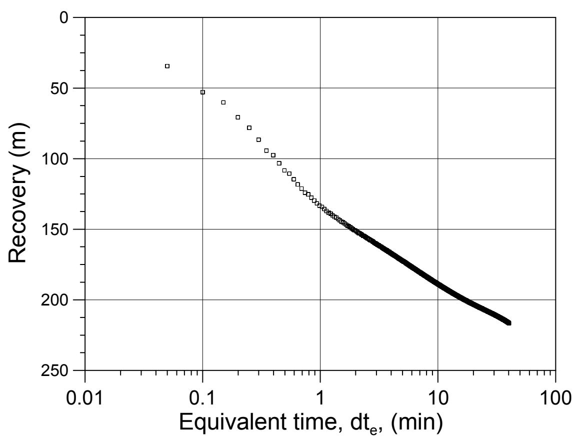
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:5c
Borehole ID:	KA3542G01	Test start:	2006-09-27 16:00
Test section (m):	18.60-20.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



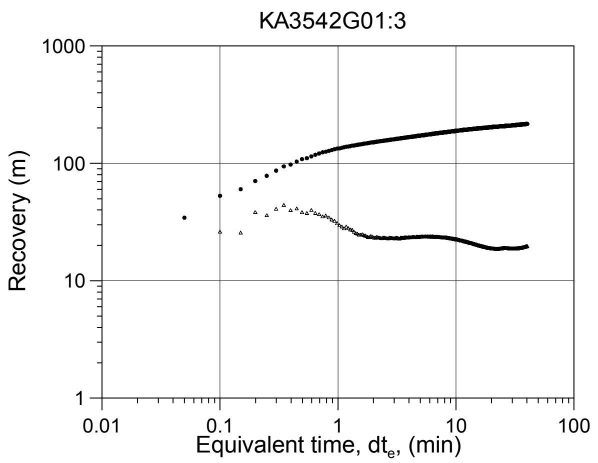
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	2430.6		
p_i (kPa)			
p_p(kPa)	176.8	p_F (kPa)	2341.7
Q_p (m^3/s)	$1.03 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		Results	
Q/s (m^2/s)	$4.6 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$3.0 \cdot 10^{-8}$	dt_{e1} (min)	20
Flow regime:		dt_{e2} (min)	40
dt_1 (min)		T (m^2/s)	$4.4 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-0.2
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	20	C_D (-)	
dt_2 (min)	40	ξ (-)	-0.2
T_T (m^2/s)	$4.4 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A successful test. During the earlier test campaigns the rather flat shape of the derivative curve for the period 2 – 8 min was not as apparent as now. This may be an indication of an earler radial flow period that is presented above. The transmissivity for this period is $T = 3.4 \cdot 10^{-8}$ m^2/s. However, the late radial flow period is used to estimate the transmissivity to give a fairer comparison with results from earlier test campaigns.

6.1.13 KA3542G02:2 , test No 7:7a

General test data for the pressure build-up test in the interval 25.60-27.20 m of borehole KA3542G02 are presented in Table 6-13.

Table 6-13. General test data for the pressure build-up test in section 25.60-27.20 m of borehole KA3542G02

General test data			
Borehole section	KA3542G02:2		
Test No	7:7a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approximate 100 m)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	25.60
Test section- seclow	Seclow	m	27.20
Test section length	L_w	m	1.60
Test section diameter	$2\cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060928 14:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060928 15:00:00
Stop of flow period		yymmdd hh:mm:ss	20060928 18:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060928 20:00:00
Total flow time	t_p	min	180
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1796.8	
Absolute pressure in test section before stop of flow	p_p	kPa	951.5	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1734.7	
Maximal pressure change during flow period	dp_p	kPa	845.3	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$8.00 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$8.60 \cdot 10^{-8}$
Total volume discharged during flow period	V_p	m^3	$9.285 \cdot 10^{-4}$

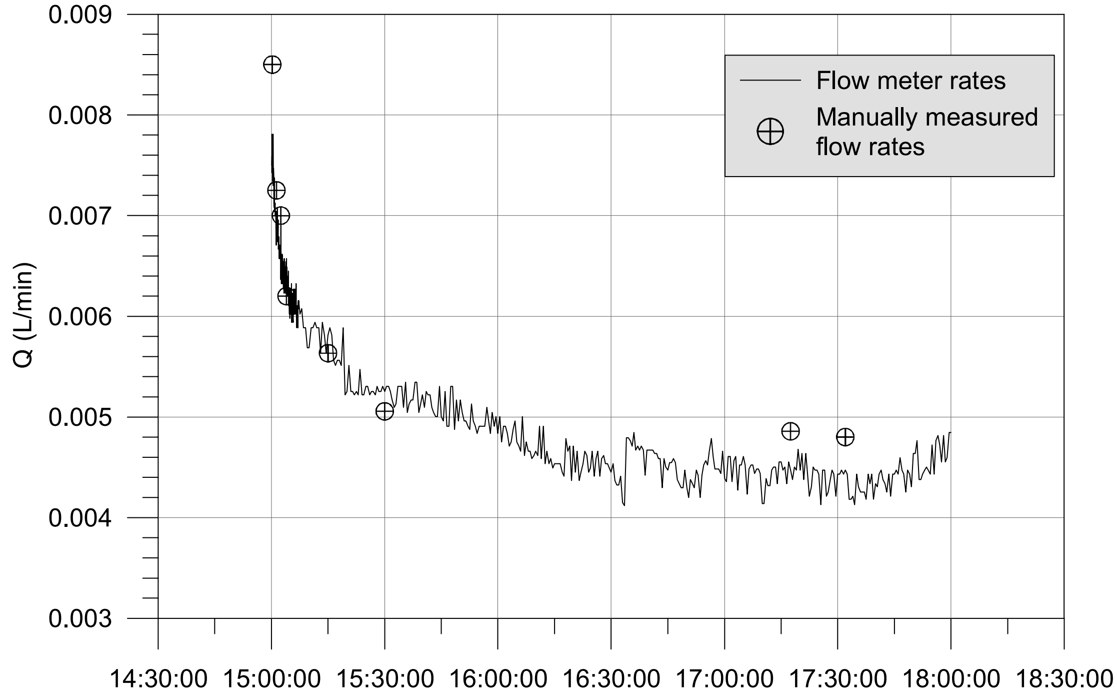


Figure 6-13. *Flow rate during draw down in KA3542G02:2.*

Comments to the test

The test is successful in regard to pressure response.

Interpreted flow regimes

0 – 0.5	minutes	Well Bore Storage (WBS)
0.5 – 12	minutes	Transition period
12 – 20	minutes	Radial flow
20 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

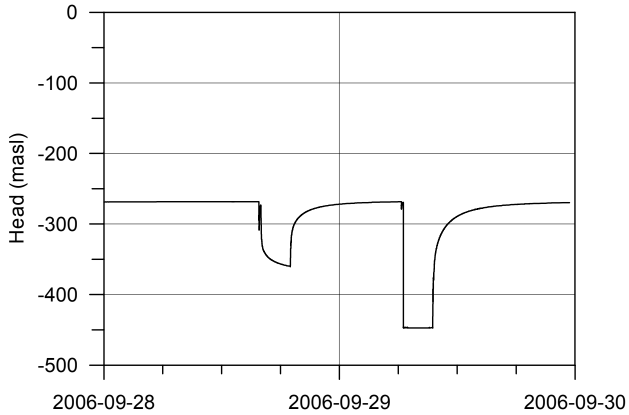
Selected representative parameters

The selected representative parameters from the test in the interval 25.60-27.20 m in KA3542G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

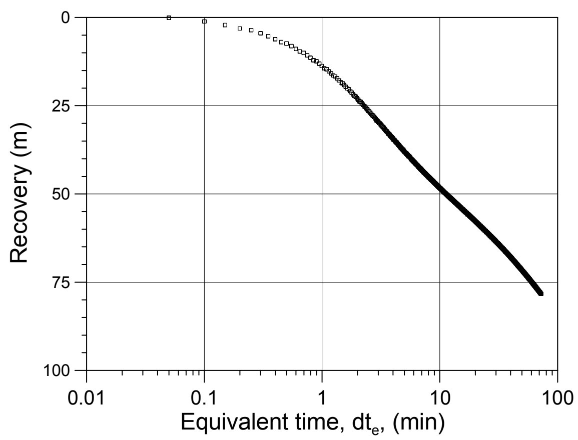
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:7a
Borehole ID:	KA3542G02	Test start:	2006-09-28 14:00
Test section (m):	25.60-27.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



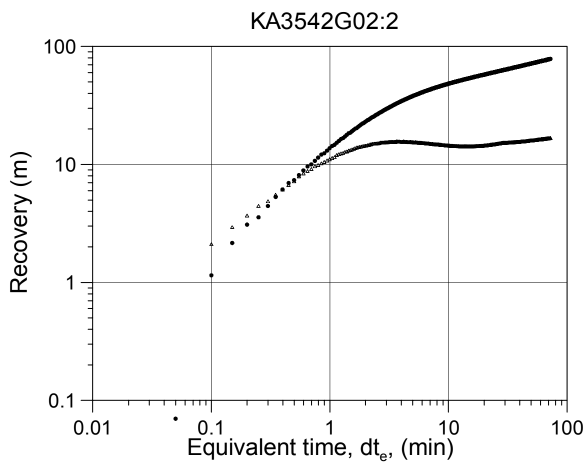
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1796.8		
p_i (kPa)			
p_p(kPa)	951.5	p_F (kPa)	1734.7
Q_p (m^3/s)	$8.00 \cdot 10^{-8}$		
tp (min)	180	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$9.5 \cdot 10^{-10}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$6.1 \cdot 10^{-10}$	dt_{e1} (min)	12
Flow regime:		dt_{e2} (min)	20
dt_1 (min)		T (m^2/s)	$4.2 \cdot 10^{-10}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-1.5
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	12	C_D (-)	
dt_2 (min)	20	ξ (-)	-1.5
T_T (m^2/s)	$4.2 \cdot 10^{-10}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A successful test.

6.1.14 KA3542G02:2 , test No 7:7b

General test data for the pressure build-up test in the interval 25.60-27.20 m of borehole KA3542G02 are presented in Table 6-14.

Table 6-14. General test data for the pressure build-up test in section 25.60-27.20 m of borehole KA3542G02

General test data			
Borehole section	KA3542G02:2		
Test No	7:7b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	25.60
Test section- seclow	Seclow	m	27.20
Test section length	L_w	m	1.60
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060929 04:30:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060929 05:30:00
Stop of flow period		yymmdd hh:mm:ss	20060929 08:30:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060929 10:30:00
Total flow time	t_p	min	180
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1840.3	
Absolute pressure in test section before stop of flow	p_p	kPa	97.8	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1600.7	
Maximal pressure change during flow period	dp_p	kPa	1742.5	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.84 \cdot 10^{-7}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$2.02 \cdot 10^{-7}$
Total volume discharged during flow period	V_p	m^3	$2.18 \cdot 10^{-3}$

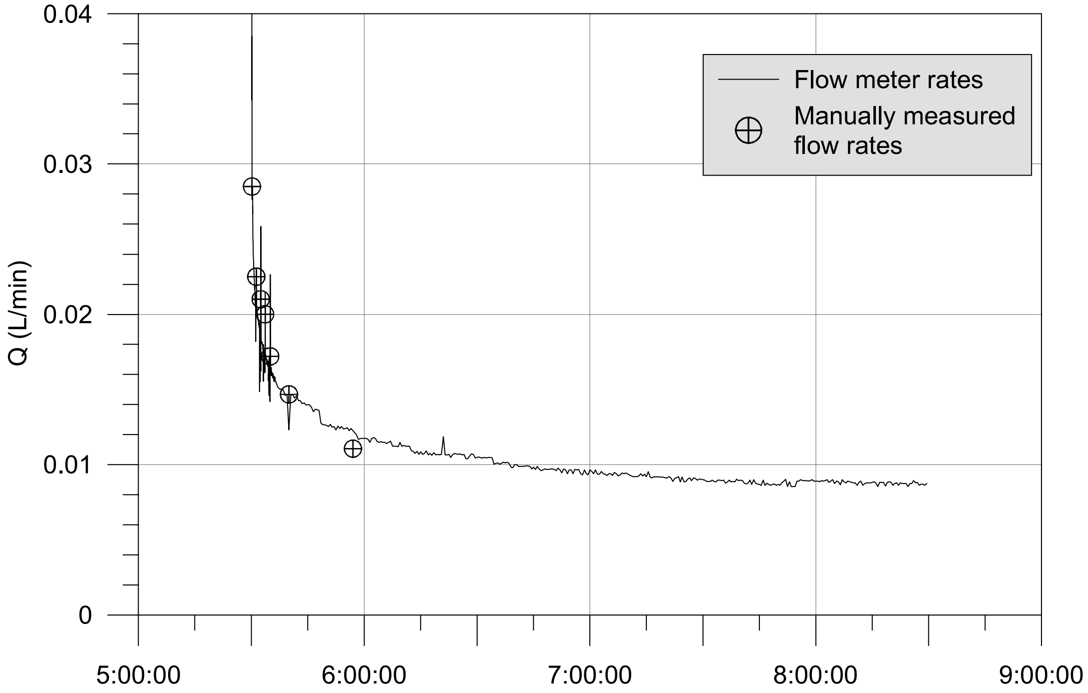


Figure 6-14. *Flow rate during draw down in KA3542G02:2.*

Comments to the test

The reason to the pressure disturbance during recovery is not known. However, the later part of the recovery is considered as reliable.

Interpreted flow regimes

0 – 1	minutes	Well Bore Storage (WBS)
1 – 18	minutes	Transition period
18 – 28	minutes	Radial flow
28 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

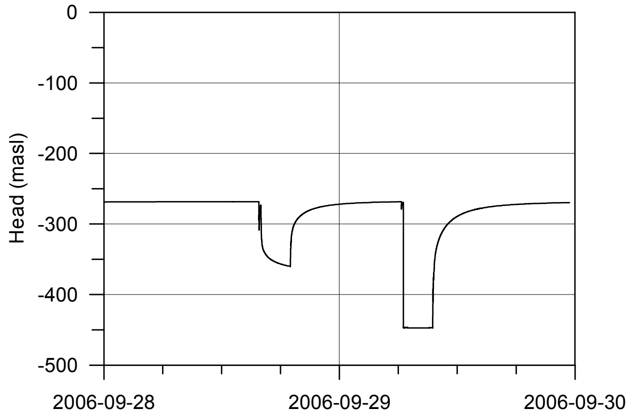
Selected representative parameters

The selected representative parameters from the test in the interval 25.60-27.20 m in KA3542G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

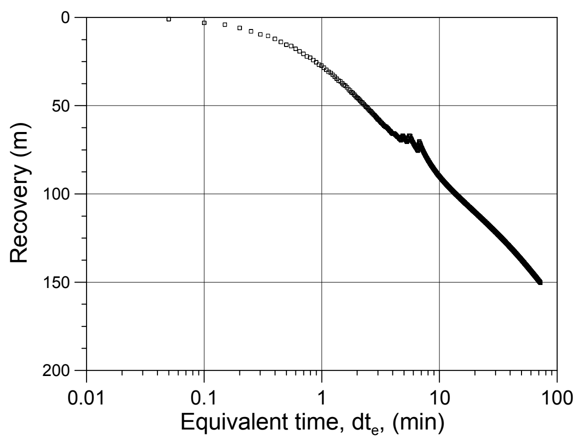
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:7b
Borehole ID:	KA3542G02	Test start:	2006-09-29 04:30
Test section (m):	25.60-27.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



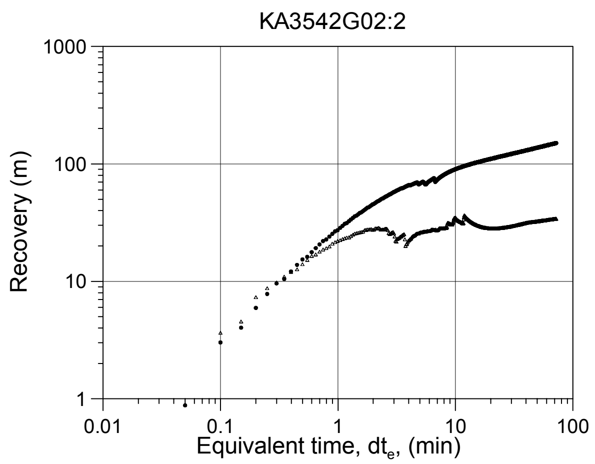
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1840.3		
p_i (kPa)			
p_p(kPa)	97.8	p_F (kPa)	1600.7
Q_p (m^3/s)	$1.84 \cdot 10^{-7}$		
tp (min)	180	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.1 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$6.8 \cdot 10^{-10}$	dt_{e1} (min)	18
Flow regime:		dt_{e2} (min)	28
dt_1 (min)		T (m^2/s)	$5.1 \cdot 10^{-10}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-1.5
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	18	C_D (-)	
dt_2 (min)	28	ξ (-)	-1.5
T_T (m^2/s)	$5.1 \cdot 10^{-10}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The reason to the pressure disturbance during recovery is not known. However, the later part of the recovery is considered as reliable.

6.1.15 KA3546G01:2 , test No 7:9

General test data for the pressure build-up test in the interval 6.75-8.30 m of borehole KA3546G01 are presented in Table 6-15.

Table 6-15. General test data for the pressure build-up test in section 6.75-8.30 m of borehole KA3546G01

General test data			
Borehole section	KA3546G01:2		
Test No	7:9		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	6.75
Test section- seclow	Seclow	m	8.30
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060927 11:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060927 12:00:00
Stop of flow period		yymmdd hh:mm:ss	20060927 15:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060927 17:00:00
Total flow time	t_p	min	180
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	658.5	
Absolute pressure in test section before stop of flow	p_p	kPa	77.7	
Absolute pressure in test section at stop of recovery period	p_f	kPa	685.7	
Maximal pressure change during flow period	dp_p	kPa	580.8	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$3.04 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	–
Total volume discharged during flow period	V_p	m^3	–

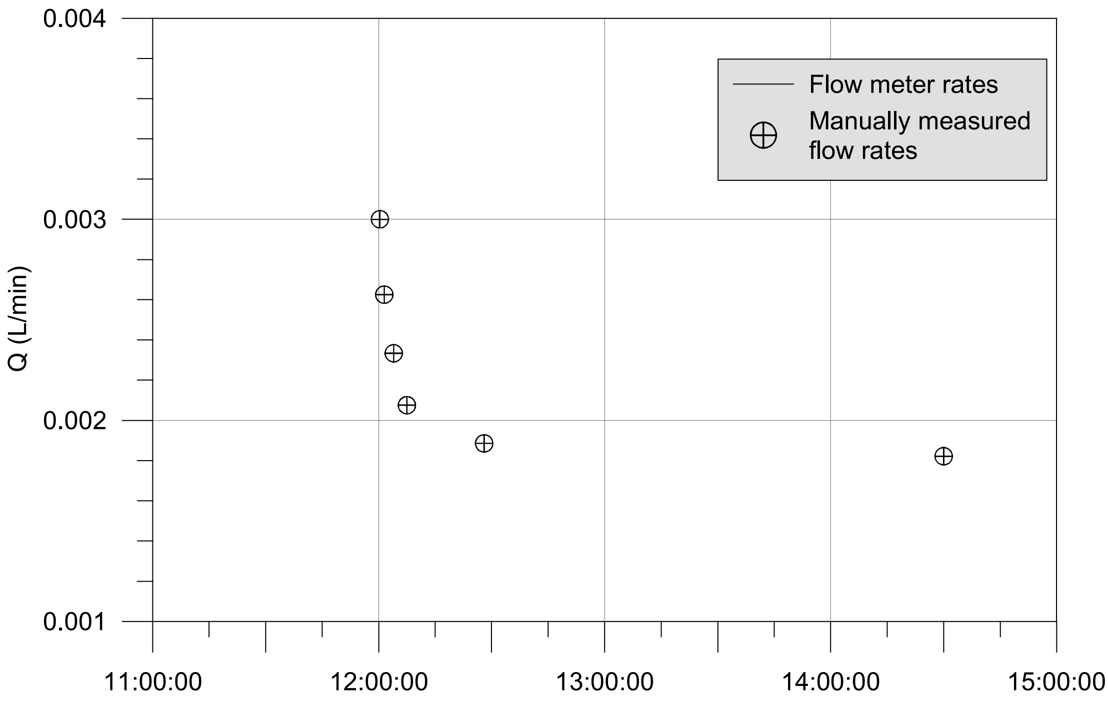


Figure 6-15. *Flow rate during draw down in KA3546G01:2. The flow in this section is very low. No flowmeter readings are available.*

Comments to the test

A very low flowrate is established from this borehole.

Interpreted flow regimes

0 – 3	minutes	Well Bore Storage (WBS)
3 –	minutes	Transition period

No radial flow regime period is established.

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

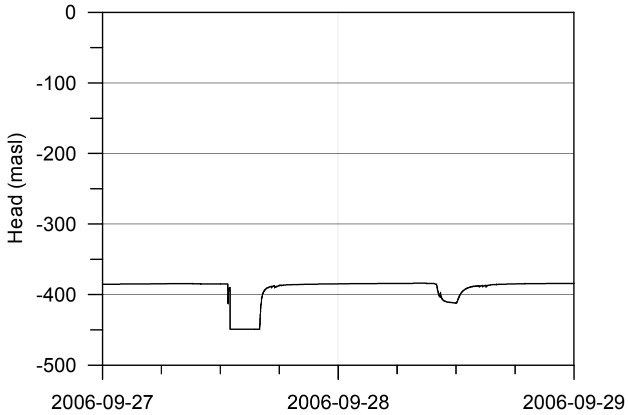
Selected representative parameters

The selected representative parameters from the test in the interval 6.75-8.30 m in KA3546G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

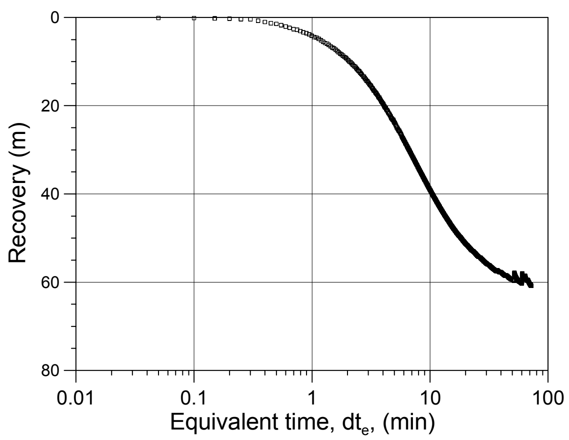
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:9
Borehole ID:	KA3546G01	Test start:	2005-11-30 07:00
Test section (m):	6.75-8.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



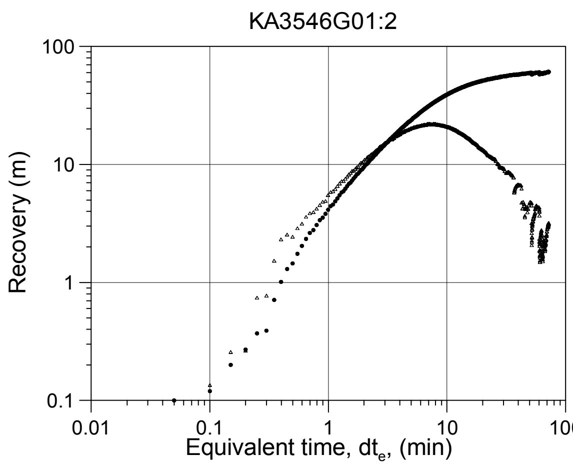
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	658.5		
p_i (kPa)			
p_p(kPa)	77.7	p_F (kPa)	685.7
Q_p (m^3/s)	$3.04 \cdot 10^{-8}$		
tp (min)	180	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$5.2 \cdot 10^{-10}$	Flow regime:	-
T_{Moye}(m^2/s)	$3.3 \cdot 10^{-10}$	dt_{e1} (min)	-
Flow regime:		dt_{e2} (min)	-
dt_1 (min)		T (m^2/s)	-
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:		C (m^3/Pa)	
dt_1 (min)		C_D (-)	
dt_2 (min)		ξ (-)	
T_T (m^2/s)			
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: No radial flow regime occurred during the test period.

6.1.16 KA3539G:2, test No 7:13a

General test data for the pressure build-up test in the interval 15.85-17.60 m of borehole KA3539G are presented in Table 6-16.

Table 6-16. General test data for the pressure build-up test in section 15.85-17.60 m of borehole KA3539G

General test data			
Borehole section	KA3539G:2		
Test No	7:13a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomencl ature	Unit	Value
Test section- secup	Secup	m	15.85
Test section- seclow	Seclow	m	17.60
Test section length	L_w	m	1.75
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060925 16:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060925 17:00:00
Stop of flow period		yymmdd hh:mm:ss	20051128 18:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20051128 19:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1456.1	
Absolute pressure in test section before stop of flow	p_p	kPa	643.5	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1209.1	
Maximal pressure change during flow period	dp_p	kPa	812.6	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.51 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.68 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.0603

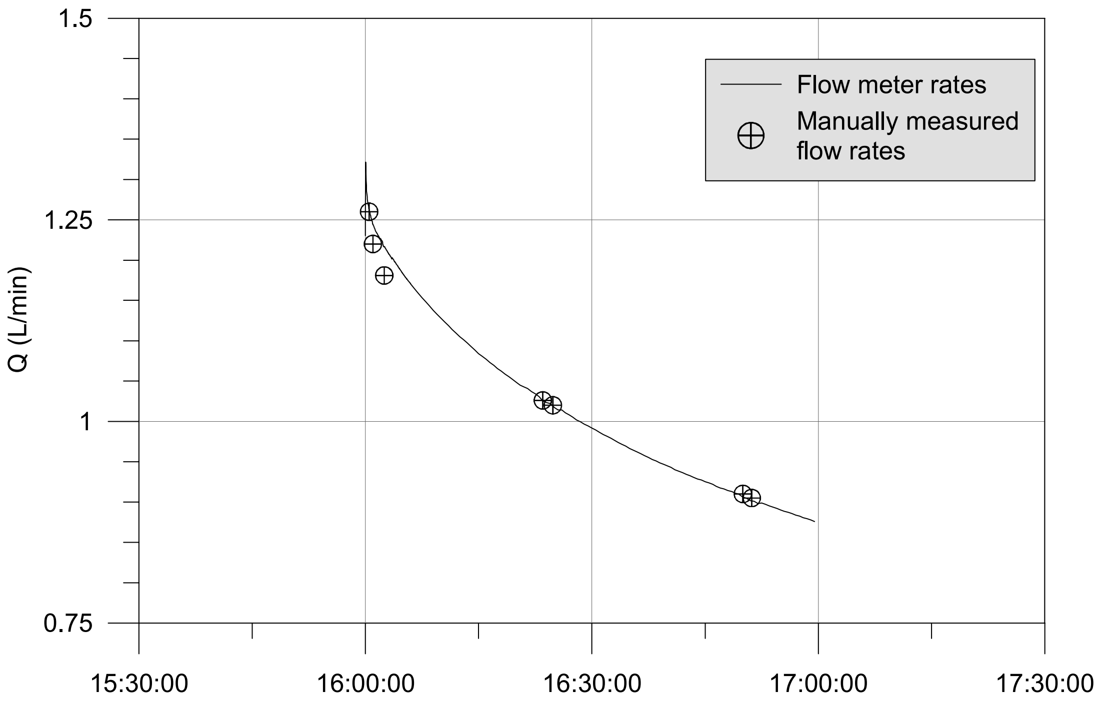


Figure 6-16. *Flow rate during draw down in KA3539G:2.*

Comments to the test

The test is successful in regard to pressure response. A linear channel flow period occurs during this test.

Interpreted flow regimes

0 – 0.05	minutes	Well Bore Storage (WBS)
0.05 – 0.25	minutes	Transition period
0.25 – 0.5	minutes	Radial flow period
0.5 – 10	minutes	Transition period
10 –	minutes	Possible linear channel flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

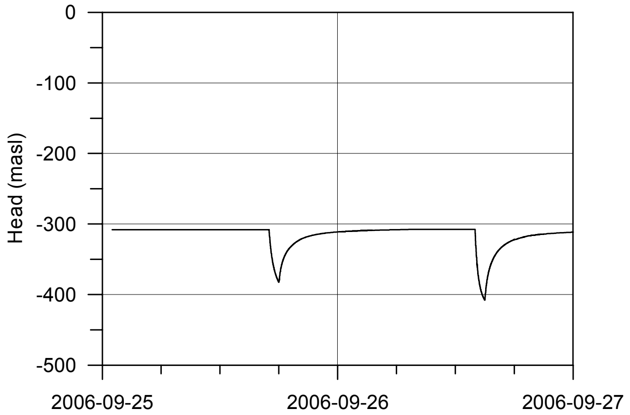
Selected representative parameters

The selected representative parameters from the test in the interval 15.85-17.60 m in KA3539G are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

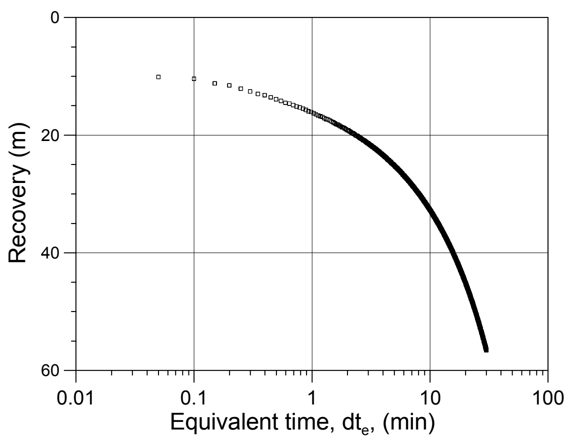
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:13a
Borehole ID:	KA3539G	Test start:	2006-09-25 15:00
Test section (m):	15.85-17.60	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



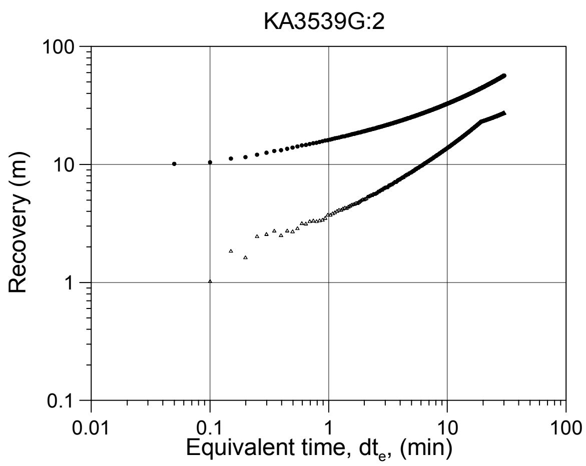
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	1456.1		
p_i (kPa)			
p_p(kPa)	643.5	p_F (kPa)	1209.1
Q_p (m^3/s)	$1.51 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.9 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.2 \cdot 10^{-7}$	dt_{e1} (min)	0.25
Flow regime:		dt_{e2} (min)	0.5
dt_1 (min)		T (m^2/s)	$4.7 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-2.3
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.25	C_D (-)	
dt_2 (min)	0.5	ξ (-)	-2.3
T_T (m^2/s)	$4.7 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A channel flow regime is established during this test.

6.1.17 KA3539G:2, test No 7:13b

General test data for the pressure build-up test in the interval 15.85-17.60 m of borehole KA3539G are presented in Table 6-17.

Table 6-17. General test data for the pressure build-up test in section 15.85-17.60 m of borehole KA3539G

General test data			
Borehole section	KA3539G:2		
Test No	7:13b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	15.85
Test section- seclow	Seclow	m	17.60
Test section length	L_w	m	1.75
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20060926 12:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20060926 13:00:00
Stop of flow period		yymmdd hh:mm:ss	20060926 14:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20060926 15:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1463.7	
Absolute pressure in test section before stop of flow	p_p	kPa	371.2	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1118.4	
Maximal pressure change during flow period	dp_p	kPa	1092.5	

Flow data

Flow data	Nomenclature	Unit	Value
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.90 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$2.42 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.0873

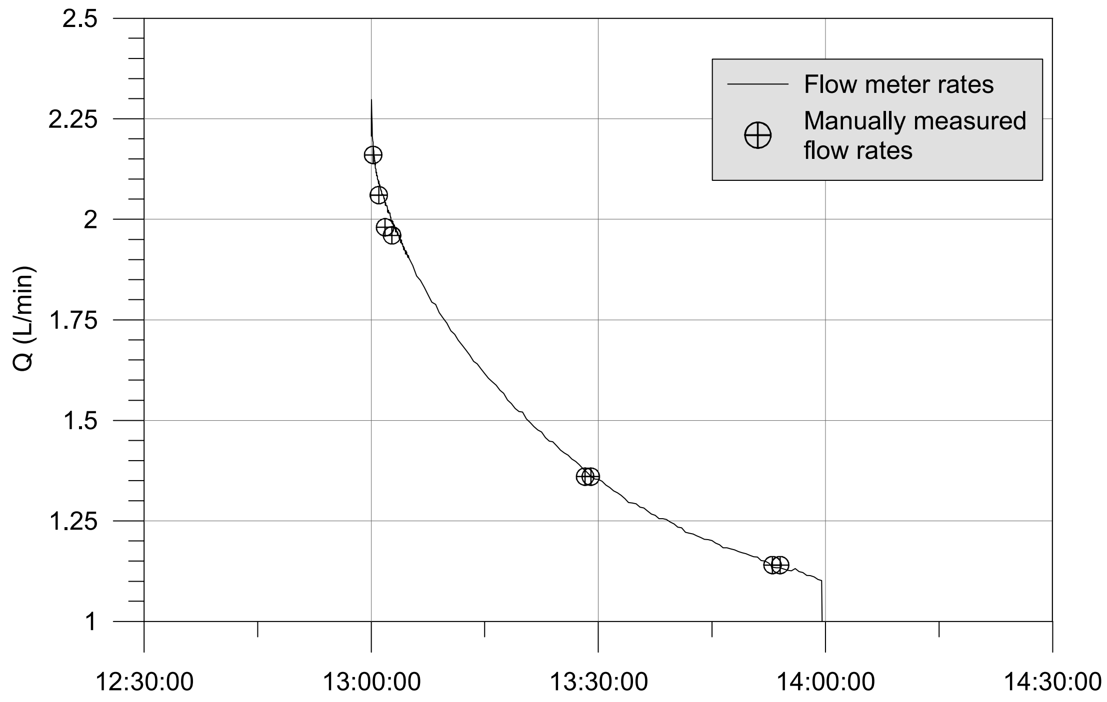


Figure 6-17. *Flow rate during draw down in KA3539G:2.*

Comments to the test

The test is successful in regard to pressure response. A linear channel flow period during this test.

Interpreted flow regimes

0 – 0.05	minutes	Well Bore Storage (WBS)
0.05 – 0.25	minutes	Transition period
0.25 – 0.5	minutes	Radial flow period
0.25 – 10	minutes	Transition period
10 –	minutes	Possible linear channel flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

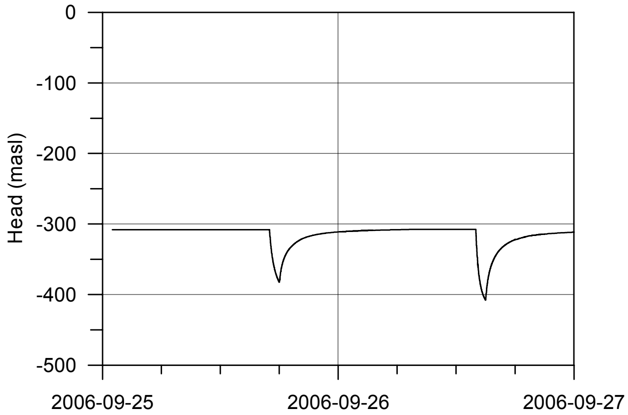
Selected representative parameters

The selected representative parameters from the test in the interval 15.85-17.60 m in KA3539G are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

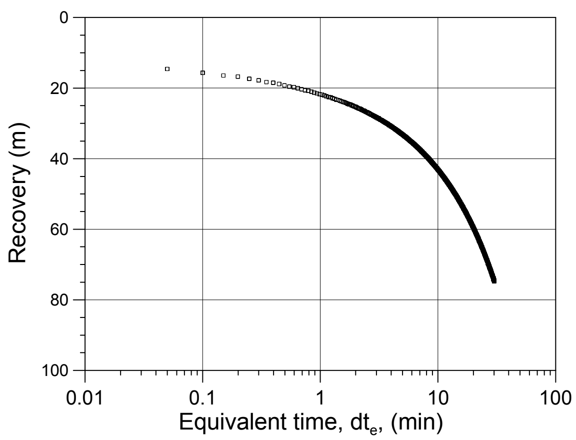
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	7:13b
Borehole ID:	KA3539G	Test start:	2006-09-26 12:00
Test section (m):	15.85-17.60	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



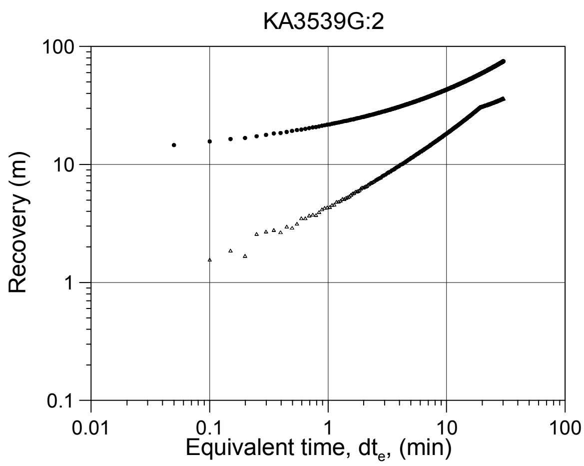
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	1463.7		
p_i (kPa)			
p_p(kPa)	371.2	p_F (kPa)	1118.4
Q_p (m^3/s)	$1.90 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.7 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.1 \cdot 10^{-7}$	dt_{e1} (min)	0.25
Flow regime:		dt_{e2} (min)	0.5
dt_1 (min)		T (m^2/s)	$5.5 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-1.6
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.25	C_D (-)	
dt_2 (min)	0.5	ξ (-)	-1.6
T_T (m^2/s)	$5.5 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A channel flow regime is established during this test.

6.2 Deformation measurements

Deformation measurements started 2003-05-06. Evaluation of the deformations will be made in a separate report.

7 Conclusion

In order to use the measured variable rates in a more qualitative manner an alternative evaluation method, *(Dougherty, Babu, 1984)*, have been used in using the software AQTESOLV and detailed in the appendices. All data from the earlier test campaigns 1–6 have been re-evaluated and are considered as the results that should prevail from now on.

AQTESOLV is the all-in-one software package for the design and analysis of aquifer tests including pumping tests, step-drawdown tests, variable-rate tests, recovery tests, single-well tests, slug tests and constant-head tests. The software is developed by HydroSOLVE, Inc., USA.

References

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Forsmark T, Rhén I, 2005c. Äspö HRL - Prototype repository – Hydraulic tests and displacement measurements during operation phase. Test campaign 5 – Single hole tests. SKB IPR-05-17.

Forsmark T, 2006. Äspö HRL - Prototype repository – Hydraulic tests and displacement measurements during operation phase. Test campaign 6 – Single hole tests. SKB IPR-06-01.

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Spane F A, Wurstner S K, 1993. DERIV: A computer program for calculating pressure derivatives for use in hydraulic tests. Groundwater Vol 31, No. 5, pp 814 – 822.

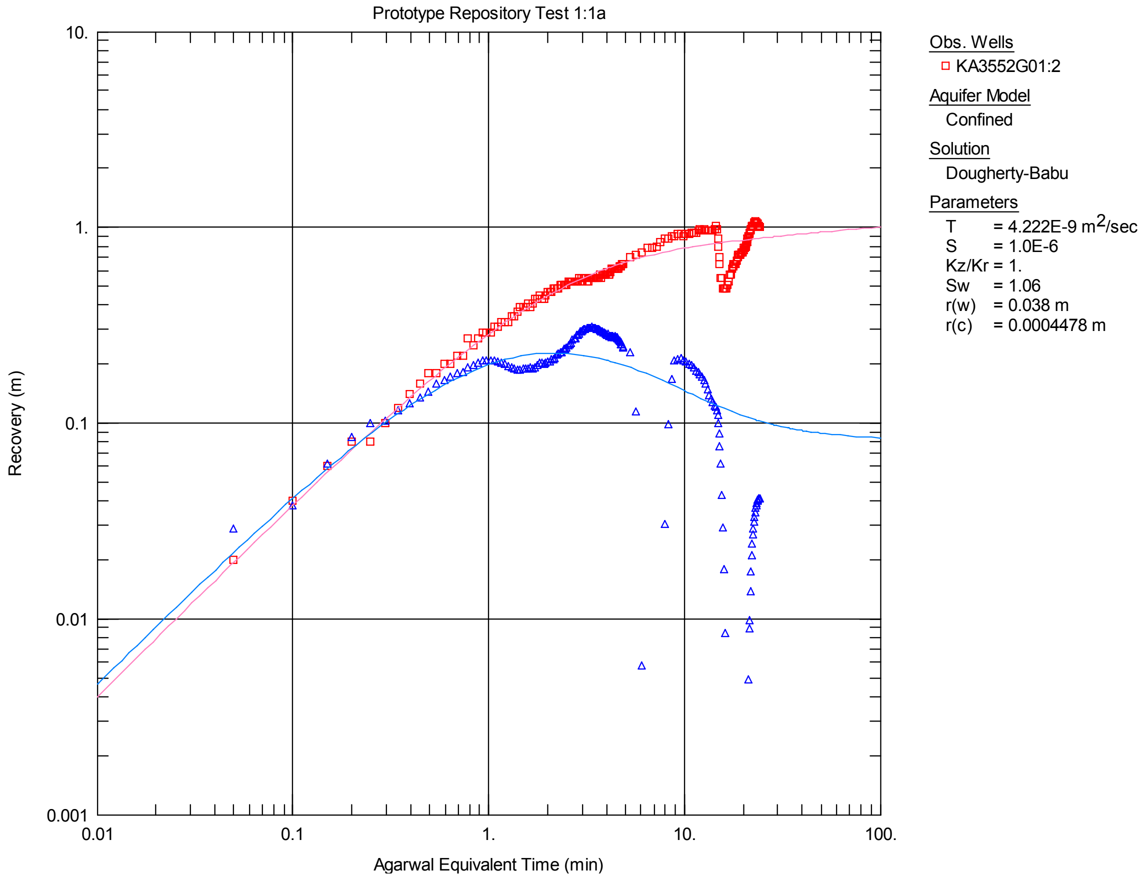
Appendices

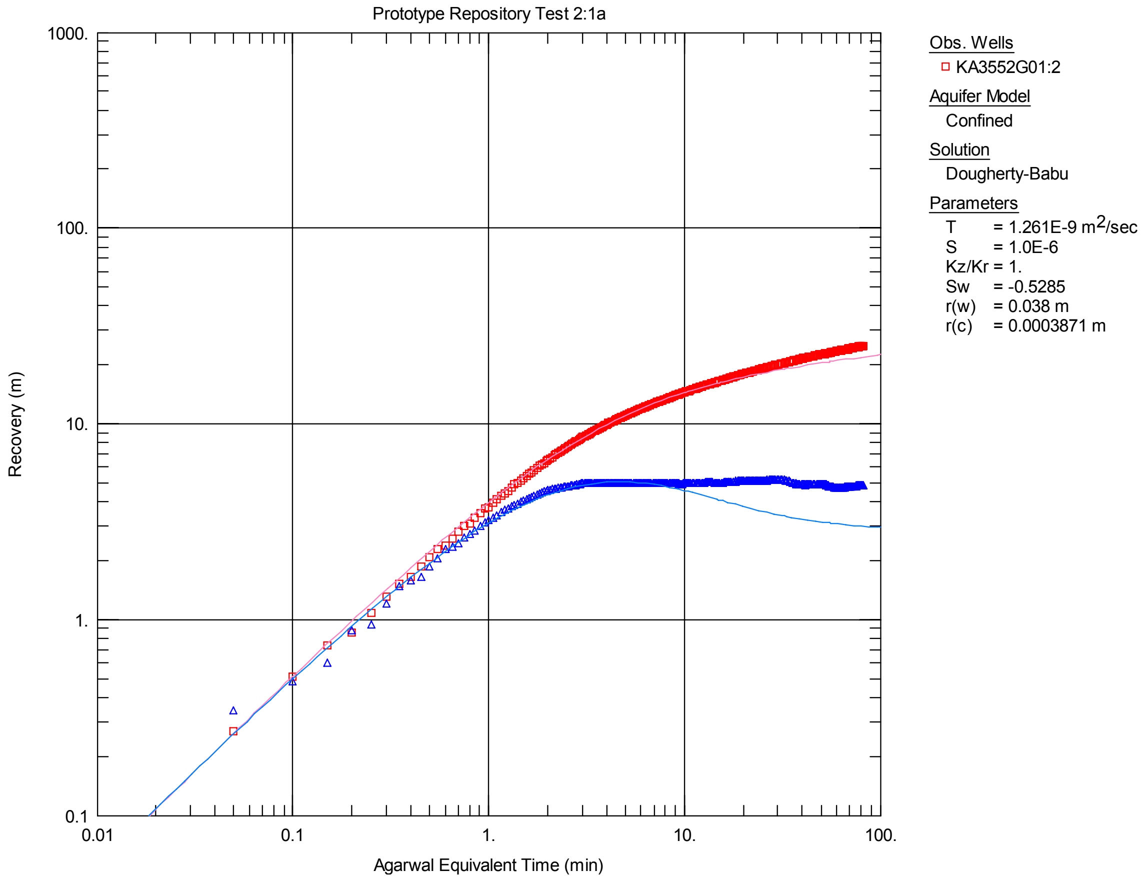
In the appendices all hydraulic tests made during the test campaigns 1 – 7 are re-evaluated using the software AQTESOLV developed by HydroSOLVE, Inc., USA.

All base data are presented earlier in this report (TC 7) and in the earlier evaluation reports (TC 1 – TC 6), (see reference list).

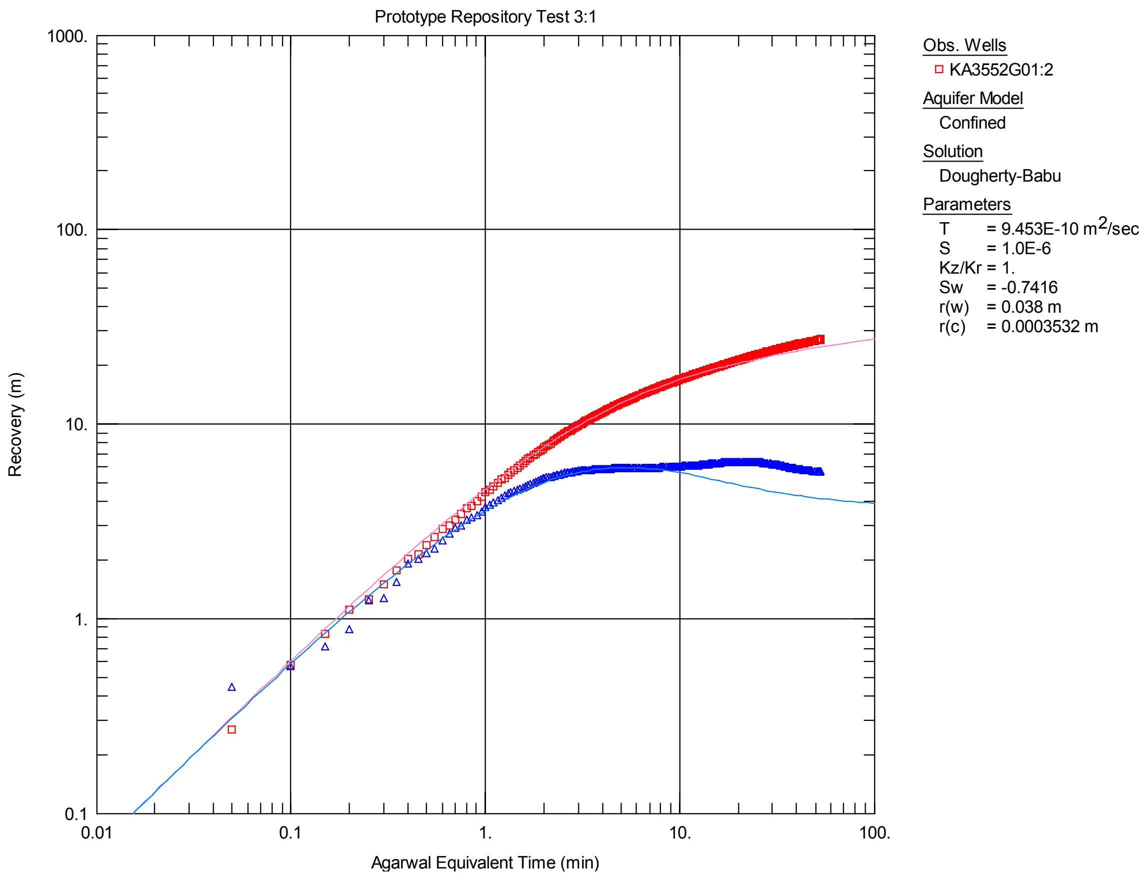
The solution used in these analysis is the Dougherty-Babu model for a pumping test in a confined aquifer (Dougherty, Babu, 1984). The model assumes radial flow in a porous medium. Aqtesolv uses the principle of superposition in time to simulate variable-rate tests including recovery with the solution.

Appendix 1 – KA3552G01:2

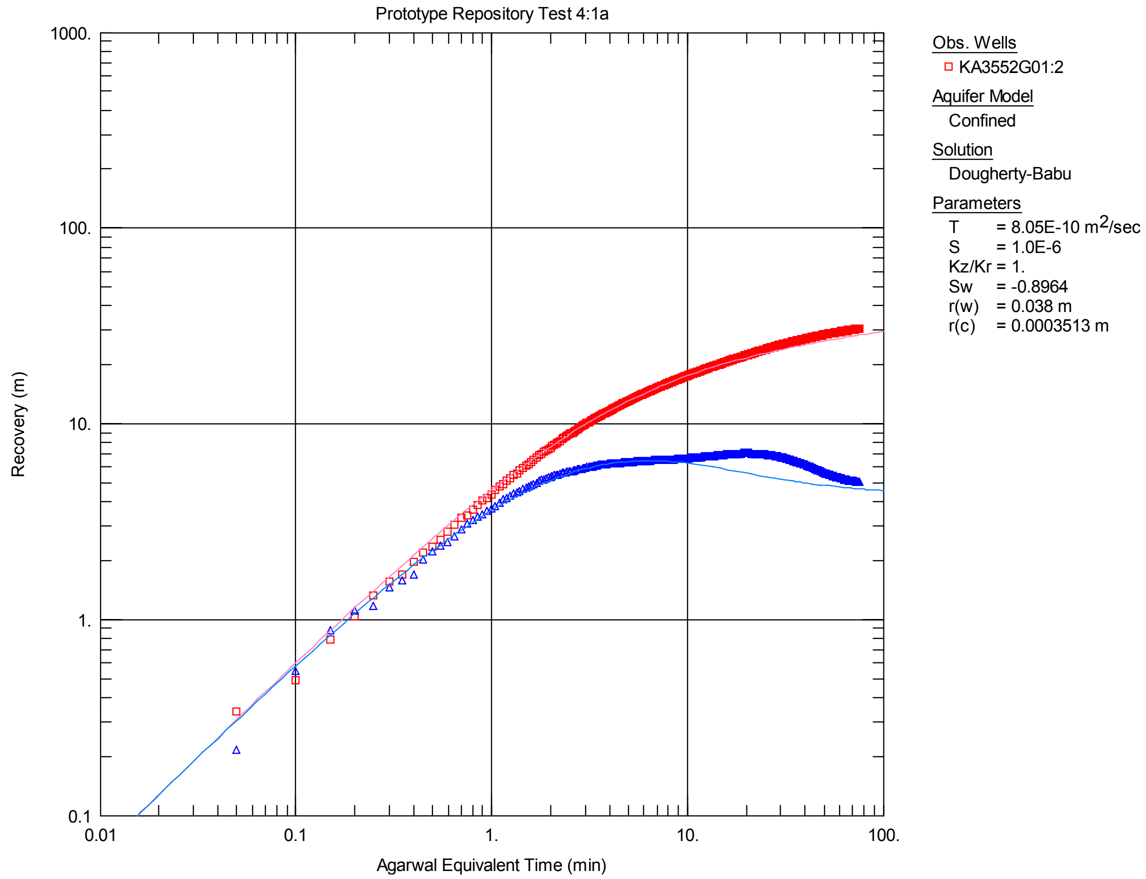


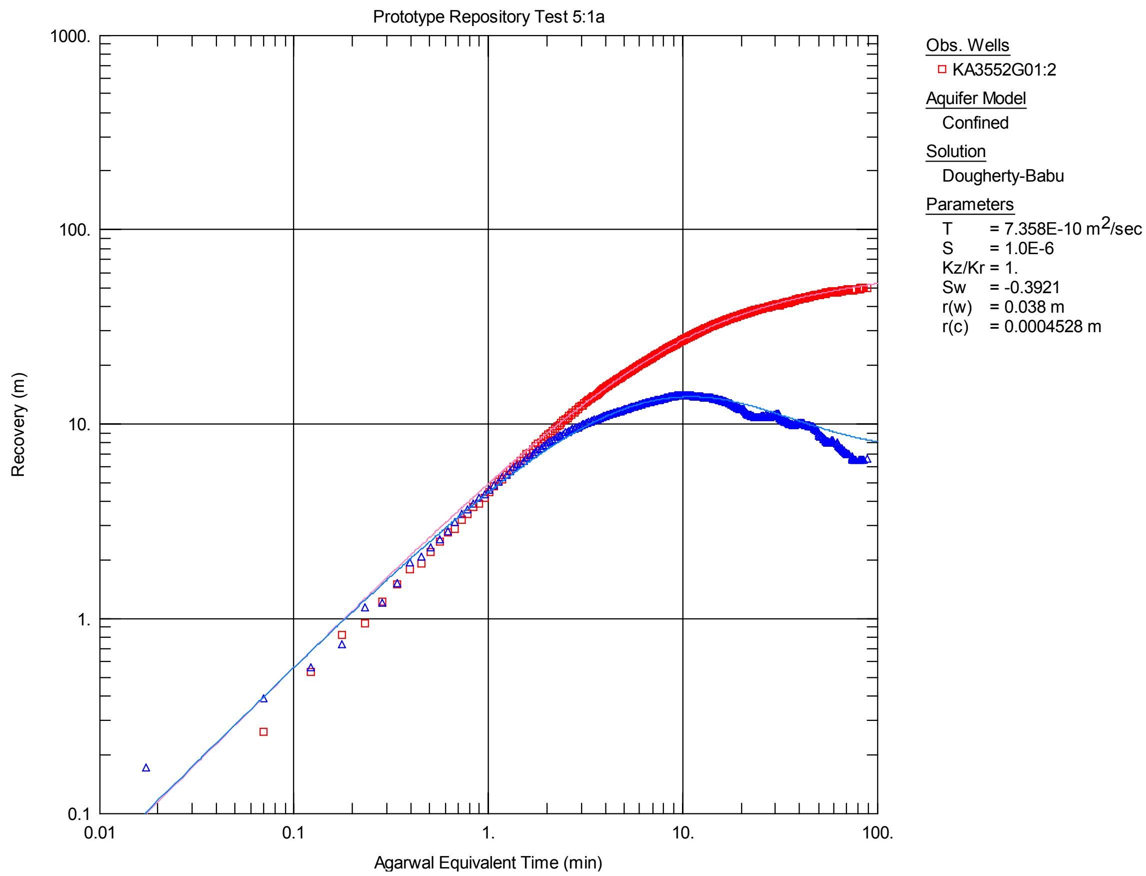


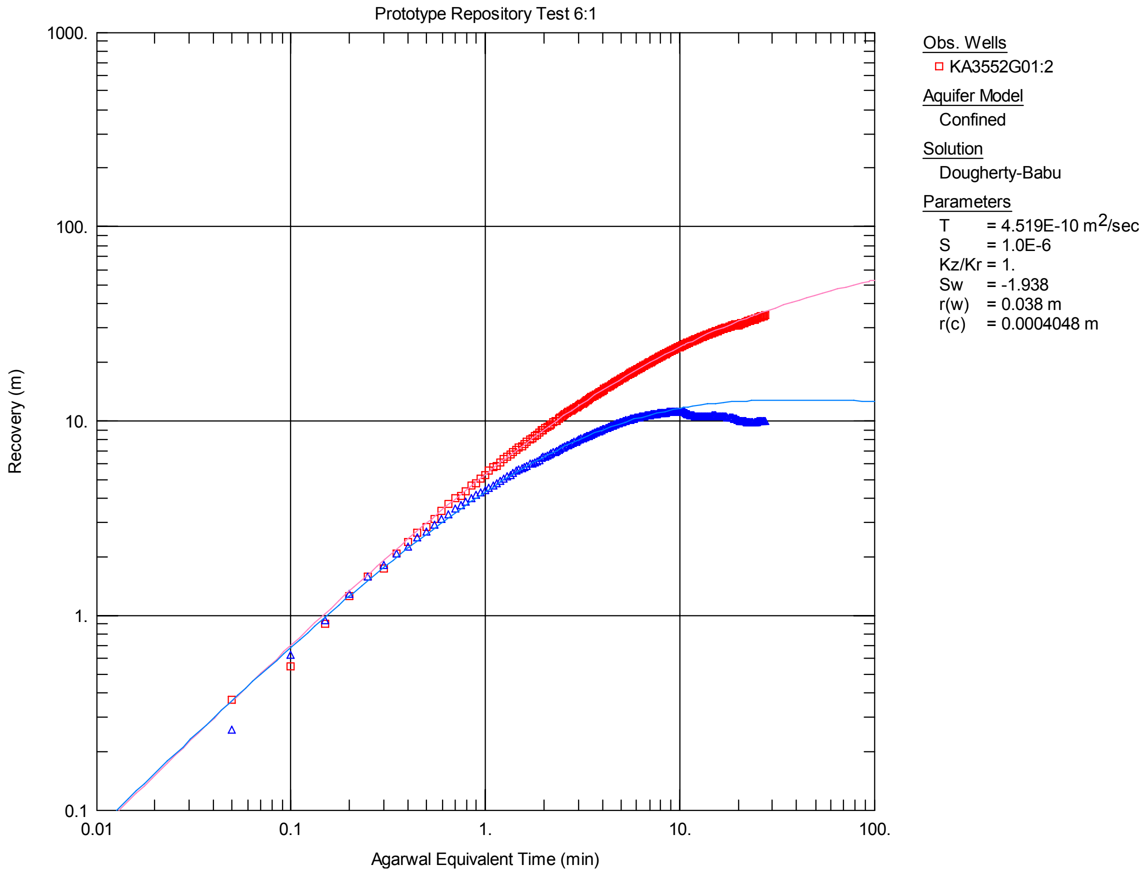
Prototype Repository Test 2:1a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3552G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.261E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.5285
r(w) = 0.038 m
r(c) = 0.0003871 m

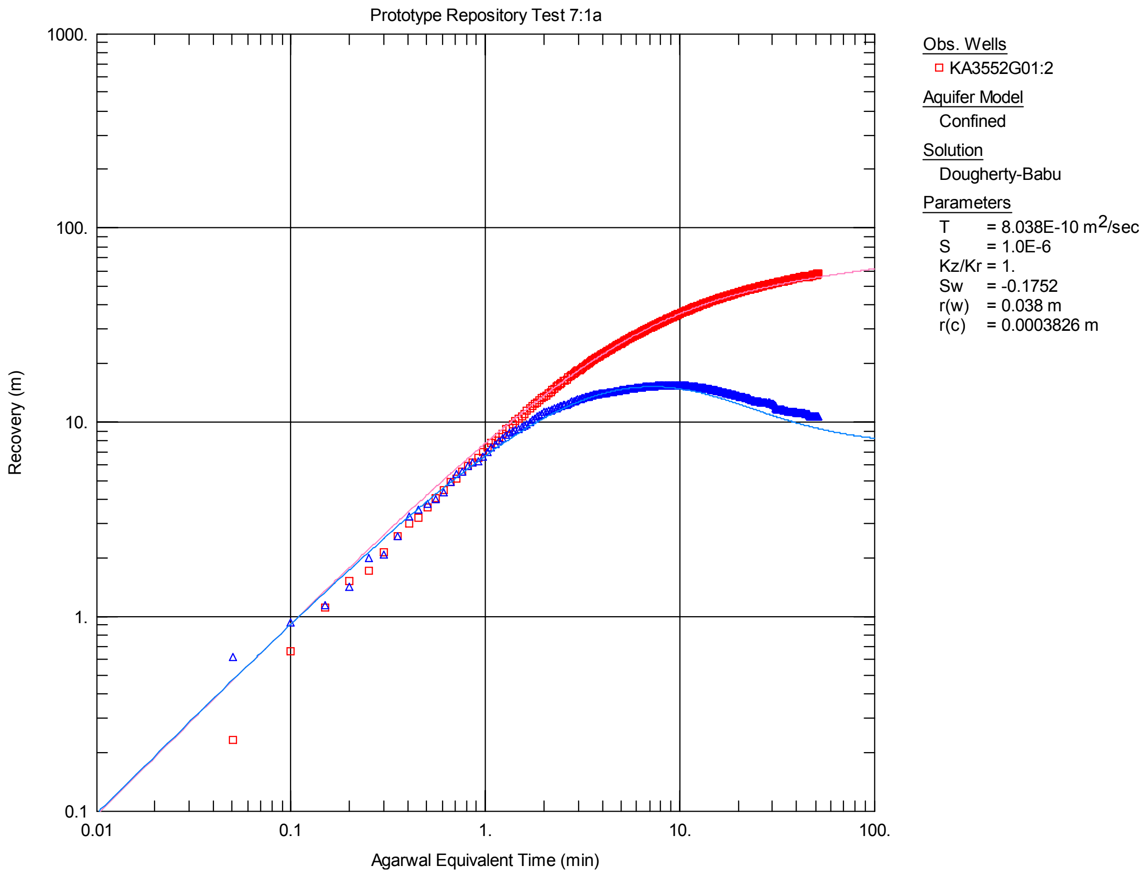


Prototype Repository Test 3:1
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3552G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.453E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.7416
r(w) = 0.038 m
r(c) = 0.0003532 m

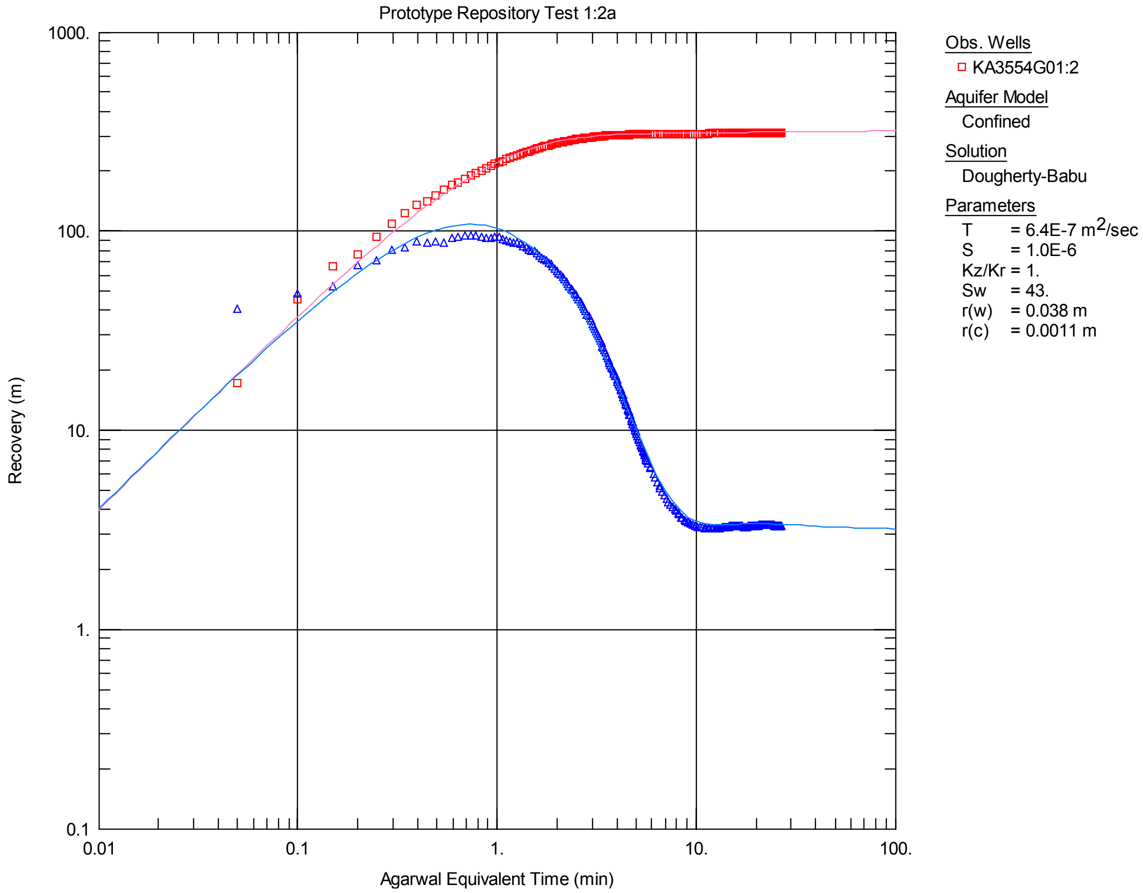

Prototype Repository Test 4:1a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3552G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.05E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.8964
r(w) = 0.038 m
r(c) = 0.0003513 m

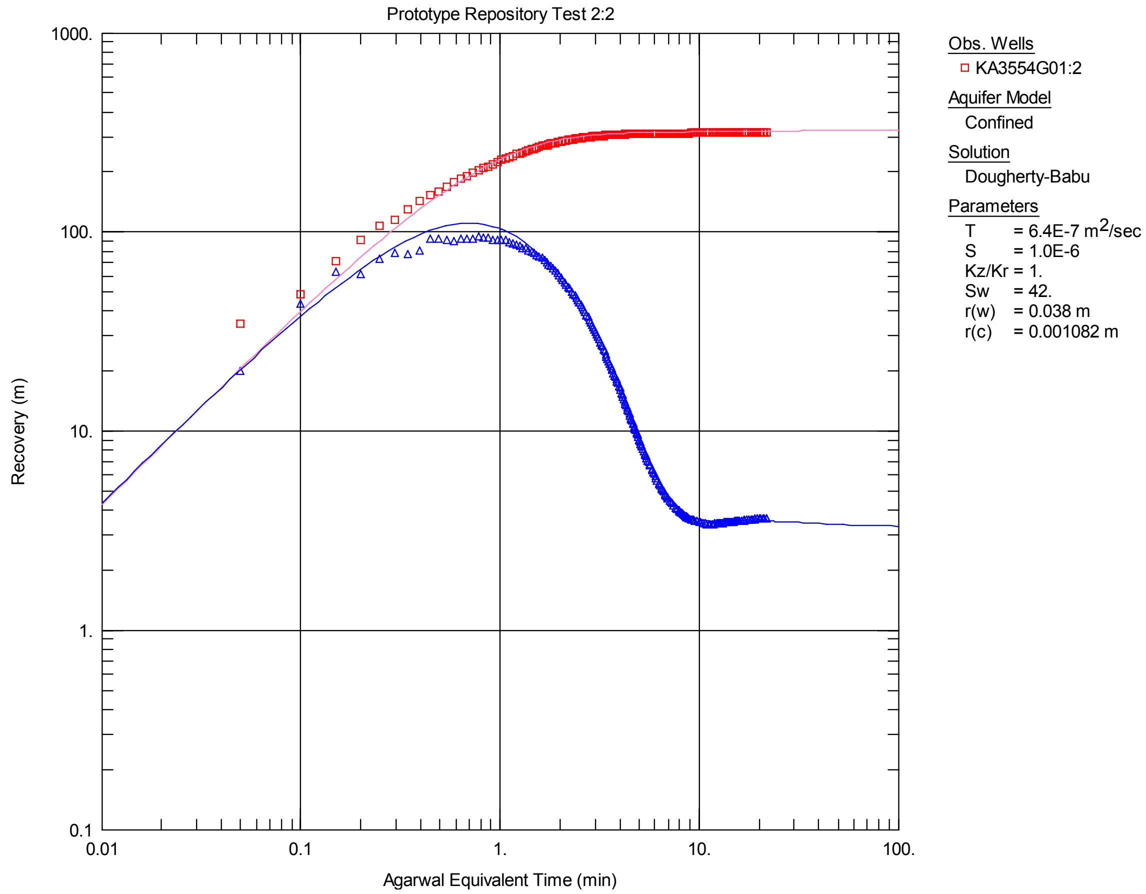

Prototype Repository Test 5:1a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3552G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 7.358E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.3921
r(w) = 0.038 m
r(c) = 0.0004528 m


Prototype Repository Test 6:1
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3552G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.519E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.938
r(w) = 0.038 m
r(c) = 0.0004048 m

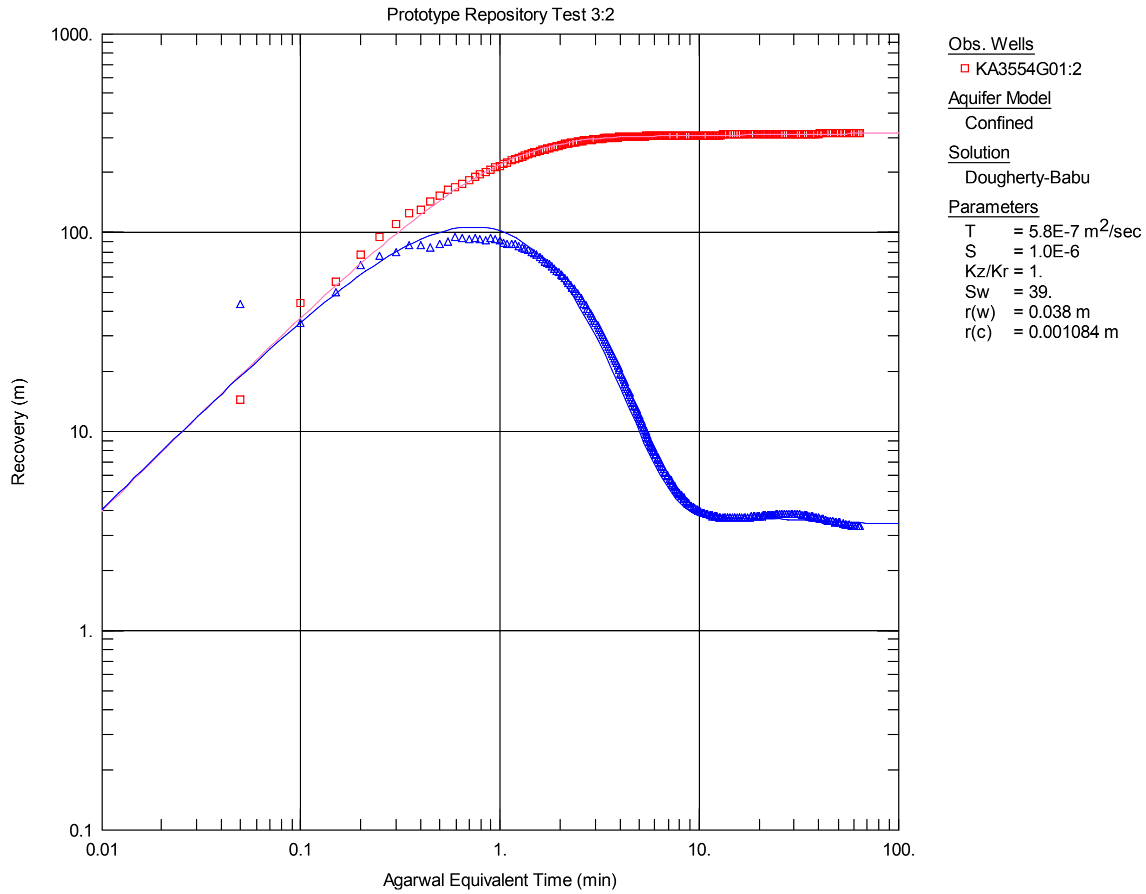

Prototype Repository Test 7:1a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3552G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.038E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.1752
r(w) = 0.038 m
r(c) = 0.0003826 m

Appendix 2 – KA3554G01:2

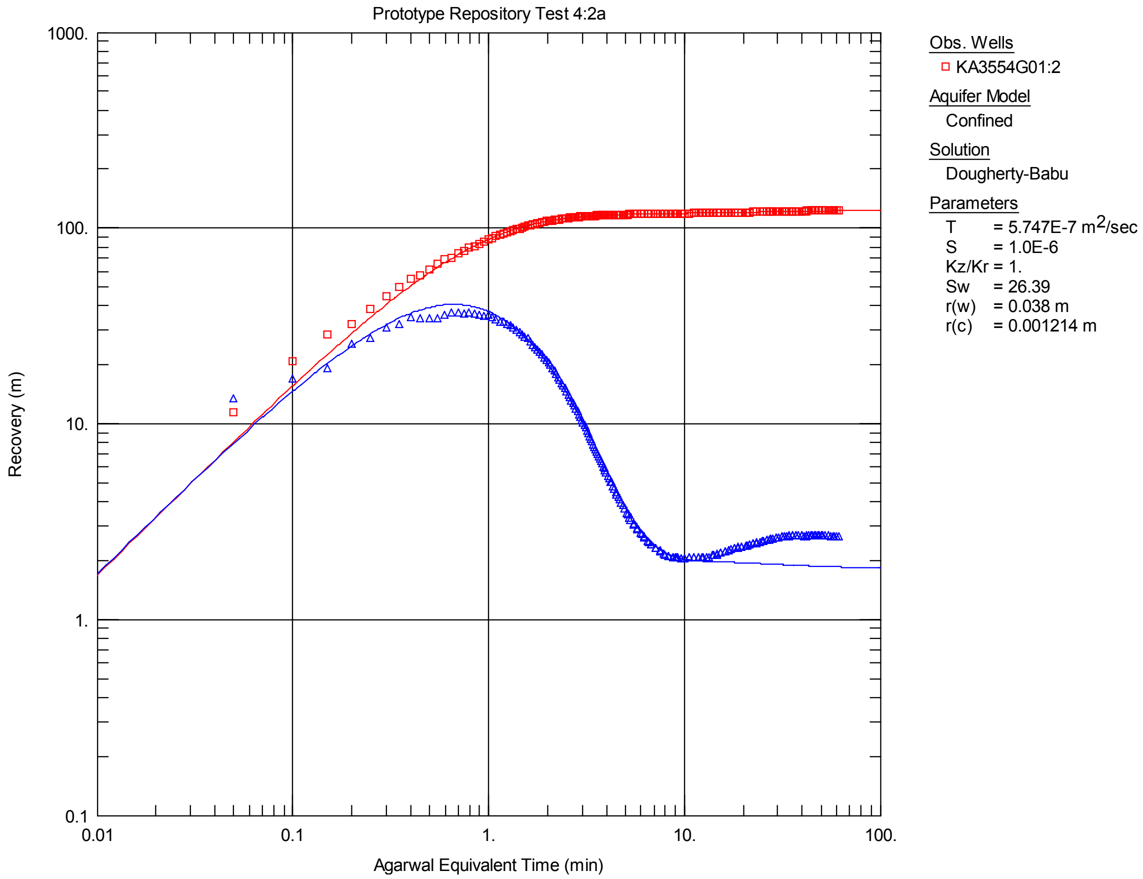


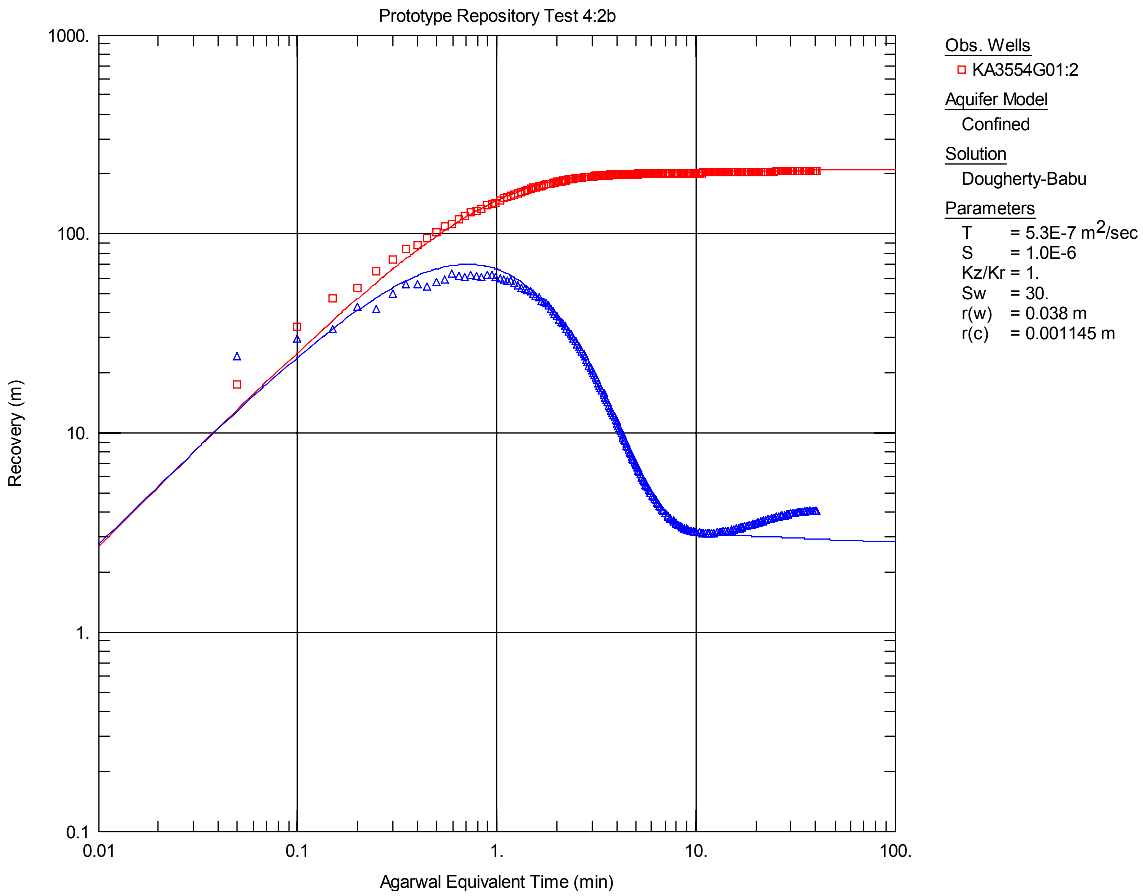


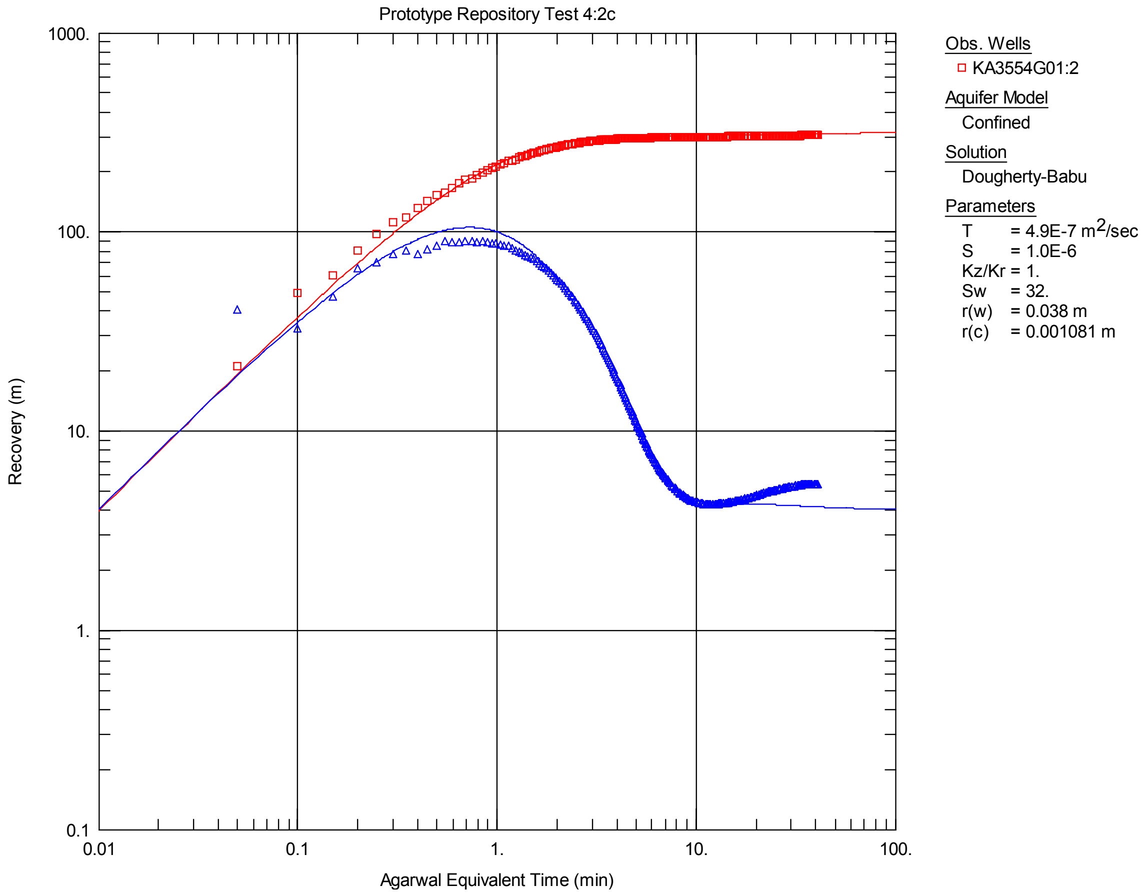
Prototype Repository Test 2:2
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 6.4E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 42.
r(w) = 0.038 m
r(c) = 0.001082 m



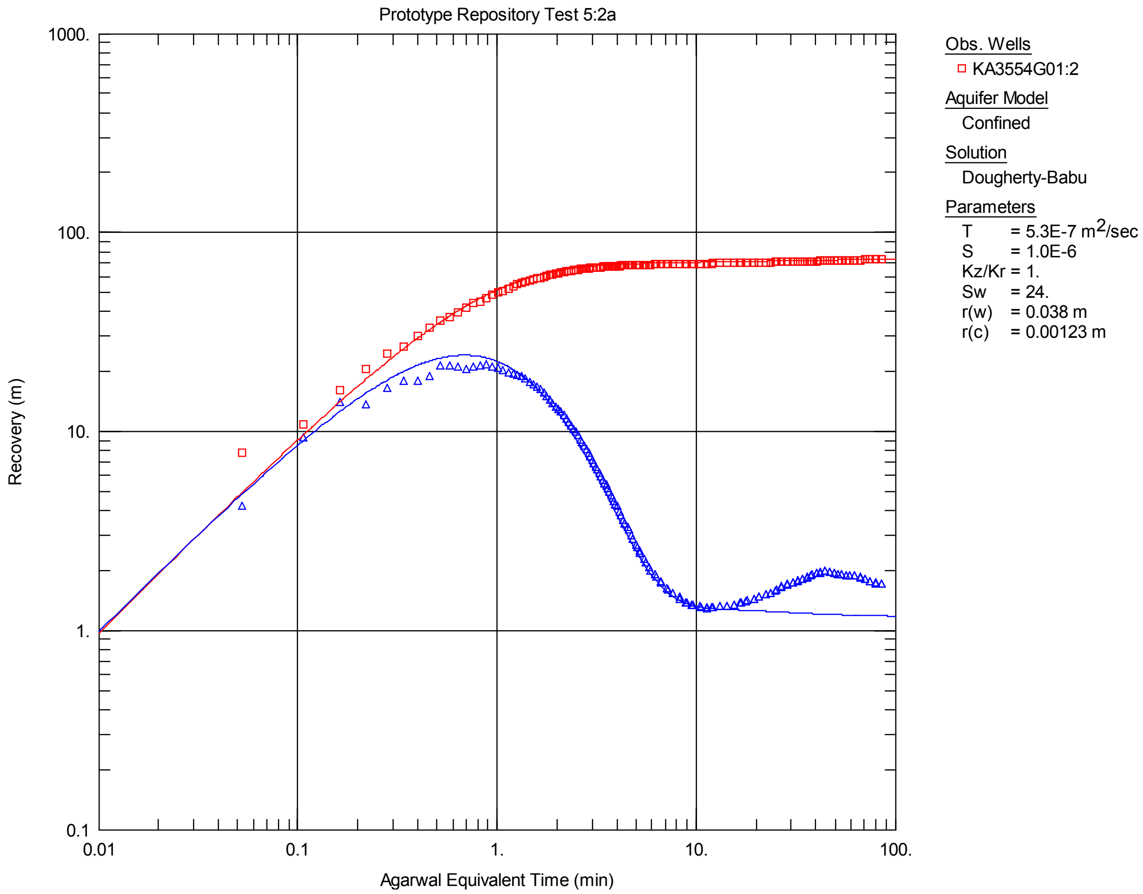
Prototype Repository Test 3:2
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.8E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 39.
r(w) = 0.038 m
r(c) = 0.001084 m


Prototype Repository Test 4:2a
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.747E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 26.39
r(w) = 0.038 m
r(c) = 0.001214 m

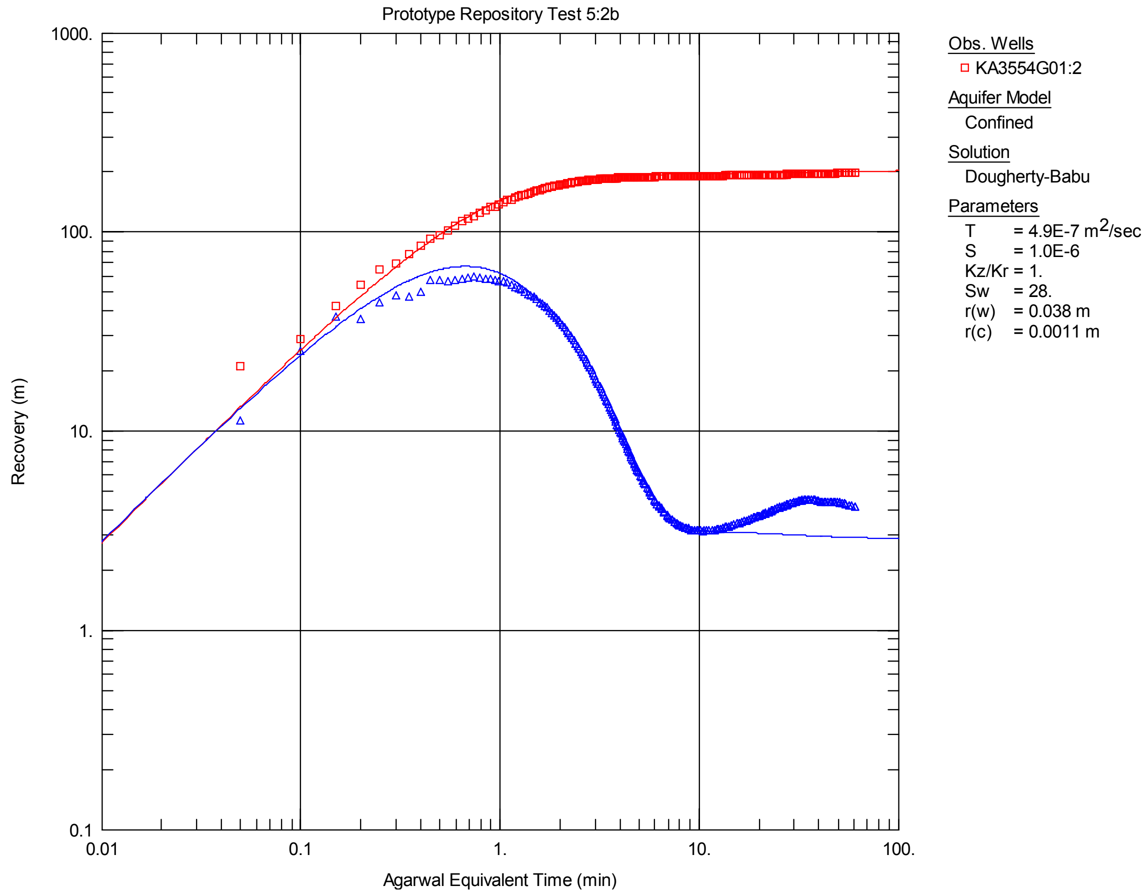

Prototype Repository Test 4:2b
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.3E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 30.
r(w) = 0.038 m
r(c) = 0.001145 m



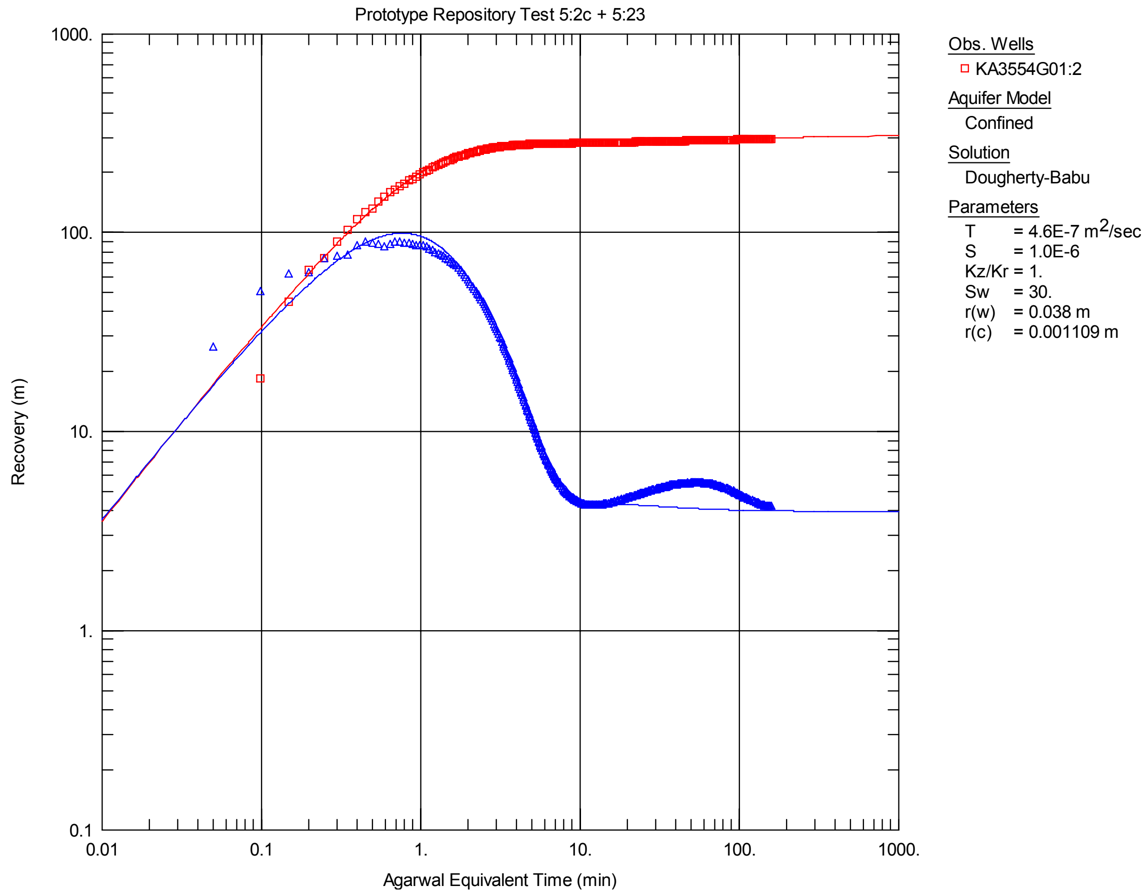
Prototype Repository Test 4:2c
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.9E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 32.
r(w) = 0.038 m
r(c) = 0.001081 m



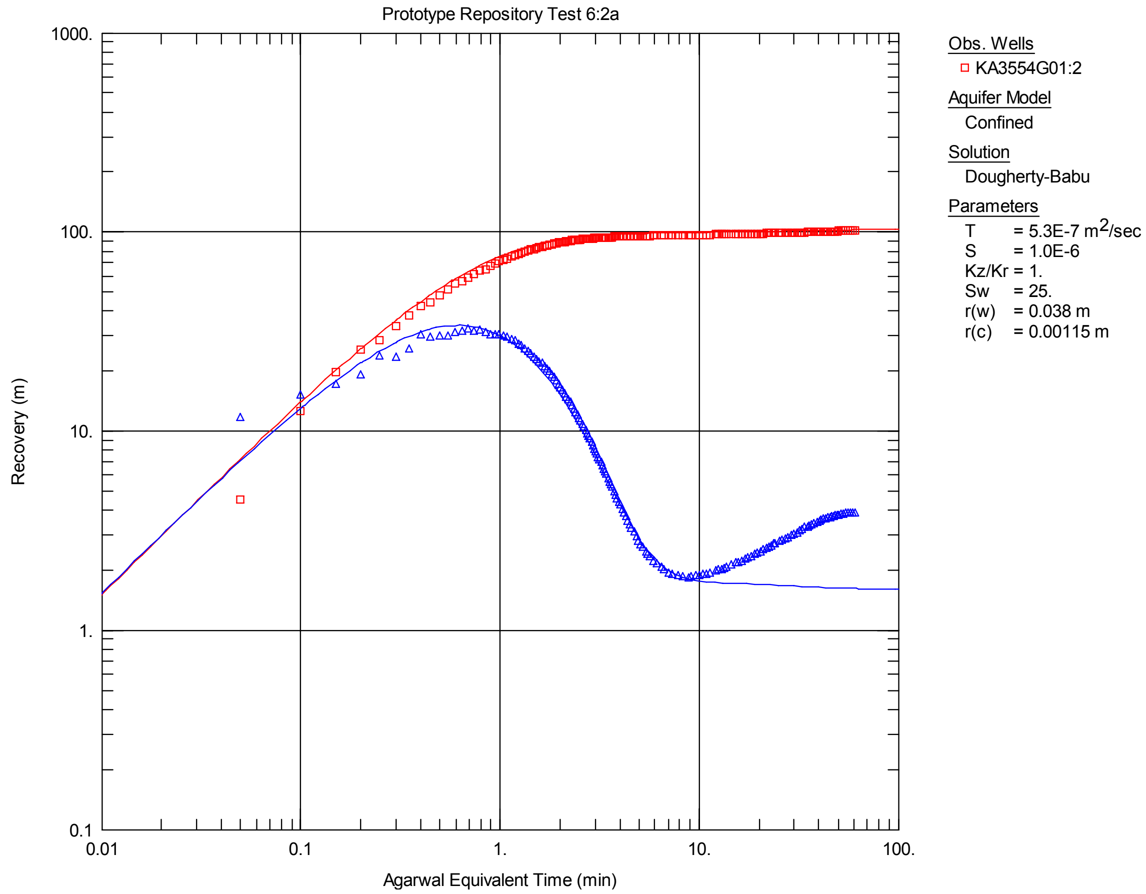
Prototype Repository Test 5:2a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.3E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 24.
r(w) = 0.038 m
r(c) = 0.00123 m

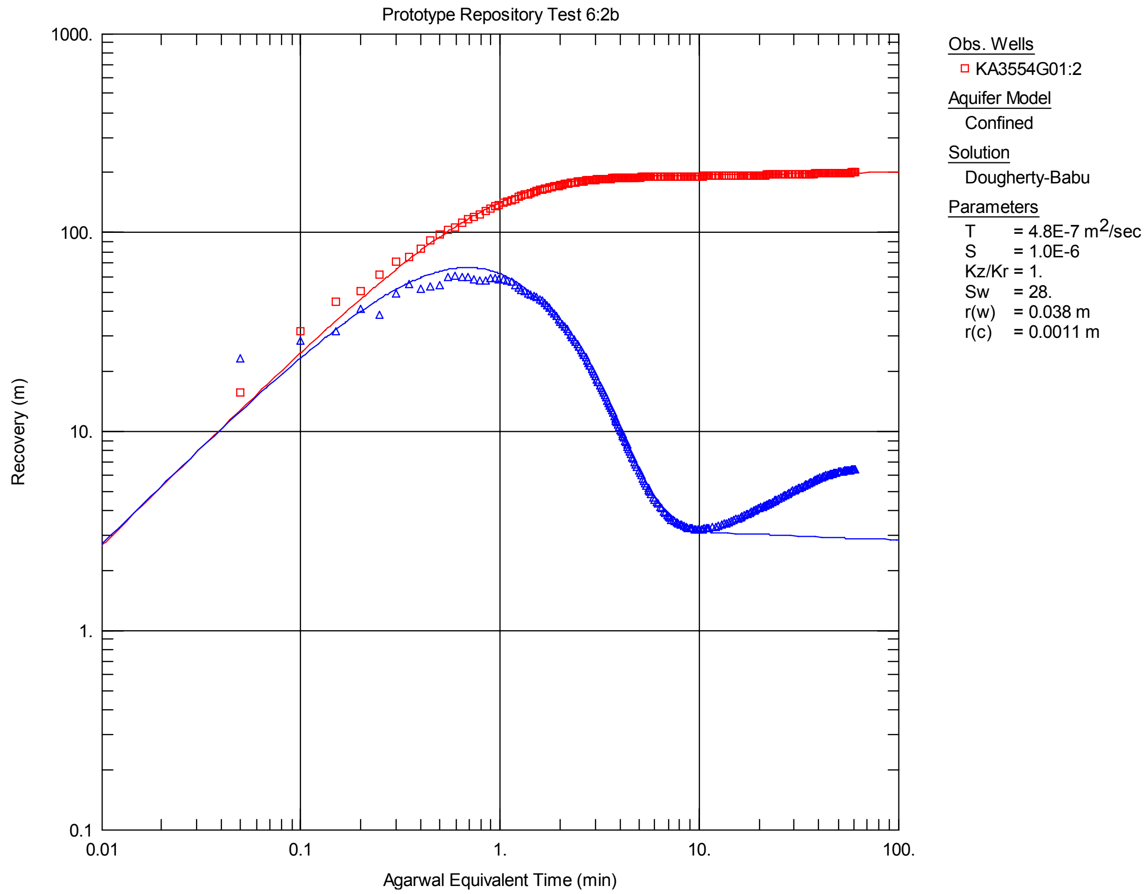


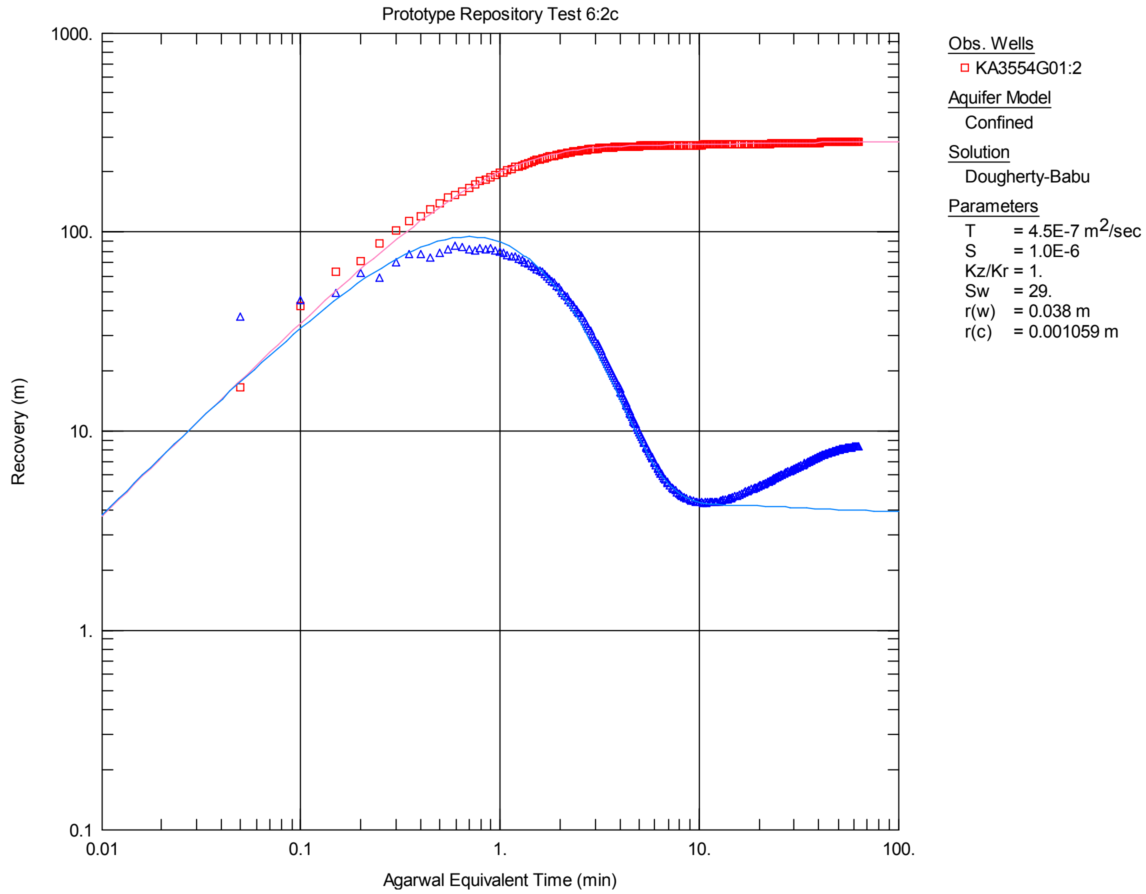
Prototype Repository Test 5:2b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.9E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 28.
r(w) = 0.038 m
r(c) = 0.0011 m

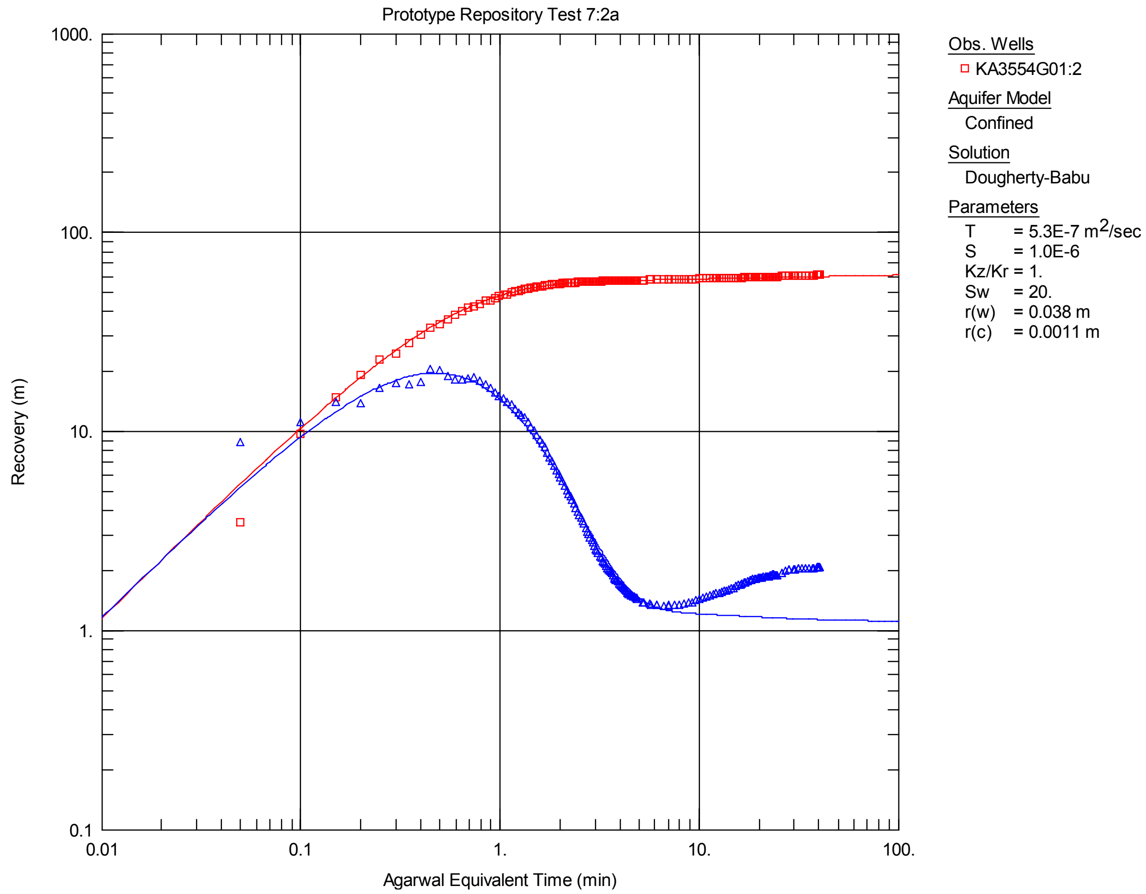


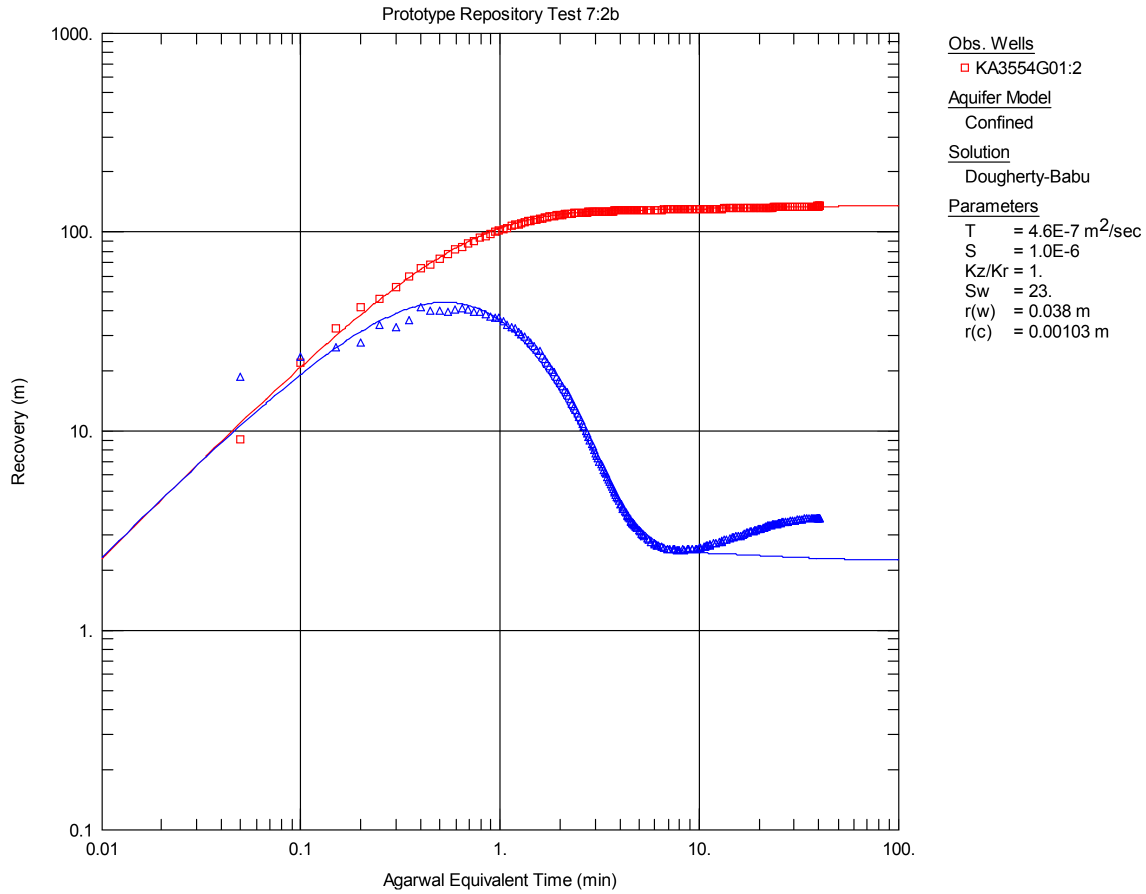
Prototype Repository Test 5:2c + 5:23
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
1000.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.6E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 30.
r(w) = 0.038 m
r(c) = 0.001109 m

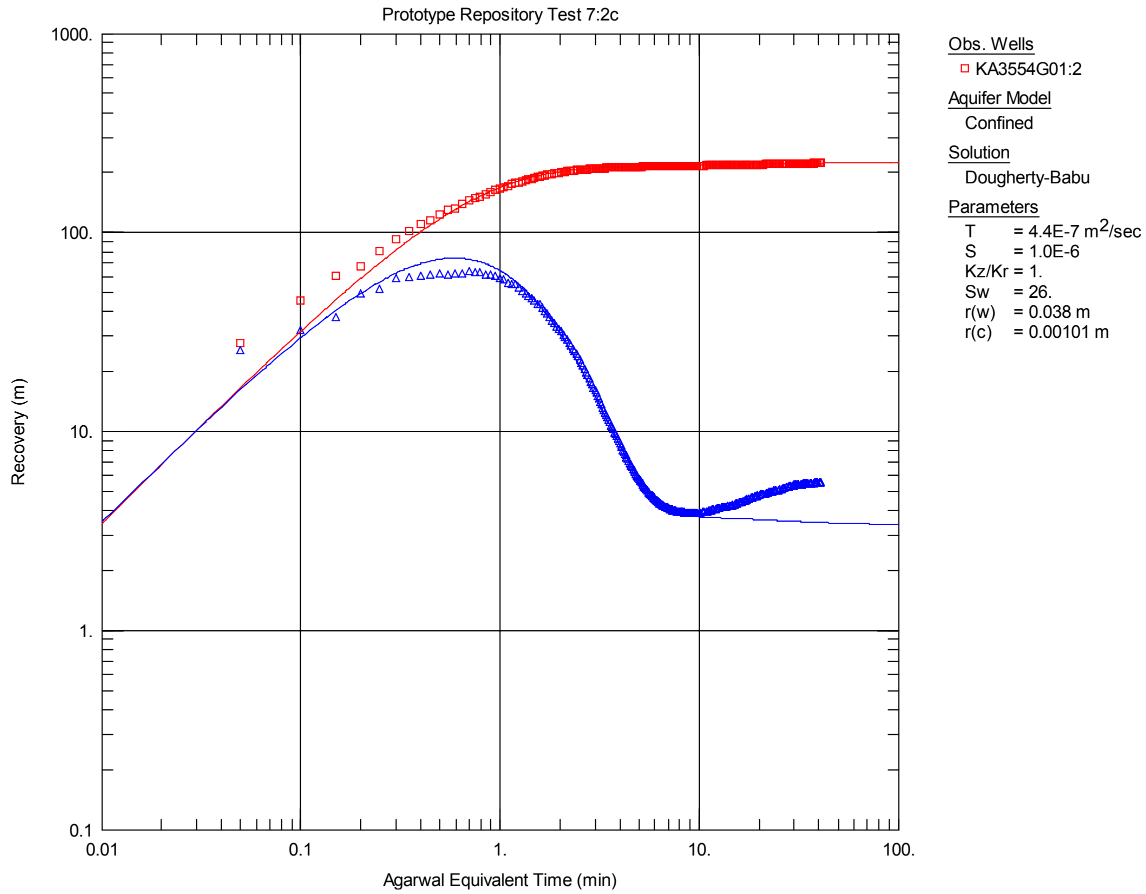

Prototype Repository Test 6:2a
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.3E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 25.
r(w) = 0.038 m
r(c) = 0.00115 m


Prototype Repository Test 6:2b
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.8E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 28.
r(w) = 0.038 m
r(c) = 0.0011 m

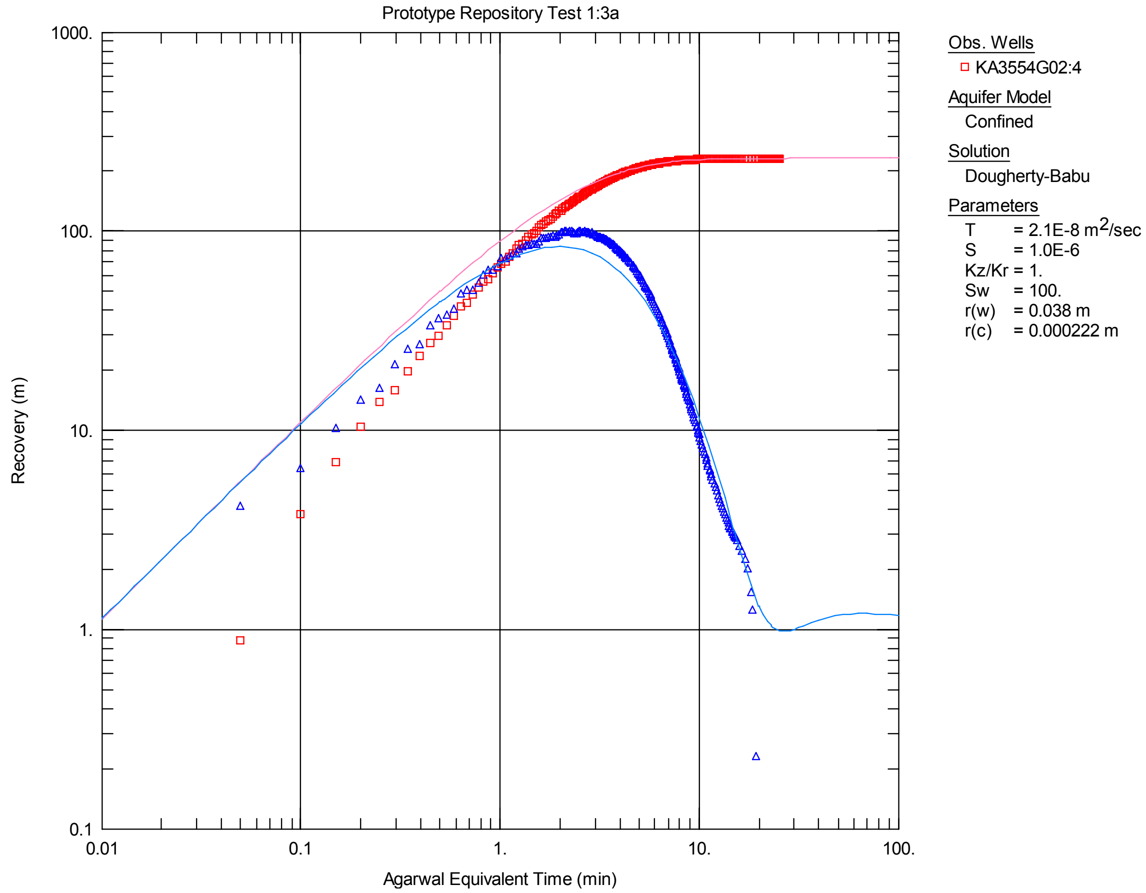

Prototype Repository Test 6:2c
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.5E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 29.
r(w) = 0.038 m
r(c) = 0.001059 m

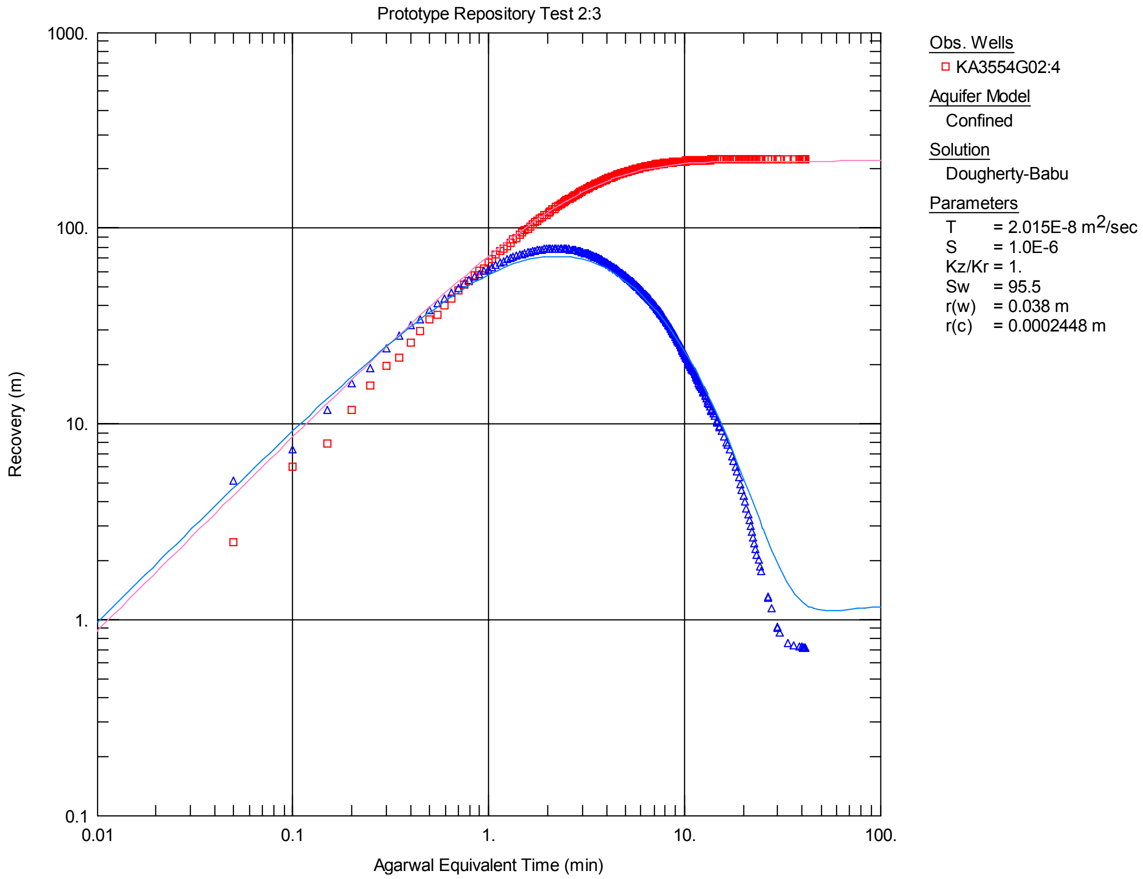

Prototype Repository Test 7:2a
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.3E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 20.
r(w) = 0.038 m
r(c) = 0.0011 m

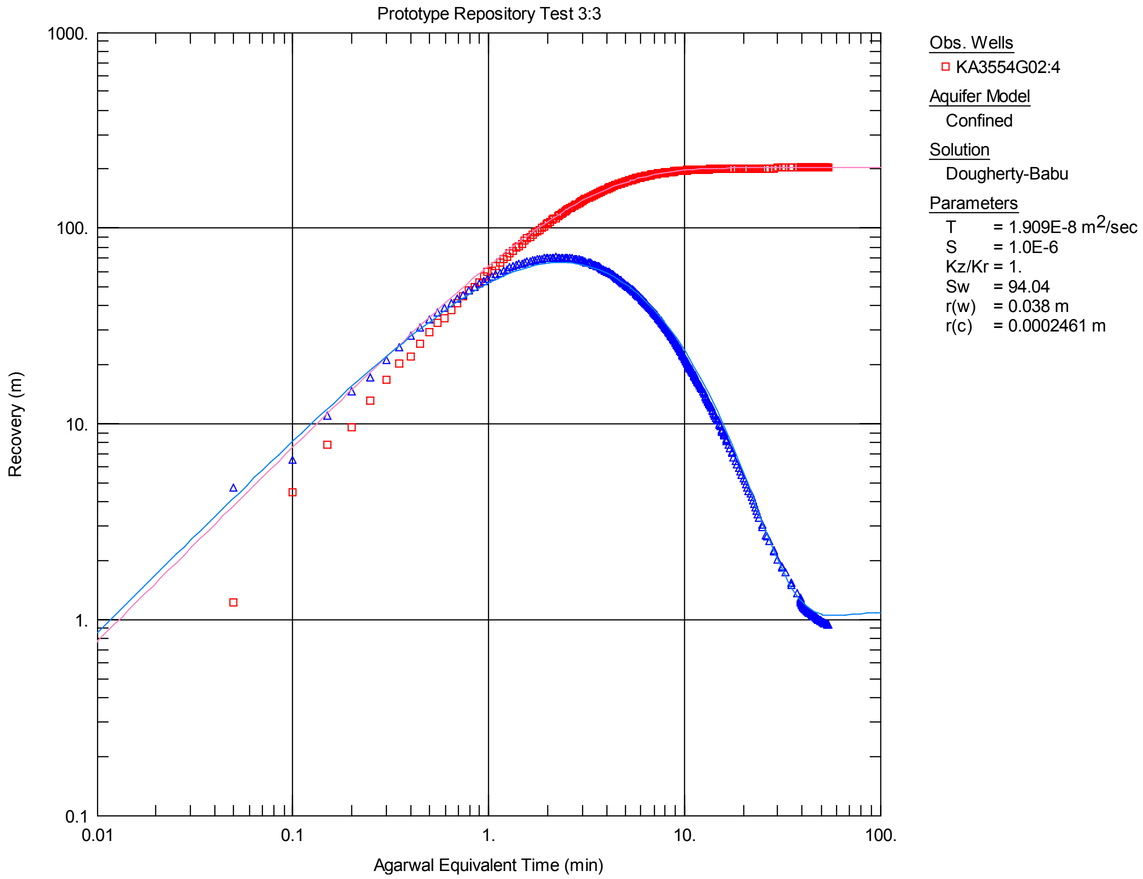

Prototype Repository Test 7:2b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.6E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 23.
r(w) = 0.038 m
r(c) = 0.00103 m

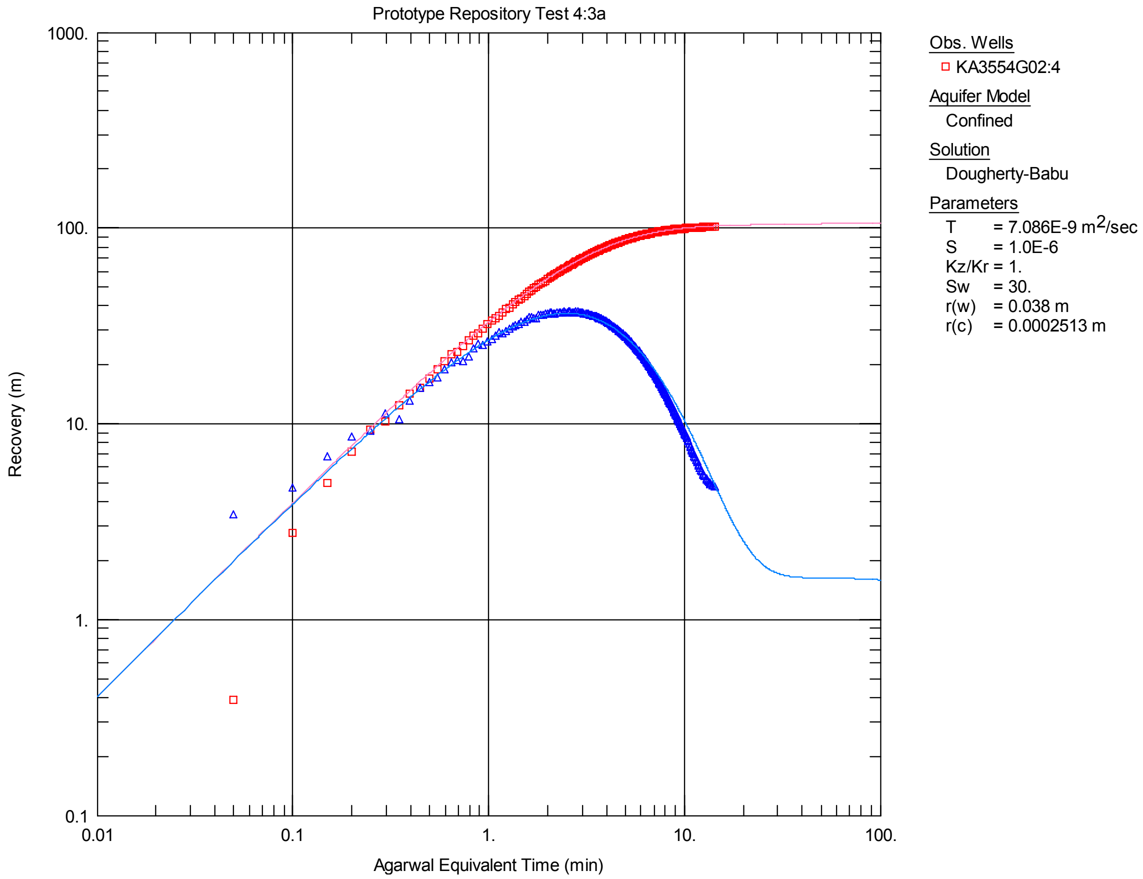

Prototype Repository Test 7:2c
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.4E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 26.
r(w) = 0.038 m
r(c) = 0.00101 m

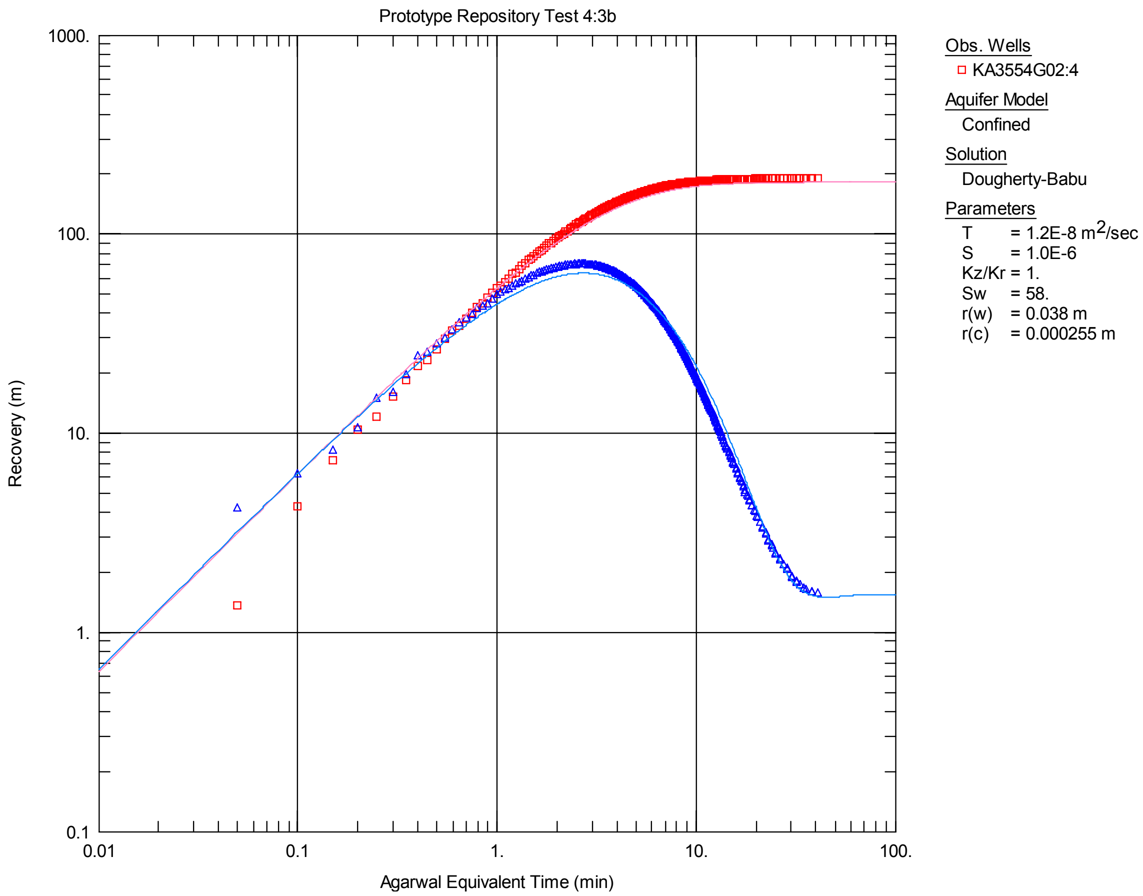
Appendix 3 – KA3554G02:4

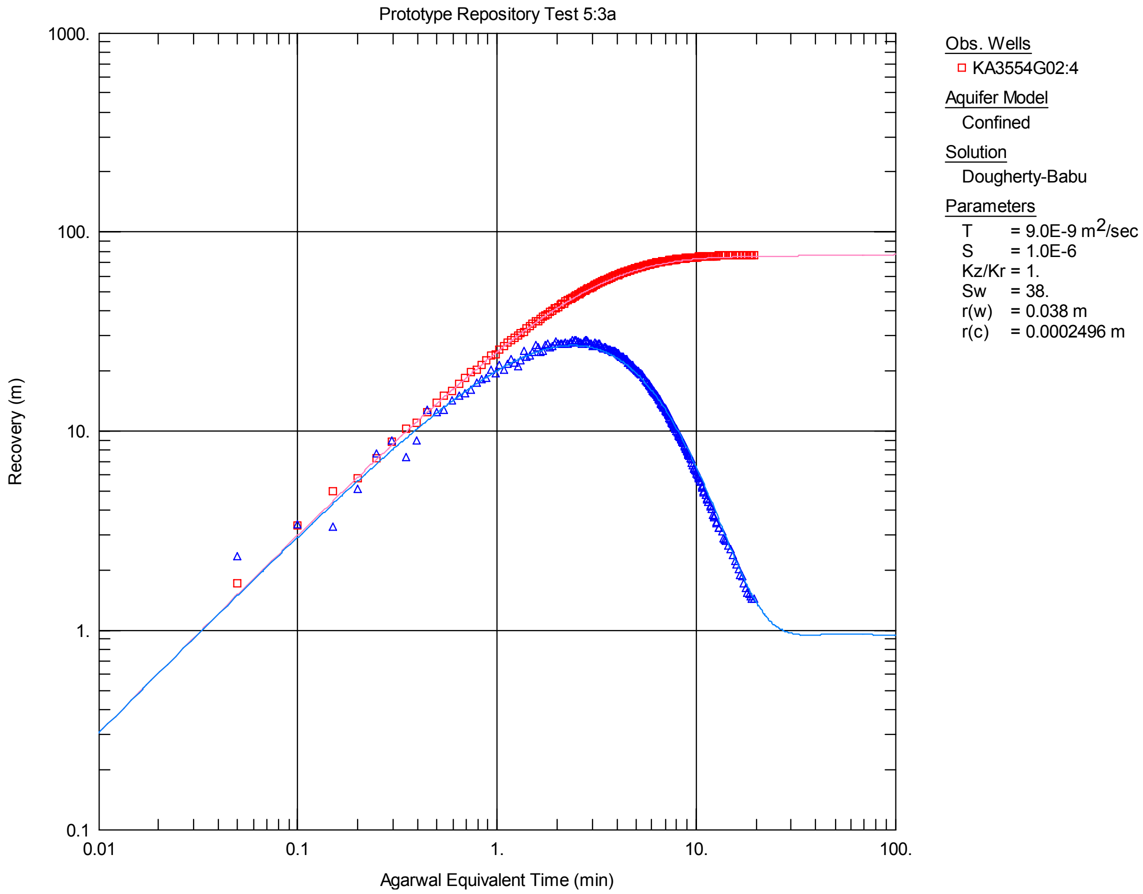


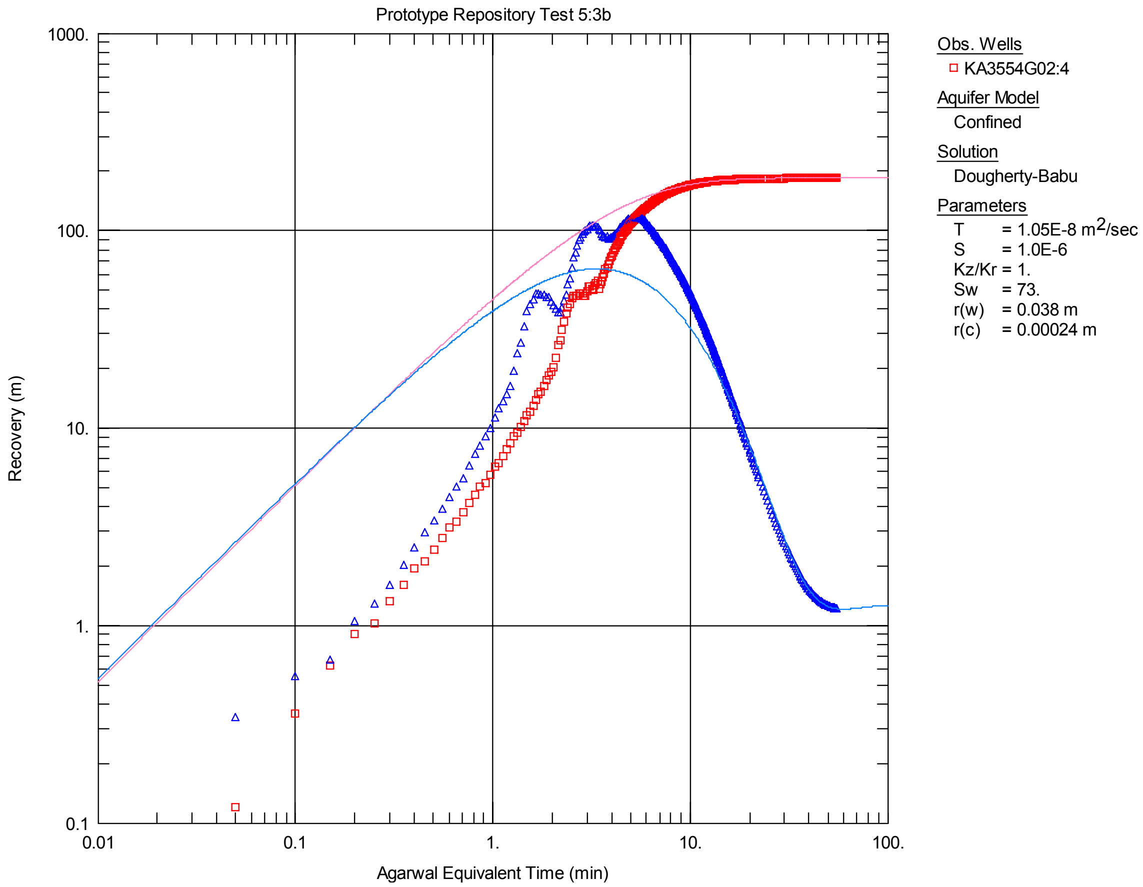

Prototype Repository Test 2:3
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 2.015E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 95.5
r(w) = 0.038 m
r(c) = 0.0002448 m

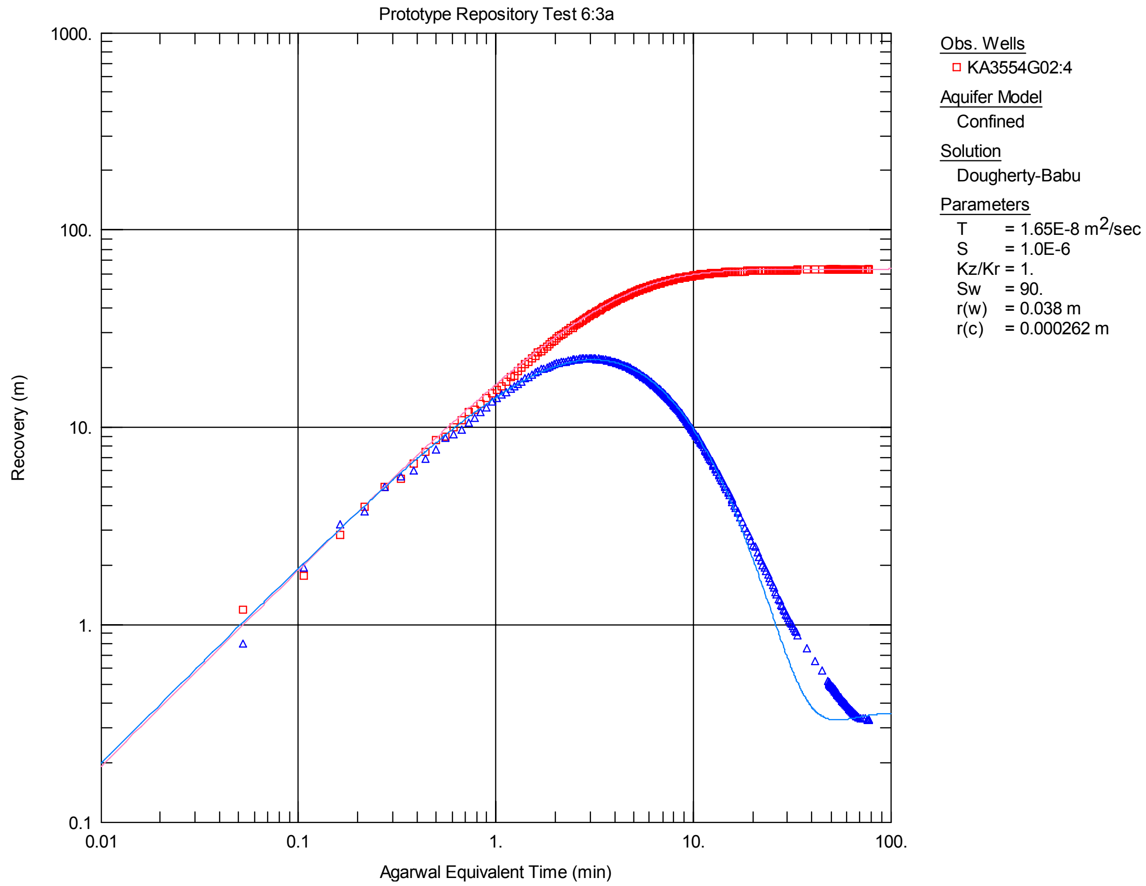

Prototype Repository Test 3:3
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.909E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 94.04
r(w) = 0.038 m
r(c) = 0.0002461 m


Prototype Repository Test 4:3a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 7.086E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 30.
r(w) = 0.038 m
r(c) = 0.0002513 m

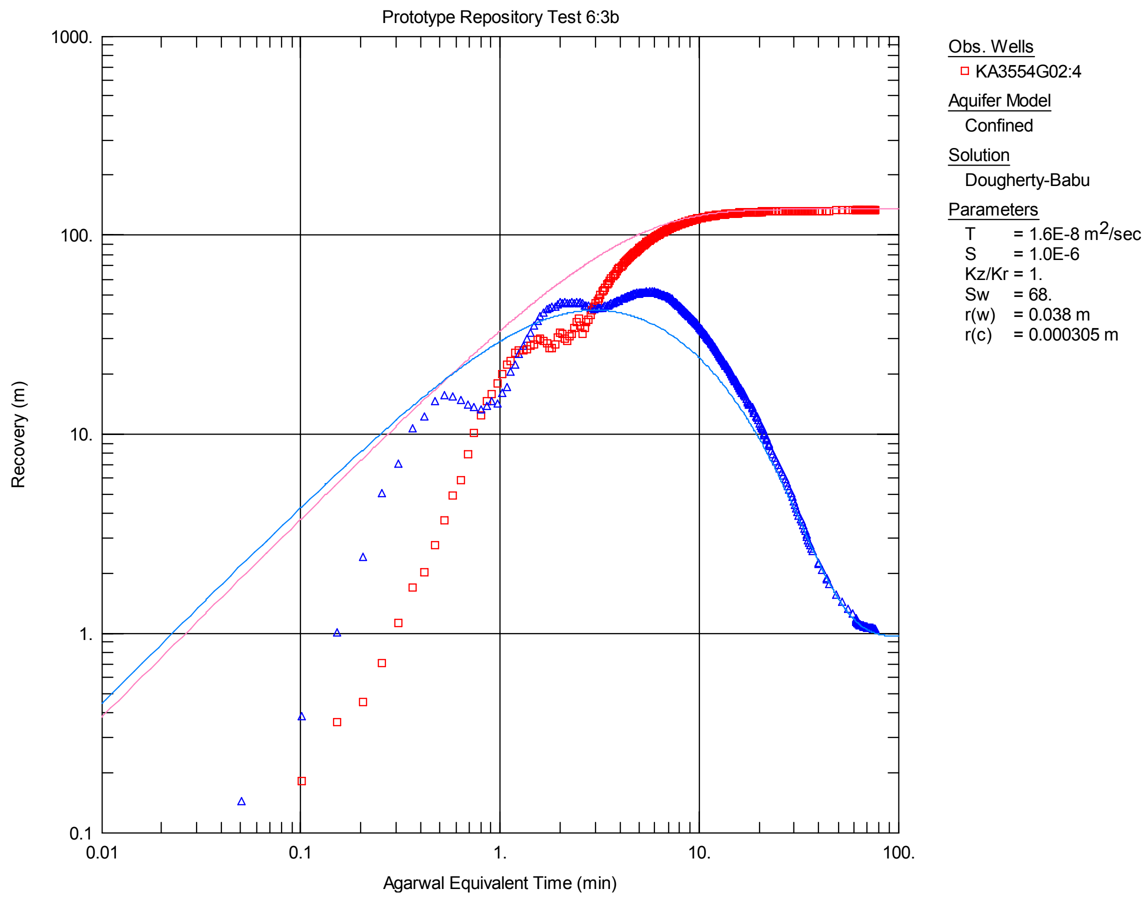

Prototype Repository Test 4:3b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.2E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 58.
r(w) = 0.038 m
r(c) = 0.000255 m


Prototype Repository Test 5:3a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.0E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 38.
r(w) = 0.038 m
r(c) = 0.0002496 m

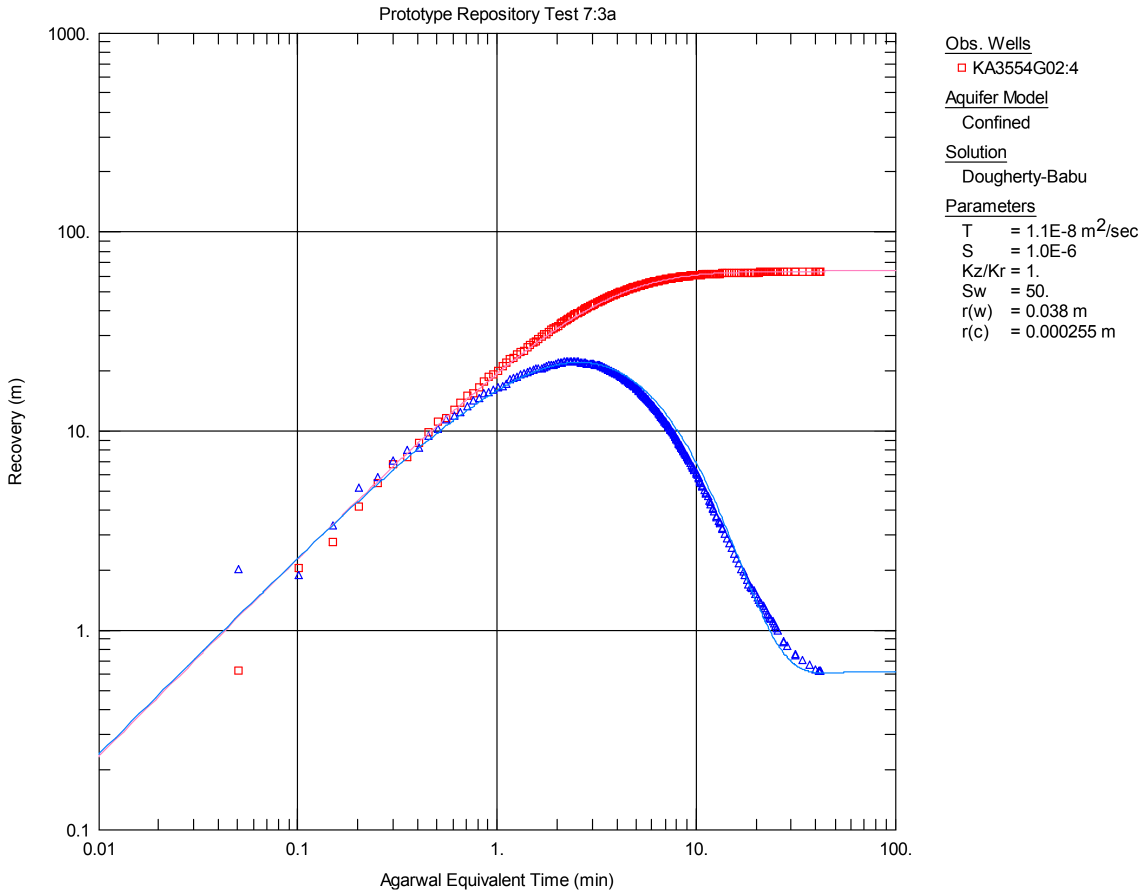

Prototype Repository Test 5:3b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.05E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 73.
r(w) = 0.038 m
r(c) = 0.00024 m



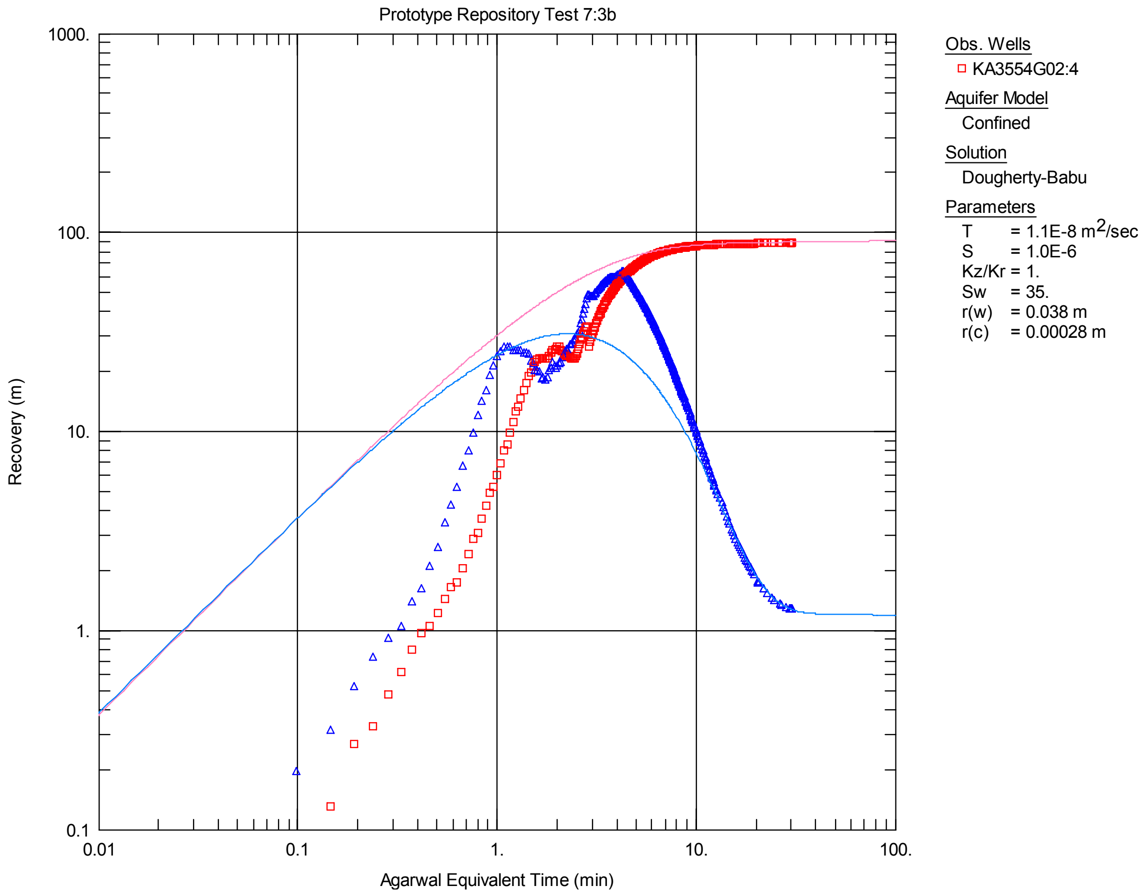
Prototype Repository Test 6:3a
Recovery (m)
Agarwal Equivalent Time (min)
0.01
0.1
1.
10.
100.
1000.
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.65E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 90.
r(w) = 0.038 m
r(c) = 0.000262 m



Prototype Repository Test 6:3b
Recovery (m)
Agarwal Equivalent Time (min)
0.01
0.1
1.
10.
100.
1000.
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.6E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 68.
r(w) = 0.038 m
r(c) = 0.000305 m

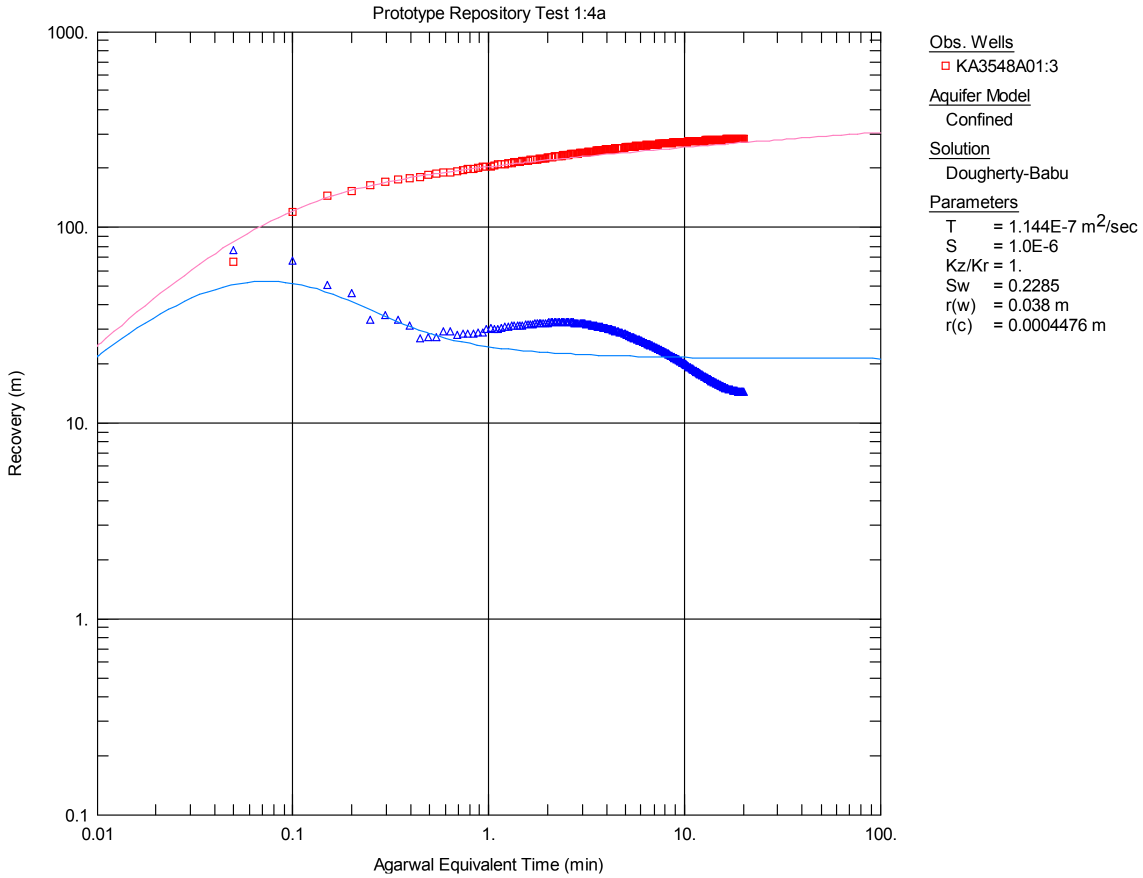


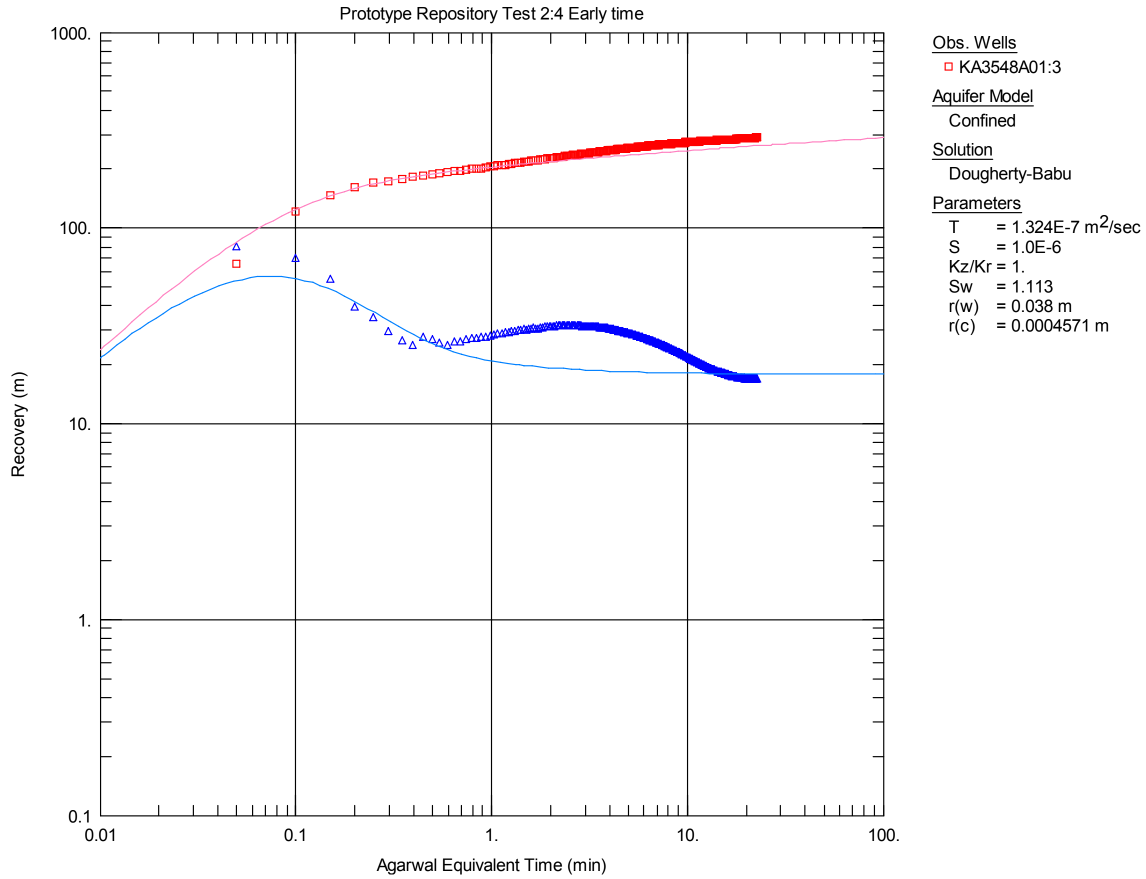
Prototype Repository Test 7:3a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.1E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 50.
r(w) = 0.038 m
r(c) = 0.000255 m

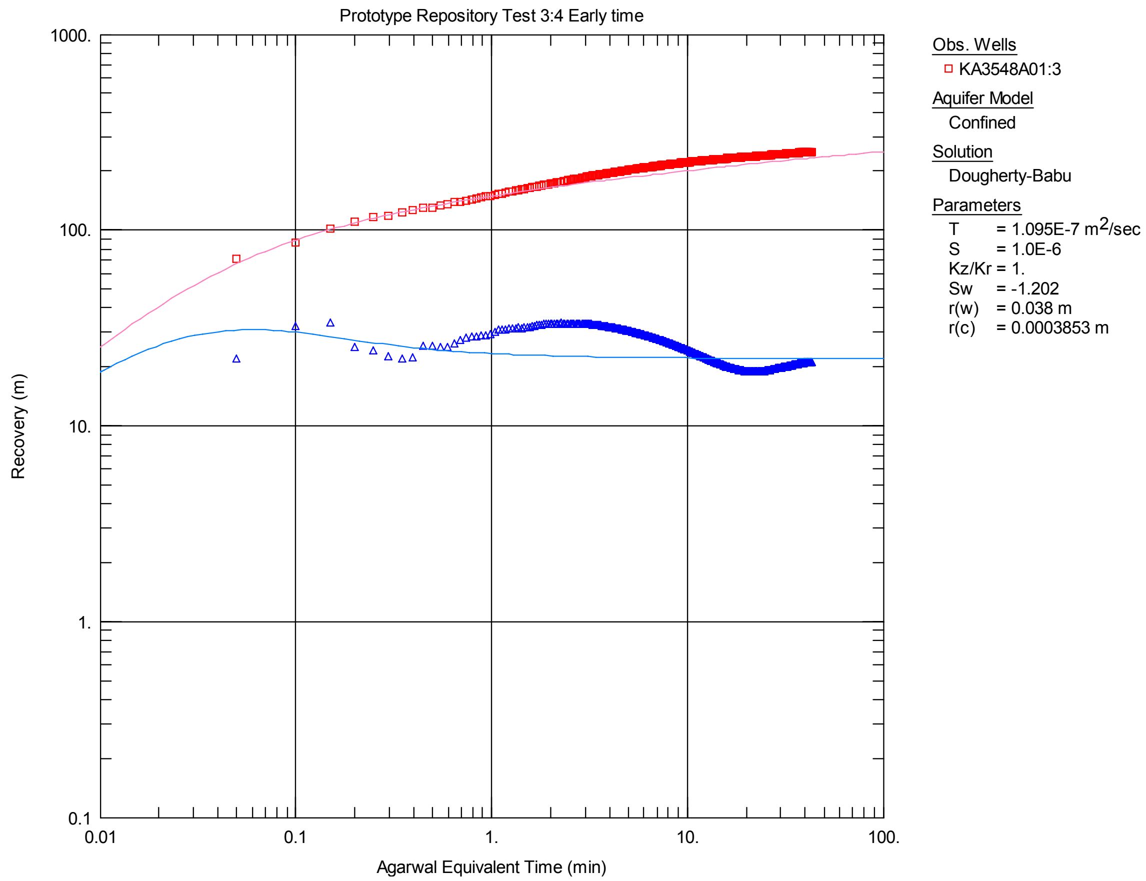


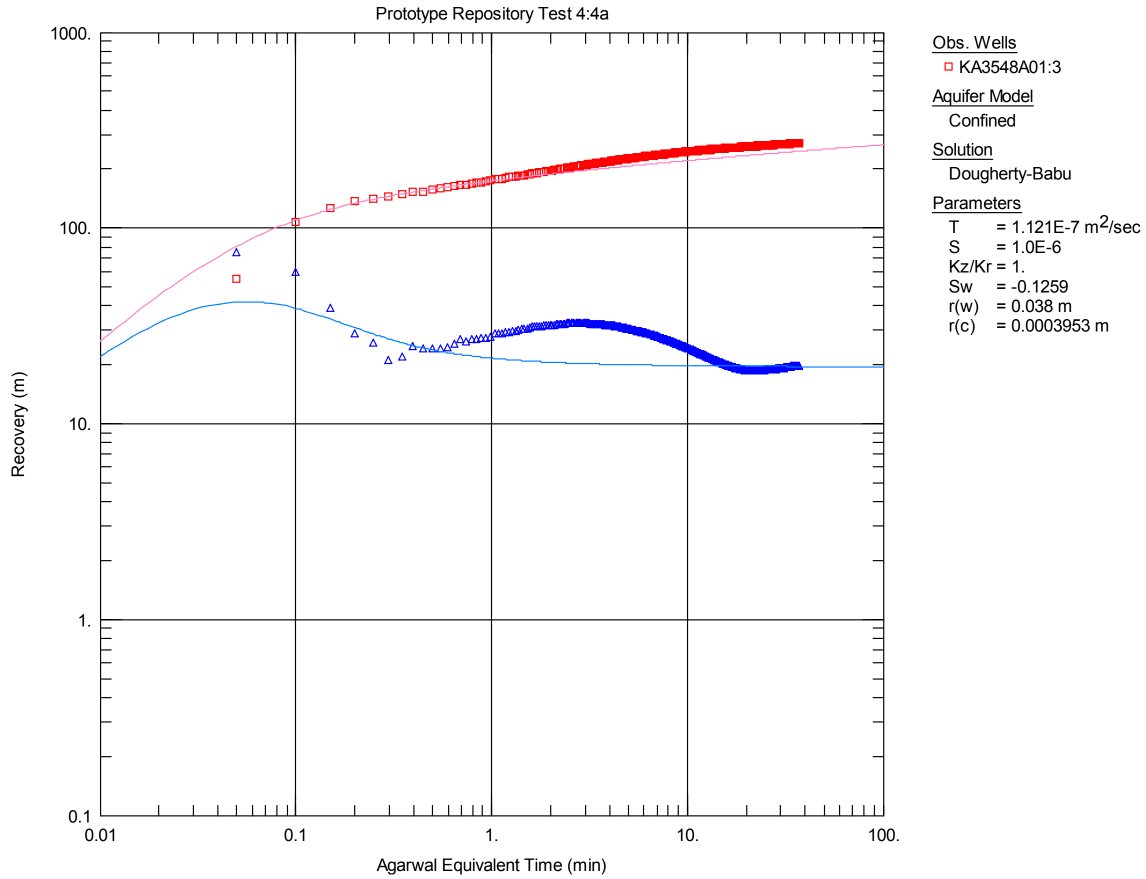
Prototype Repository Test 7:3b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3554G02:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.1E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 35.
r(w) = 0.038 m
r(c) = 0.00028 m

Appendix 4 – KA3548A01:3

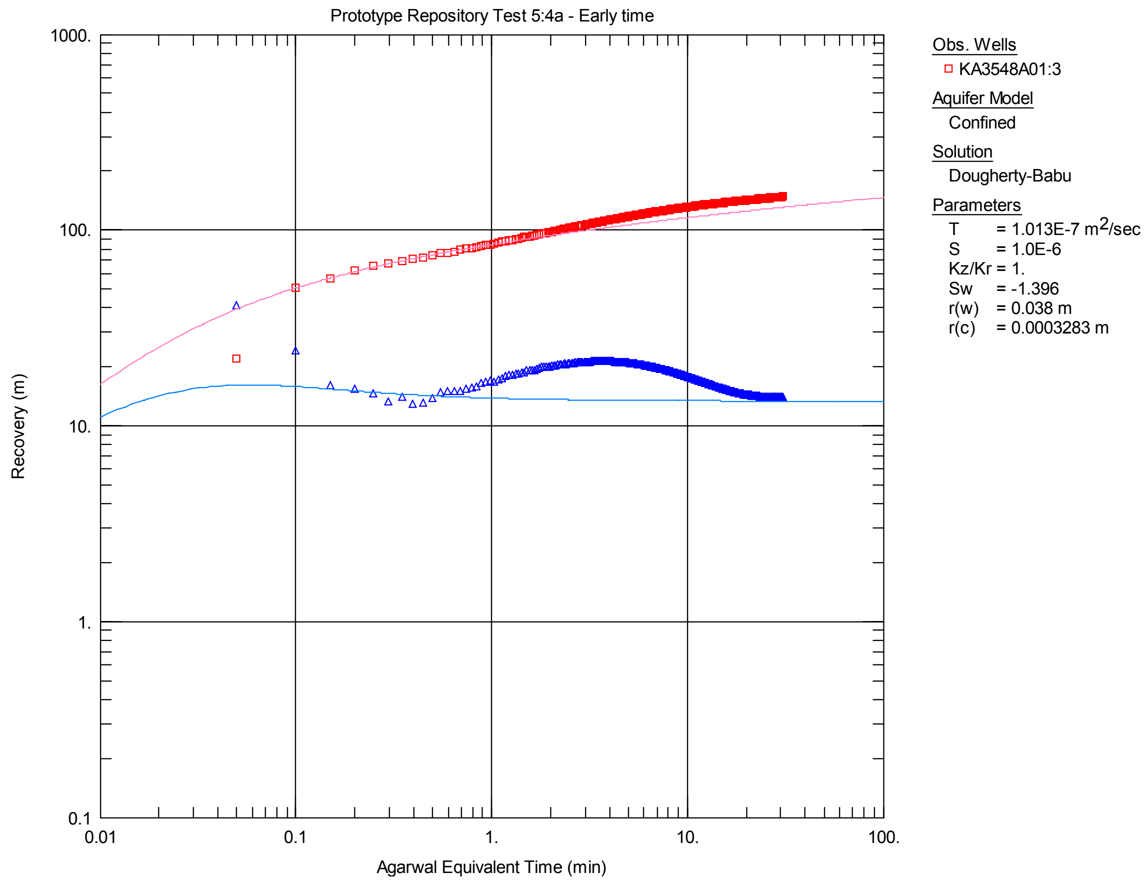



Prototype Repository Test 2:4 Early time
1000.
100.
10.
1.
0.1
Recovery (m)
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.324E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 1.113
r(w) = 0.038 m
r(c) = 0.0004571 m

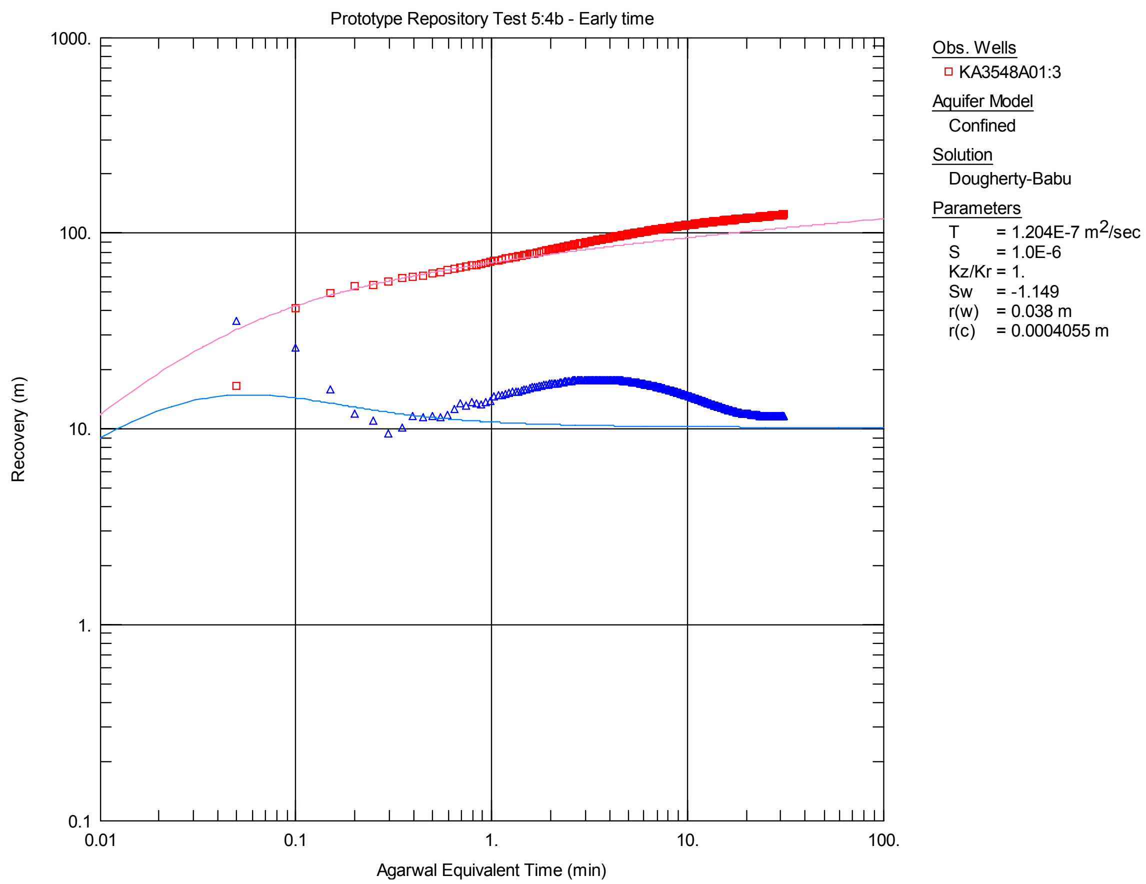

Prototype Repository Test 3:4 Early time
1000.
100.
10.
1.
0.1
Recovery (m)
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.095E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.202
r(w) = 0.038 m
r(c) = 0.0003853 m



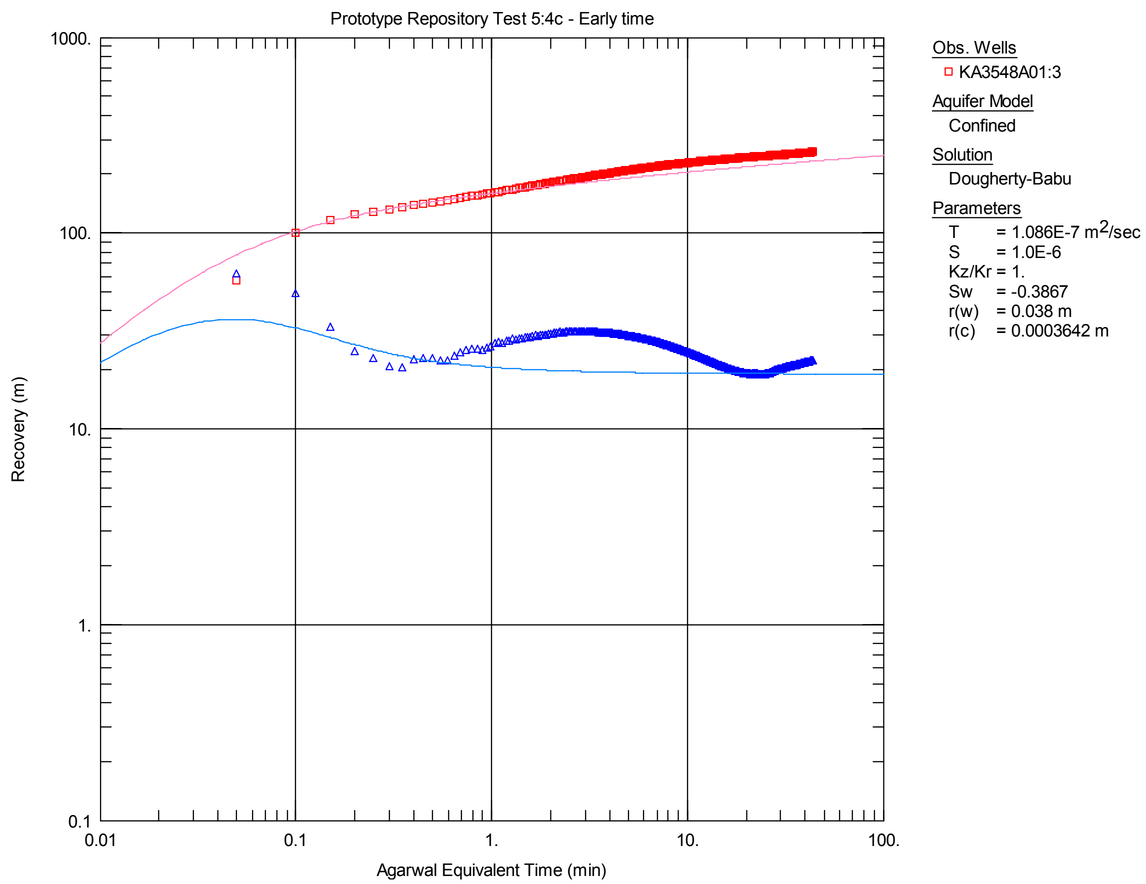
Prototype Repository Test 4:4a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.121E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.1259
r(w) = 0.038 m
r(c) = 0.0003953 m



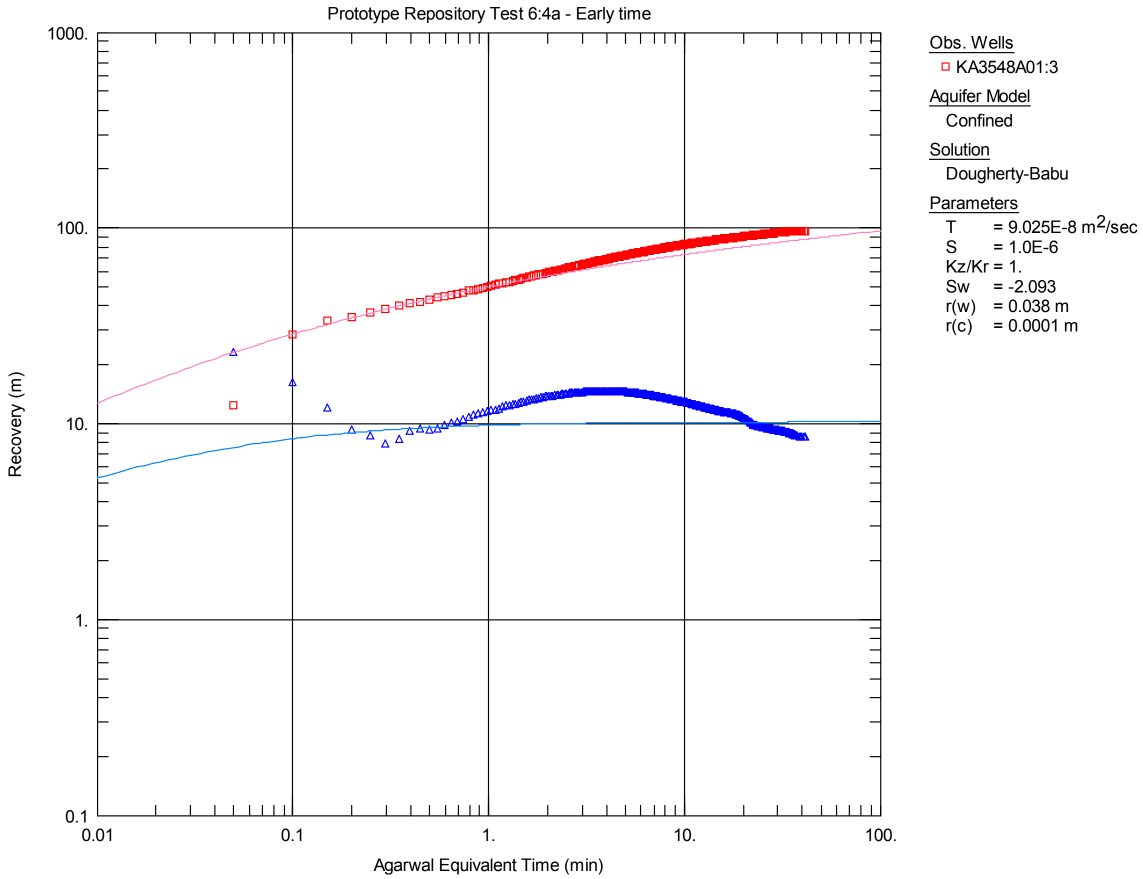
Prototype Repository Test 5:4a - Early time
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.013E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.396
r(w) = 0.038 m
r(c) = 0.0003283 m



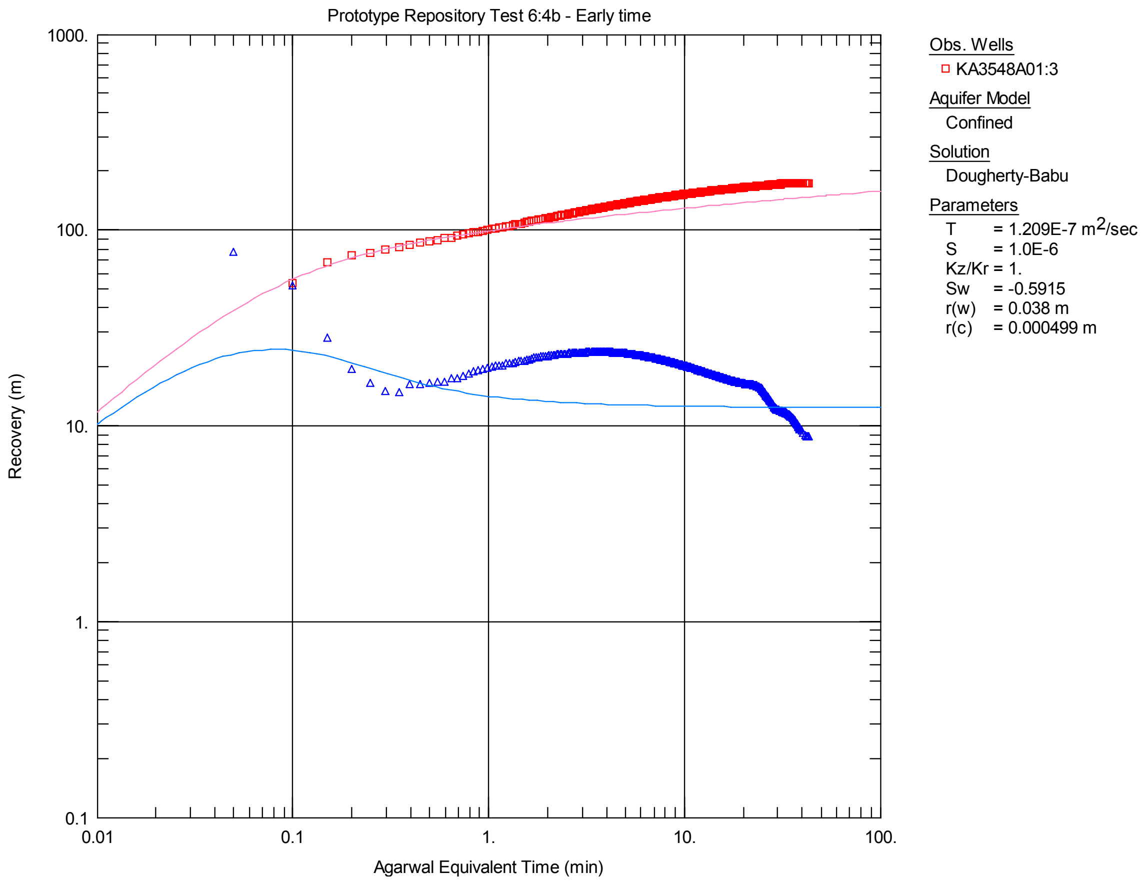
Prototype Repository Test 5:4b - Early time
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.204E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.149
r(w) = 0.038 m
r(c) = 0.0004055 m



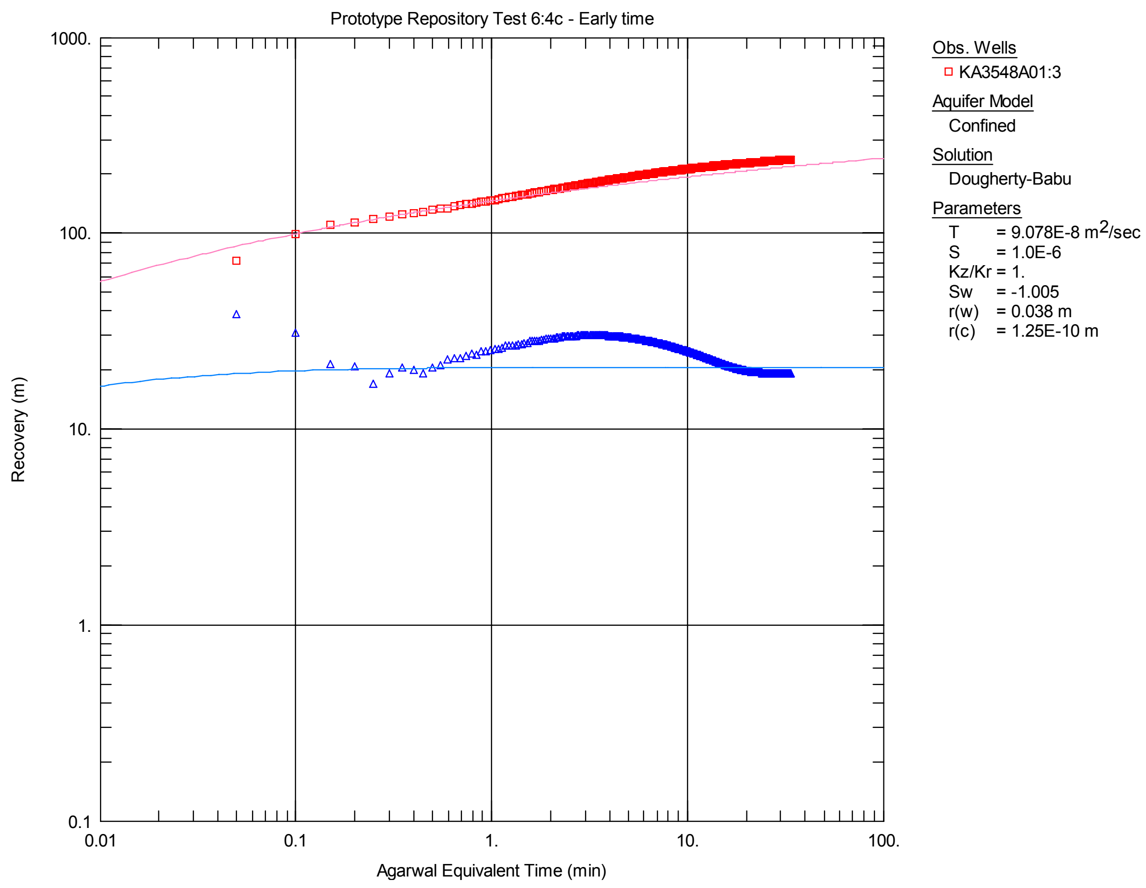
Prototype Repository Test 5:4c - Early time
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.086E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.3867
r(w) = 0.038 m
r(c) = 0.0003642 m



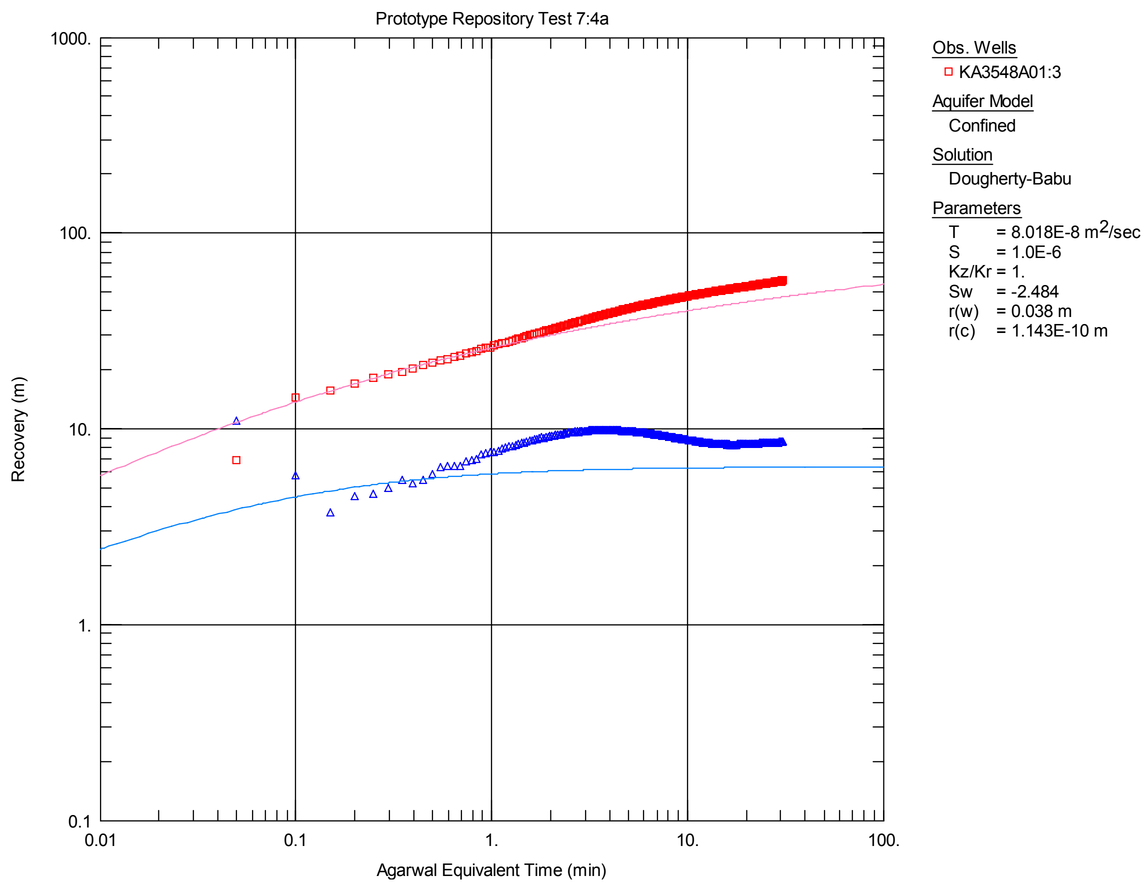
Prototype Repository Test 6:4a - Early time
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.025E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -2.093
r(w) = 0.038 m
r(c) = 0.0001 m



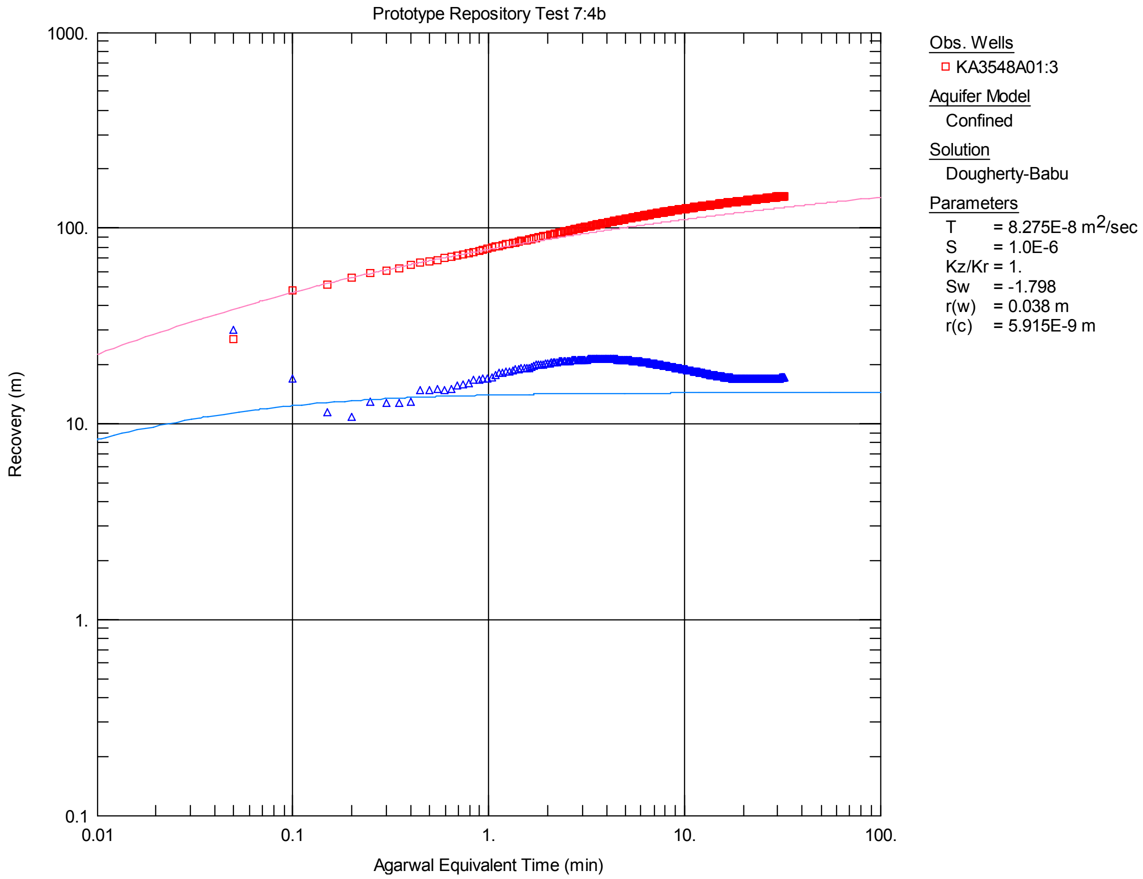
Prototype Repository Test 6:4b - Early time
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.209E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.5915
r(w) = 0.038 m
r(c) = 0.000499 m

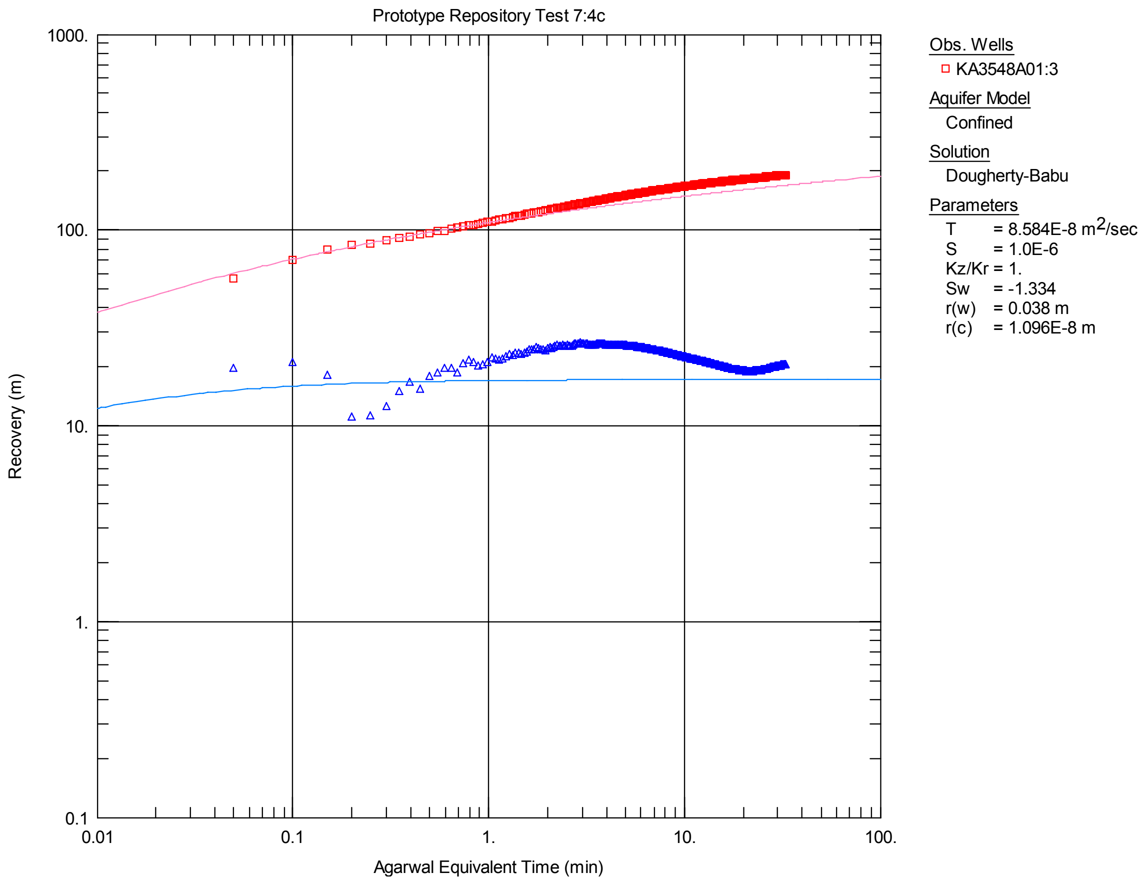


Prototype Repository Test 6:4c - Early time
Recovery (m)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.078E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.005
r(w) = 0.038 m
r(c) = 1.25E-10 m

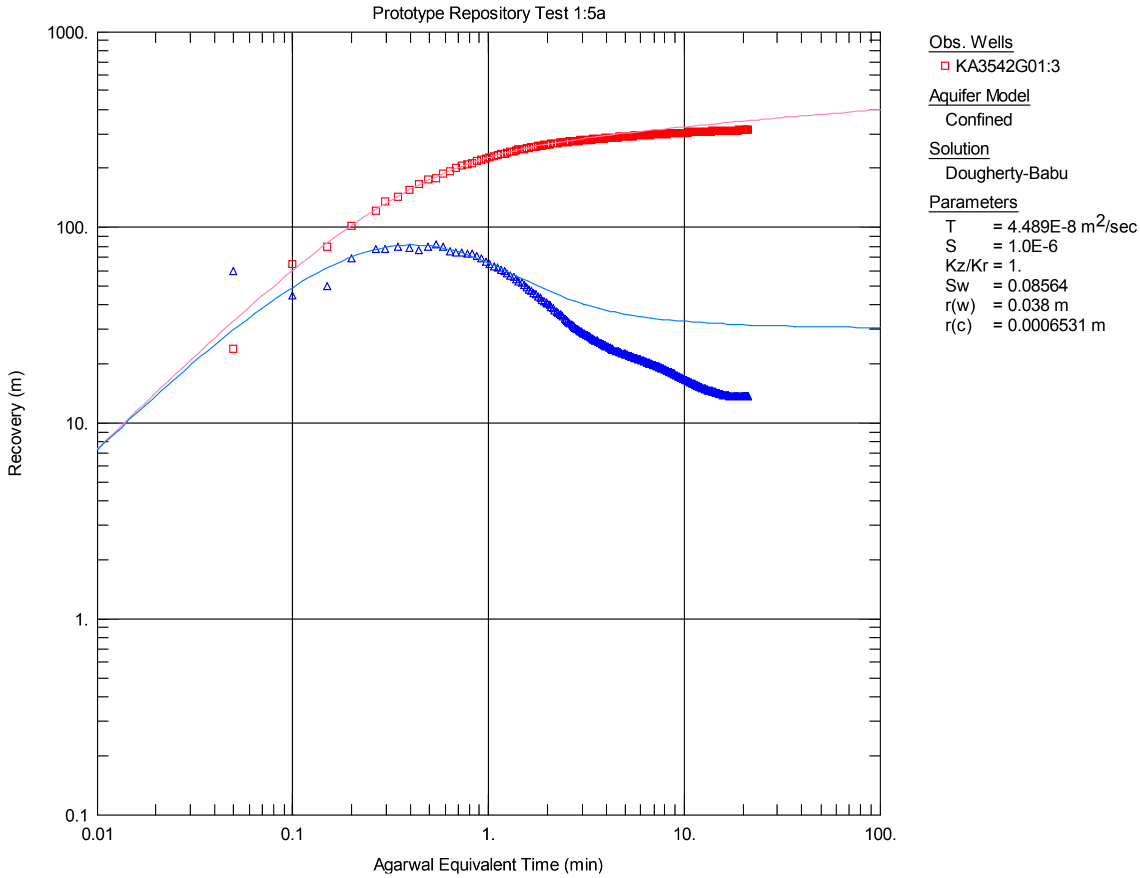


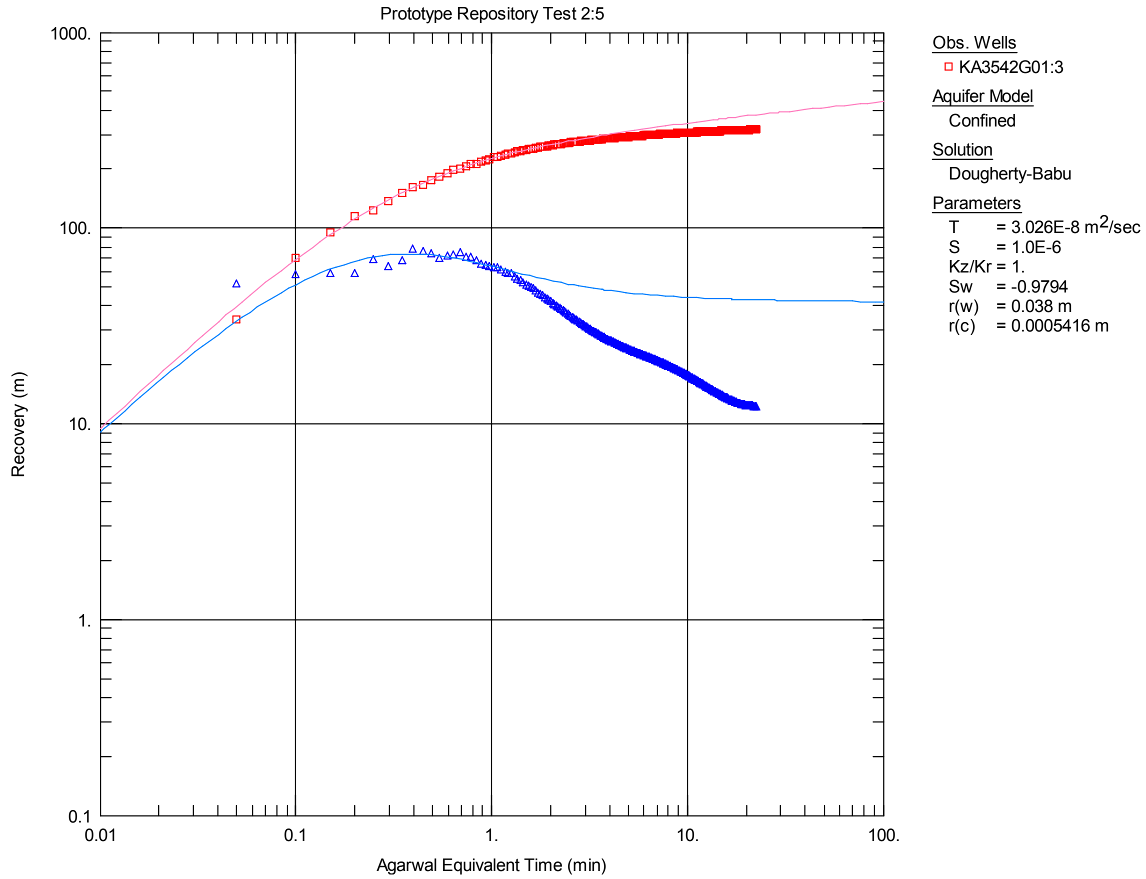
Prototype Repository Test 7:4a
Recovery (m)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.018E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -2.484
r(w) = 0.038 m
r(c) = 1.143E-10 m


Prototype Repository Test 7:4b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Recovery (m)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.275E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.798
r(w) = 0.038 m
r(c) = 5.915E-9 m

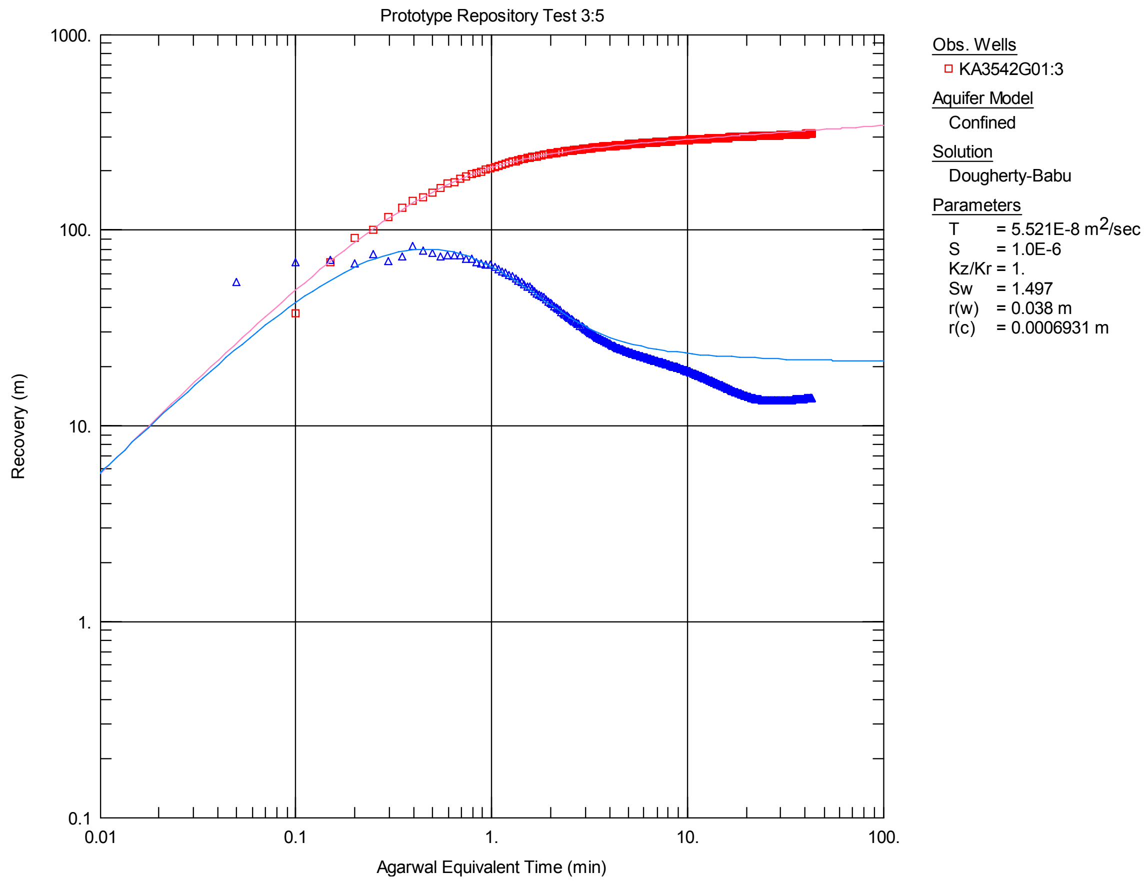

Prototype Repository Test 7:4c
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Recovery (m)
Obs. Wells
KA3548A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.584E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.334
r(w) = 0.038 m
r(c) = 1.096E-8 m

Appendix 5 – KA3542G01:3

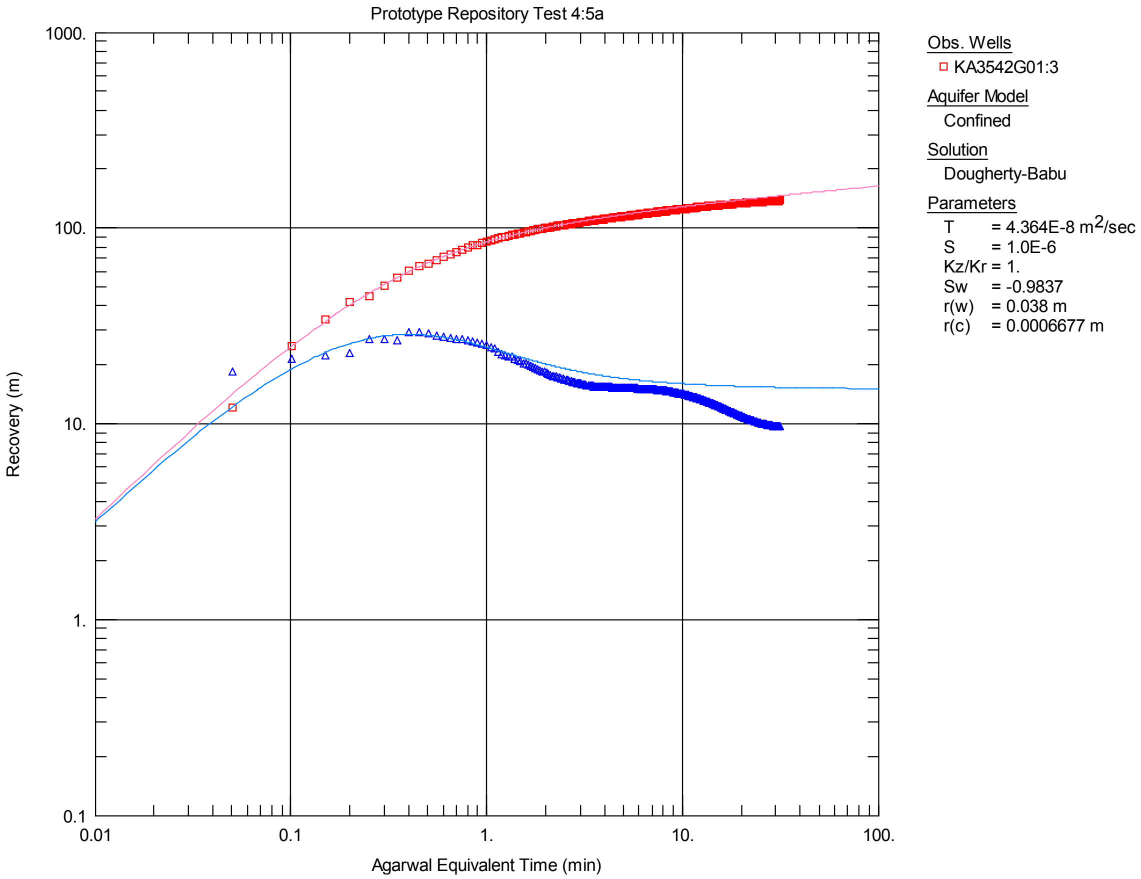




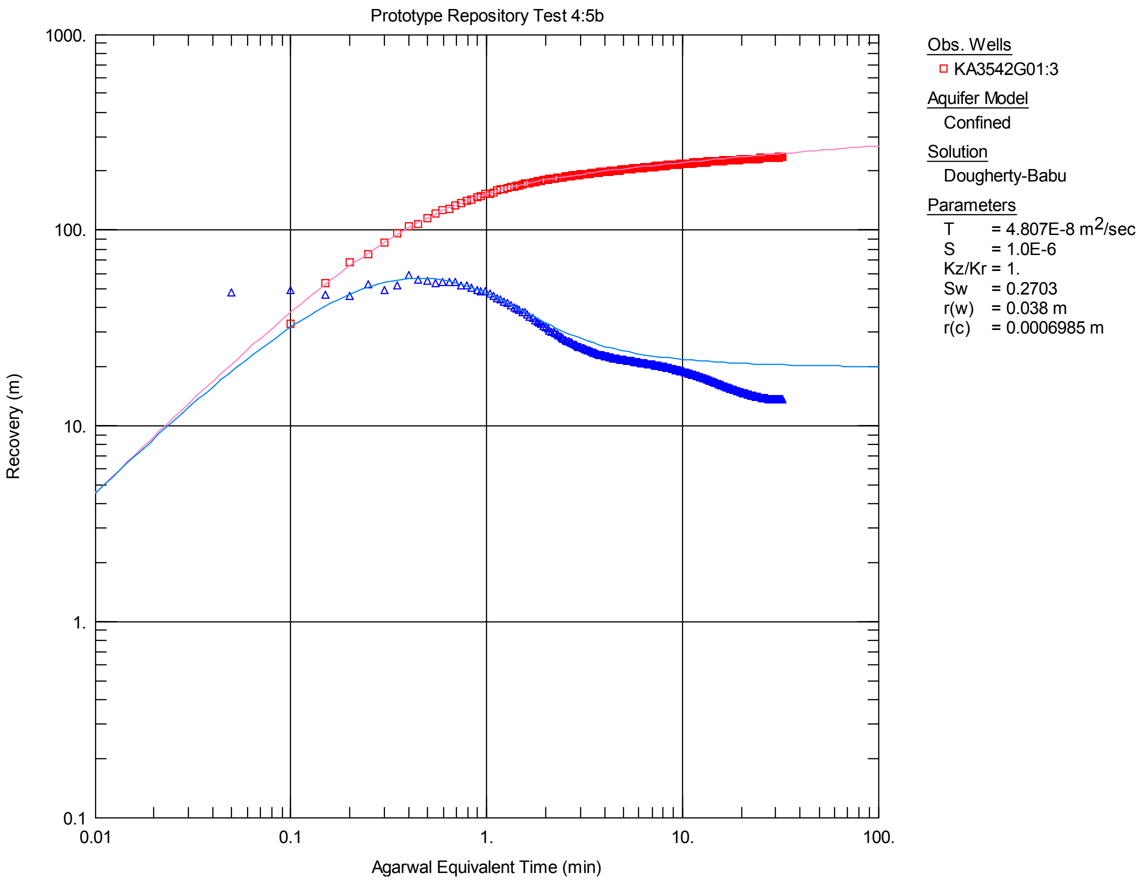
Prototype Repository Test 2:5
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 3.026E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.9794
r(w) = 0.038 m
r(c) = 0.0005416 m



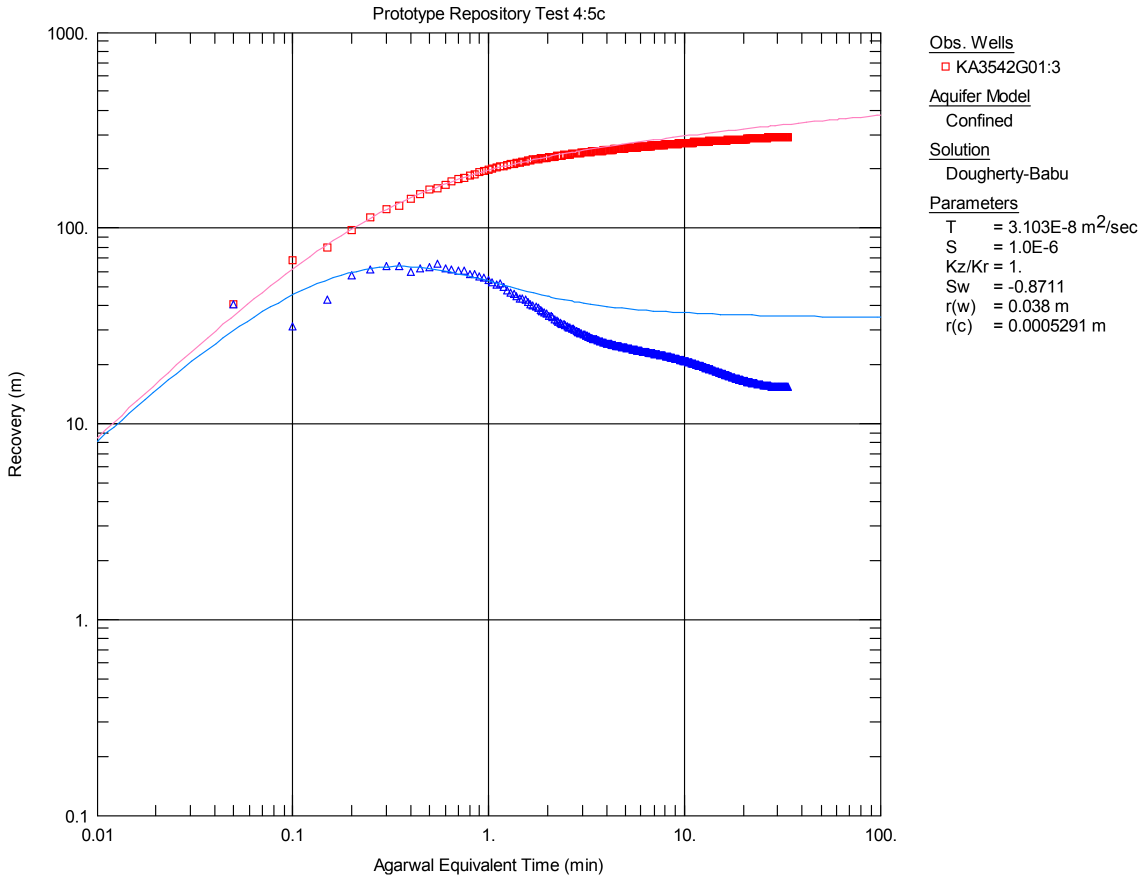
Prototype Repository Test 3:5
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.521E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 1.497
r(w) = 0.038 m
r(c) = 0.0006931 m

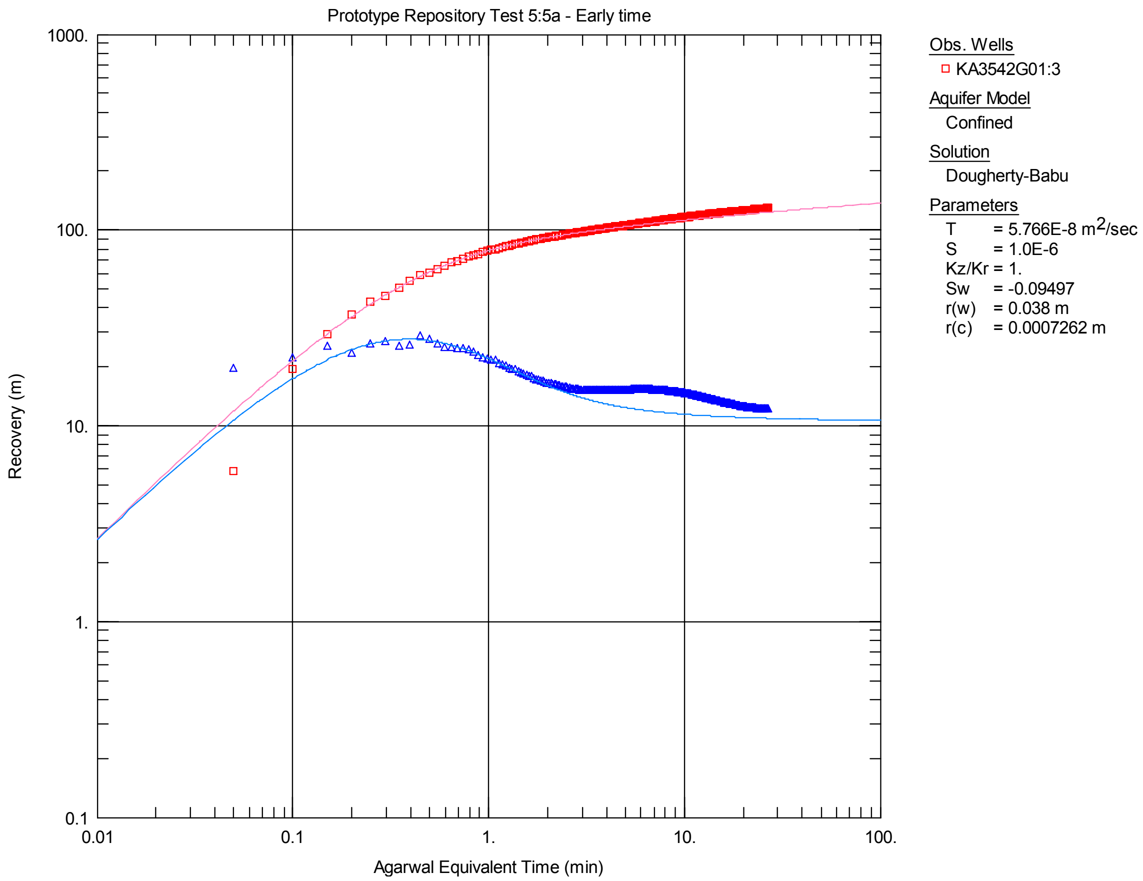


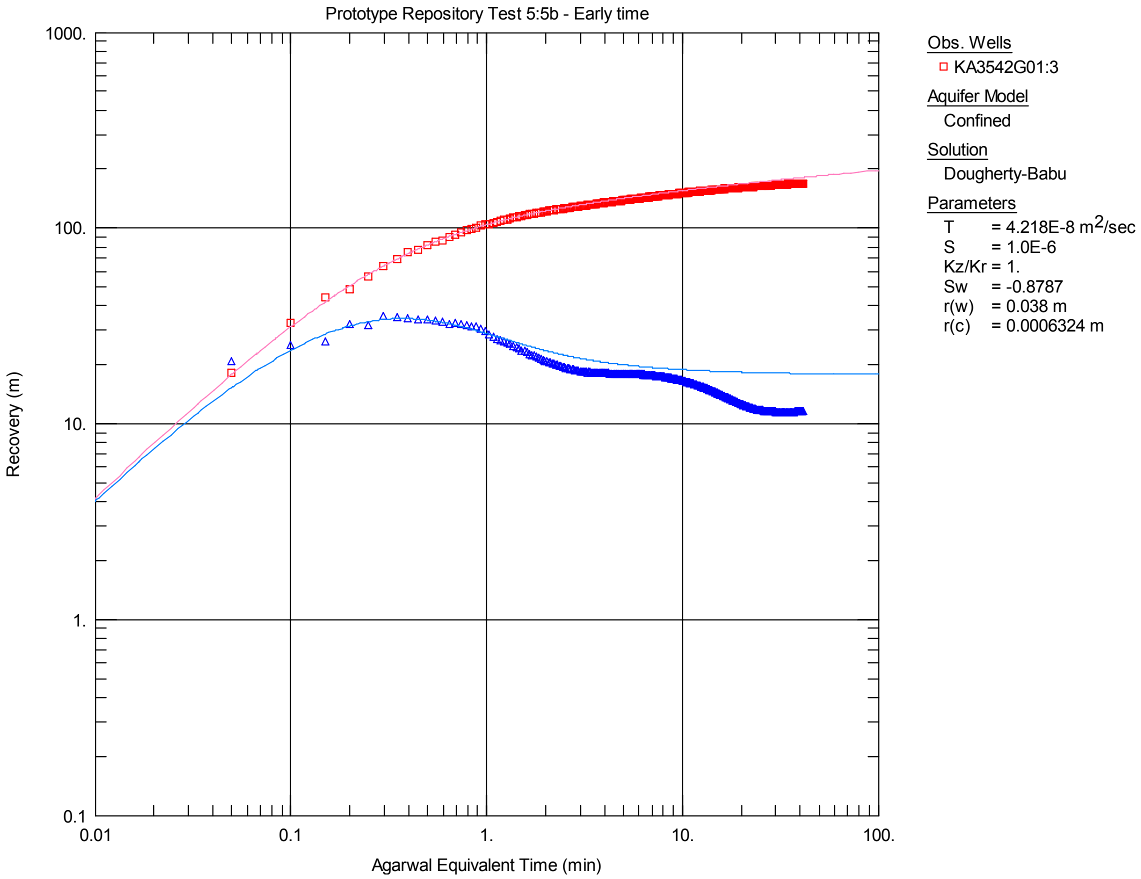
Prototype Repository Test 4:5a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.364E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.9837
r(w) = 0.038 m
r(c) = 0.0006677 m



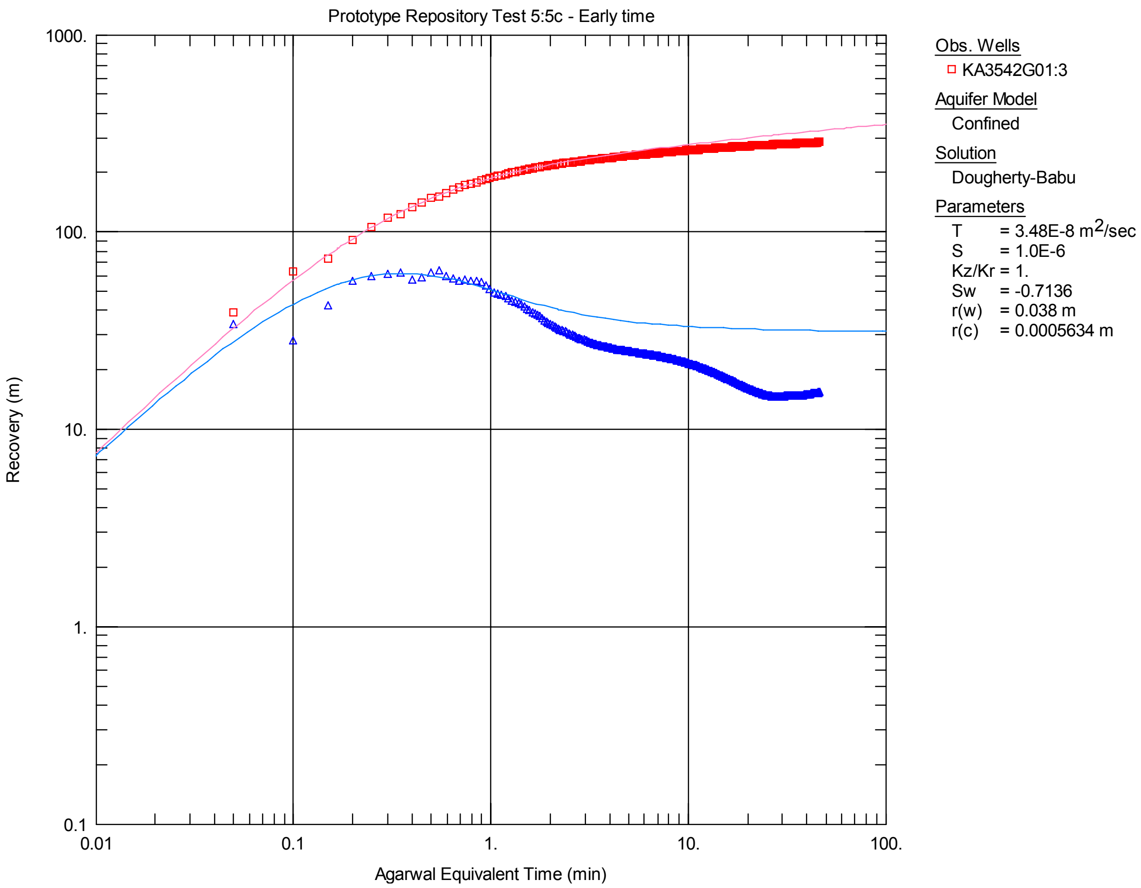
Prototype Repository Test 4:5b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.807E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.2703
r(w) = 0.038 m
r(c) = 0.0006985 m


Prototype Repository Test 4:5c
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Recovery (m)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 3.103E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.8711
r(w) = 0.038 m
r(c) = 0.0005291 m

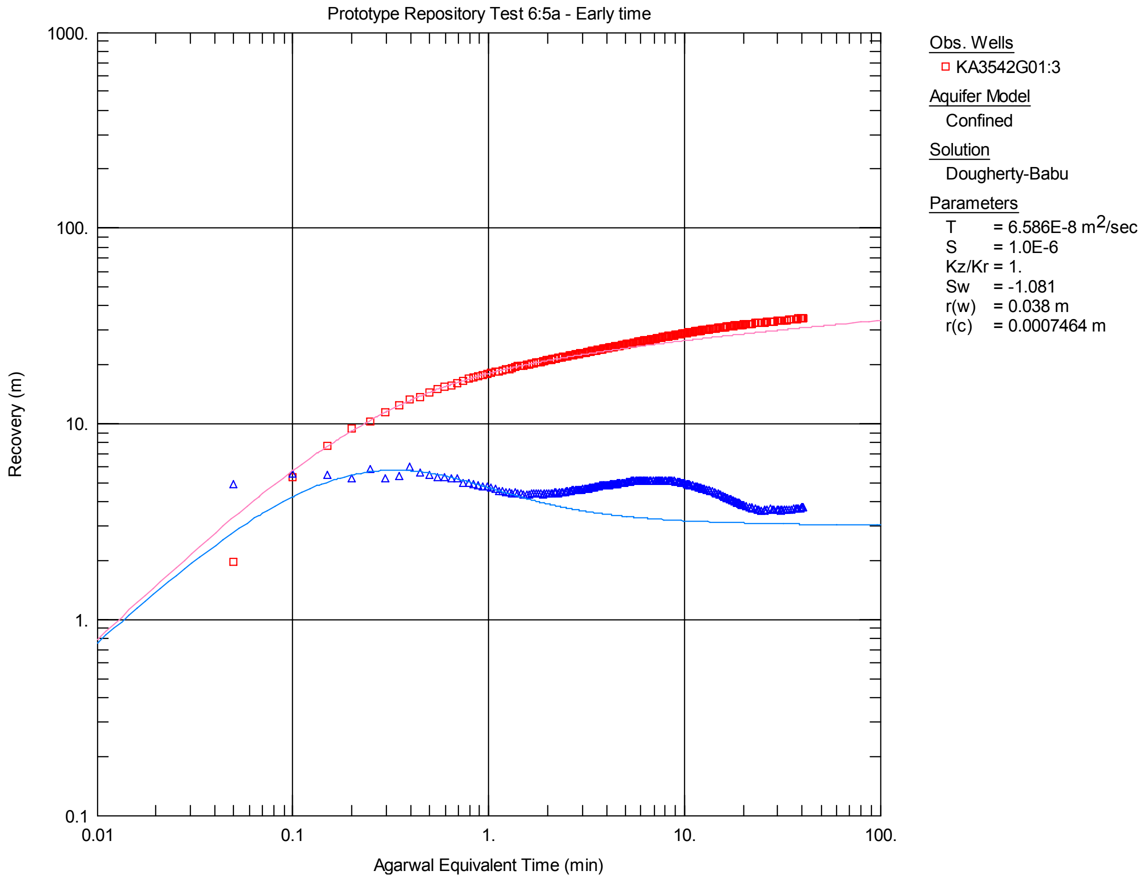

Prototype Repository Test 5:5a - Early time
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Recovery (m)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 5.766E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.09497
r(w) = 0.038 m
r(c) = 0.0007262 m

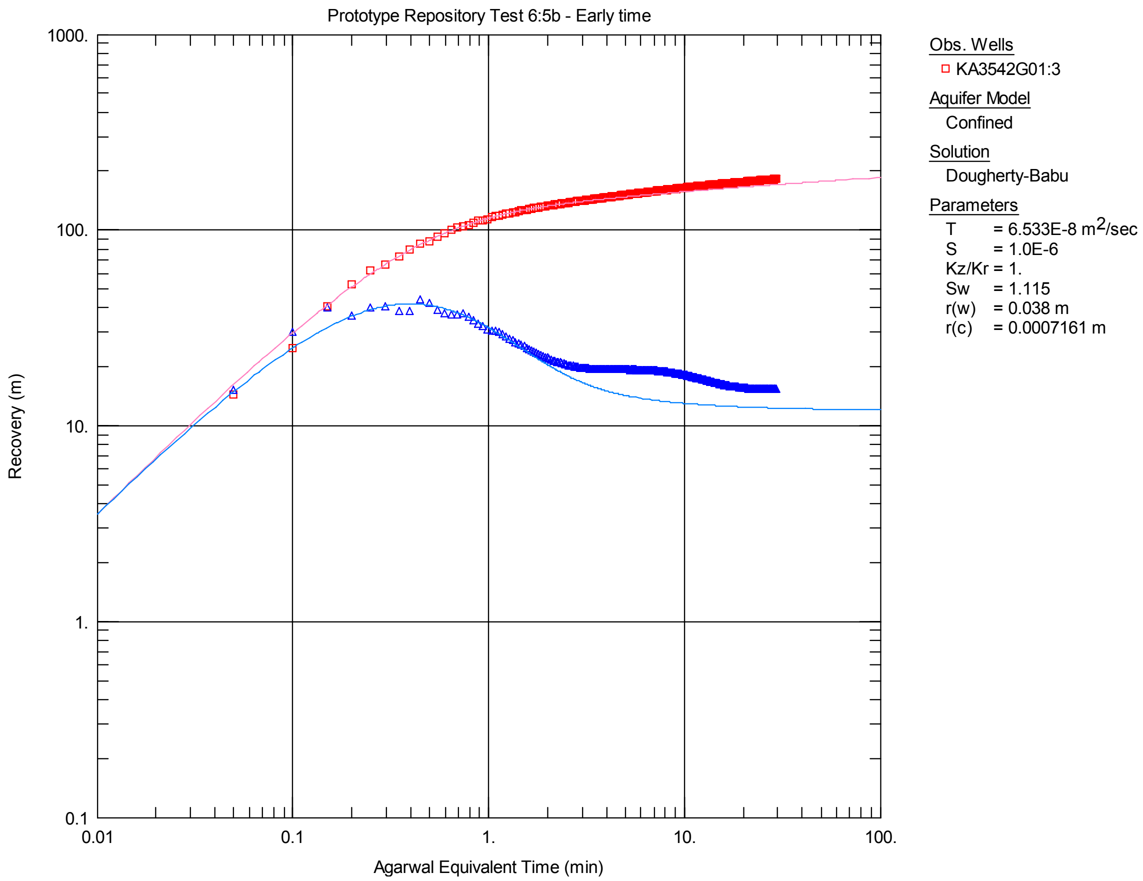


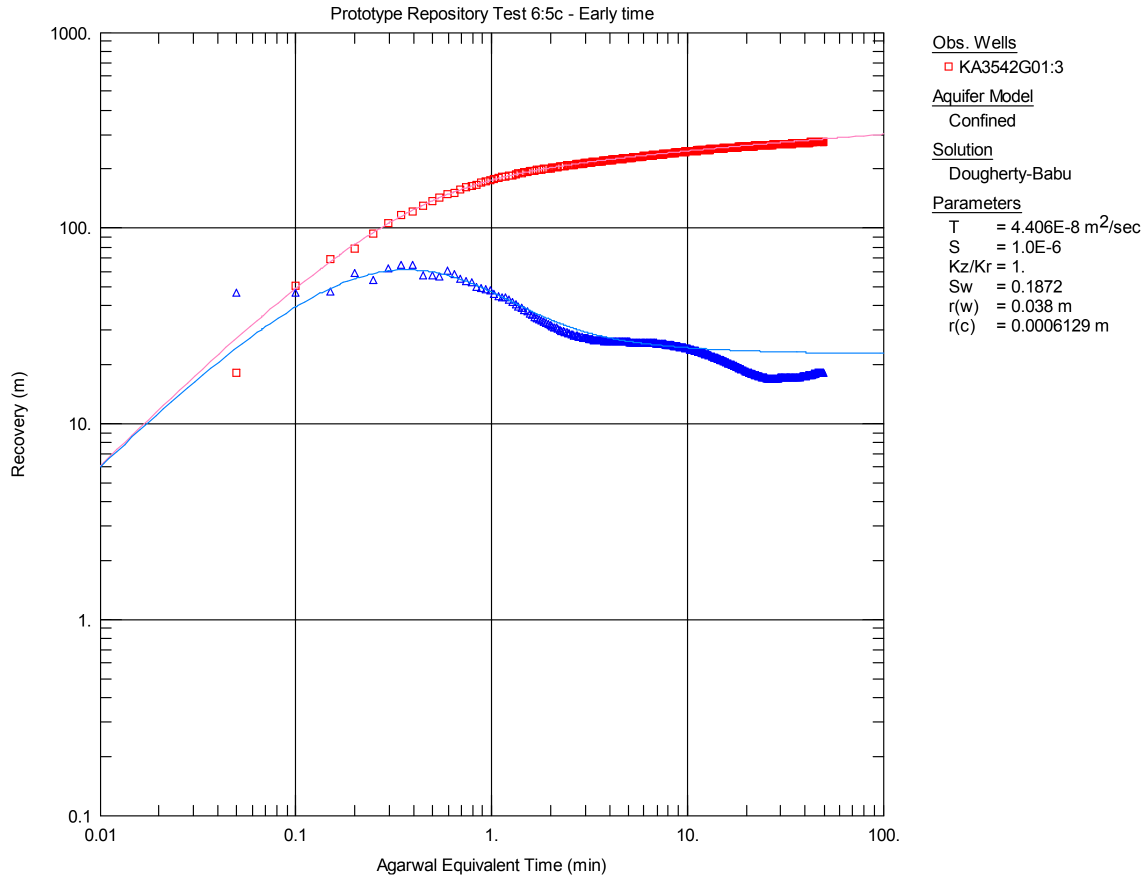
Prototype Repository Test 5:5b - Early time
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.218E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.8787
r(w) = 0.038 m
r(c) = 0.0006324 m

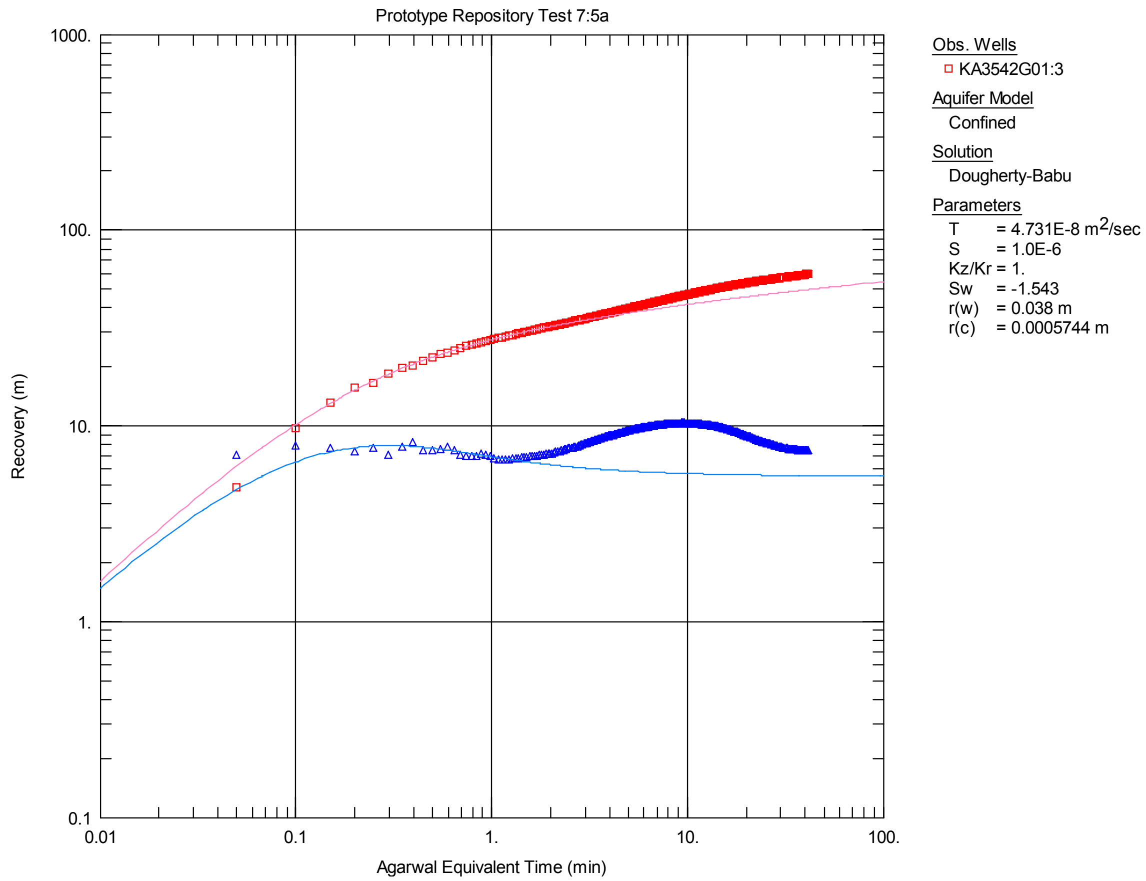


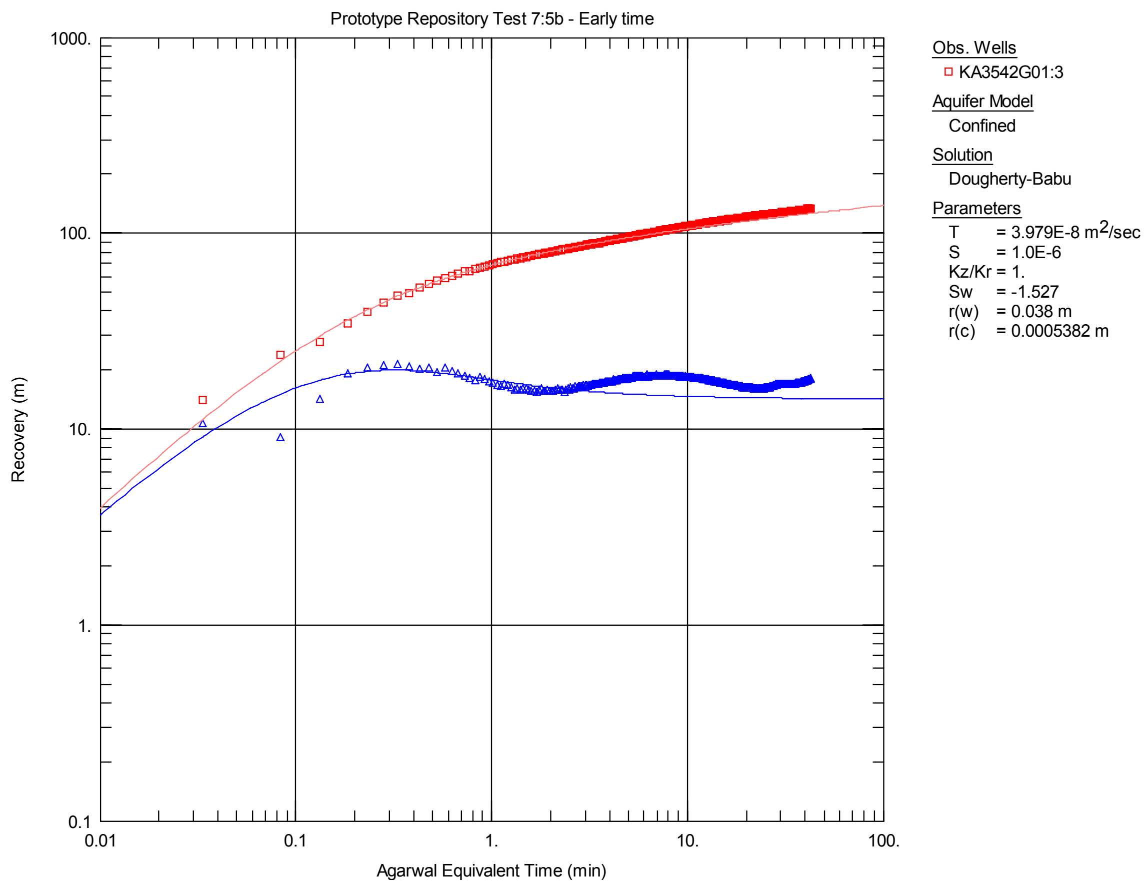
Prototype Repository Test 5:5c - Early time
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 3.48E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.7136
r(w) = 0.038 m
r(c) = 0.0005634 m

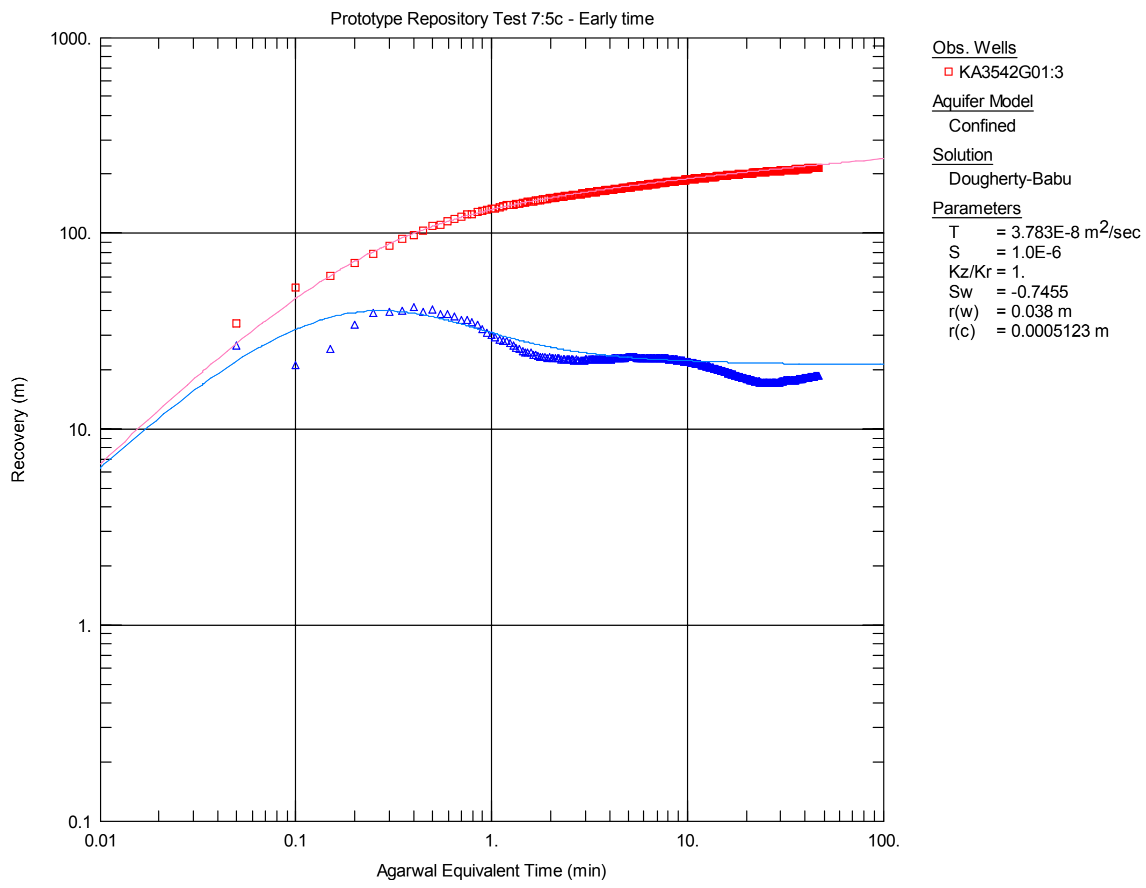

Prototype Repository Test 6:5a - Early time
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 6.586E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.081
r(w) = 0.038 m
r(c) = 0.0007464 m


Prototype Repository Test 6:5b - Early time
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 6.533E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 1.115
r(w) = 0.038 m
r(c) = 0.0007161 m

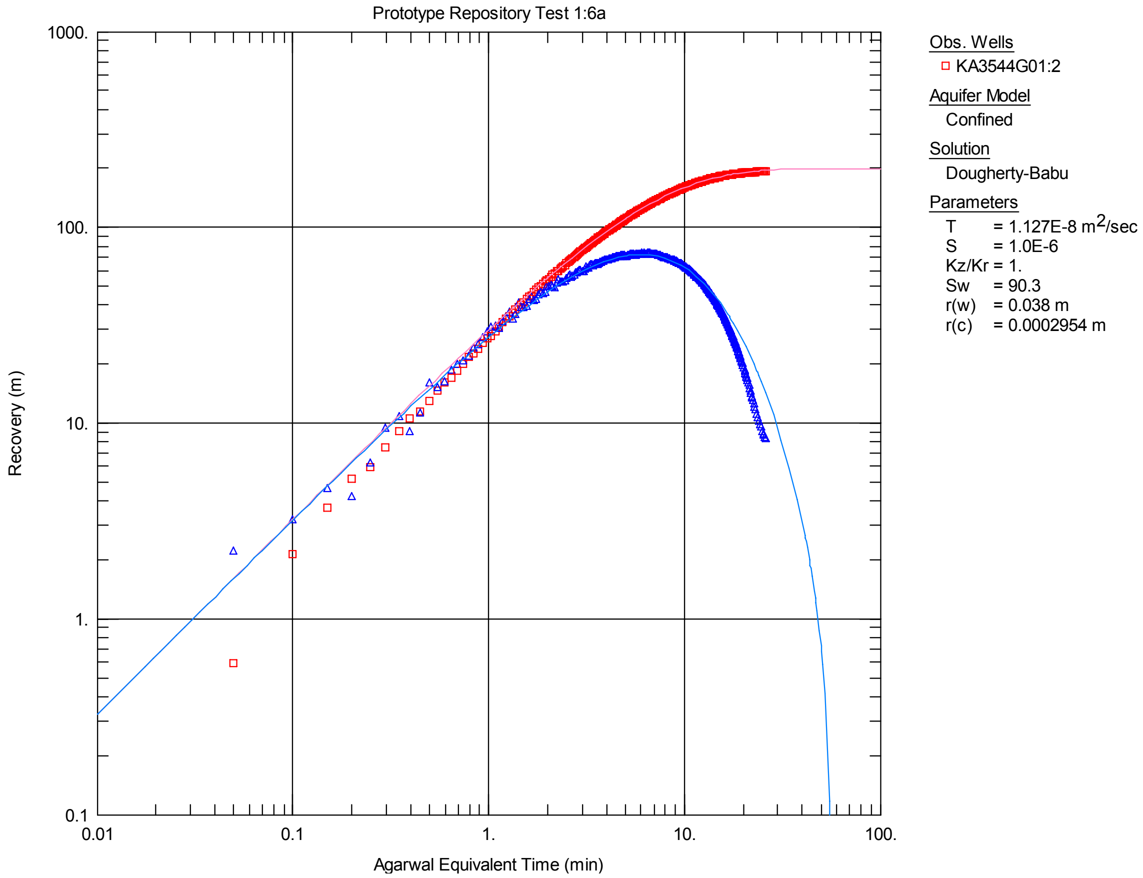

Prototype Repository Test 6:5c - Early time
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.406E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.1872
r(w) = 0.038 m
r(c) = 0.0006129 m

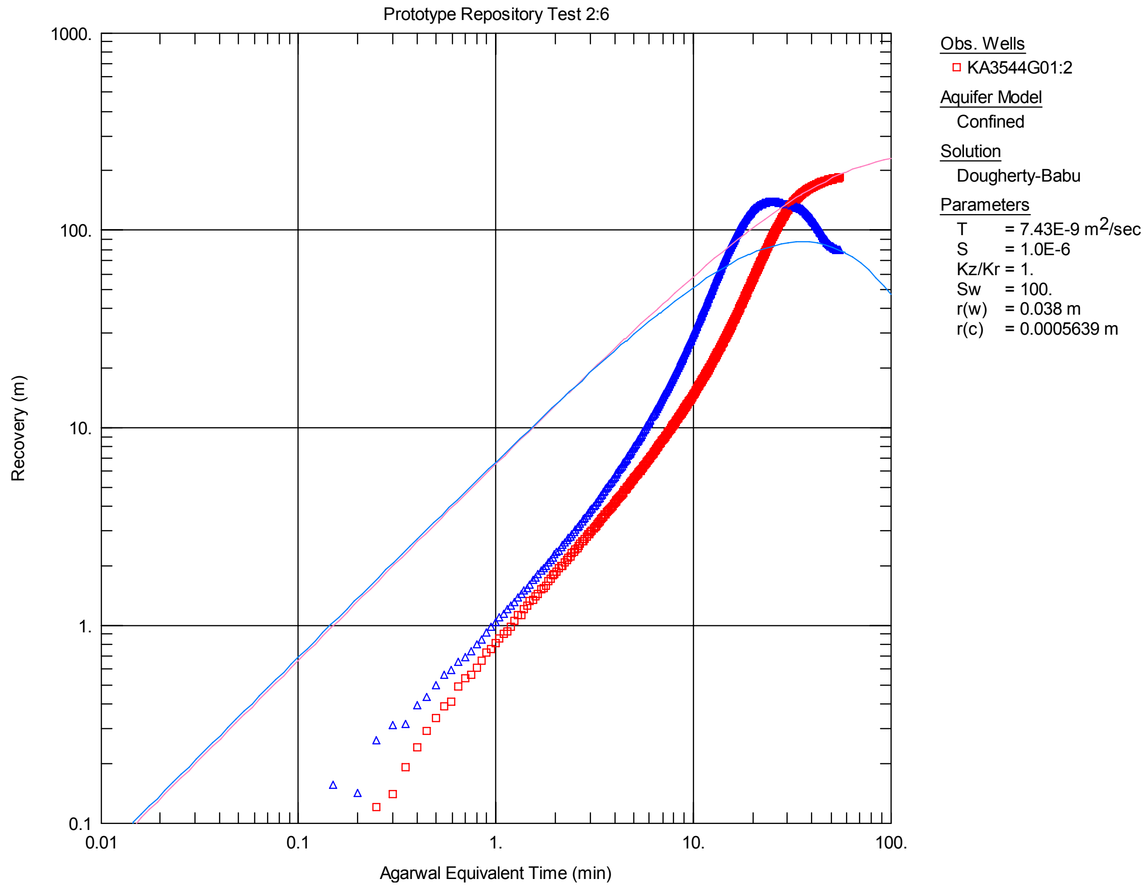

Prototype Repository Test 7:5a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.731E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.543
r(w) = 0.038 m
r(c) = 0.0005744 m


Prototype Repository Test 7:5b - Early time
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 3.979E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.527
r(w) = 0.038 m
r(c) = 0.0005382 m


Prototype Repository Test 7:5c - Early time
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 3.783E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.7455
r(w) = 0.038 m
r(c) = 0.0005123 m

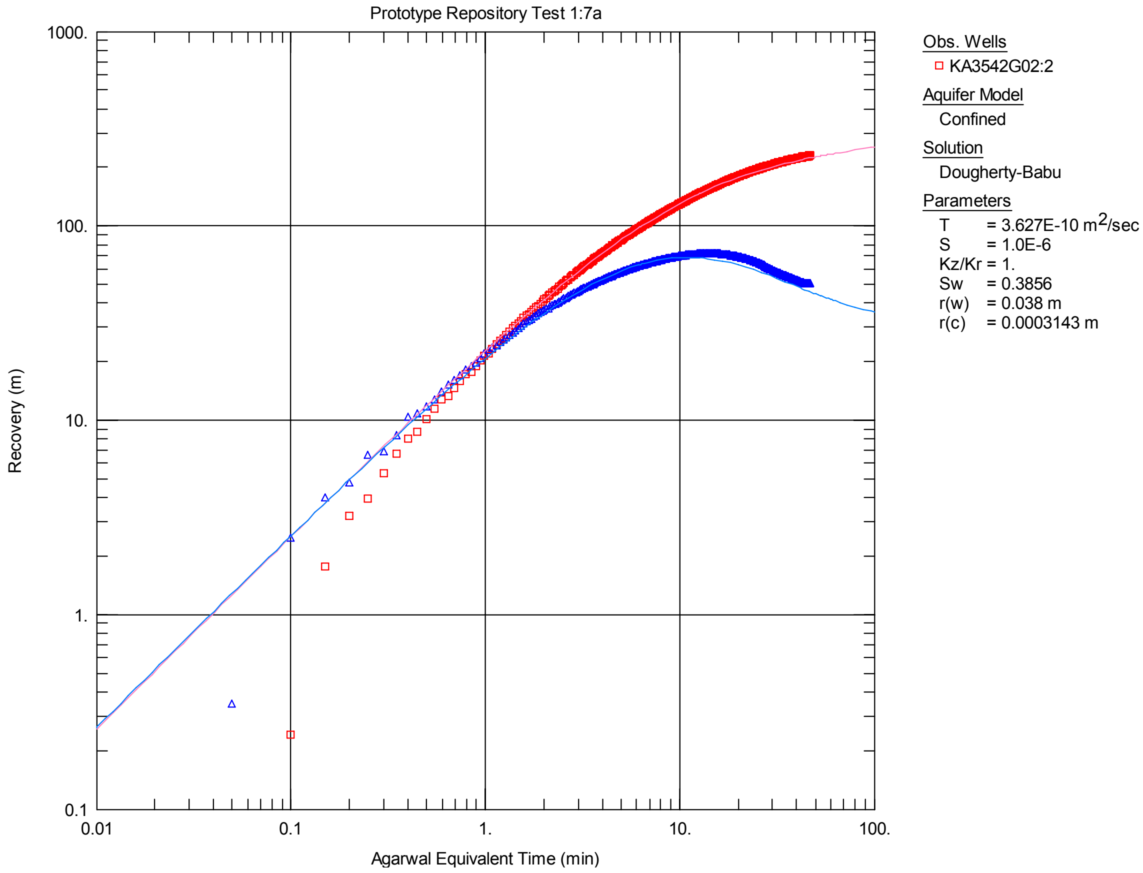
Appendix 6 – KA3544G01:2

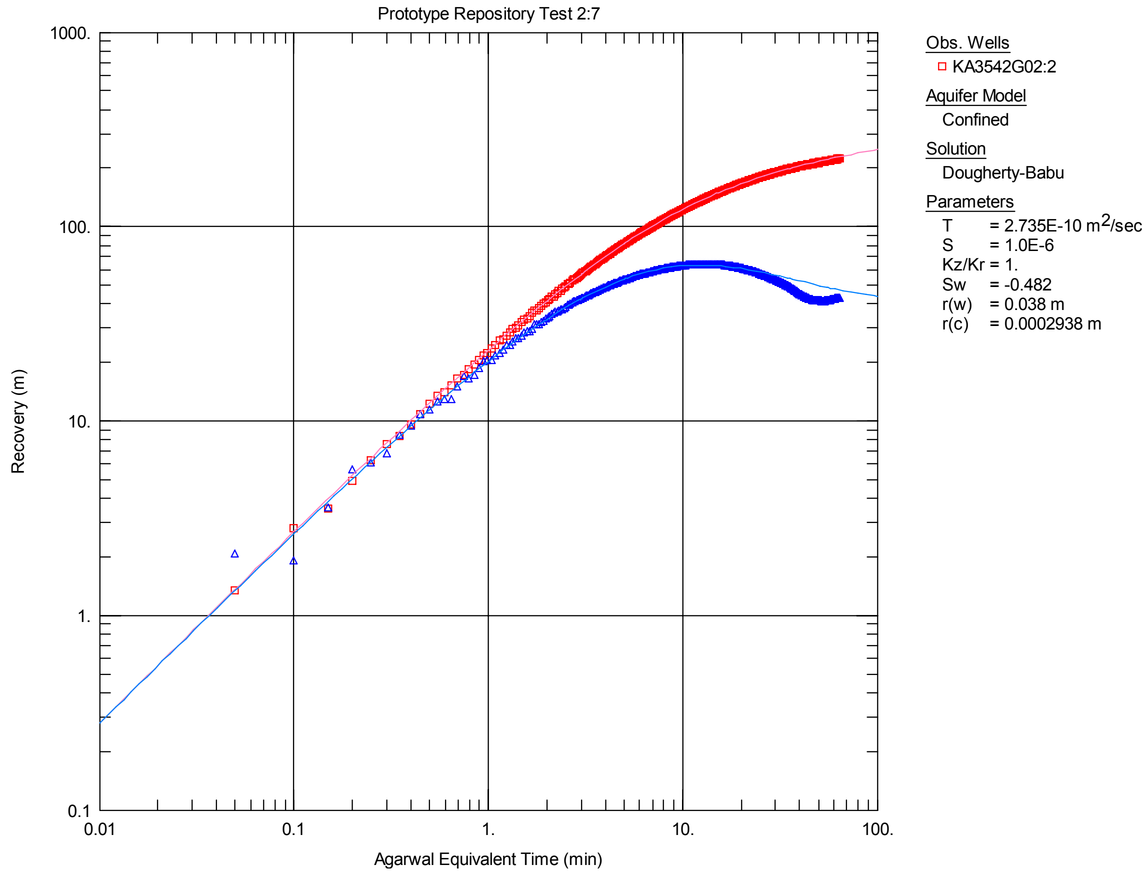




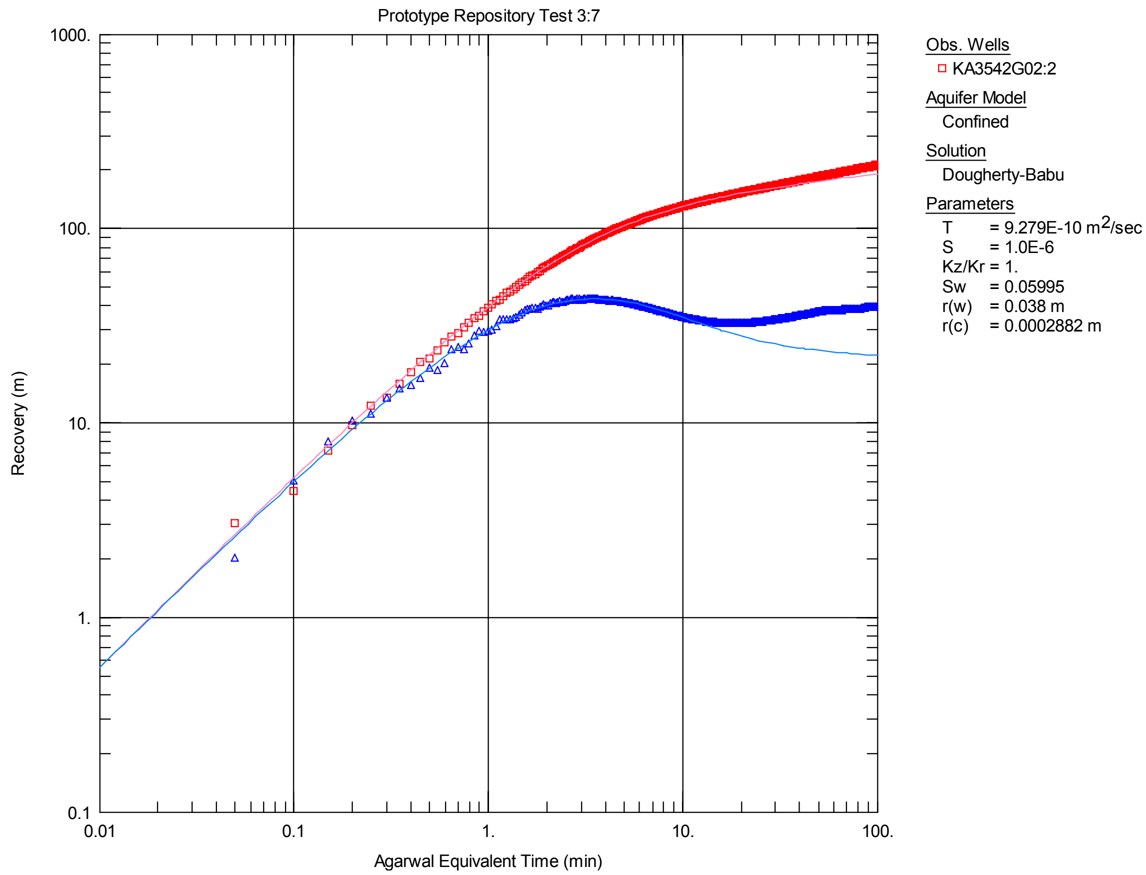
- Probably air in tube system. Uncertain evaluation.

Appendix 7 – KA3542G02:2

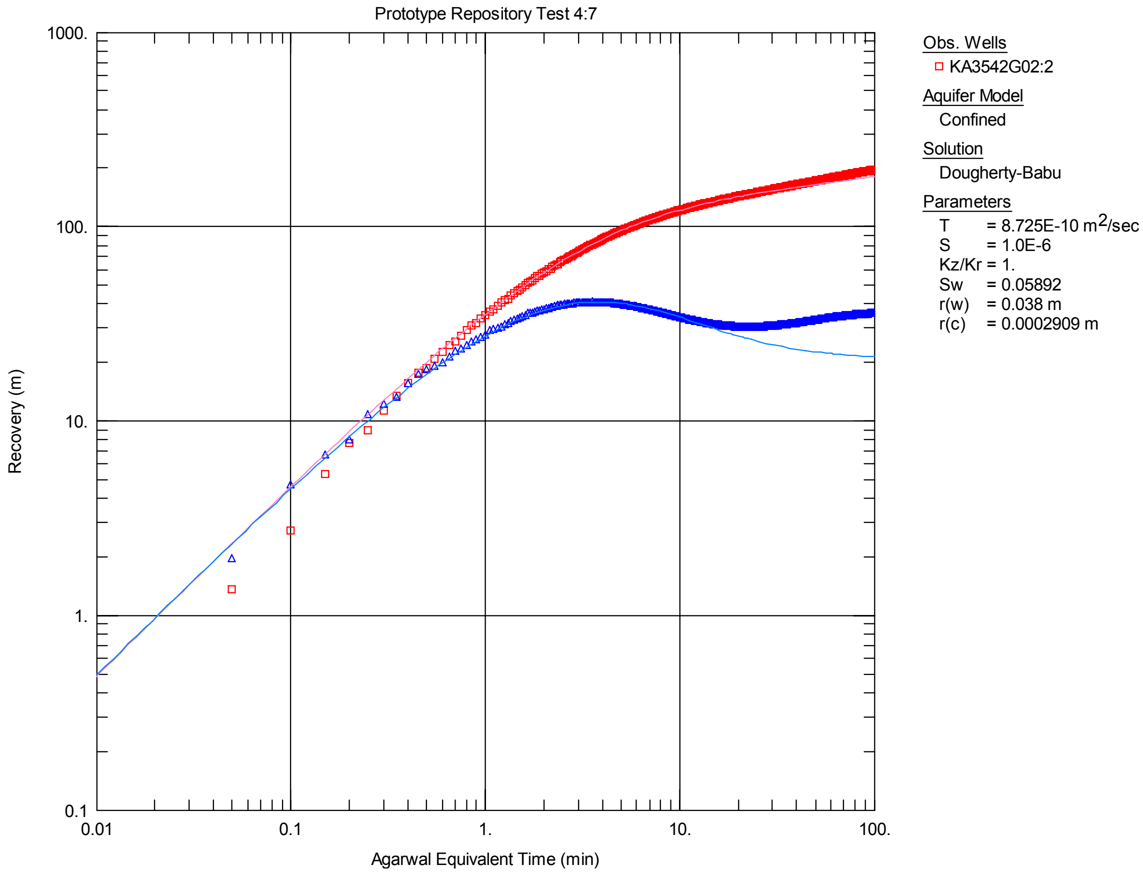


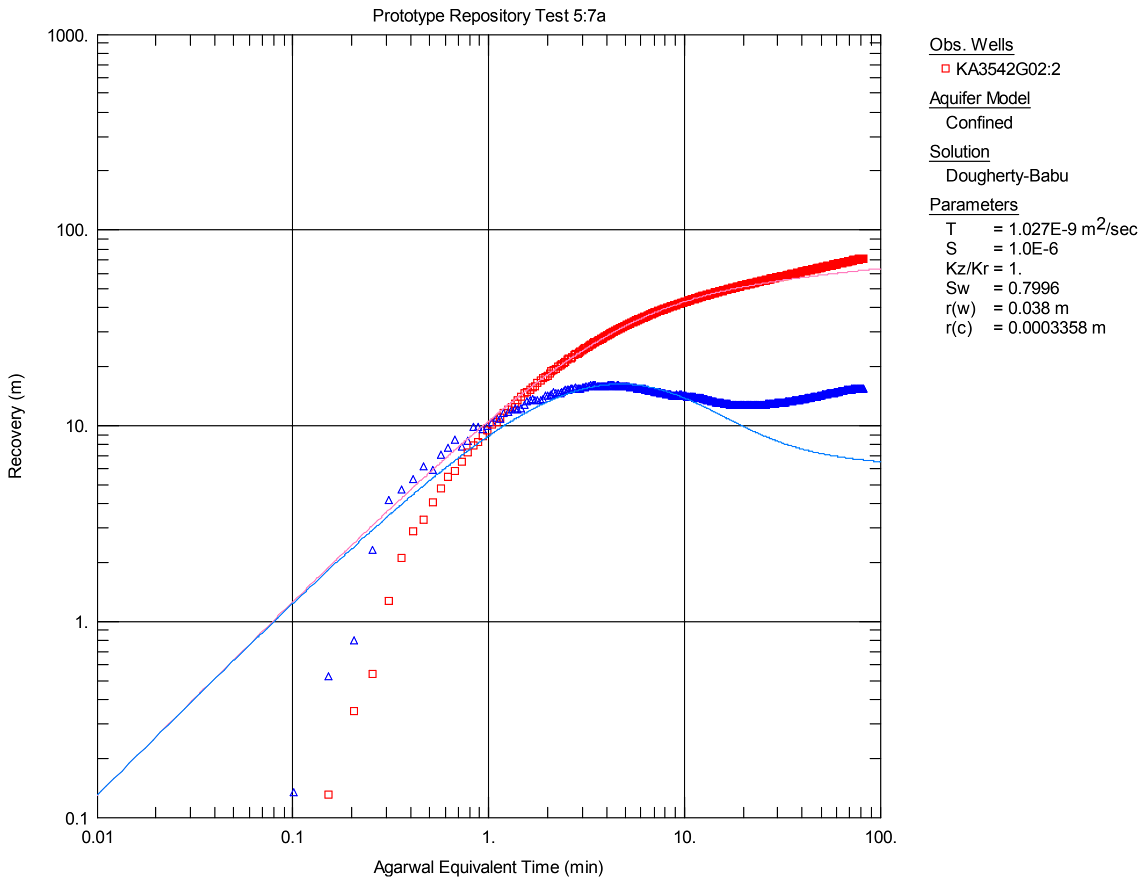


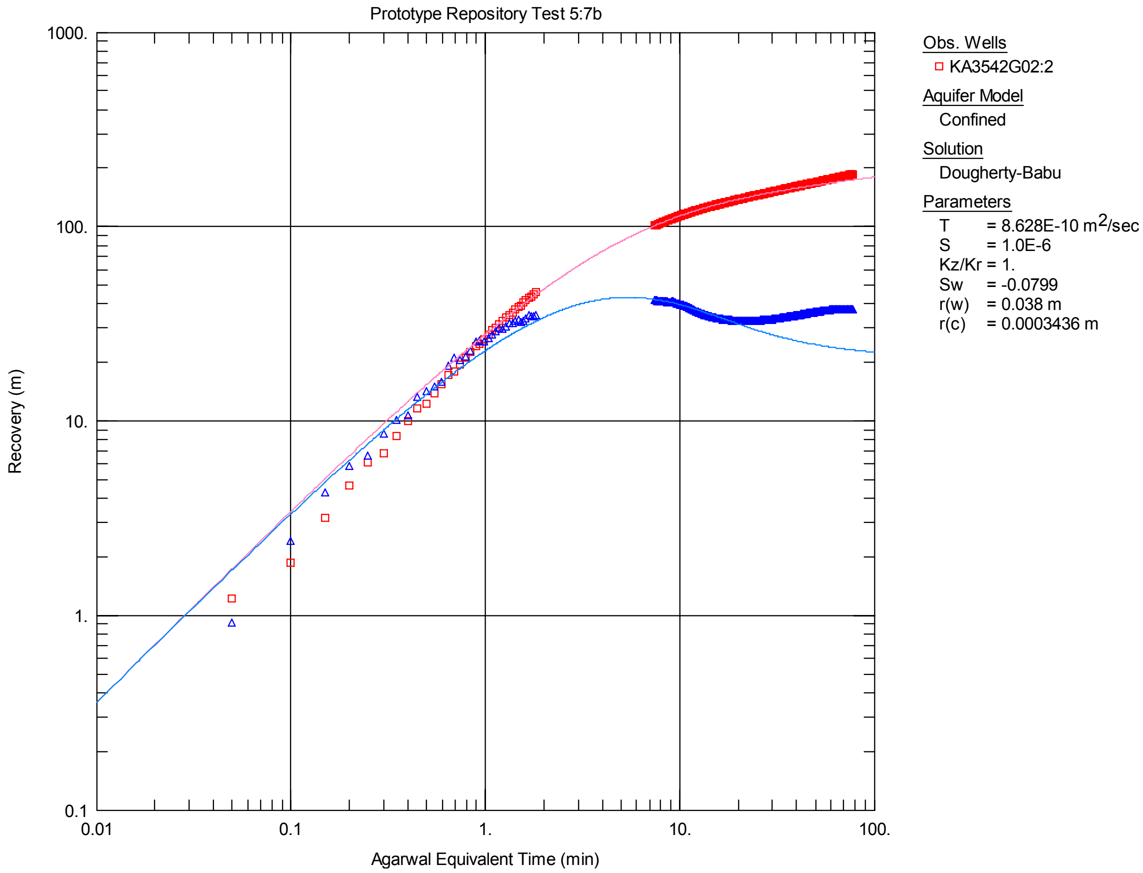
Prototype Repository Test 2:7
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 2.735E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.482
r(w) = 0.038 m
r(c) = 0.0002938 m



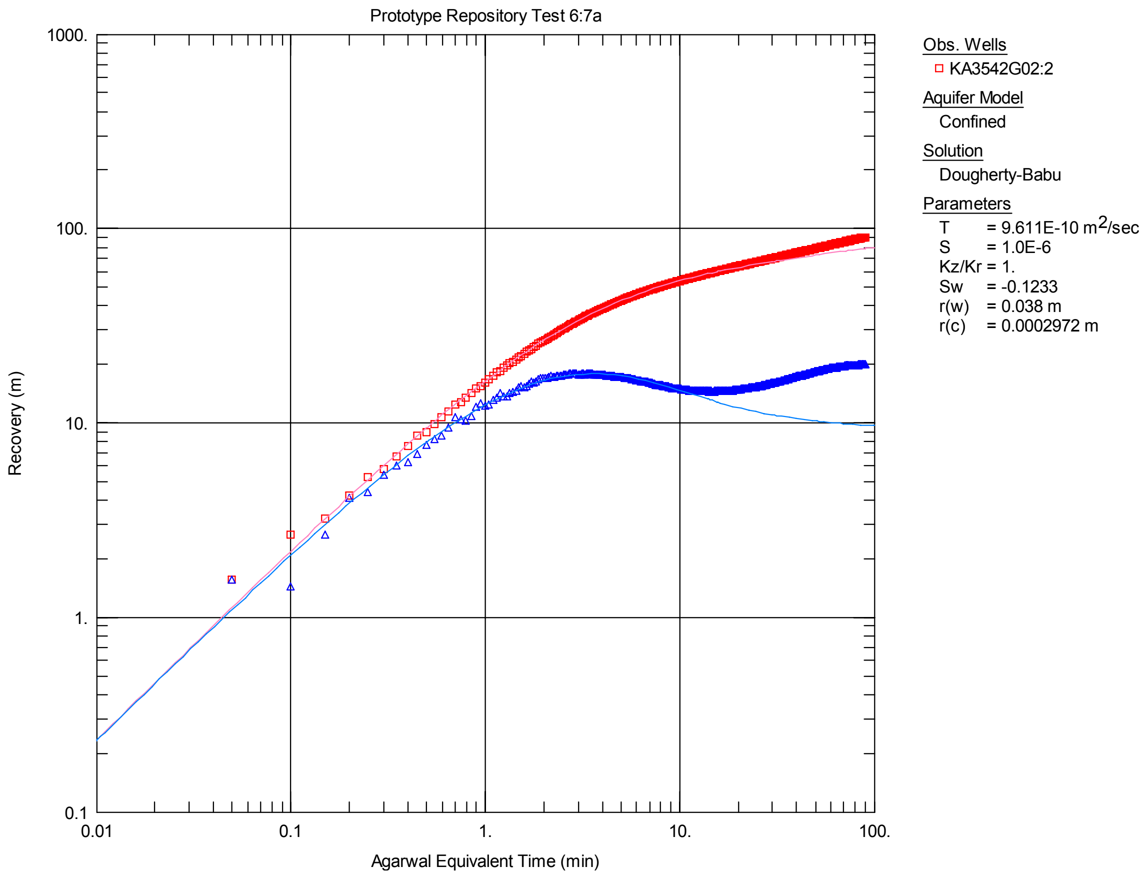
Prototype Repository Test 3:7
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.279E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.05995
r(w) = 0.038 m
r(c) = 0.0002882 m


Prototype Repository Test 4:7
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.725E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.05892
r(w) = 0.038 m
r(c) = 0.0002909 m

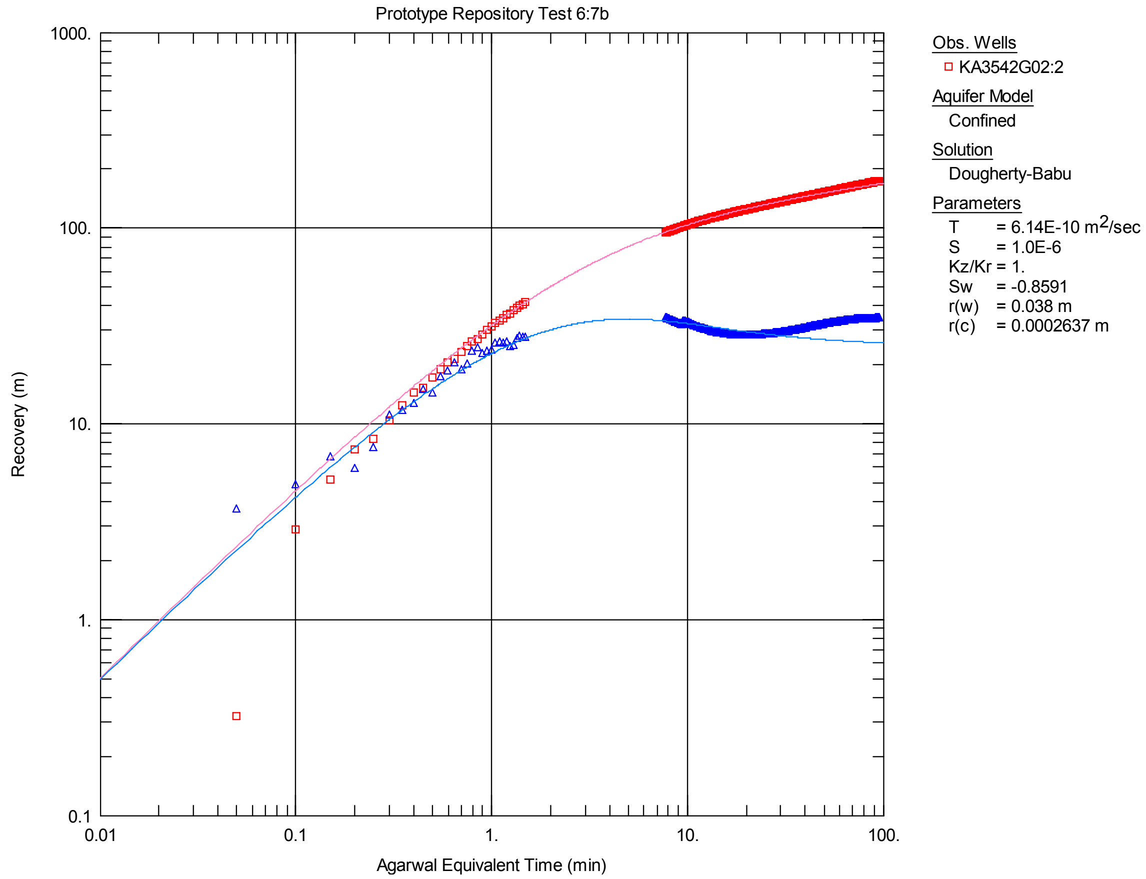

Prototype Repository Test 5:7a
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.027E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.7996
r(w) = 0.038 m
r(c) = 0.0003358 m

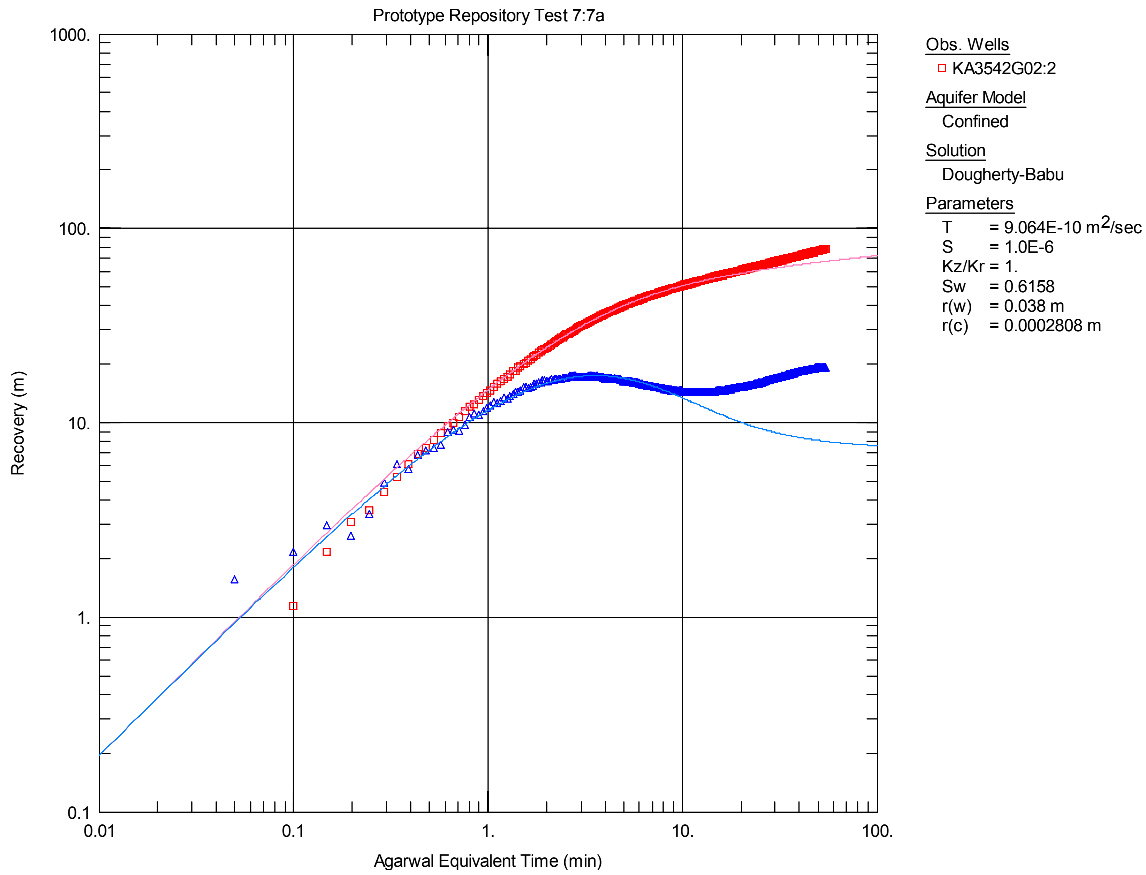


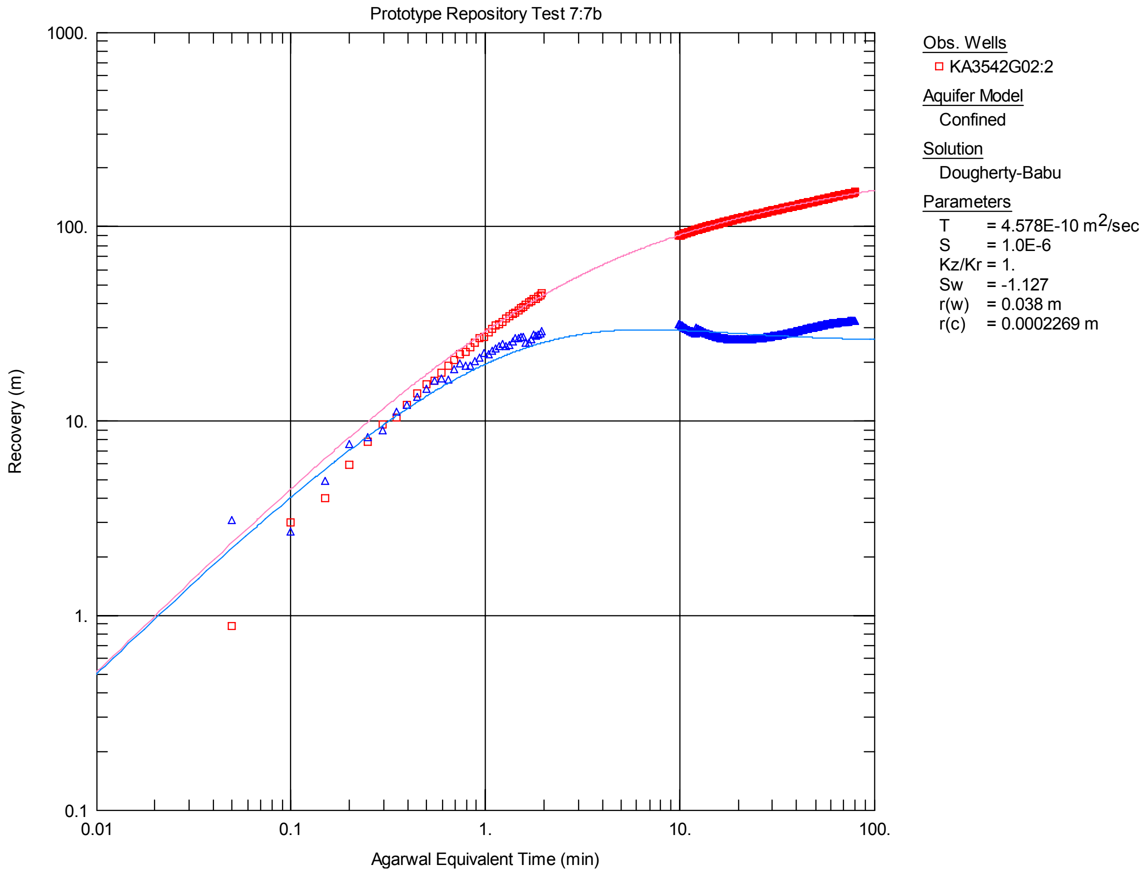
Prototype Repository Test 5:7b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.628E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.0799
r(w) = 0.038 m
r(c) = 0.0003436 m



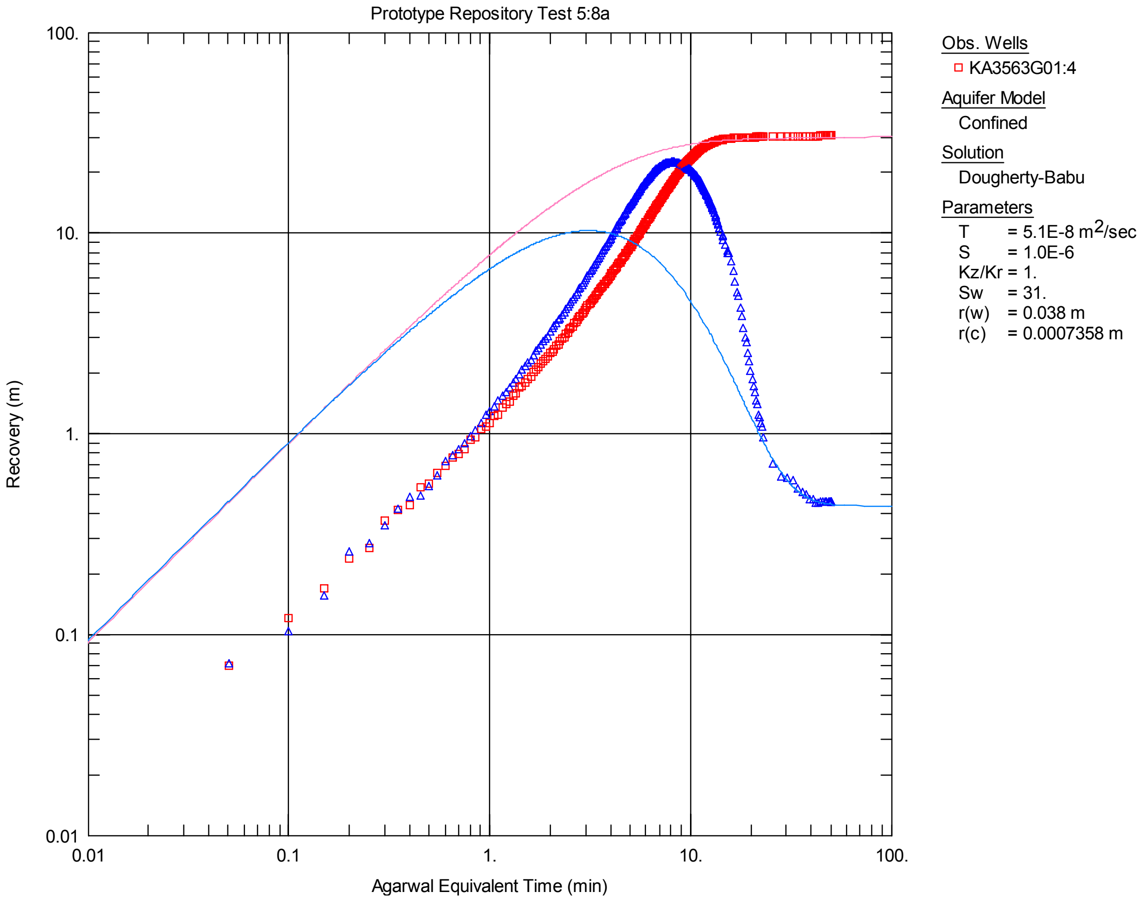
Prototype Repository Test 6:7a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.611E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.1233
r(w) = 0.038 m
r(c) = 0.0002972 m


Prototype Repository Test 6:7b
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 6.14E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.8591
r(w) = 0.038 m
r(c) = 0.0002637 m


Prototype Repository Test 7:7a
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.064E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.6158
r(w) = 0.038 m
r(c) = 0.0002808 m

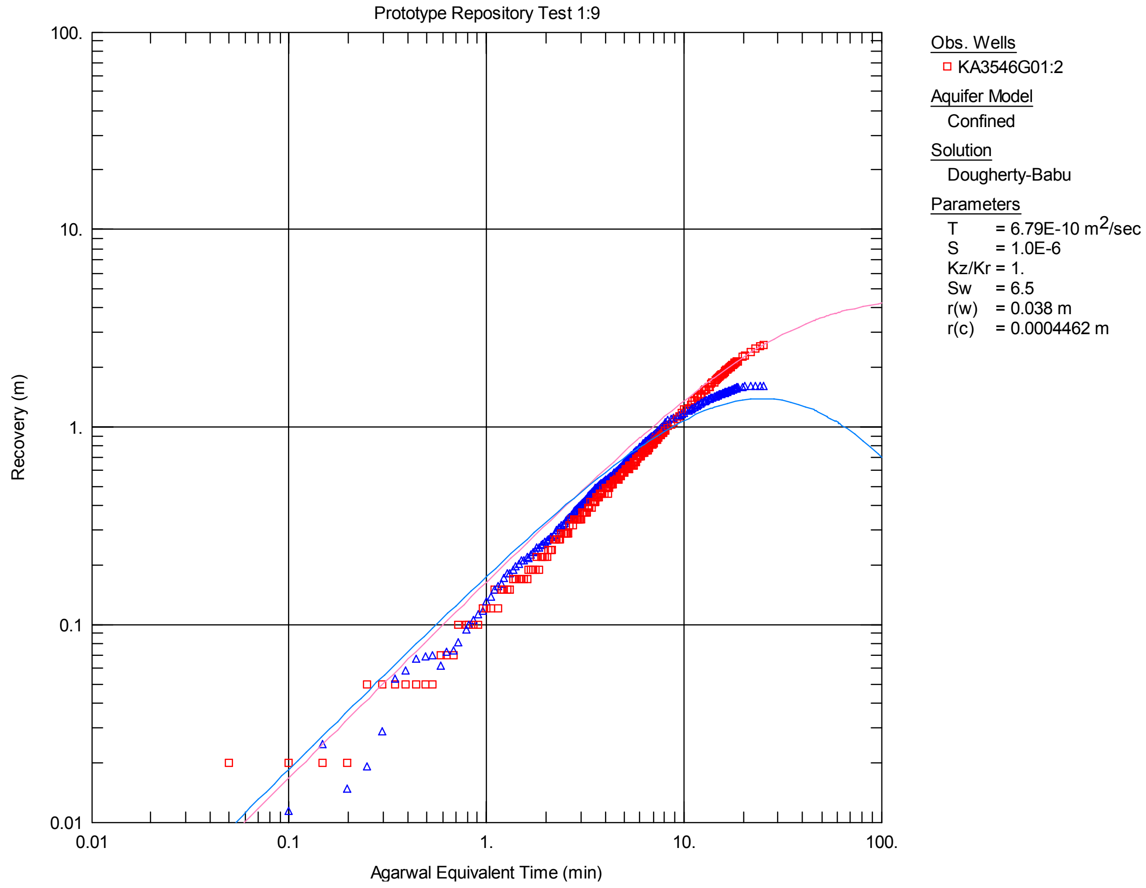

Prototype Repository Test 7:7b
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G02:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 4.578E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.127
r(w) = 0.038 m
r(c) = 0.0002269 m

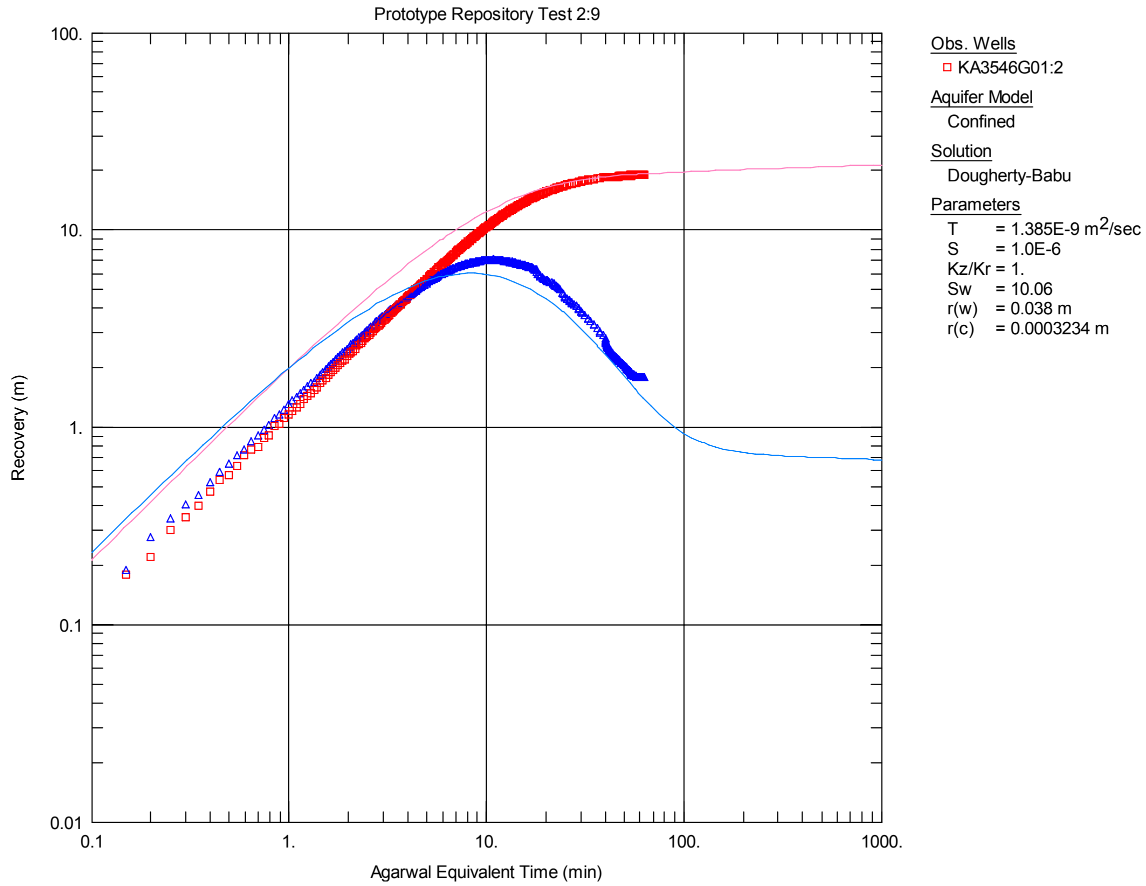
Appendix 8 – KA3563G:4



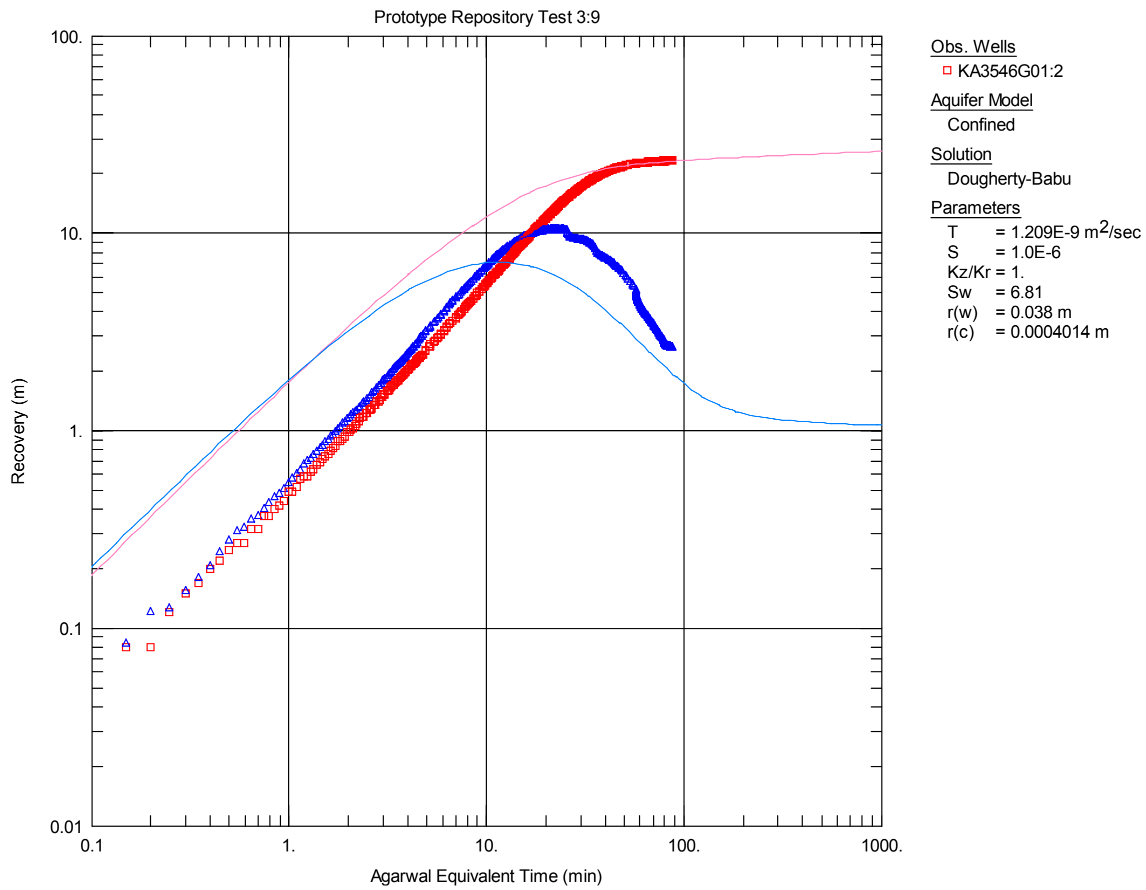
- Probably air in tube system.

Appendix 9 – KA3546G01:2

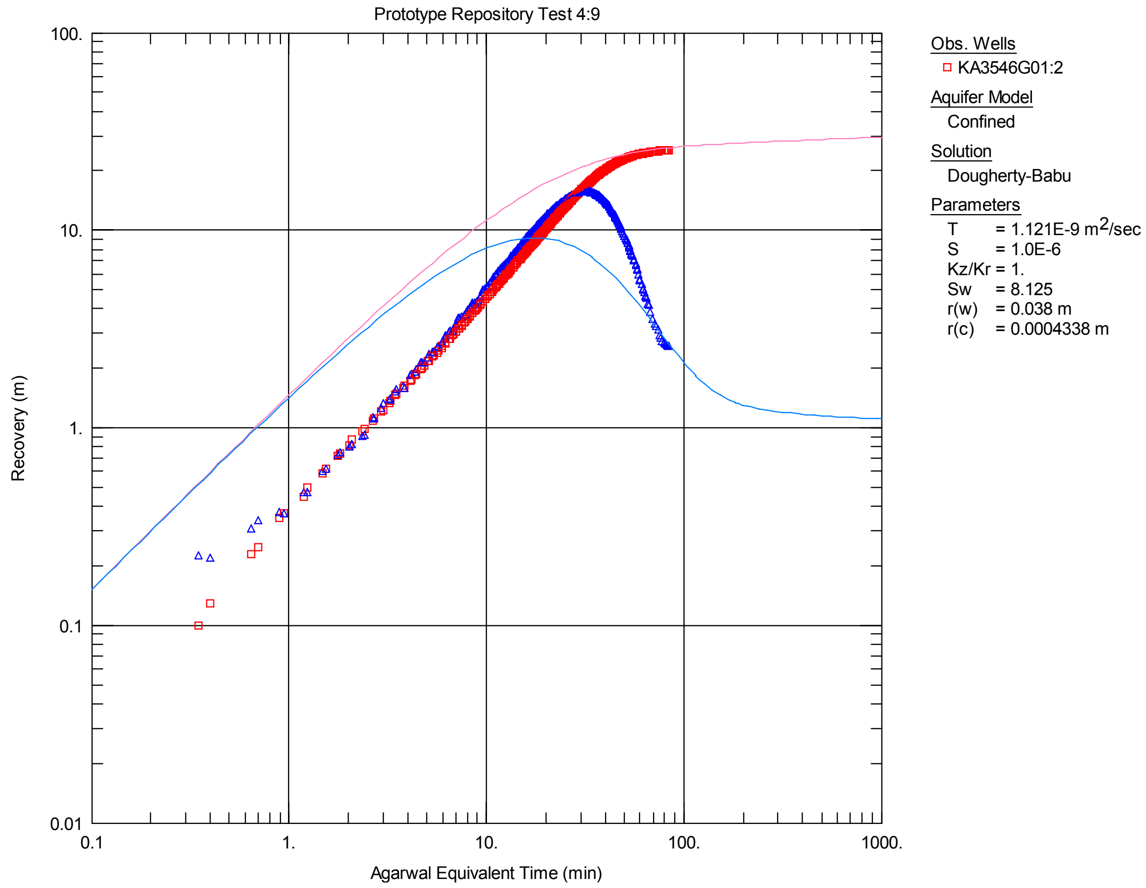


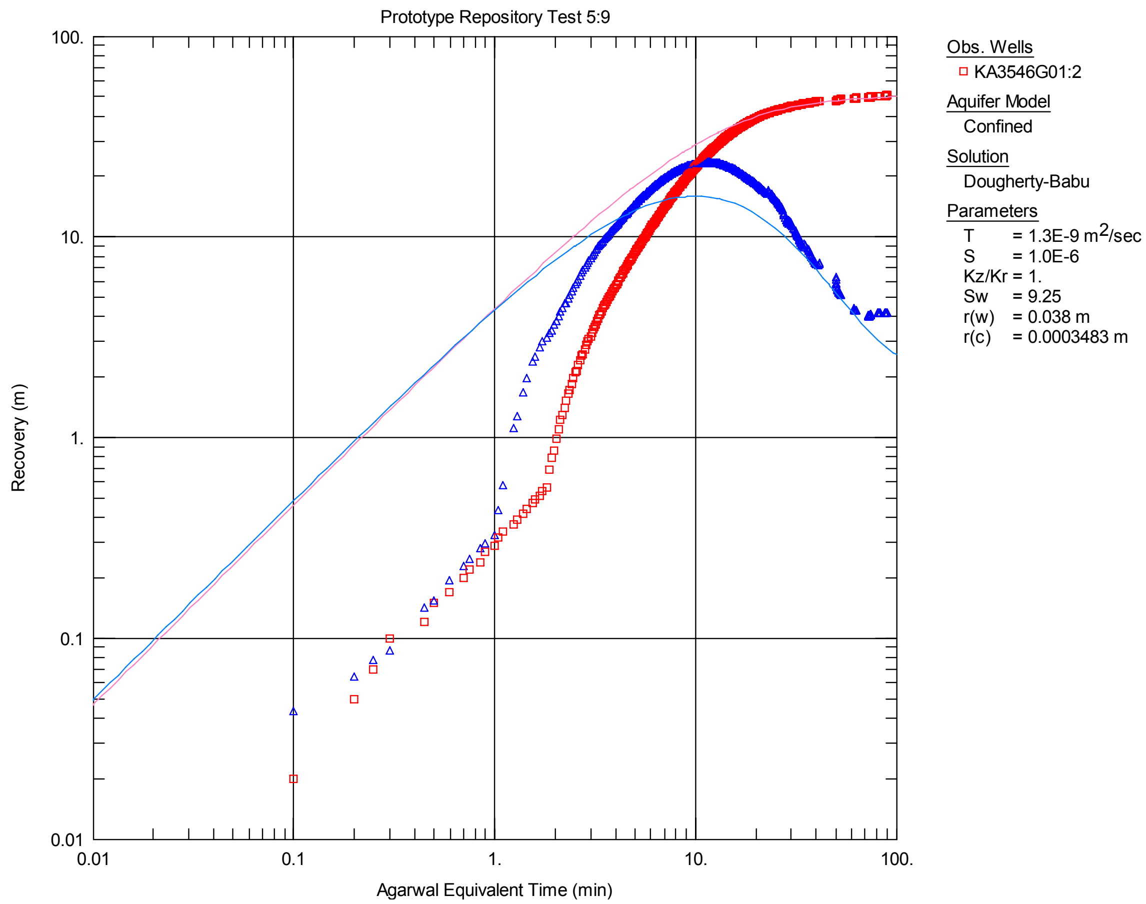


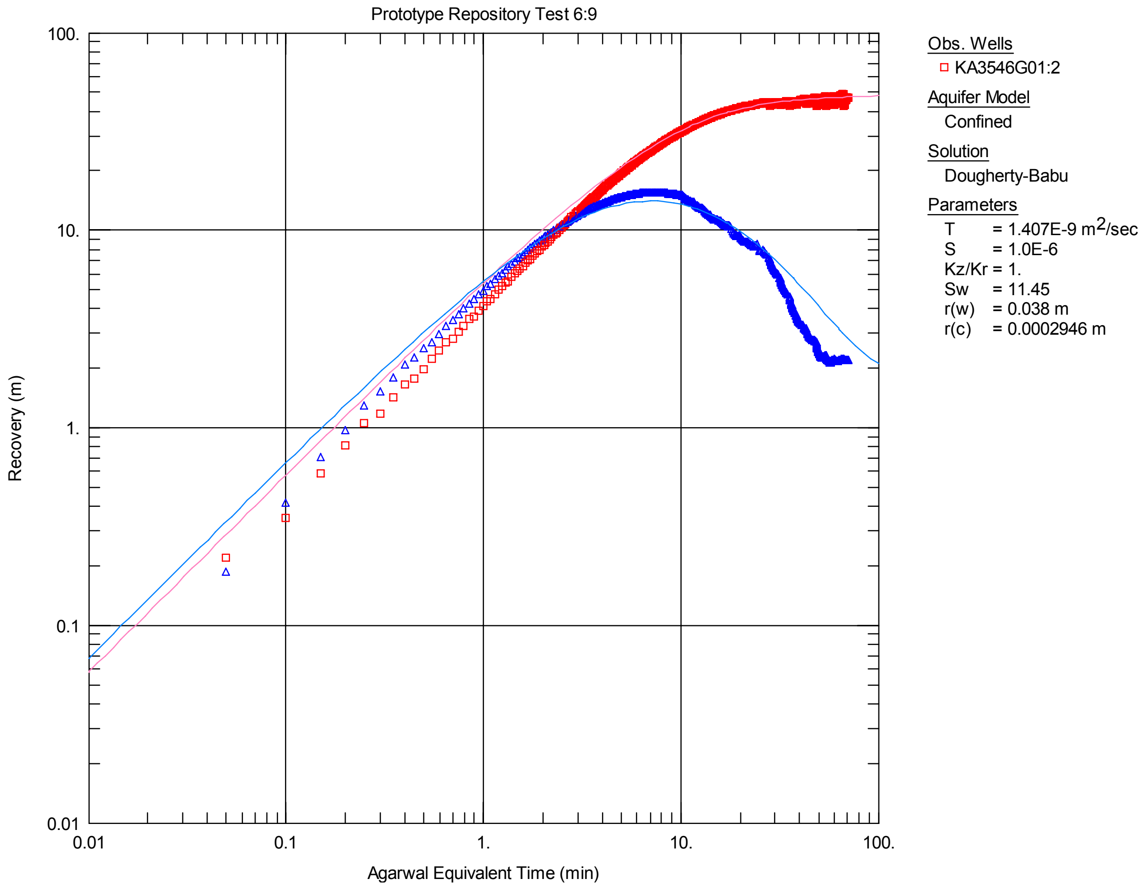
Prototype Repository Test 2:9
Recovery (m)
Agarwal Equivalent Time (min)
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
1000.
Obs. Wells
KA3546G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.385E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 10.06
r(w) = 0.038 m
r(c) = 0.0003234 m

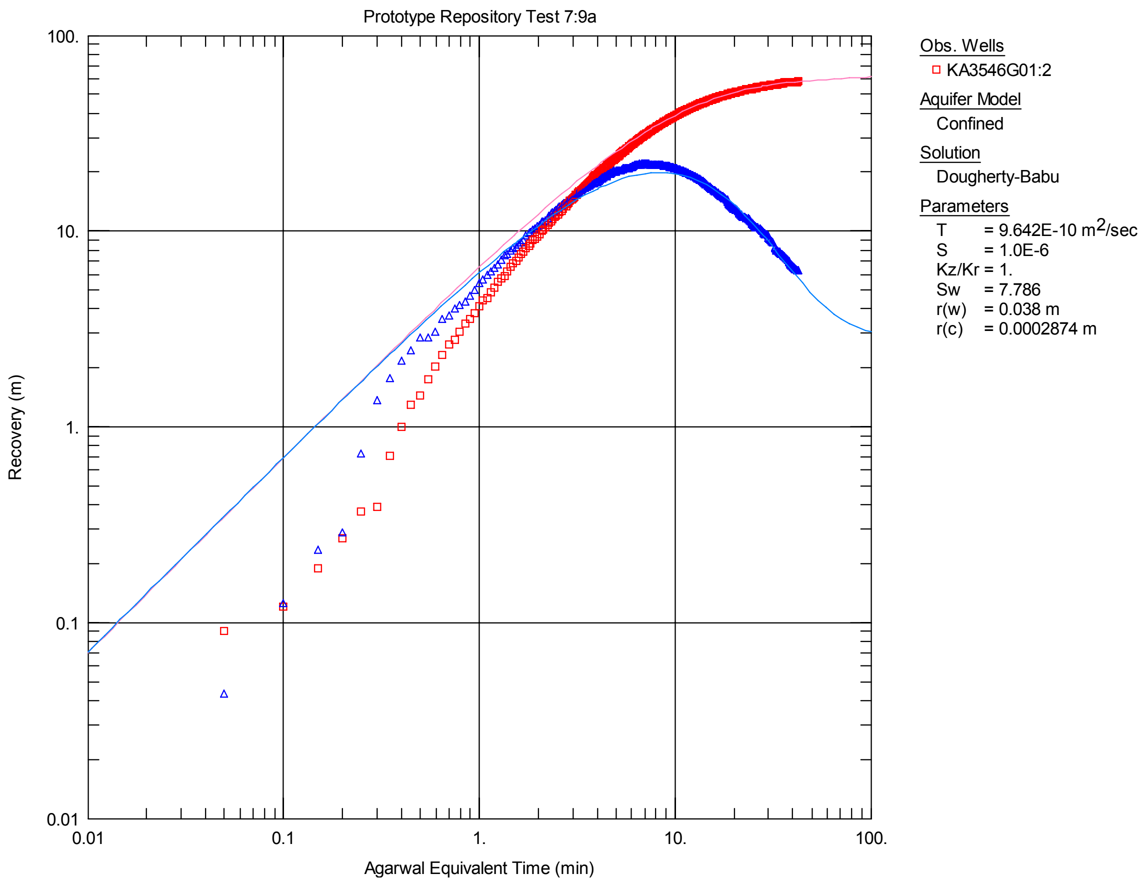


Prototype Repository Test 3:9
Recovery (m)
Agarwal Equivalent Time (min)
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
1000.
Obs. Wells
KA3546G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.209E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 6.81
r(w) = 0.038 m
r(c) = 0.0004014 m

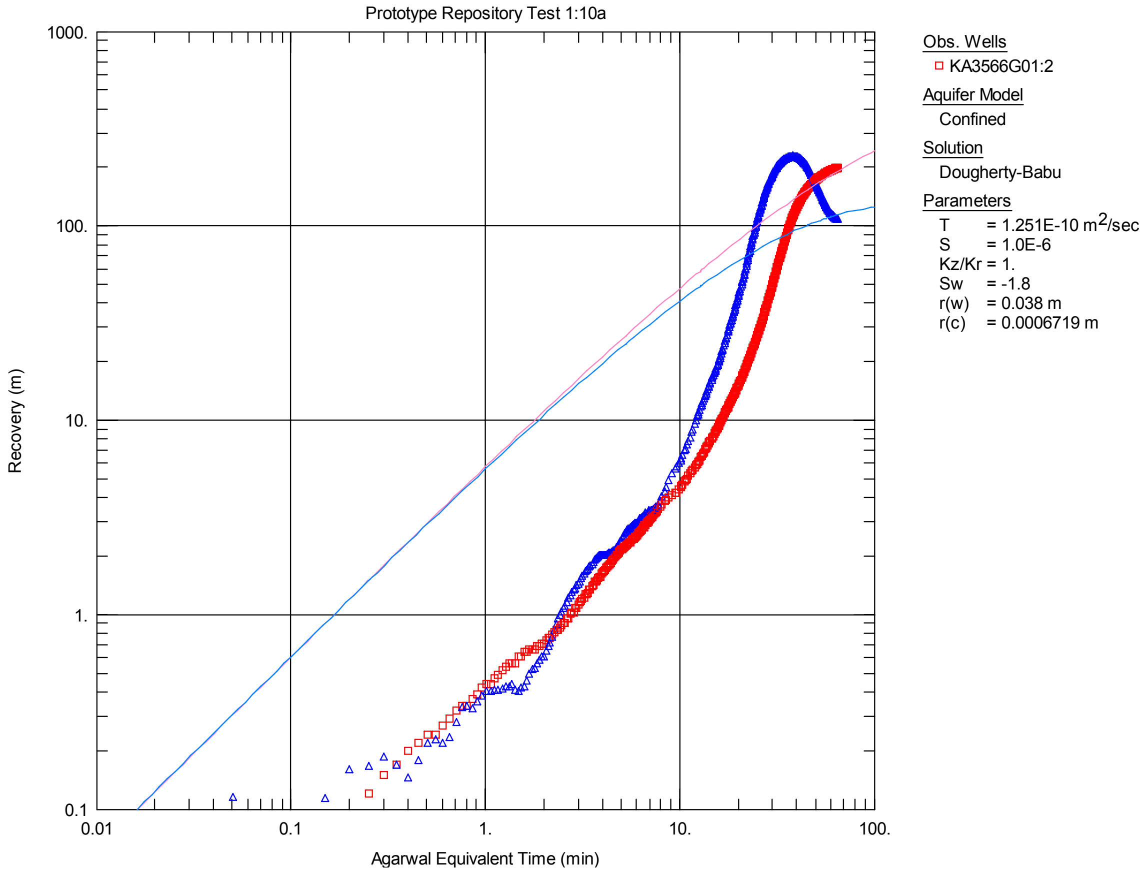

Prototype Repository Test 4:9
Recovery (m)
Agarwal Equivalent Time (min)
0.01
0.1
1.
10.
100.
0.1
1.
10.
100.
1000.
Obs. Wells
KA3546G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.121E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 8.125
r(w) = 0.038 m
r(c) = 0.0004338 m


Prototype Repository Test 5:9
Recovery (m)
Agarwal Equivalent Time (min)
0.01
0.1
1.
10.
100.
0.01
0.1
1.
10.
100.
Obs. Wells
KA3546G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.3E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 9.25
r(w) = 0.038 m
r(c) = 0.0003483 m

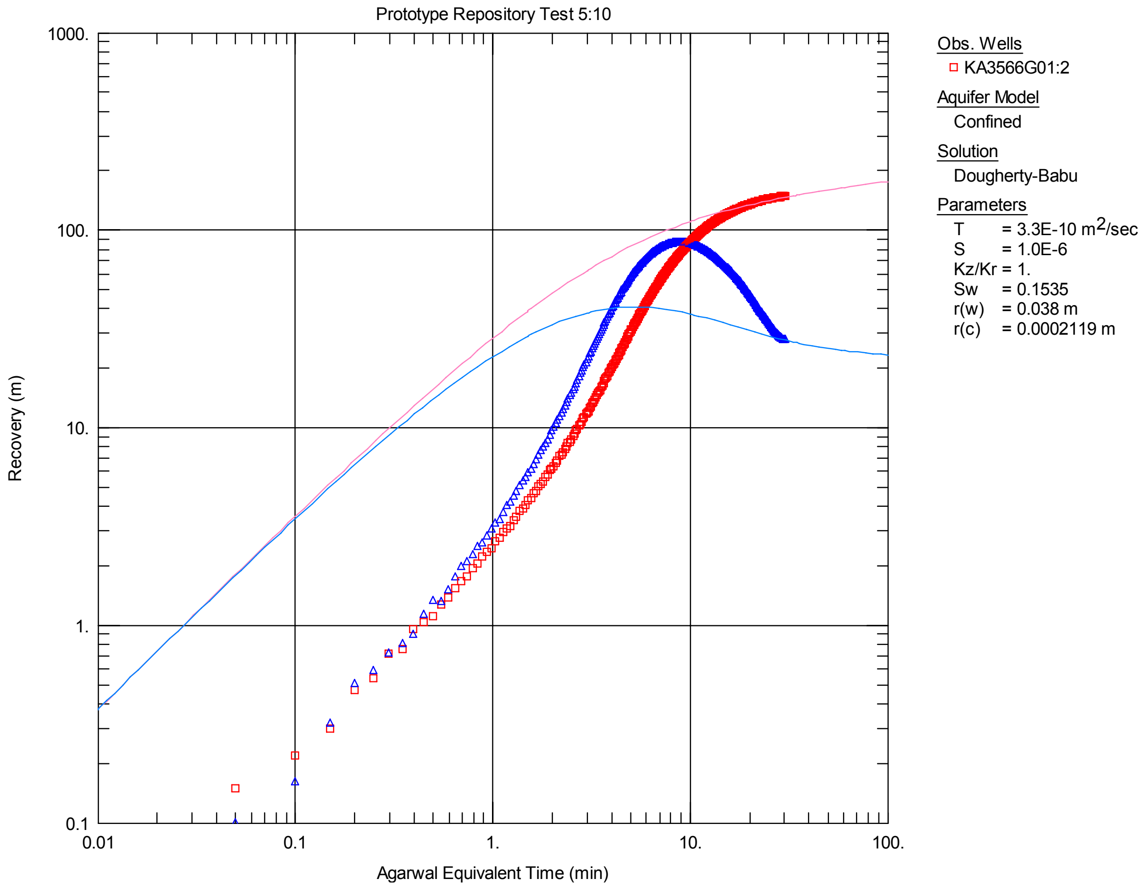

Prototype Repository Test 6:9
Recovery (m)
Agarwal Equivalent Time (min)
100.
10.
1.
0.1
0.01
0.01
0.1
1.
10.
100.
Obs. Wells
KA3546G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.407E-9 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 11.45
r(w) = 0.038 m
r(c) = 0.0002946 m


Prototype Repository Test 7:9a
Recovery (m)
Agarwal Equivalent Time (min)
100.
10.
1.
0.1
0.01
0.01
0.1
1.
10.
100.
Obs. Wells
KA3546G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.642E-10 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 7.786
r(w) = 0.038 m
r(c) = 0.0002874 m

Appendix 10 – KA3566G01:2

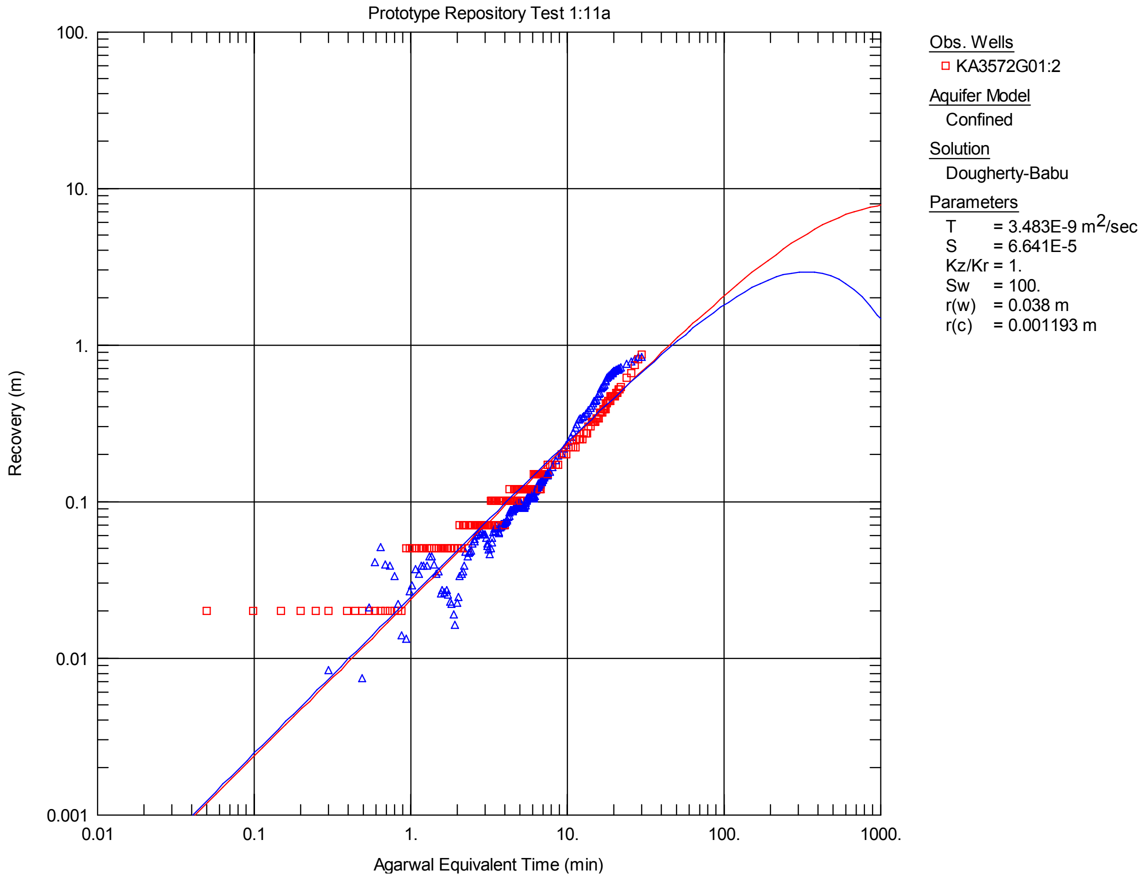


- Probably air in tube system. Uncertain evaluation.



- Probably air in tube system.

Appendix 11 – KA3572G01:2

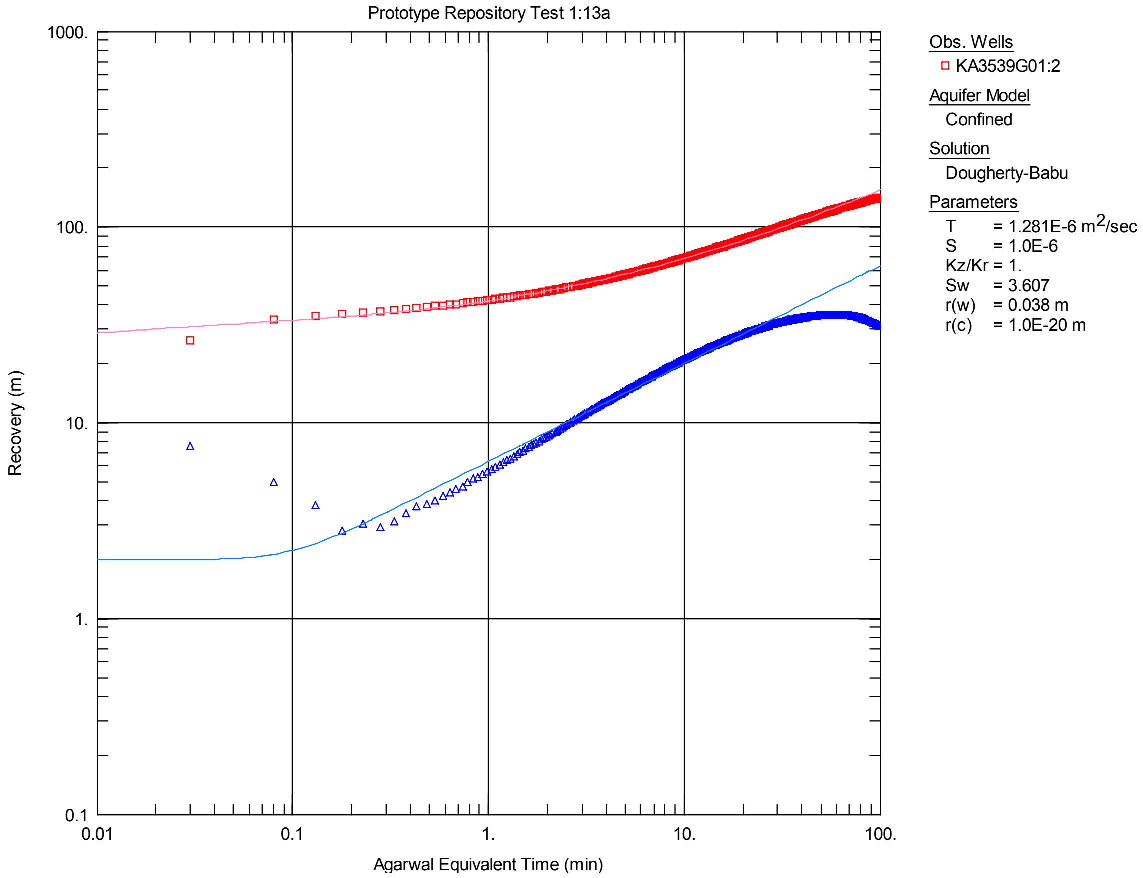


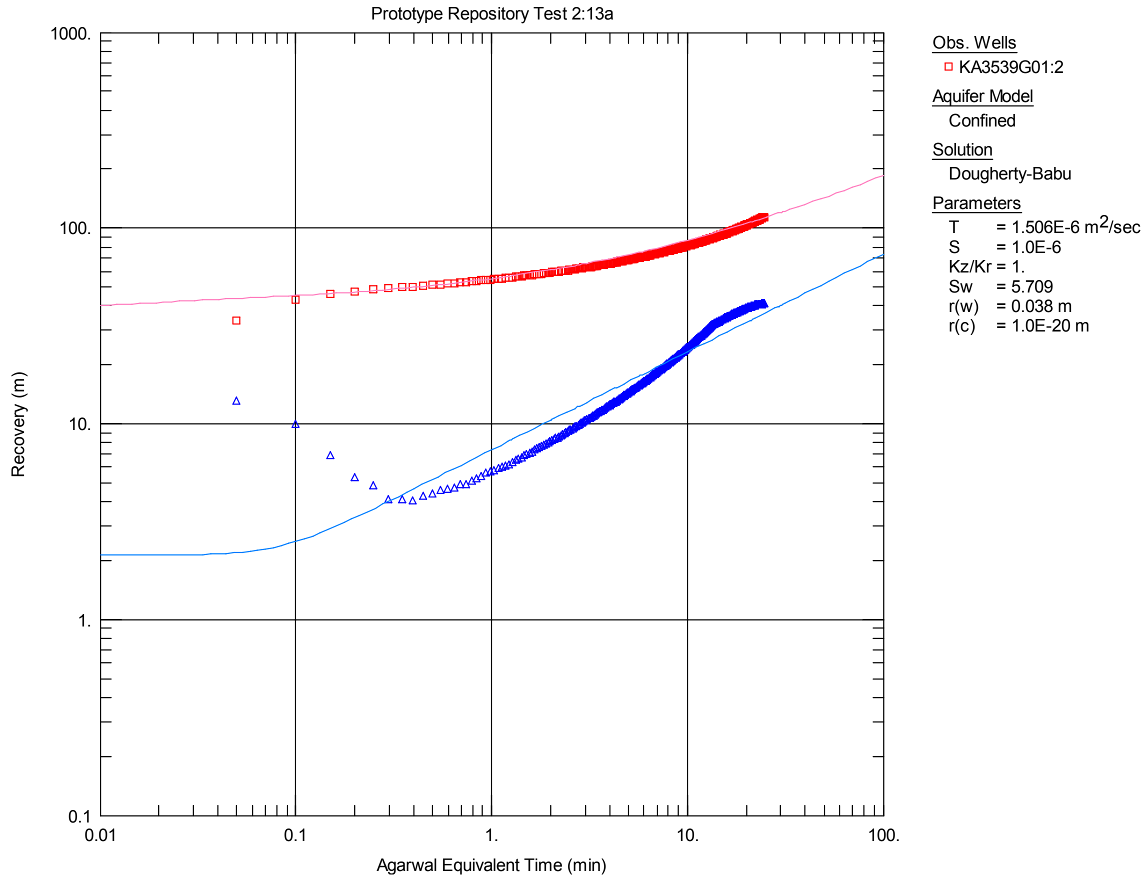
- Uncertain evaluation.

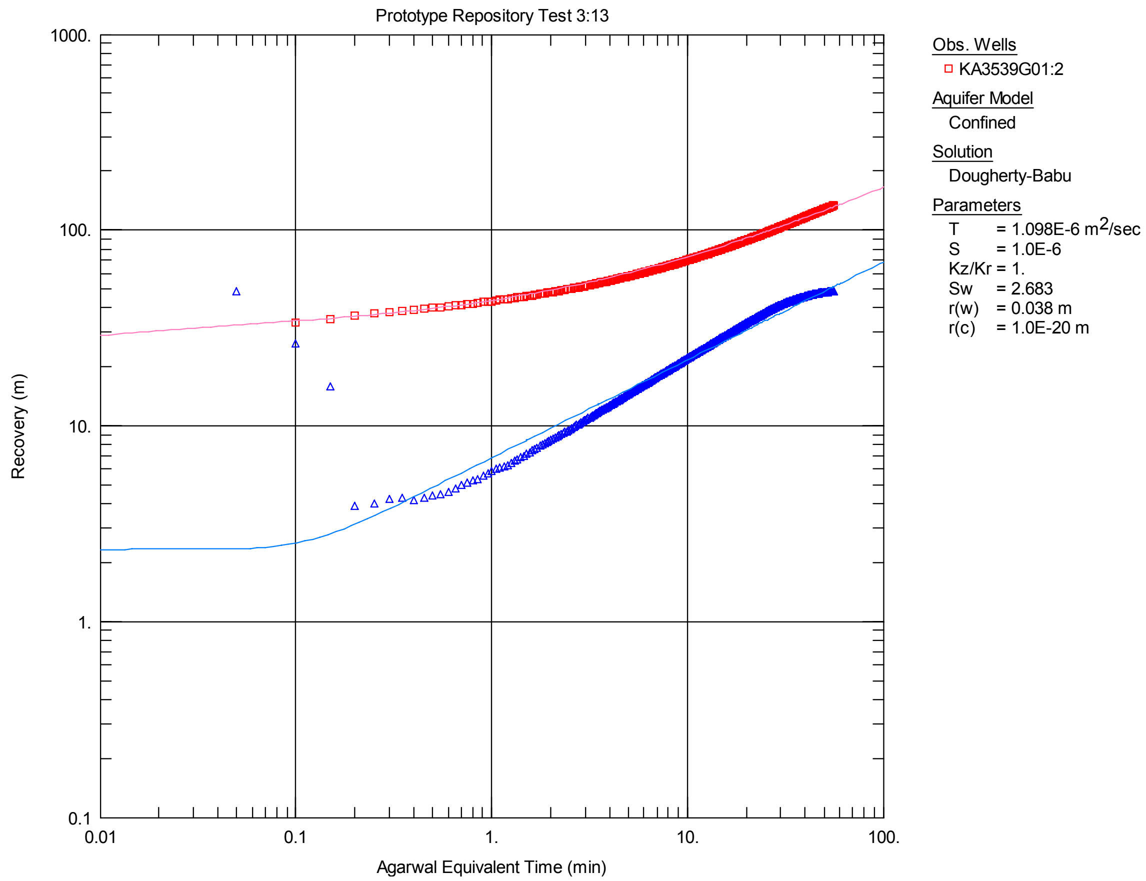
Appendix 12 – KA3574G01:3

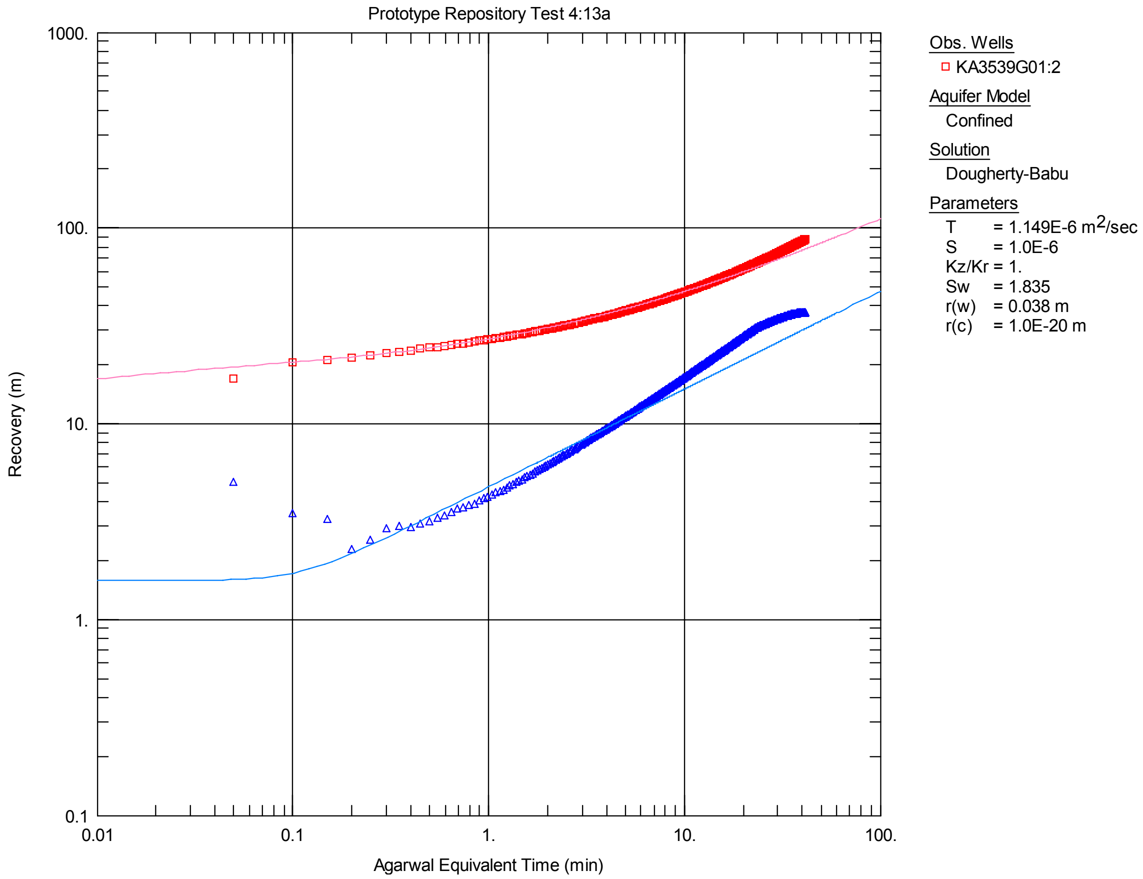
No tests were possible to evaluate

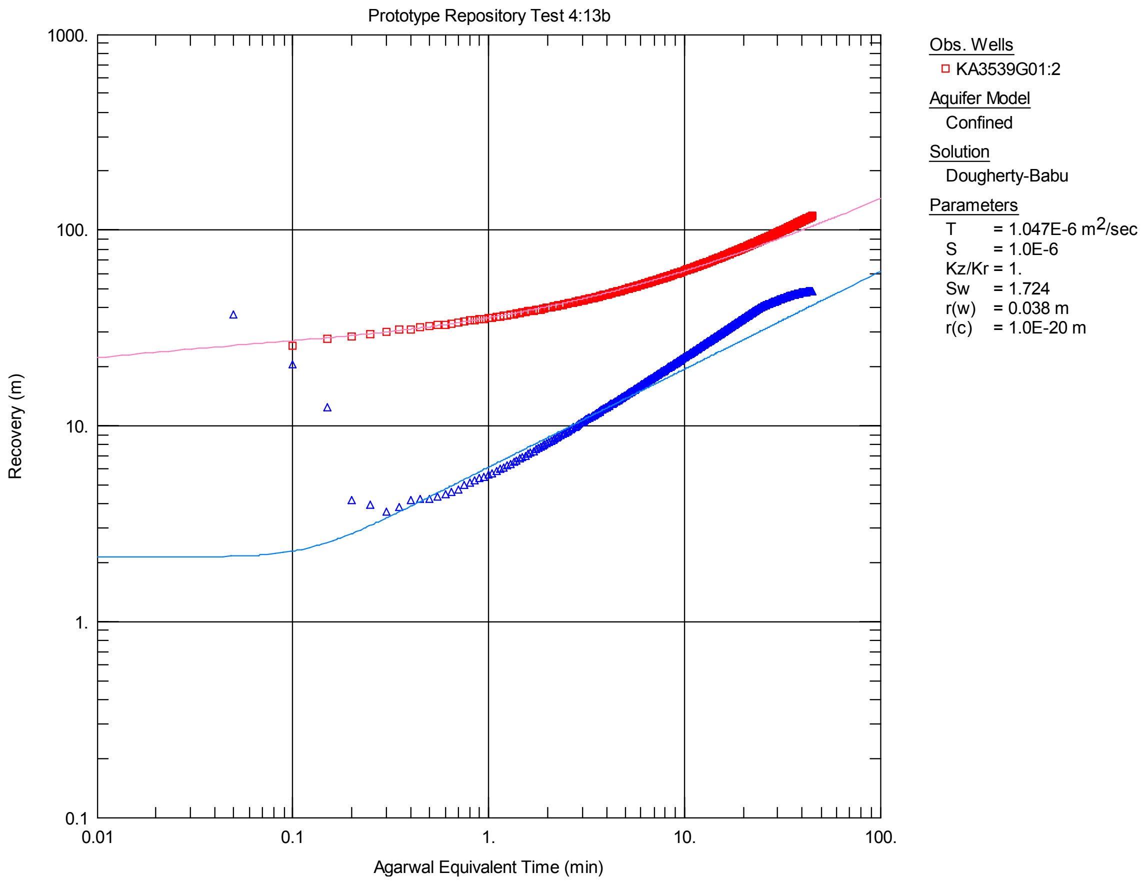
Appendix 13 – KA3539G:2

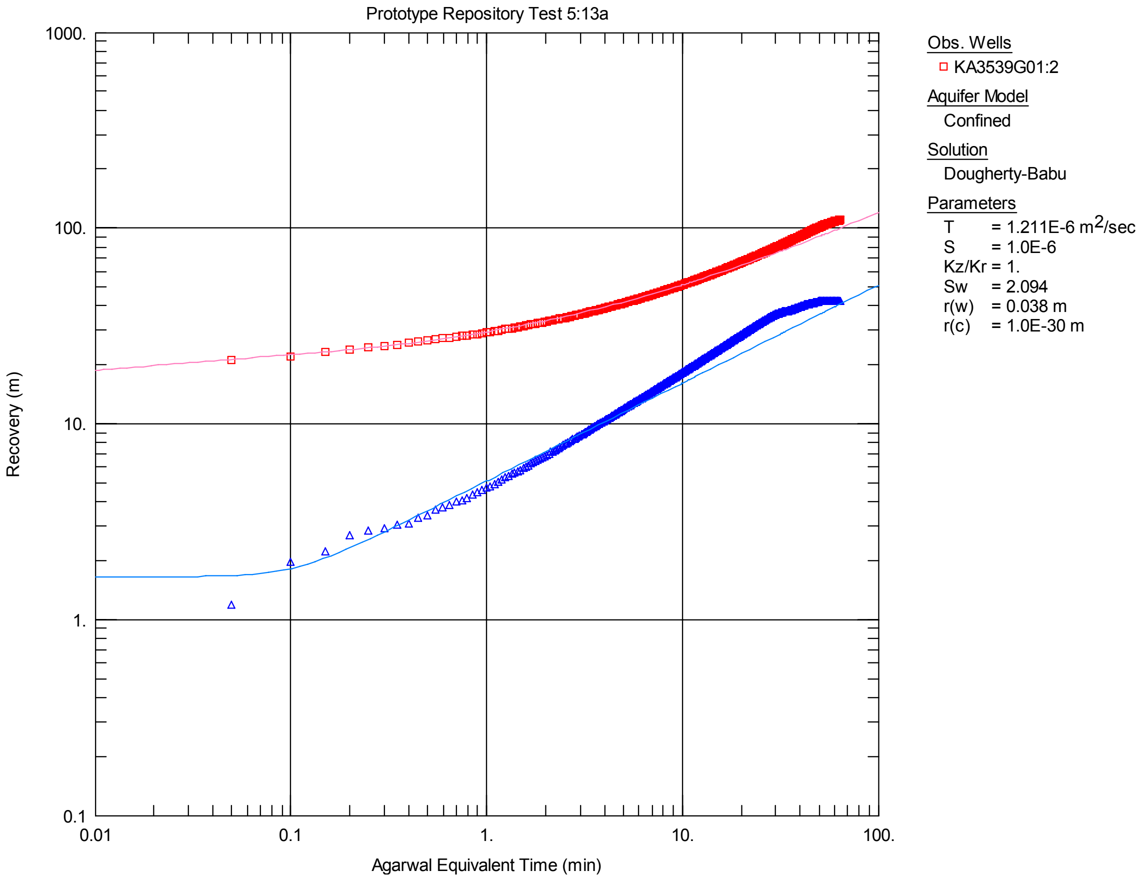



Prototype Repository Test 2:13a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.506E-6 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 5.709
r(w) = 0.038 m
r(c) = 1.0E-20 m

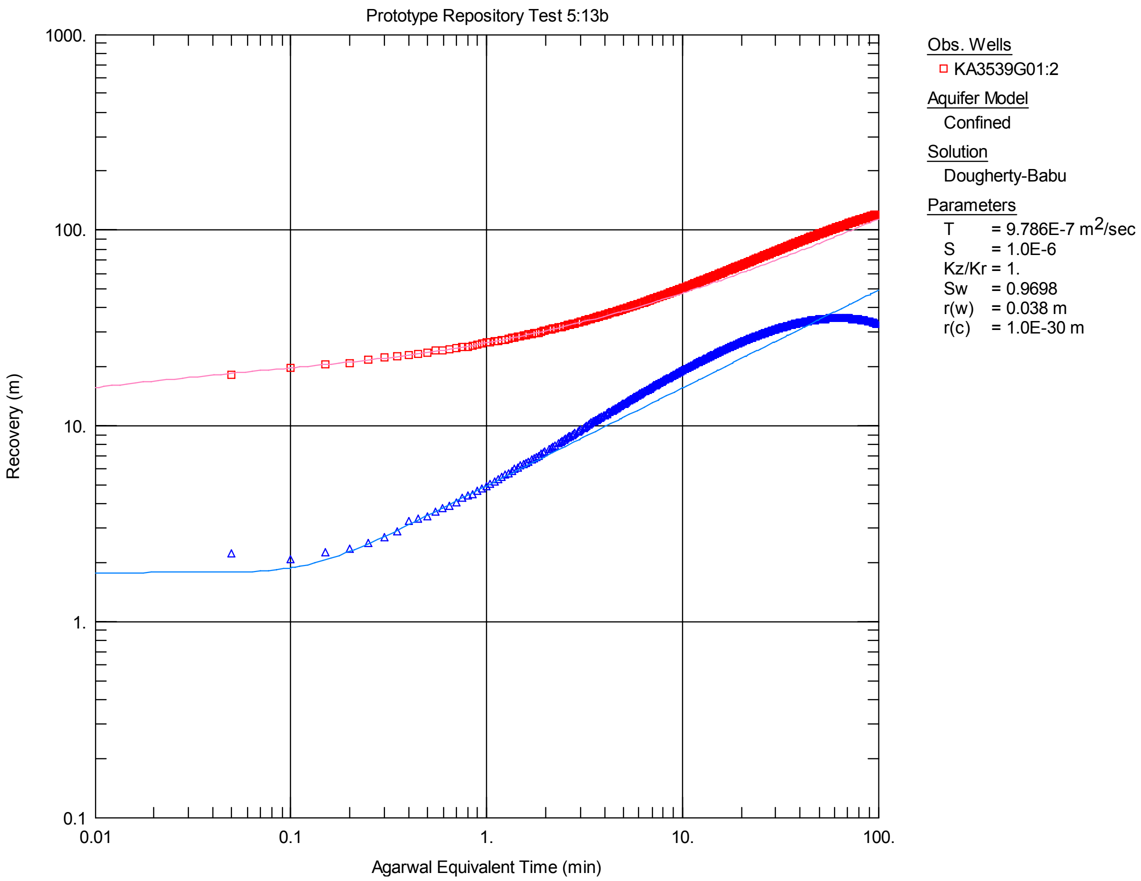

Prototype Repository Test 3:13
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.098E-6 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 2.683
r(w) = 0.038 m
r(c) = 1.0E-20 m


Prototype Repository Test 4:13a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Recovery (m)
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.149E-6 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 1.835
r(w) = 0.038 m
r(c) = 1.0E-20 m

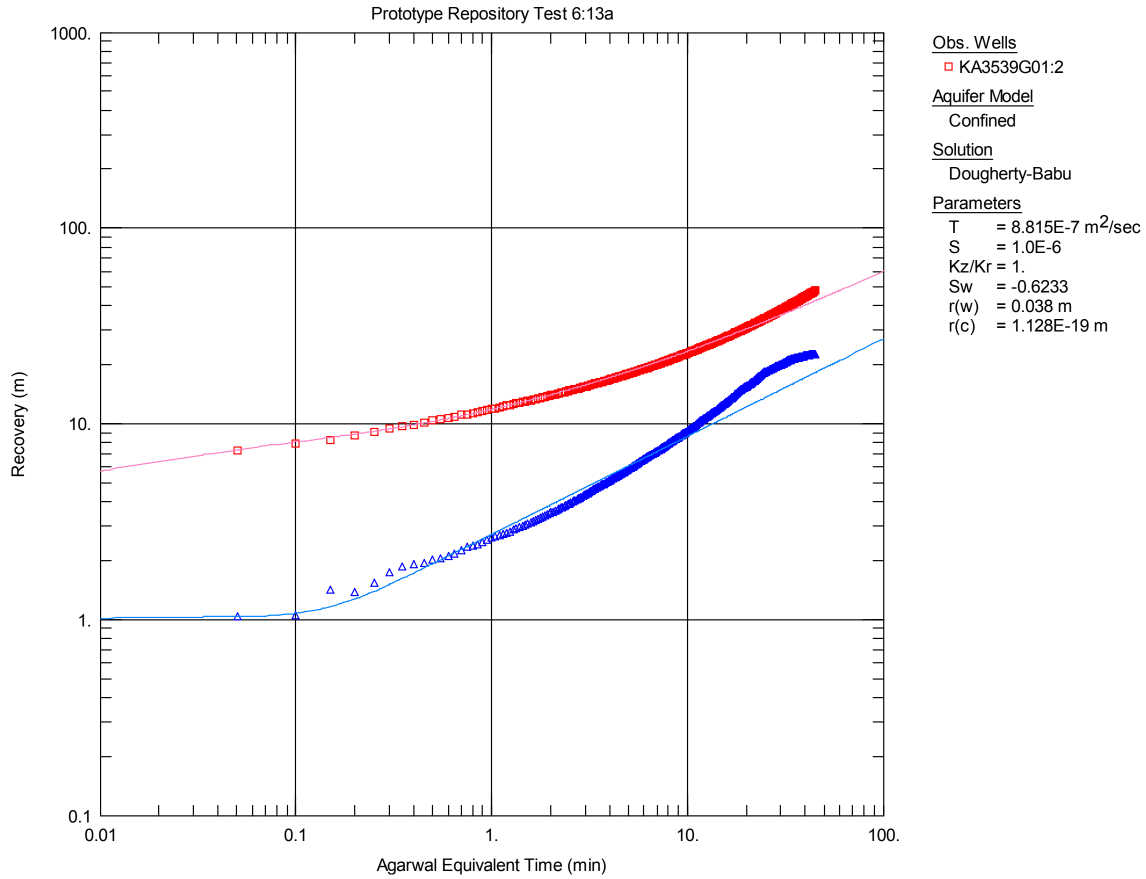

Prototype Repository Test 4:13b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Agarwal Equivalent Time (min)
Recovery (m)
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.047E-6 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 1.724
r(w) = 0.038 m
r(c) = 1.0E-20 m

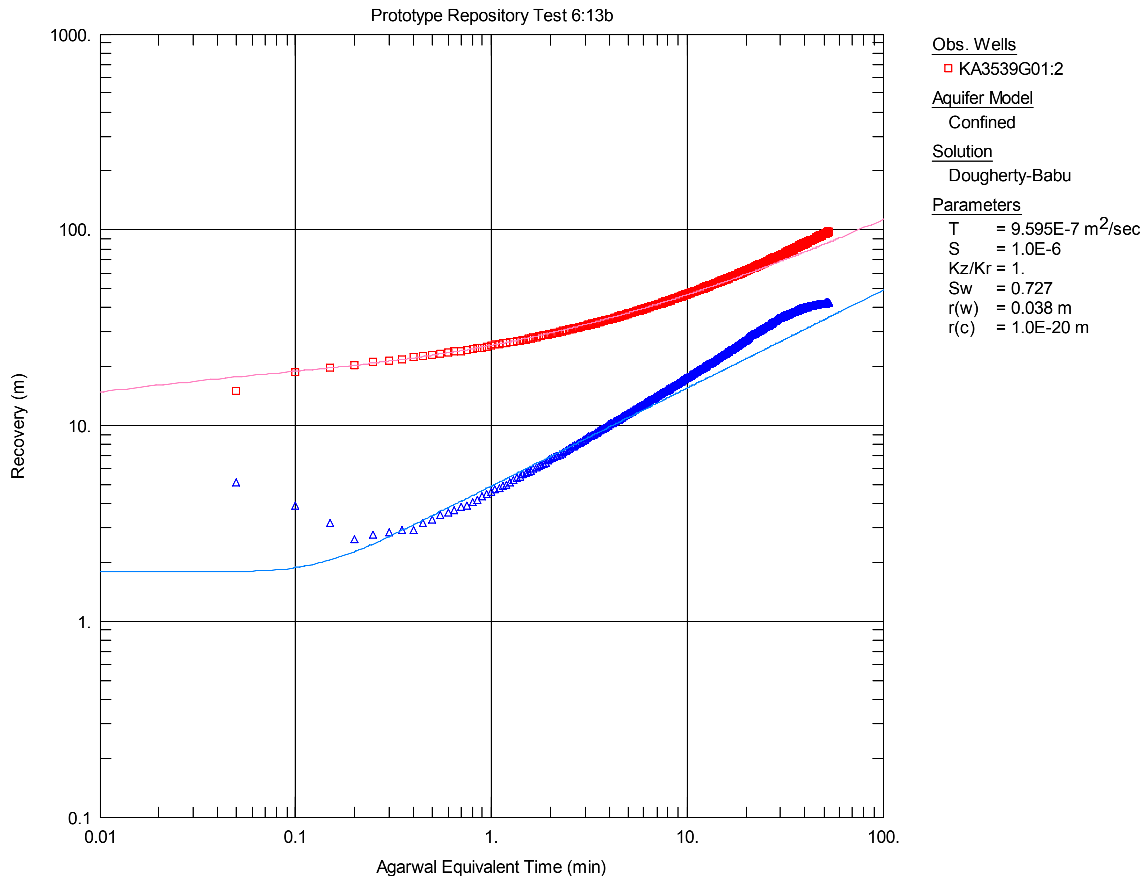


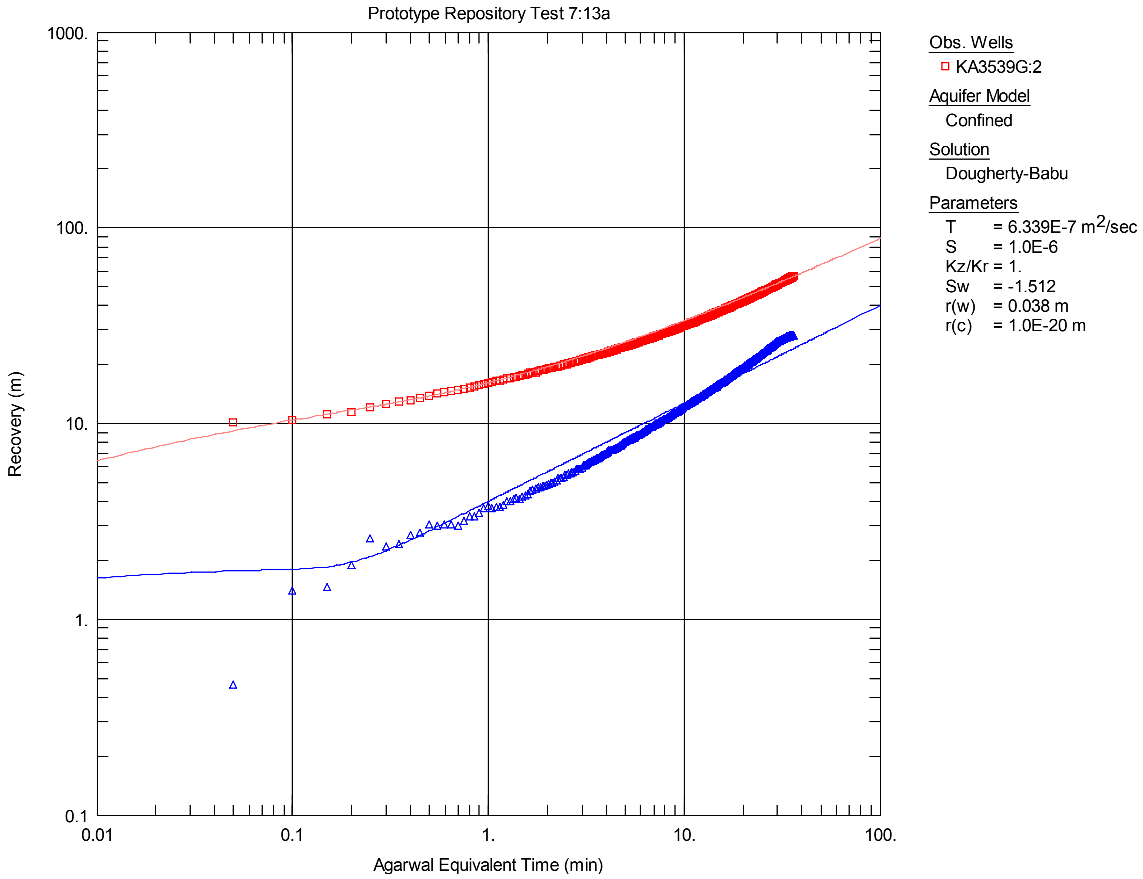
Prototype Repository Test 5:13a
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.211E-6 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 2.094
r(w) = 0.038 m
r(c) = 1.0E-30 m



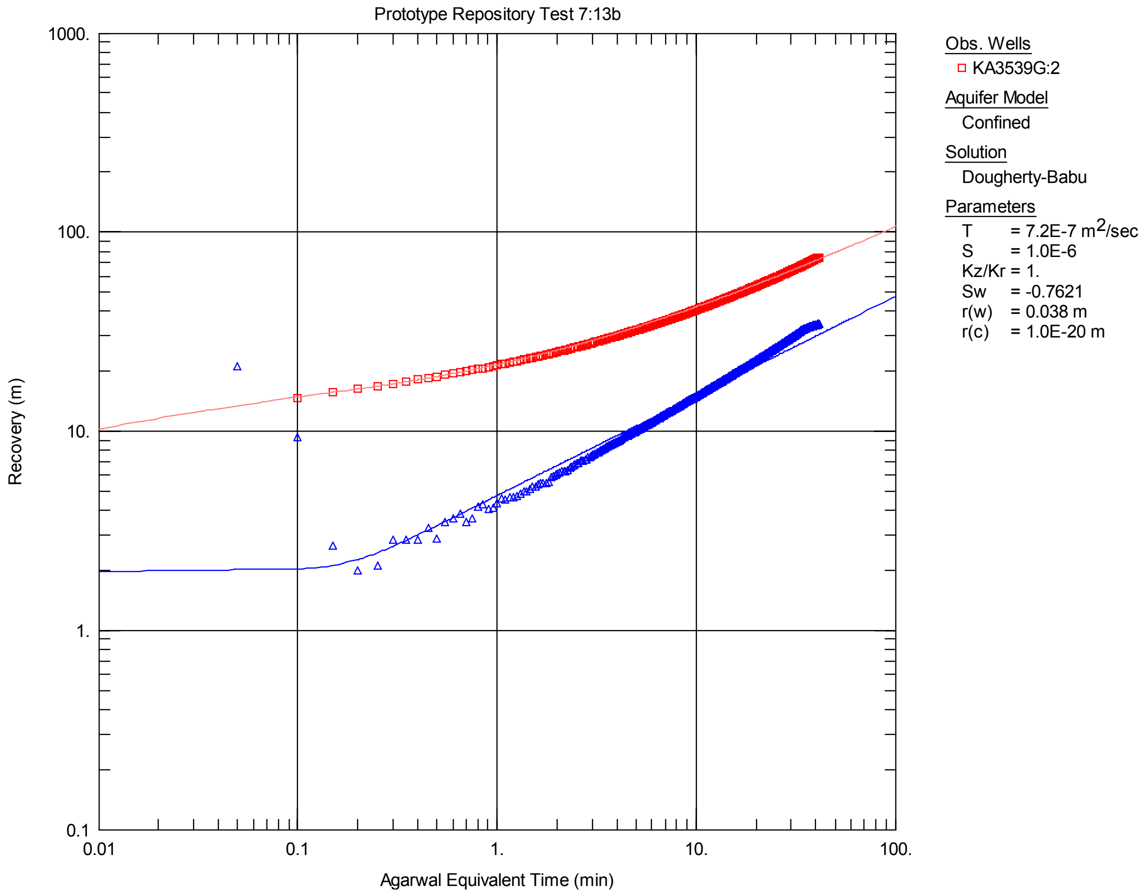
Prototype Repository Test 5:13b
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.786E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.9698
r(w) = 0.038 m
r(c) = 1.0E-30 m


Prototype Repository Test 6:13a
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 8.815E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.6233
r(w) = 0.038 m
r(c) = 1.128E-19 m


Prototype Repository Test 6:13b
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Obs. Wells
KA3539G01:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 9.595E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 0.727
r(w) = 0.038 m
r(c) = 1.0E-20 m

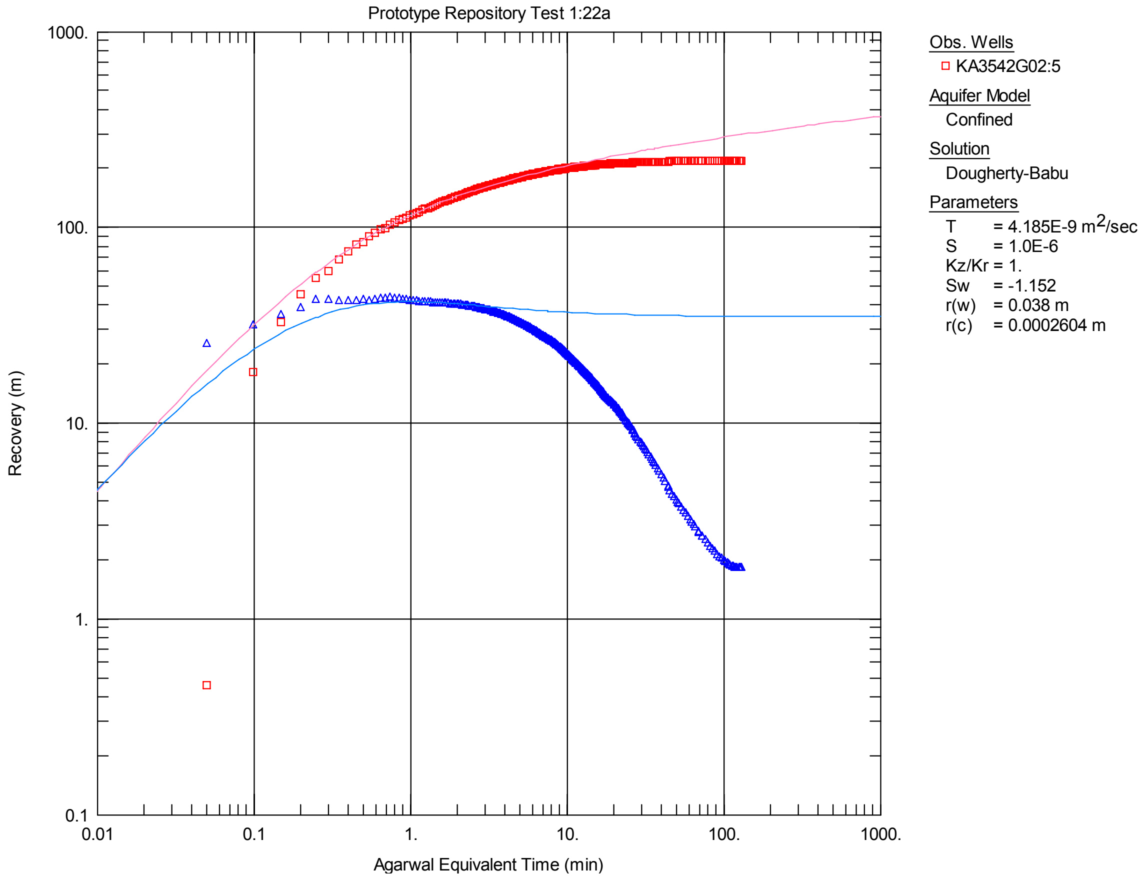


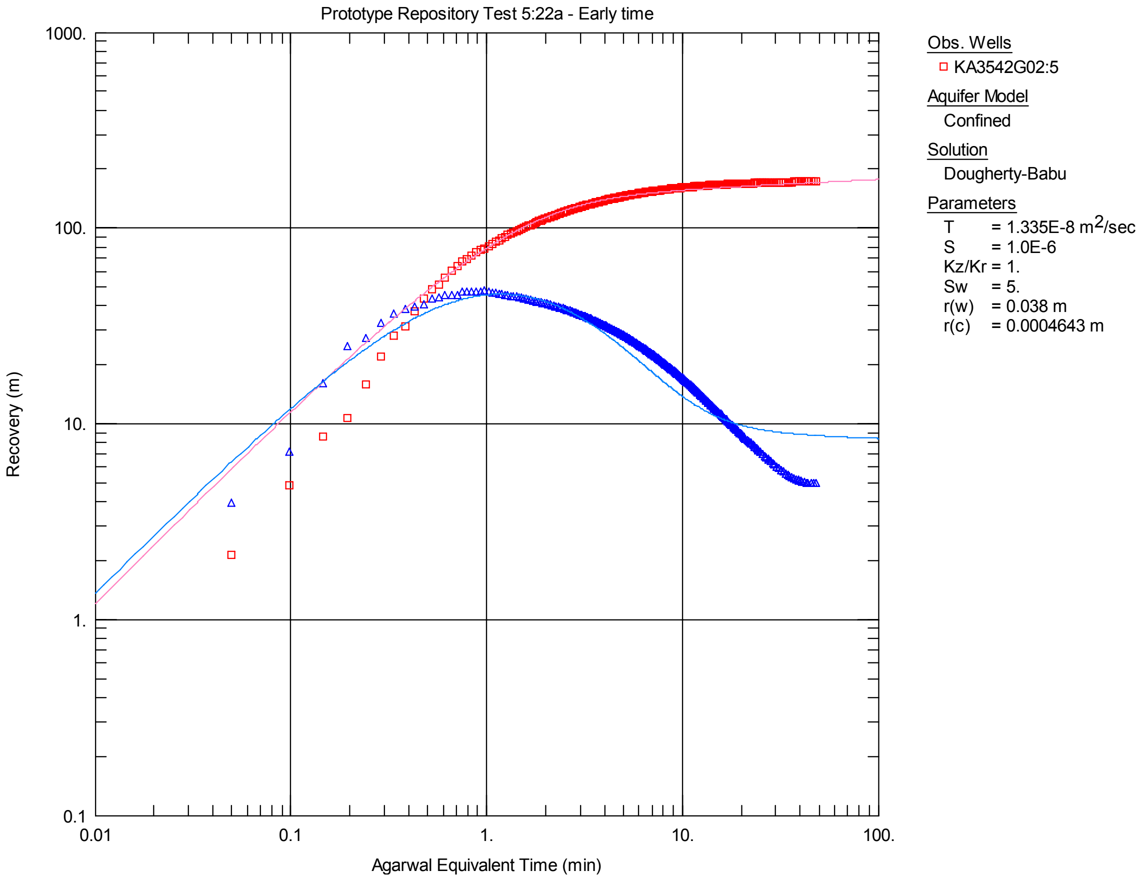
Prototype Repository Test 7:13a
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3539G:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 6.339E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -1.512
r(w) = 0.038 m
r(c) = 1.0E-20 m



Prototype Repository Test 7:13b
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3539G:2
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 7.2E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -0.7621
r(w) = 0.038 m
r(c) = 1.0E-20 m

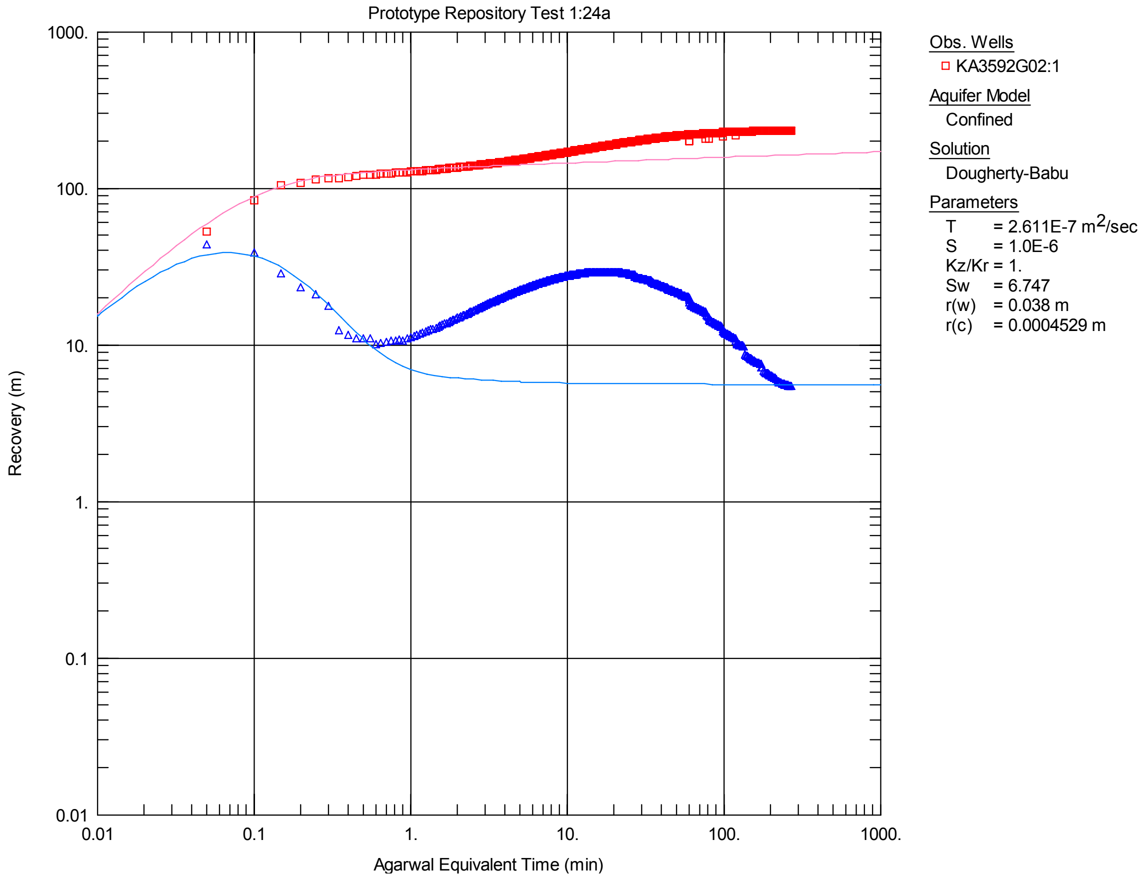
Appendix 14 – KA3542G02:5

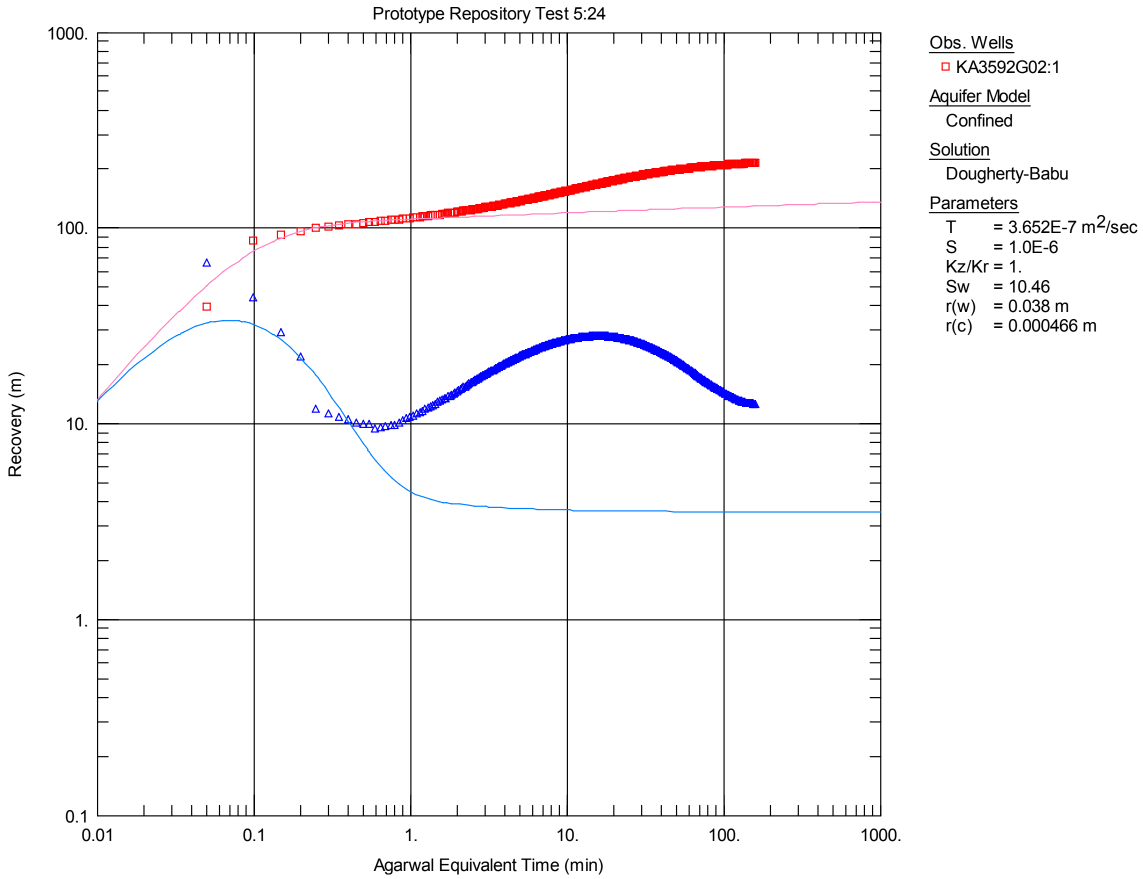




Prototype Repository Test 5:22a - Early time
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3542G02:5
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.335E-8 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 5.
r(w) = 0.038 m
r(c) = 0.0004643 m

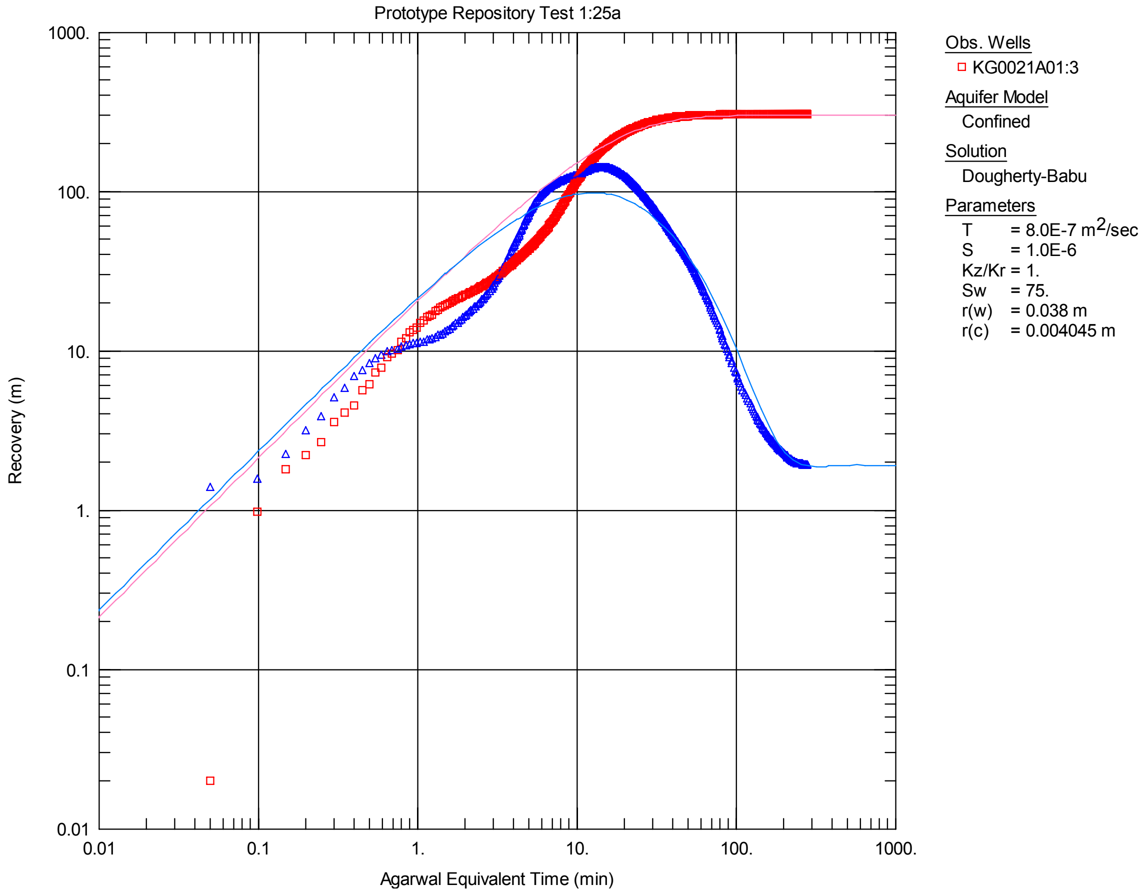
Appendix 15 – KA3590G02:1

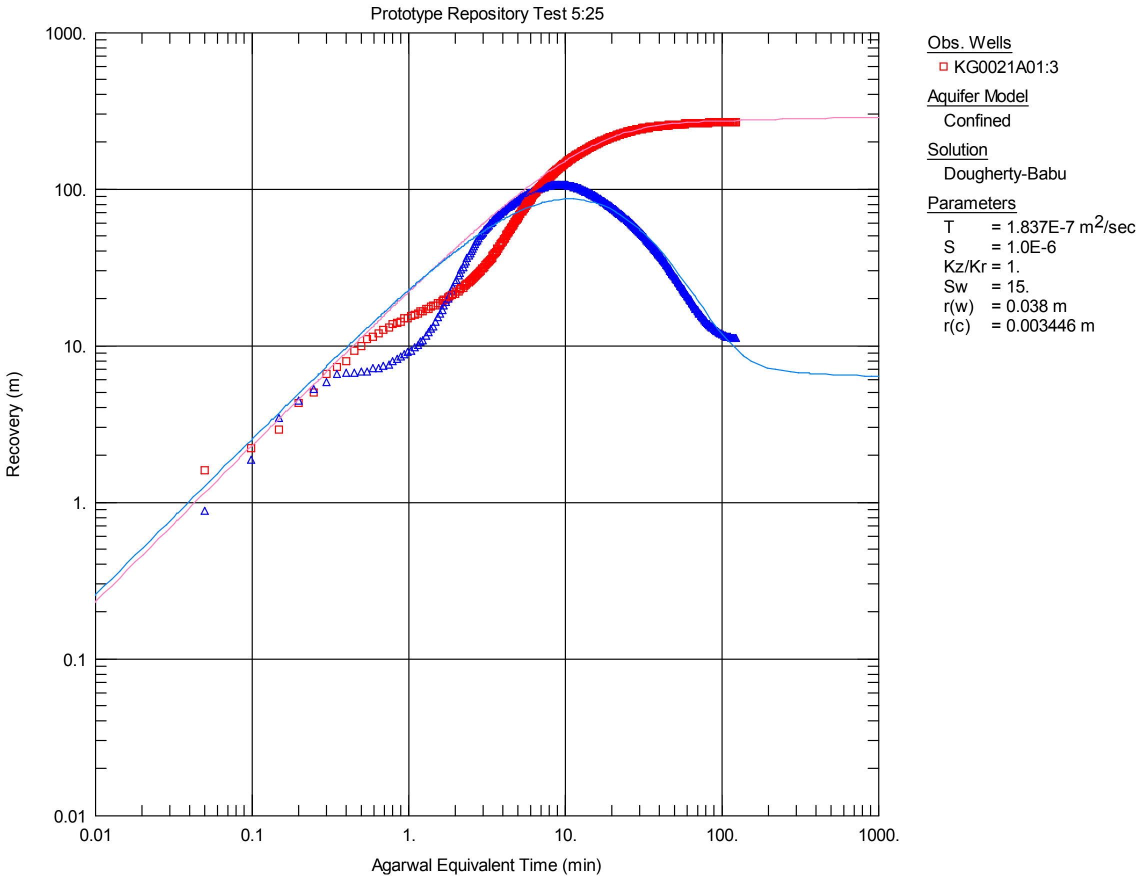




Prototype Repository Test 5:24
1000.
100.
10.
1.
0.1
0.01
0.1
1.
10.
100.
1000.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3592G02:1
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 3.652E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 10.46
r(w) = 0.038 m
r(c) = 0.000466 m

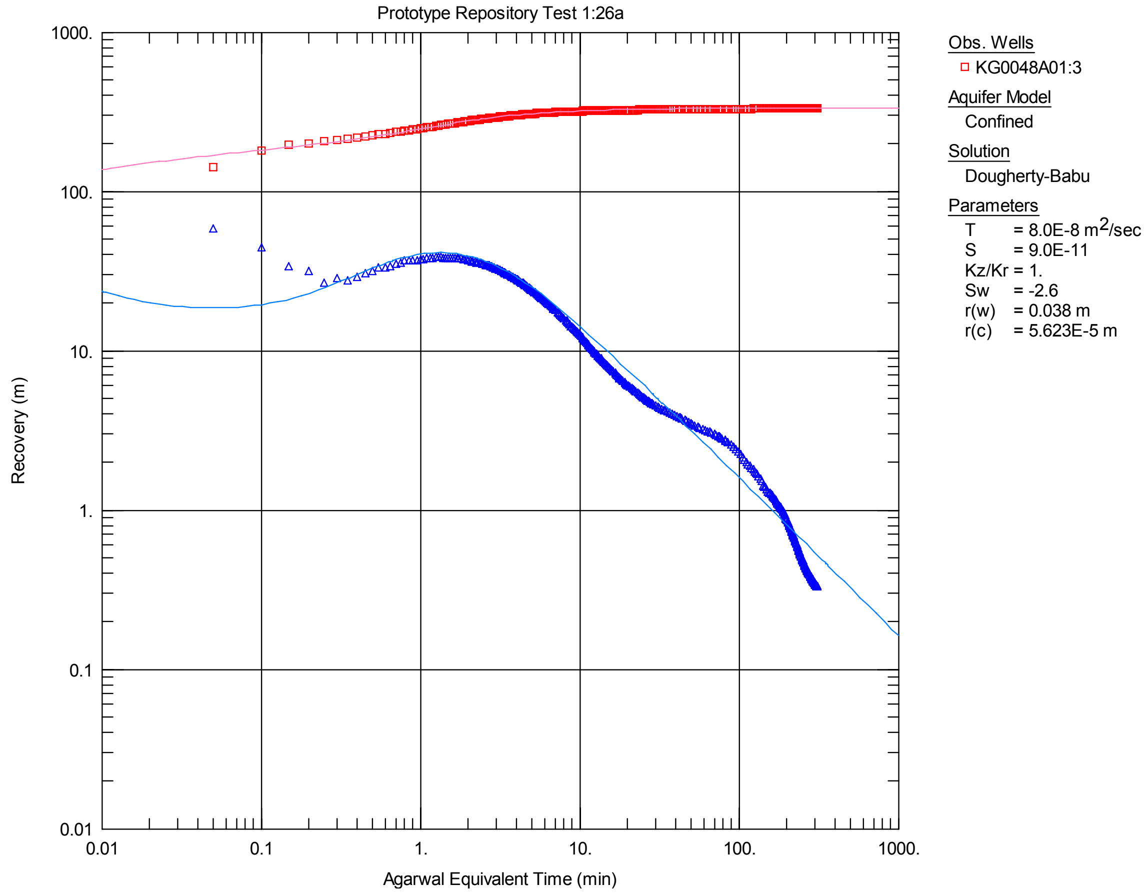
Appendix 16 – KG0021A01:3

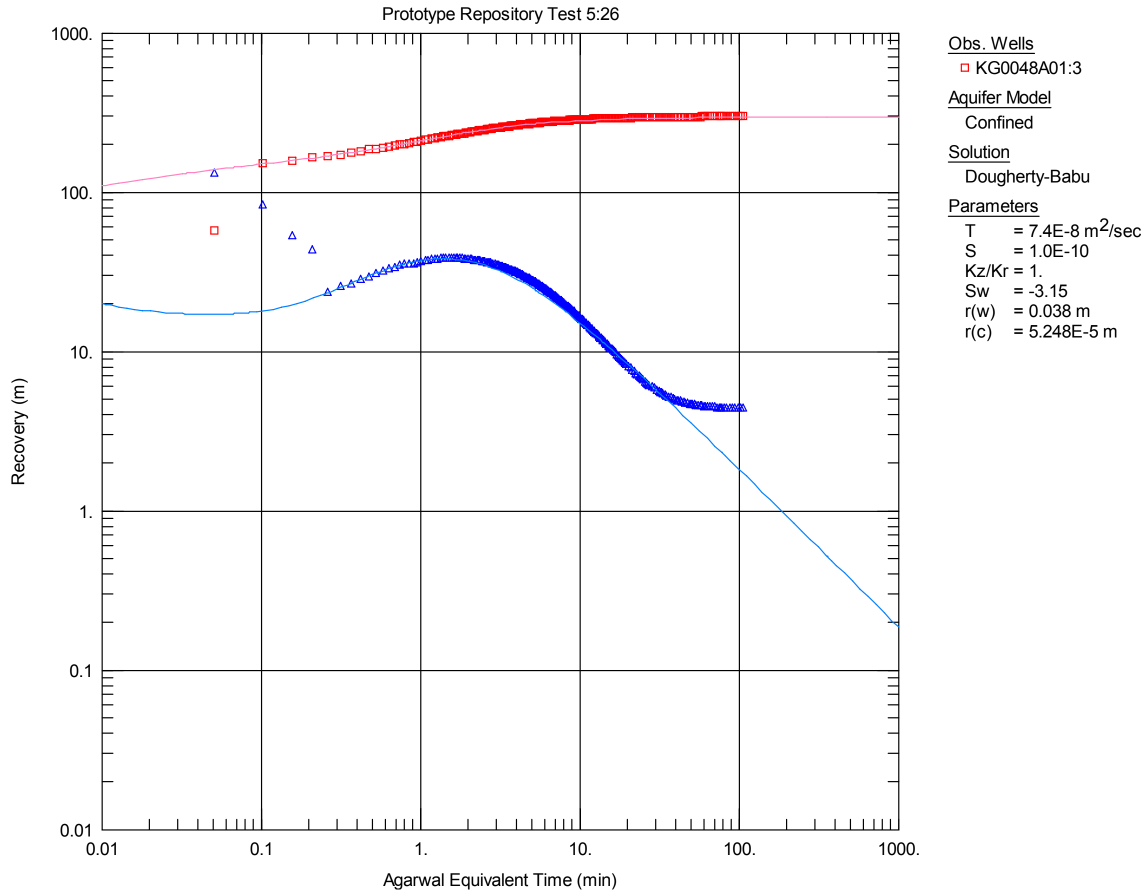




Prototype Repository Test 5:25
Recovery (m)
Agarwal Equivalent Time (min)
1000.
100.
10.
1.
0.1
0.01
0.01
0.1
1.
10.
100.
1000.
Obs. Wells
KG0021A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 1.837E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = 15.
r(w) = 0.038 m
r(c) = 0.003446 m

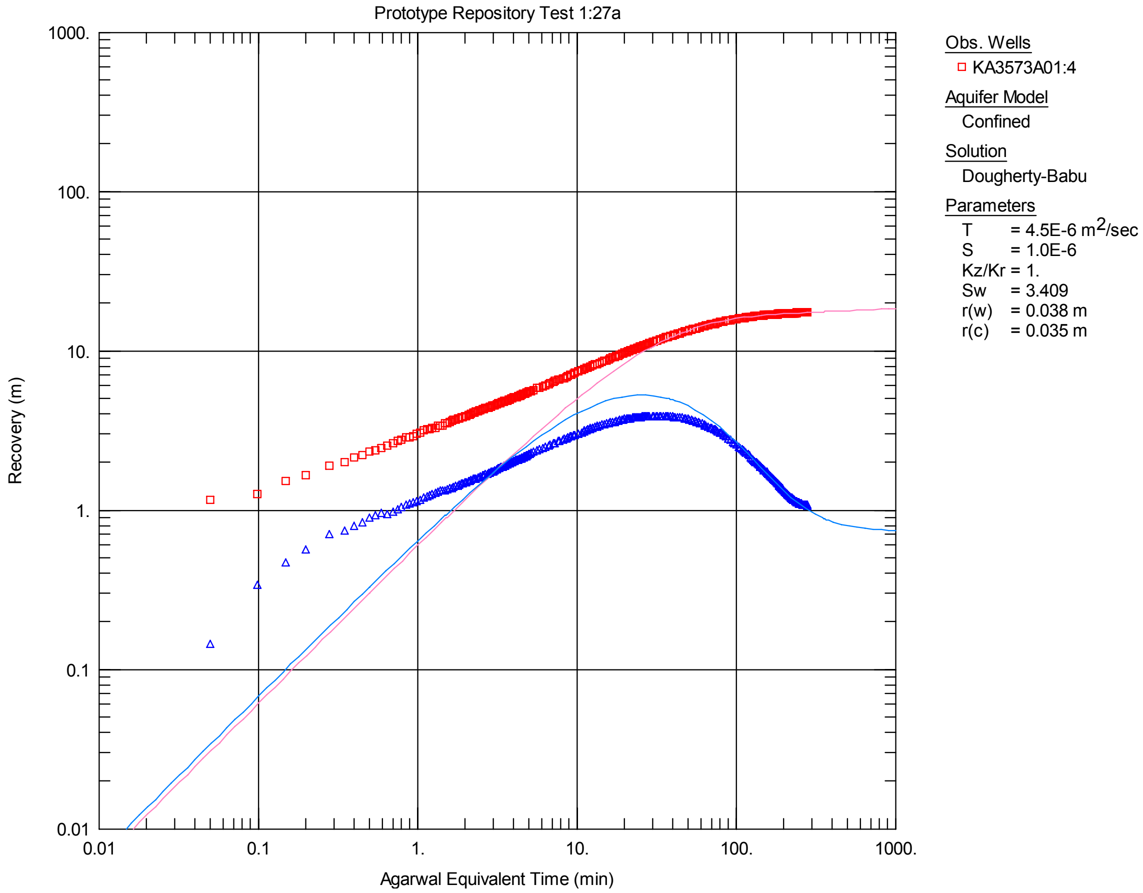
Appendix 17 – KG0048A01:3

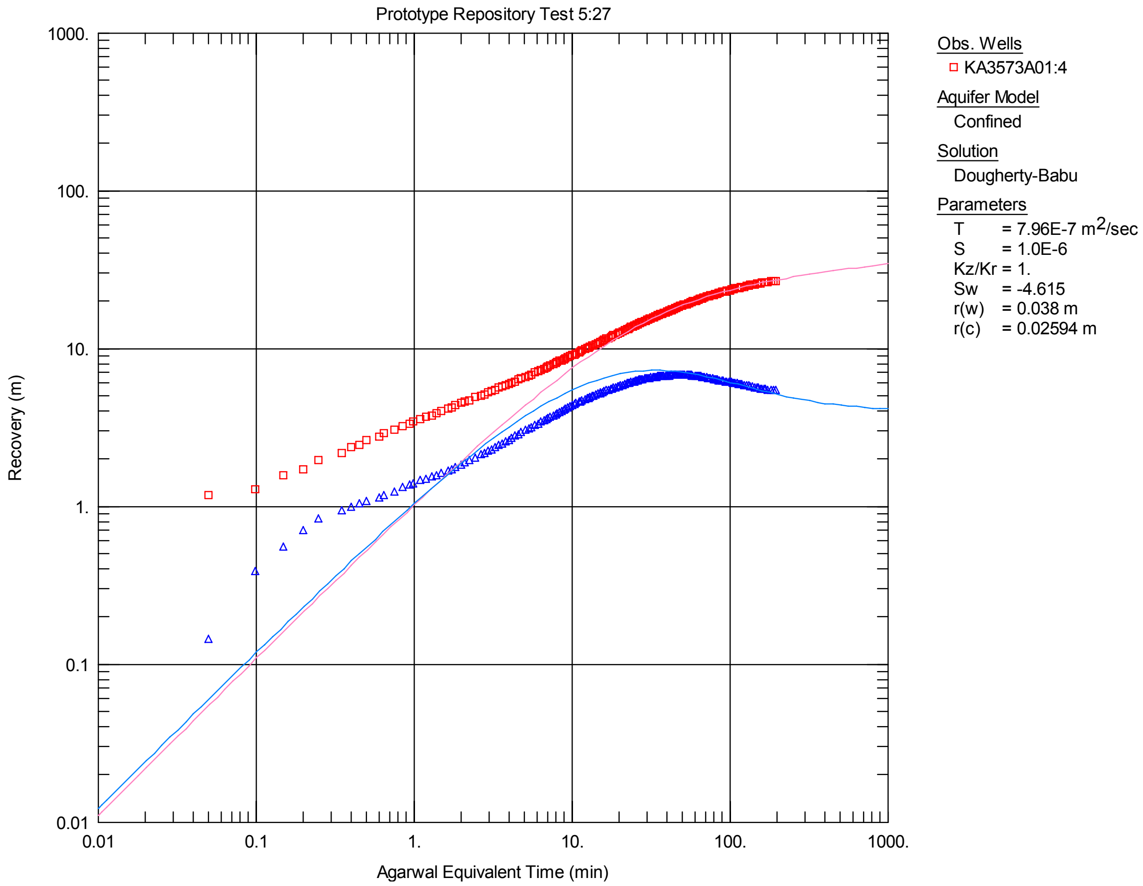




Prototype Repository Test 5:26
1000.
100.
10.
1.
0.1
0.01
Recovery (m)
0.01
0.1
1.
10.
100.
1000.
Agarwal Equivalent Time (min)
Obs. Wells
KG0048A01:3
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 7.4E-8 m2/sec
S = 1.0E-10
Kz/Kr = 1.
Sw = -3.15
r(w) = 0.038 m
r(c) = 5.248E-5 m

Appendix 18 – KA3573A:4




Prototype Repository Test 5:27
1000.
100.
10.
1.
0.1
0.01
0.01
0.1
1.
10.
100.
1000.
Recovery (m)
Agarwal Equivalent Time (min)
Obs. Wells
KA3573A01:4
Aquifer Model
Confined
Solution
Dougherty-Babu
Parameters
T = 7.96E-7 m2/sec
S = 1.0E-6
Kz/Kr = 1.
Sw = -4.615
r(w) = 0.038 m
r(c) = 0.02594 m

Appendix 19 – Comparison of results

The transmissivity is displayed in the tables A19-1 and A19-2, where T TRAN is the transmissivity evaluated using Jacob´s semi-logarithmic approximation while T AQTS is the transmissivity evaluated using the Dougherty-Babu solution in the software AQTESOLV.

Table A19-1. Transmissivity results from the test campaigns 1 - 4. (1) Indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	dp_p (m)	TC 1 T TRAN (m^2/s)	TC 1 T AQTS (m^2/s)	TC 2 T TRAN (m^2/s)	TC 2 T AQTS (m^2/s)	TC 3 T TRAN (m^2/s)	TC 3 T AQTS (m^2/s)	TC 4 T TRAN (m^2/s)	TC 4 T AQTS (m^2/s)
KA3552G01:2	max	-	$4.2 \cdot 10^{-9}$	$6.5 \cdot 10^{-10}$	$1.3 \cdot 10^{-9}$	$5.3 \cdot 10^{-10}$	$9.5 \cdot 10^{-10}$	$2.2 \cdot 10^{-9}$	$8.1 \cdot 10^{-10}$
KA3554G01:2	~100	(2)	(2)	(2)	(2)	(2)	(2)	$4.9 \cdot 10^{-7}$	$5.7 \cdot 10^{-7}$
KA3554G01:2	~200	(2)	(2)	(2)	(2)	(2)	(2)	$4.7 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$
KA3554G01:2	max	$6.4 \cdot 10^{-7}$	$6.4 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$6.4 \cdot 10^{-7}$	$5.1 \cdot 10^{-7}$	$5.8 \cdot 10^{-7}$	$4.7 \cdot 10^{-7}$	$4.9 \cdot 10^{-7}$
KA3554G02:4	~100	(2)	(2)	(2)	(2)	(2)	(2)	-	$7.0 \cdot 10^{-9}$
KA3554G02:4	max	$1.1 \cdot 10^{-8}$	$2.1 \cdot 10^{-8}$	$2.5 \cdot 10^{-8}$	$2.0 \cdot 10^{-8}$	-	$1.9 \cdot 10^{-8}$	-	$1.2 \cdot 10^{-8}$
KA3548A01:3	~100	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
KA3548A01:3	~200	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
KA3548A01:3	max	$8.1 \cdot 10^{-8}$	$1.1 \cdot 10^{-7}$	$9.8 \cdot 10^{-8}$	$1.3 \cdot 10^{-7}$	$8.9 \cdot 10^{-8}$	$1.1 \cdot 10^{-7}$	$8.2 \cdot 10^{-8}$	$1.1 \cdot 10^{-7}$
KA3542G01:3	~100	(2)	(2)	(2)	(2)	(2)	(2)	$6.9 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$
KA3542G01:3	~200	(2)	(2)	(2)	(2)	(2)	(2)	$6.6 \cdot 10^{-8}$	$4.8 \cdot 10^{-8}$
KA3542G01:3	max	$9.5 \cdot 10^{-8}$	$4.5 \cdot 10^{-8}$	$9.7 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$8.3 \cdot 10^{-8}$	$5.5 \cdot 10^{-8}$	$6.4 \cdot 10^{-8}$	$3.1 \cdot 10^{-8}$
KA3544G01:2	(1)	-	$1.1 \cdot 10^{-8}$	-	$7.4 \cdot 10^{-9}$	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
KA3542G02:2	max	$2.2 \cdot 10^{-10}$	$3.6 \cdot 10^{-10}$	$1.9 \cdot 10^{-10}$	$2.7 \cdot 10^{-10}$	$5.4 \cdot 10^{-10}$	$9.3 \cdot 10^{-10}$	$5.3 \cdot 10^{-10}$	$8.7 \cdot 10^{-10}$
KA3563G:4	max	-	$1.7 \cdot 10^{-7}$	(2)	(2)	(2)	(2)	(2)	(2)
KA3546G01:2	max	$7.8 \cdot 10^{-11}$	$6.8 \cdot 10^{-10}$	-	$1.4 \cdot 10^{-9}$	-	$1.2 \cdot 10^{-9}$	-	$1.1 \cdot 10^{-9}$
KA3566G01:2	max	-	*$1.3 \cdot 10^{-10}$*	(2)	(2)	(2)	(2)	(2)	(2)
KA3572G01:2	max	-	*$3.5 \cdot 10^{-9}$*	(2)	(2)	(2)	(2)	(2)	(2)
KA3574G01:3	max	-	-	(2)	(2)	(2)	(2)	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	(2)	(2)	(2)	$5.5 \cdot 10^{-7}$	$1.1 \cdot 10^{-6}$
KA3539G:2	max	$7.0 \cdot 10^{-7}$	$1.3 \cdot 10^{-6}$	$8.6 \cdot 10^{-7}$	$1.5 \cdot 10^{-6}$	$6.2 \cdot 10^{-7}$	$1.1 \cdot 10^{-6}$	$5.4 \cdot 10^{-7}$	$1.0 \cdot 10^{-6}$
KA3542G02:5	max	$3.2 \cdot 10^{-9}$	$4.2 \cdot 10^{-9}$	(2)	(2)	(2)	(2)	(2)	(2)
KA3590G02:1	max	$1.3 \cdot 10^{-7}$	$3.4 \cdot 10^{-7}$	(2)	(2)	(2)	(2)	(2)	(2)
KG0021A01:3	max	$1.2 \cdot 10^{-7}$	$8.0 \cdot 10^{-7}$	(2)	(2)	(2)	(2)	(2)	(2)
KG0048A01:3	max	$3.8 \cdot 10^{-8}$	$8.0 \cdot 10^{-8}$	(2)	(2)	(2)	(2)	(2)	(2)
KA3573A:4	max	$4.9 \cdot 10^{-6}$	$4.5 \cdot 10^{-6}$	(2)	(2)	(2)	(2)	(2)	(2)

Table A19-2. Transmissivity results from the test campaigns 5 - 7. (1) Indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	dp_p (m)	TC 5 T TRAN (m^2/s)	TC 5 T AQTS (m^2/s)	TC 6 T TRAN (m^2/s)	TC 6 T AQTS (m^2/s)	TC 7 T TRAN (m^2/s)	TC 7 T AQTS (m^2/s)
KA3552G01:2	max	$6.7 \cdot 10^{-10}$	$7.4 \cdot 10^{-10}$	$4.6 \cdot 10^{-10}$	$4.5 \cdot 10^{-10}$	$4.6 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$
KA3554G01:2	~100	$4.5 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$4.5 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$4.5 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$
KA3554G01:2	~200	$4.5 \cdot 10^{-7}$	$4.9 \cdot 10^{-7}$	$4.3 \cdot 10^{-7}$	$4.8 \cdot 10^{-7}$	$4.0 \cdot 10^{-7}$	$4.6 \cdot 10^{-7}$
KA3554G01:2	max	$4.3 \cdot 10^{-7}$	$4.6 \cdot 10^{-7}$	$4.0 \cdot 10^{-7}$	$4.5 \cdot 10^{-7}$	$3.7 \cdot 10^{-7}$	$4.4 \cdot 10^{-7}$
KA3554G02:4	~100	$2.0 \cdot 10^{-8}$	$9.0 \cdot 10^{-9}$	$1.5 \cdot 10^{-8}$	$1.7 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$
KA3554G02:4	max	$1.3 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$	$1.8 \cdot 10^{-8}$	$1.7 \cdot 10^{-8}$	$1.2 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$
KA3548A01:3	~100	$9.0 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$9.0 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	$8.0 \cdot 10^{-8}$
KA3548A01:3	~200	$9.9 \cdot 10^{-8}$	$1.2 \cdot 10^{-7}$	$9.2 \cdot 10^{-8}$	$1.2 \cdot 10^{-7}$	$9.5 \cdot 10^{-8}$	$8.3 \cdot 10^{-8}$
KA3548A01:3	max	$8.4 \cdot 10^{-8}$	$1.1 \cdot 10^{-7}$	$9.6 \cdot 10^{-8}$	$9.1 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	$8.6 \cdot 10^{-8}$
KA3542G01:3	~100	$4.9 \cdot 10^{-8}$	$5.8 \cdot 10^{-8}$	$5.0 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$	$3.4 \cdot 10^{-8}$	$4.7 \cdot 10^{-8}$
KA3542G01:3	~200	$6.0 \cdot 10^{-8}$	$4.2 \cdot 10^{-8}$	$5.0 \cdot 10^{-8}$	$6.5 \cdot 10^{-8}$	$3.3 \cdot 10^{-8}$	$4.0 \cdot 10^{-8}$
KA3542G01:3	max	$6.5 \cdot 10^{-8}$	$3.5 \cdot 10^{-8}$	$5.8 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	$3.8 \cdot 10^{-8}$
KA3544G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	$4.6 \cdot 10^{-10}$	$1.0 \cdot 10^{-9}$	$4.9 \cdot 10^{-10}$	$9.6 \cdot 10^{-10}$	$4.2 \cdot 10^{-10}$	$9.0 \cdot 10^{-10}$
KA3542G02:2	max	$4.8 \cdot 10^{-10}$	$8.6 \cdot 10^{-10}$	$5.0 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$5.1 \cdot 10^{-10}$	$4.6 \cdot 10^{-10}$
KA3563G:4	max	$3.3 \cdot 10^{-8}$	$5.1 \cdot 10^{-8}$	(2)	(2)	(2)	(2)
KA3546G01:2	max	-	$1.3 \cdot 10^{-9}$	-	$1.4 \cdot 10^{-9}$	-	$9.6 \cdot 10^{-10}$
KA3566G01:2	max	$6.4 \cdot 10^{-11}$	*$3.3 \cdot 10^{-10}$*	(2)	(2)	(2)	(2)
KA3572G01:2	max	-	-	(2)	(2)	(2)	(2)
KA3574G01:3	max	-	-	(2)	(2)	(2)	(2)
KA3539G:2	~100	$5.9 \cdot 10^{-7}$	$1.2 \cdot 10^{-6}$	$5.5 \cdot 10^{-7}$	$8.8 \cdot 10^{-7}$	$4.7 \cdot 10^{-7}$	$6.3 \cdot 10^{-7}$
KA3539G:2	max	$6.6 \cdot 10^{-7}$	$9.8 \cdot 10^{-7}$	$6.6 \cdot 10^{-7}$	$9.6 \cdot 10^{-7}$	$5.5 \cdot 10^{-7}$	$7.2 \cdot 10^{-7}$
KA3542G02:5	max	$2.4 \cdot 10^{-9}$	$1.3 \cdot 10^{-8}$	(2)	(2)	(2)	(2)
KA3590G02:1	max	$1.3 \cdot 10^{-7}$	$2.5 \cdot 10^{-7}$	(2)	(2)	(2)	(2)
KG0021A01:3	max	$1.5 \cdot 10^{-7}$	$5.7 \cdot 10^{-7}$	(2)	(2)	(2)	(2)
KG0048A01:3	max	$4.1 \cdot 10^{-8}$	$7.4 \cdot 10^{-8}$	(2)	(2)	(2)	(2)
KA3573A:4	max	$2.4 \cdot 10^{-6}$	$8.0 \cdot 10^{-7}$	(2)	(2)	(2)	(2)

The skinfactor results is displayed in the tables A19-3 and A19-4, where SKIN TRAN is the skinfactor evaluated using Jacob´s semi-logarithmic approximation while SKIN AQTS is the skinfactor evaluated using the Dougherty-Babu solution utilizing the software AQTESOLV.

Table A19-3. SKIN Results from the test campaigns 1 - 4. (1) Indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

Section	dp_p (m)	TC 1 SKIN TRAN (m^2/s)	TC 1 SKIN AQTS (m^2/s)	TC 2 SKIN TRAN (m^2/s)	TC 2 SKIN AQTS (m^2/s)	TC 3 SKIN TRAN (m^2/s)	TC 3 SKIN AQTS (m^2/s)	TC 4 SKIN TRAN (m^2/s)	TC 4 SKIN AQTS (m^2/s)
KA3552G01:2	max	-	1.1	-1.8	-0.5	-1.7	-0.7	-2.5	-0.9
KA3554G01:2	~100	(2)	(2)	(2)	(2)	(2)	(2)	22	26
KA3554G01:2	~200	(2)	(2)	(2)	(2)	(2)	(2)	26	30
KA3554G01:2	max	43	43	34	42	34	39	30	32
KA3554G02:4	~100	(2)	(2)	(2)	(2)	(2)	(2)	-	30
KA3554G02:4	max	51	100	120	95	-	94	-	58
KA3548A01:3	~100	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
KA3548A01:3	~200	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
KA3548A01:3	max	-2	0.2	-0.3	1.1	-1.7	-1.2	-1.2	-0.1
KA3542G01:3	~100	(2)	(2)	(2)	(2)	(2)	(2)	1.1	-1
KA3542G01:3	~200	(2)	(2)	(2)	(2)	(2)	(2)	2.1	0.3
KA3542G01:3	max	5	0.1	6	-1	4.9	1.5	2.7	-0.9
KA3544G01:2	(1)	-	90	-	100	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
KA3542G02:2	max	-0.3	0.4	-1.3	-0.5	-1.1	0.1	-1.2	0.1
KA3563G:4	max	-	-	(2)	(2)	(2)	(2)	(2)	(2)
KA3546G01:2	max	-2	6	-	10	-	7	-	8
KA3566G01:2	max	-	-	(2)	(2)	(2)	(2)	(2)	(2)
KA3572G01:2	max	-	-	(2)	(2)	(2)	(2)	(2)	(2)
KA3574G01:3	max	-	-	(2)	(2)	(2)	(2)	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	(2)	(2)	(2)	-1.5	1.8
KA3539G:2	max	1.5	3.6	1.6	5.7	-0.2	2.7	-1.2	1.7
KA3542G02:5	max	-1.6	-1.2	(2)	(2)	(2)	(2)	(2)	(2)
KA3590G02:1	max	0.9	9.3	(2)	(2)	(2)	(2)	(2)	(2)
KG0021A01:3	max	-4	75	(2)	(2)	(2)	(2)	(2)	(2)
KG0048A01:3	max	-0.7	-2.6	(2)	(2)	(2)	(2)	(2)	(2)
KA3573A:4	max	-4.5	3.4	(2)	(2)	(2)	(2)	(2)	(2)

Table A19-4. SKIN Results from the test campaigns 5 - 7. (1) Indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign

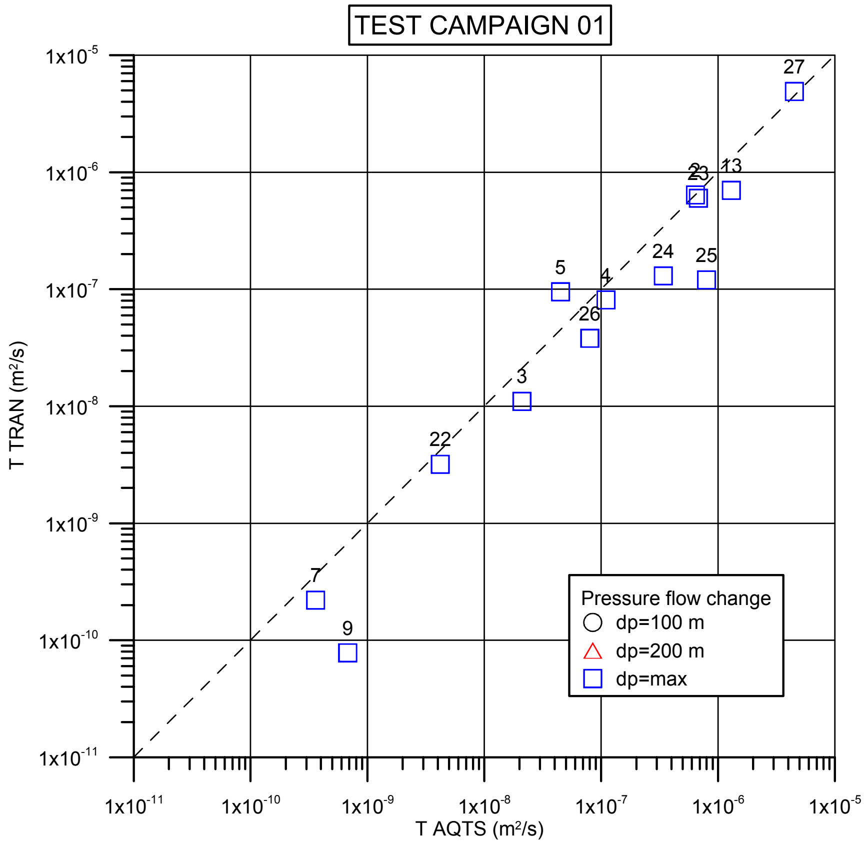
Section	dp_p (m)	TC 5 SKIN TRAN (m^2/s)	TC 5 SKIN AQTS (m^2/s)	TC 6 SKIN TRAN (m^2/s)	TC 6 SKIN AQTS (m^2/s)	TC 7 SKIN TRAN (m^2/s)	TC 7 SKIN AQTS (m^2/s)
KA3552G01:2	max	-1.7	-0.4	-1.6	-1.9	-1.6	-0.2
KA3554G01:2	~100	18	24	20	25	17	20
KA3554G01:2	~200	24	28	23	28	19	22
KA3554G01:2	max	27	30	25	29	22	26
KA3554G02:4	~100	95	38	75	90	47	50
KA3554G02:4	max	61	73	77	68	35	35
KA3548A01:3	~100	-1.7	-1.4	-1.7	-2.1	-2	-2.5
KA3548A01:3	~200	-1.8	-1.1	-1.5	-0.6	-1.5	-1.8
KA3548A01:3	max	-1.4	-0.4	-0.9	-1	-0.9	-1.3
KA3542G01:3	~100	-0.7	-0.1	-2.3	-1	-2	-1.5
KA3542G01:3	~200	0.6	-0.9	-0.5	1.1	-1.6	-1.5
KA3542G01:3	max	2.4	-0.7	1.7	0.2	-0.2	-0.7
KA3544G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	-1.3	0.8	-1.2	-0.1	-1.5	0.6
KA3542G02:2	max	-1.4	-0.1	-1.3	-0.9	-1.5	-1.1
KA3563G:4	max	16	31	(2)	(2)	(2)	(2)
KA3546G01:2	max	-	9	-	11	-	8
KA3566G01:2	max	4.3	0.1	(2)	(2)	(2)	(2)
KA3572G01:2	max	-	-	(2)	(2)	(2)	(2)
KA3574G01:3	max	-	-	(2)	(2)	(2)	(2)
KA3539G:2	~100	-1.3	2.1	-2	-0.6	-2.3	-1.5
KA3539G:2	max	-0.8	1	-0.8	0.7	-1.6	-0.8
KA3542G02:5	max	-2	5	(2)	(2)	(2)	(2)
KA3590G02:1	max	1	4.6	(2)	(2)	(2)	(2)
KG0021A01:3	max	-4	59	(2)	(2)	(2)	(2)
KG0048A01:3	max	-0.4	-3.2	(2)	(2)	(2)	(2)
KA3573A:4	max	-4.8	-4.6	(2)	(2)	(2)	(2)

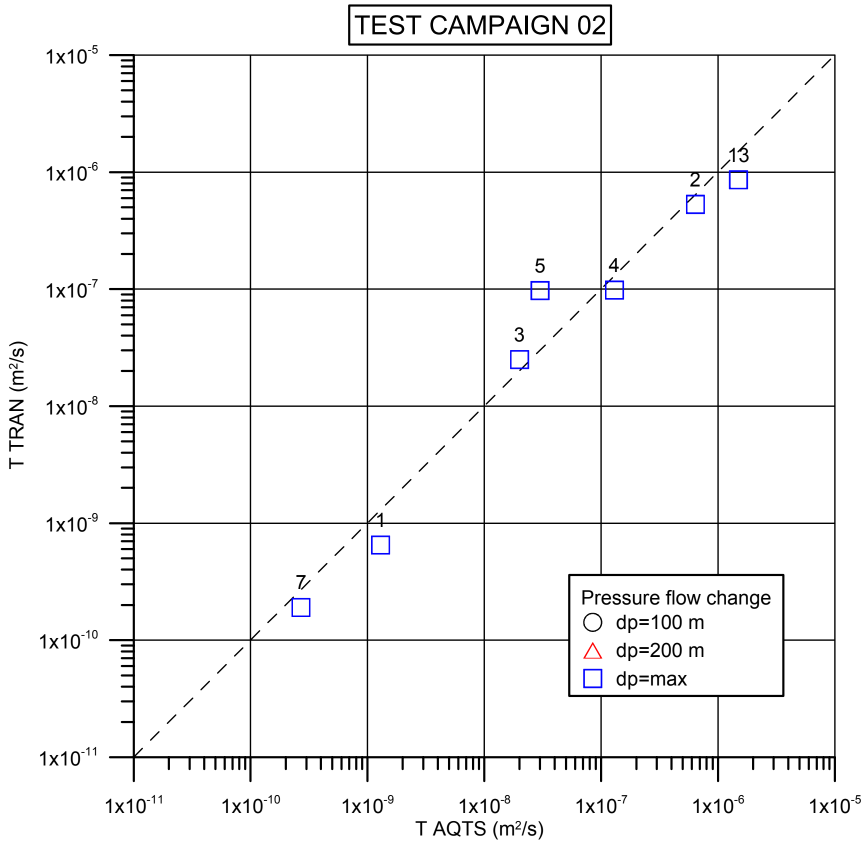
In the figures below the transmissivity is plotted in a cross-plot to visualize the differences between the two evaluation methods.

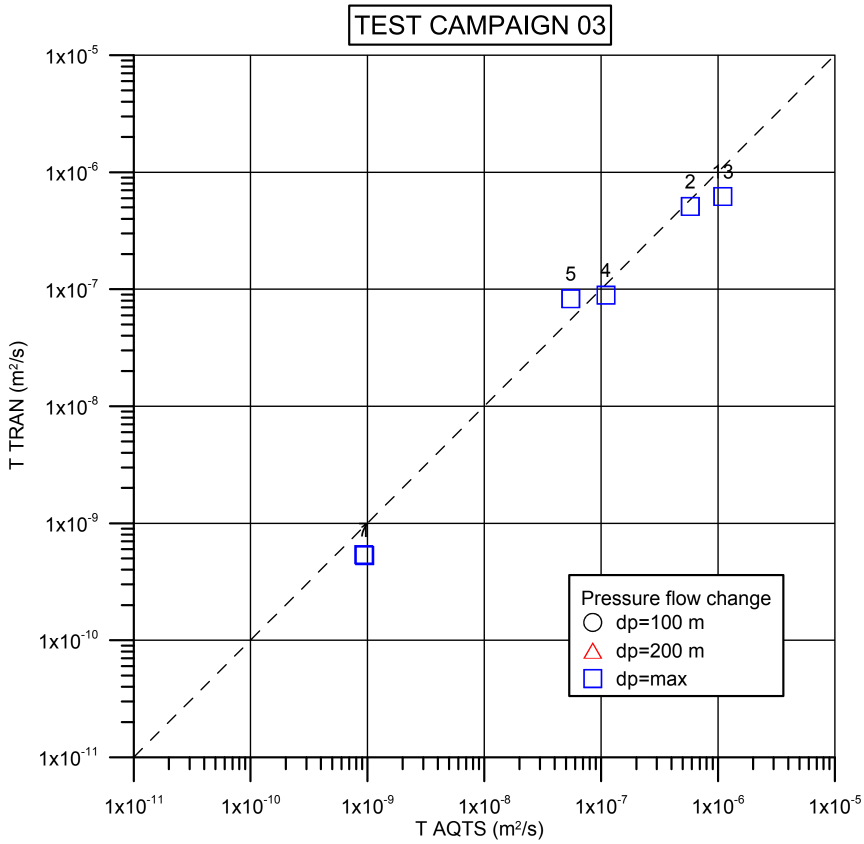
The numbers shown in the figures below is the test sequience number according to *Table A19-5*.

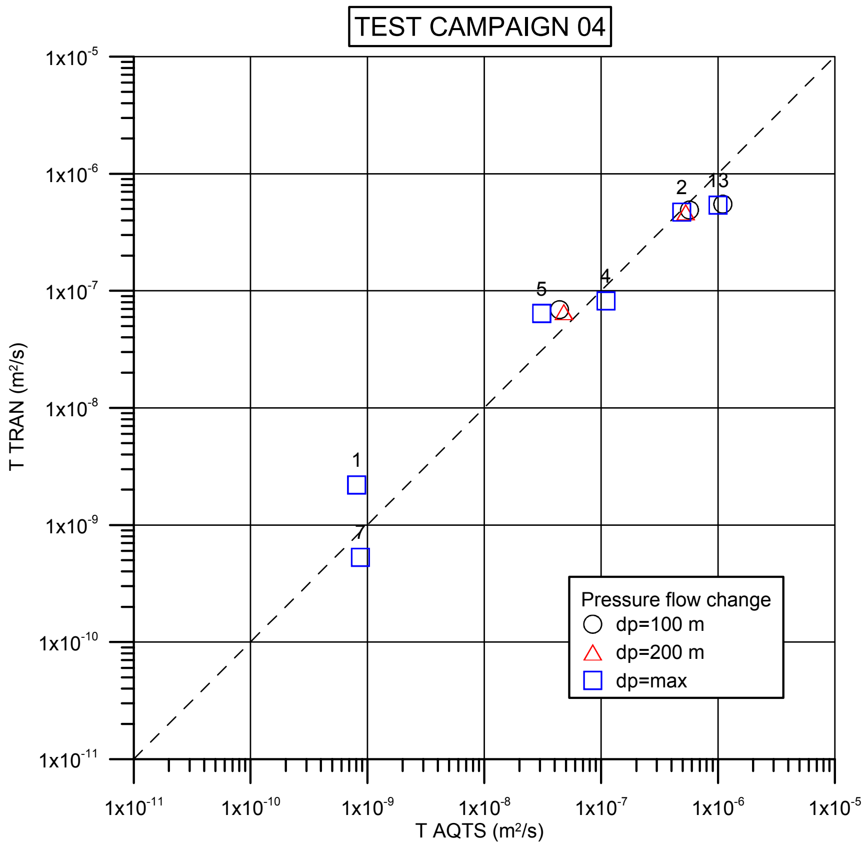
Table A19-5. Test sequence numbering

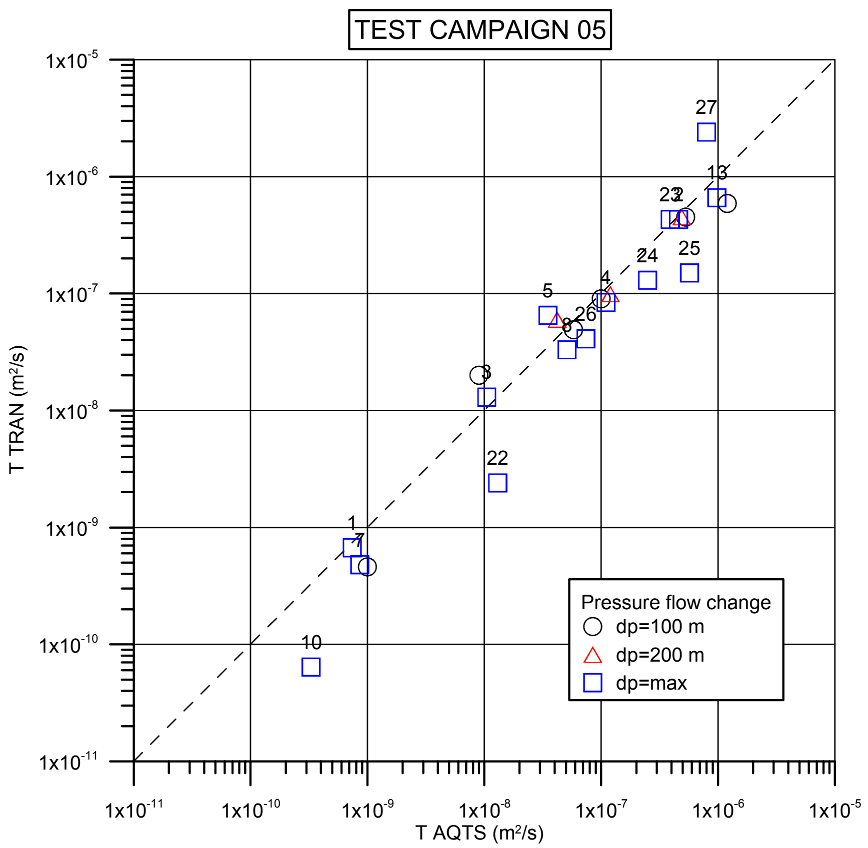
Section	dp_p (m)	Testnumber
KA3552G01:2	max	1
KA3554G01:2	~100	2a
KA3554G01:2	~200	2b
KA3554G01:2	max	2c
KA3554G02:4	~100	3a
KA3554G02:4	max	3b
KA3548A01:3	~100	4a
KA3548A01:3	~200	4b
KA3548A01:3	max	4c
KA3542G01:3	~100	5a
KA3542G01:3	~200	5b
KA3542G01:3	max	5c
KA3544G01:2	(1)	6
KA3542G02:2	~100	7a
KA3542G02:2	max	7b
KA3563G:4	max	8
KA3546G01:2	max	9
KA3566G01:2	max	10
KA3572G01:2	max	11
KA3574G01:3	max	12
KA3539G:2	~100	13a
KA3539G:2	max	13b
KA3542G02:5	max	22
KA3554G01:3	max	23
KA3590G02:1	max	24
KG0021A01:3	max	25
KG0048A01:3	max	26
KA3573A:4	max	27

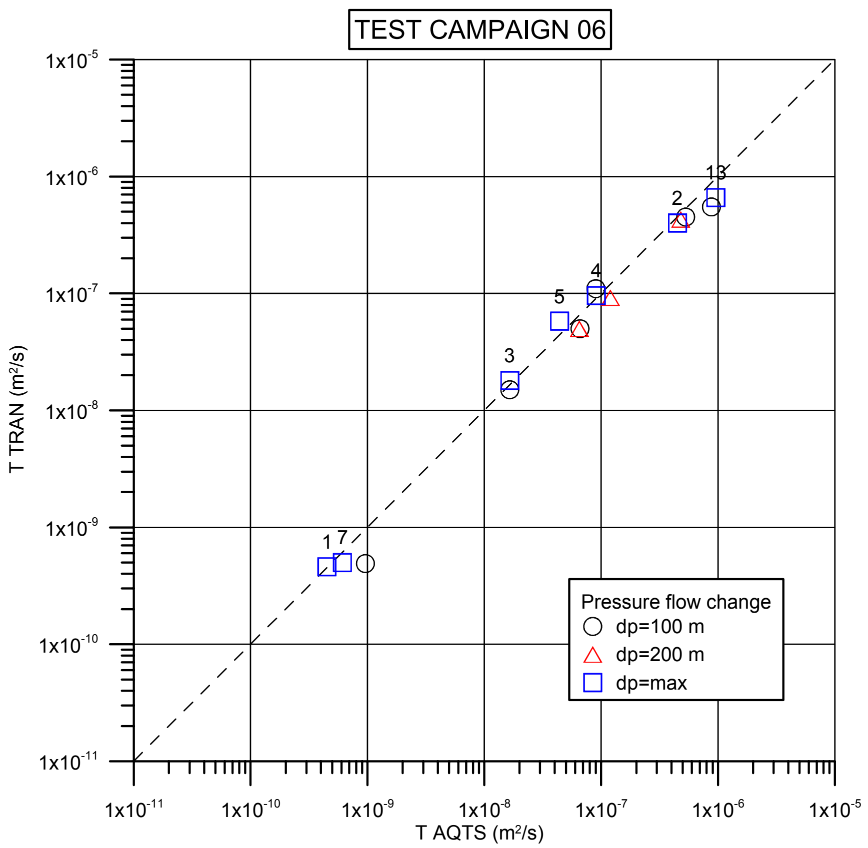

TEST CAMPAIGN 01
T TRAN (m²/s)
T AQTS (m²/s)
1x10^-11
1x10^-10
1x10^-9
1x10^-8
1x10^-7
1x10^-6
1x10^-5
27
23
13
24
25
5
4
26
3
22
7
9
Pressure flow change
dp=100 m
dp=200 m
dp=max

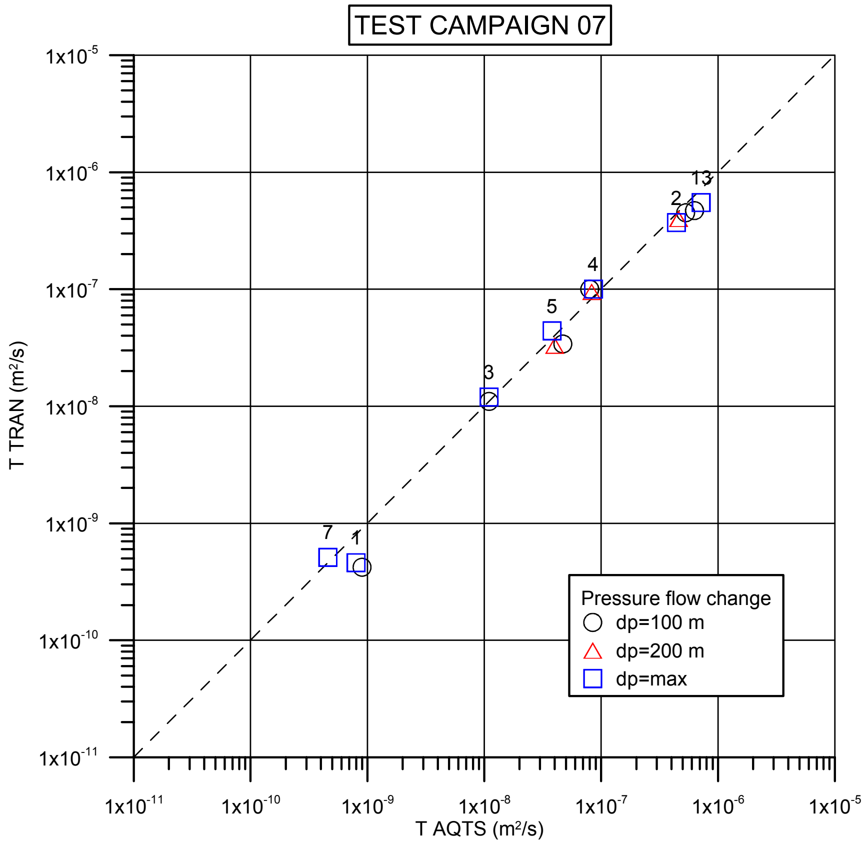

TEST CAMPAIGN 02
T TRAN (m²/s)
T AQTS (m²/s)
1x10^-11
1x10^-10
1x10^-9
1x10^-8
1x10^-7
1x10^-6
1x10^-5
13
2
5
4
3
1
7
Pressure flow change
dp=100 m
dp=200 m
dp=max


TEST CAMPAIGN 03
T TRAN (m²/s)
T AQTS (m²/s)
Pressure flow change
dp=100 m
dp=200 m
dp=max


TEST CAMPAIGN 04
T TRAN (m²/s)
T AQTS (m²/s)
Pressure flow change
dp=100 m
dp=200 m
dp=max


TEST CAMPAIGN 05
T TRAN (m²/s)
T AQTS (m²/s)
Pressure flow change
dp=100 m
dp=200 m
dp=max


TEST CAMPAIGN 06
T TRAN (m²/s)
T AQTS (m²/s)
Pressure flow change
dp=100 m
dp=200 m
dp=max



In general the evaluated AQTESOLV transmissivity using the Dougherty-Babu solution is a little higher than the Jacob`s transmissivity. The main reason is the use of the variable flowrate instead of the end of flow period flowrate. One exception are the tests in KA3542G01:3 (5 in the plots) where it have been possible to evaluate an earlier time period when using AQTESOLV, i.e a rock volume closer to the tested borehole sections.