

4 Performing an aquifer test

Figure 4.1 shows the effects of an aquifer test on a confined aquifer. This figure shows what the depression cone looks like before and during the aquifer test.

aquifer itself, indicating a true (non-leaky) confined nature.

An aquifer test is typically carried out to estimate

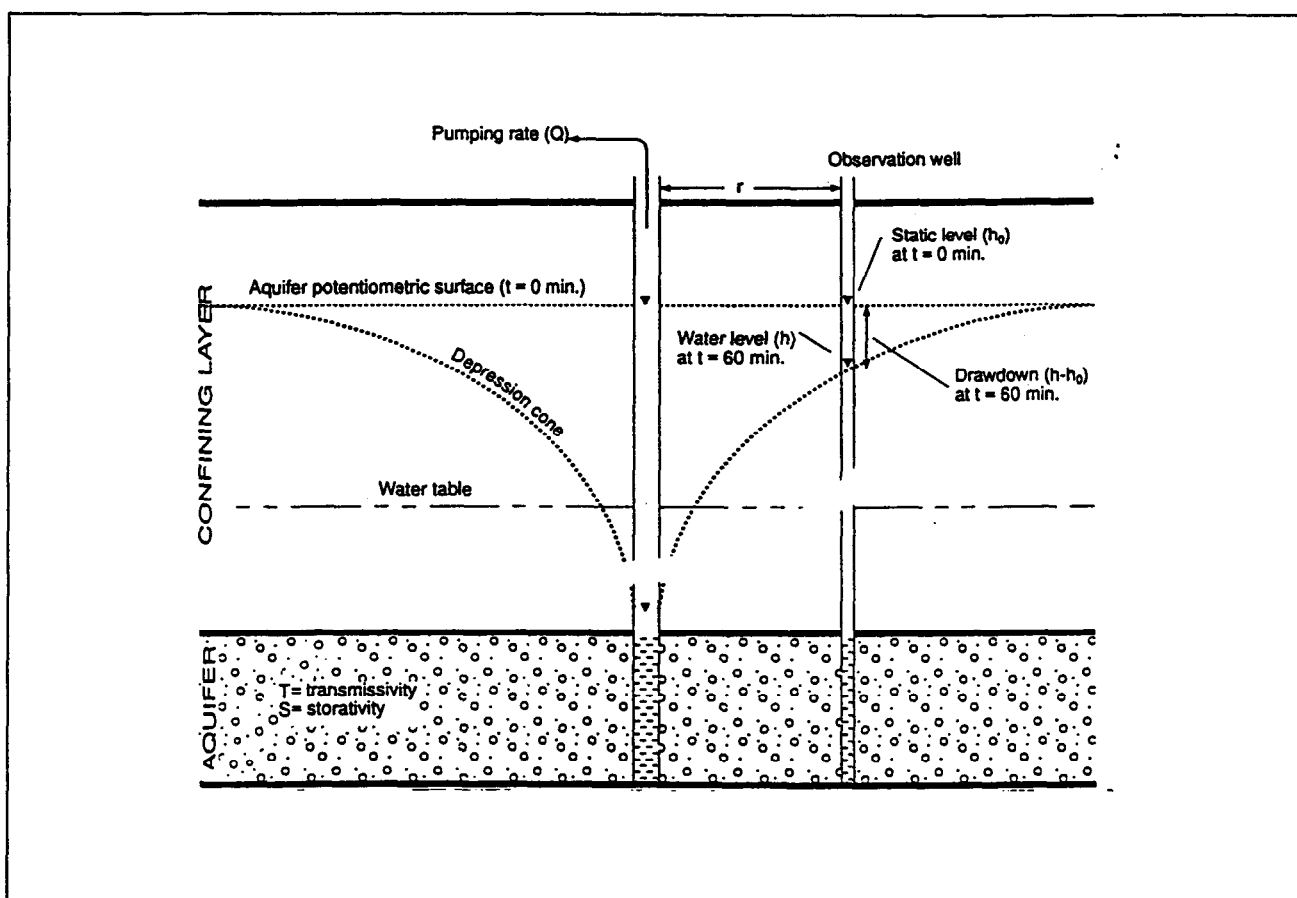


Figure 4.1. Depression cone within a hydrogeologic cross section.

Firstly, note that there are two potentiometric (water level) surfaces given as examples for the confined aquifer. The flat, upper potentiometric surface is given at time = 0 minutes, at static level. The lower is time = 60 minutes and represents what the depression cone looks like after pumping water from the well and aquifer for 60 minutes.

Secondly, note that the water table within the confining layer (overlying the aquifer) is unaffected by pumping the confined aquifer. The potentiometric surface for a confined aquifer remains above the

transmissivity (T) and storativity (S). Transmissivity describes the ability of the aquifer to transmit water whereas, storativity describes the ability of the aquifer to release water. The Theis equations, (equation 1) are used to solve for transmissivity and storativity of a confined aquifer. Other equations solve transmissivity and storativity for other aquifer conditions.

$$T = \frac{Q[W(u)]}{4\pi(h_0 - h)}; \quad S = \frac{4Tut}{r^2} \quad (1)$$

Equation 1 indicates what must be measured and recorded at the test site to allow determination of the aquifer characteristics. Terms in equation 1, such as r , are shown in Figure 4.1. The equation requires that we measure:

- ♦ Pumping rate (Q), which must be kept constant throughout the test (or step drawdown interval) for the equation and results to be valid,
- ♦ Static water level (h_0), which is measured just before pumping starts,
- ♦ Changed water level (h), which is measured simultaneously with time during the test,
- ♦ Time-into-test (t), which is recorded after pumping starts and simultaneously with changing water level, and
- ♦ Distance from the pumping well to the observation well(s) (r), where an observation well is used.

The terms $W(u)$ and u link the two parts of the above equation and will not be considered in this discussion. For further information describing these terms, see Fetter (1994, p. 200-202), Kruseman and de Ridder (1990, p. 61-62), or other groundwater texts.

An examination of the above equation shows why a single well test (such as a step drawdown test) cannot be used to determine storativity. There is no "r value" without an observation well (ie. distance between the pumping well and observation well) so storativity cannot be calculated.

4.1 Critical factors

The most critical things to get right in an aquifer test are, in order of importance:

1. **Keep the pumping rate constant** from test start to test end. The exception is for a step drawdown test in which the pumping rate must be kept constant from start to end of each step increment. The reason for keeping the pumping rate constant is that fluctuating pumping rates will also cause water levels to fluctuate, making the test analysis inaccurate.
2. **Accurately measure depth-to-water simultaneously with time** (within 0.01 m throughout the test).
3. **Pump long enough** to determine whether the aquifer is extensive and without boundaries or limitations, such as for 1 day for a confined aquifer and for up to 1 week for an unconfined aquifer.

It is better to pump long enough to ensure that the rate is sustainable rather than decide, some weeks after the test (when the equipment has been disassembled and workers dispersed) that the test should have been pumped longer.

4. **Record all data before leaving the test site.** This includes dates on all pages, sequential page numbers on all data pages, labels, etc. Correct and clear data is more important than the subsequent analysis. The analysis can always be revised but the test data from that day can never be re-collected or invented.

4.2 Measurements and record keeping

Keep clear and accurate records. It is better to skip an uncertain measurement than to record a guess (ie. bad information is worse than no information). Since the test data will ultimately be used for future reference it is important to clearly record data. To assist with the presentation of data specifically designed data forms are included in Appendix 2.

There should be no unexpected surprises during the course of the test. Personnel at the test site should practice timed water-level measurements and data recording before the pump is turned on. About an hour before the pump is turned on, all test participants should gather to discuss the day's work schedule and to synchronise watches.

It is useful to plot the drawdown and time on graph paper during the test. The plotted data will readily indicate a measurement error (drawdown data should plot along a distinct pattern), whether a boundary is met, or when drawdown approaches stability and pumping can cease. There is enough time to start plotting drawdown and time on graph paper after the first hour of pumping, when measurements become less frequent.

Organise and collate all test records, such as completed data forms, before leaving the test site at the test conclusion. Original pages of test data and records should be retained for subsequent quality assurance review and archiving.

4.2.1 Pumping rate

After opening the discharge valve to some preset

level, make every effort to maintain a constant discharge. It is more important at the test start to quickly open the valve and establish some constant pumping rate than to spend additional time trying to achieve a pre-determined pumping rate. Use an orifice meter and staff gauge, such as shown in Figure 3.1, or other accurate means of measuring discharge. Record pumping rate more frequently at the test start, such as every minute.

4.2.2 Depth-to-water and time measurements

Measure depth to water before pumping starts to establish the static water level. During the test, depth-to-water and time should be measured simultaneously. Ideally, one person at the observation well will give a countdown to a timed-minute measurement and at the 0-seconds prompt, another person measuring water levels will report the depth-to-water at that moment. Watches that are synchronised to within seconds at all the observation wells ensure that the recorded water level data is linked to the discharge.

Measure groundwater levels most frequently at the test start, and then lessen the frequency as the test proceeds. See an example of measurement frequency for a 24-hour test in Appendix 1. Standards Australia (1990, section 5.2) suggests the following measurement frequency:

1. **0 – 1.5 hours:** 0.5, 1, 2, 3, 4, 6, 8, 10, 15, 20, 25, 30, 45, 60, 75, 90 minutes
2. **1.5 – 8 hours:** 30-minute intervals
3. **8 – 24 hours:** 1-hour intervals
4. **24 – 48 hours:** 2-hour intervals
5. **> 48 hours:** 4-hour intervals

4.2.3 Distance to pumping well

Measure the distance from every observation well to the pumping well. This can be done before the test, later in the test when measurements are made much less frequently, or after the test.

5 Aquifer Conditions

The following three aquifer conditions are found in the Hawke's Bay region: confined, semi-confined, and unconfined. These general conditions, and the source of water that is pumped from wells are shown Figure 5.1. Semi-confined can be further distinguished as semi-confined with a compressible overlying layer (such as clay or claybound gravel) or semi-confined with an incompressible overlying layer (such as basalt). The condition of a semi-confined aquifer with an incompressible overlying layer is not common in the Hawke's Bay area.

Figure 5.1 shows the various sources of water pumped from an aquifer as being derived from:

- ♦ A **confined aquifer**, the source of water is *only* from the confined aquifer.
- ♦ A **semi-confined aquifer with an incompressible overlying (or underlying) layer**, where the source of water is from the semi-confined aquifer *and* an aquifer situated above or below the semi-confining layer.
- ♦ A **semi-confined aquifer with a compressible overlying (or underlying) layer** where the source of water is from the semi-confined aquifer

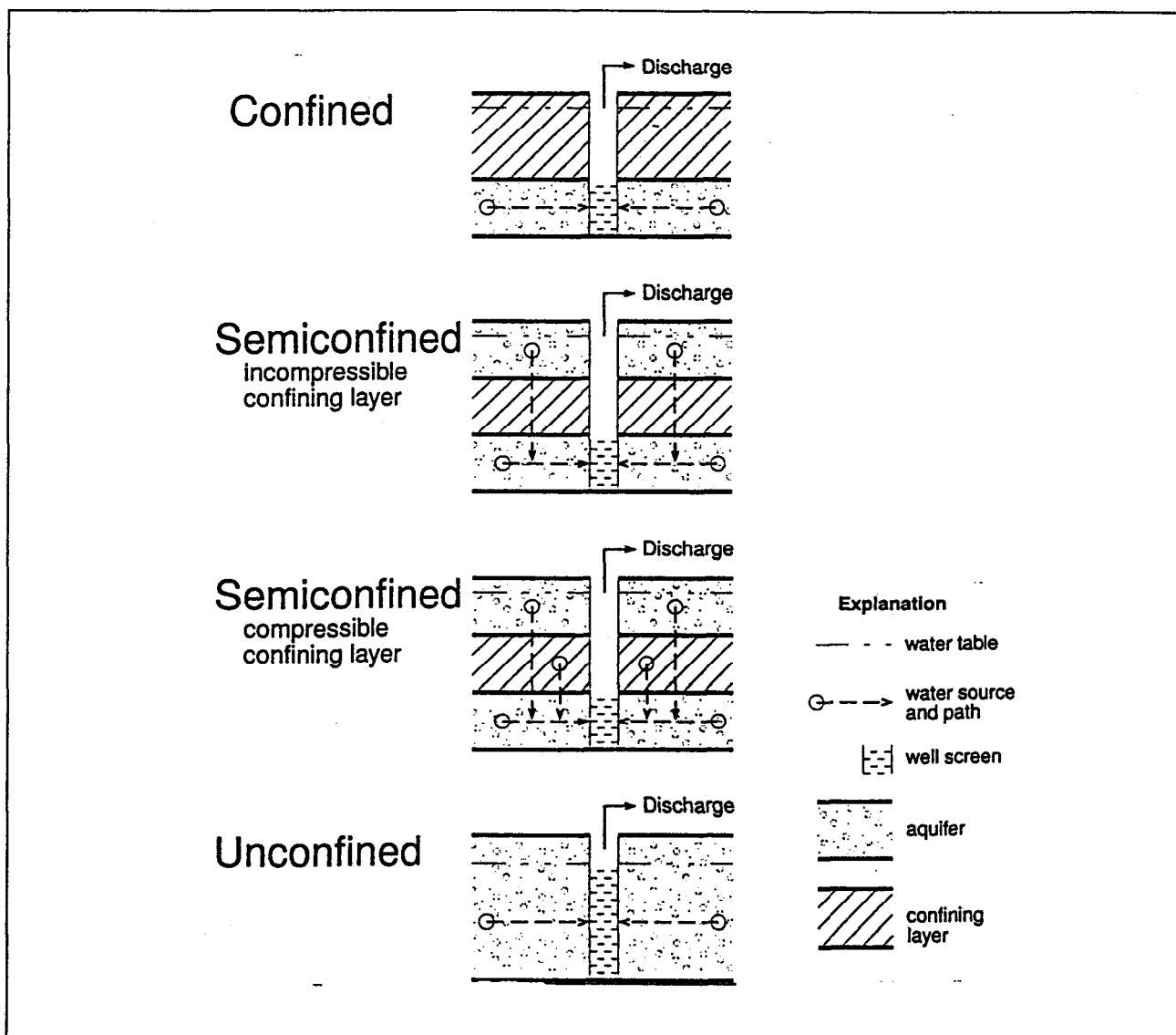


Figure 5.1. Aquifer test conditions

fer, the semi-confining layer, and an aquifer above or below the semi-confining layer.

- An **unconfined aquifer** where the source of water is from the unconfined aquifer.

Plotted data from an aquifer test may indicate which aquifer condition exists. Aquifer test data for a constant rate discharge test is typically plotted on logarithmic-logarithmic (log-log) graph paper, with drawdown increasing up the vertical axis and time increasing to the right on the horizontal axis. With this graphing format, Figure 5.2 shows how test data would plot for the three aquifer conditions.

To determine the most appropriate analysis method:

1. Determine from the bore (well or lithology) log(s) whether the aquifer condition is likely to be unconfined, semi-confined, or confined. For example, a gravel overlain by clay is likely to be semi-confined or confined.
2. Carry out an aquifer test to confirm the aquifer condition. For example, the plotted test data as shown in Figure 5.2 will distinguish whether the conditions are unconfined, semi-confined, or confined.
3. Given the above two steps, analyse the aquifer test data using *only* the most appropriate method. It is not reasonable to analyse data by a particular method just because the data fits a type curve. Instead, complete the analysis that fits the conditions.

One disadvantage with most of these methods is that they require the use of “type curves”. Some type curves are available

as hard copies by Reed (1980, plate in rear pocket) while other type curves may be available from various computer software. Computer analysis software should be used with caution since it is possible to have a good fit of data but assume unreasonable aquifer conditions. Therefore, the analyst should become experienced in manual aquifer-test analysis before using computer software.

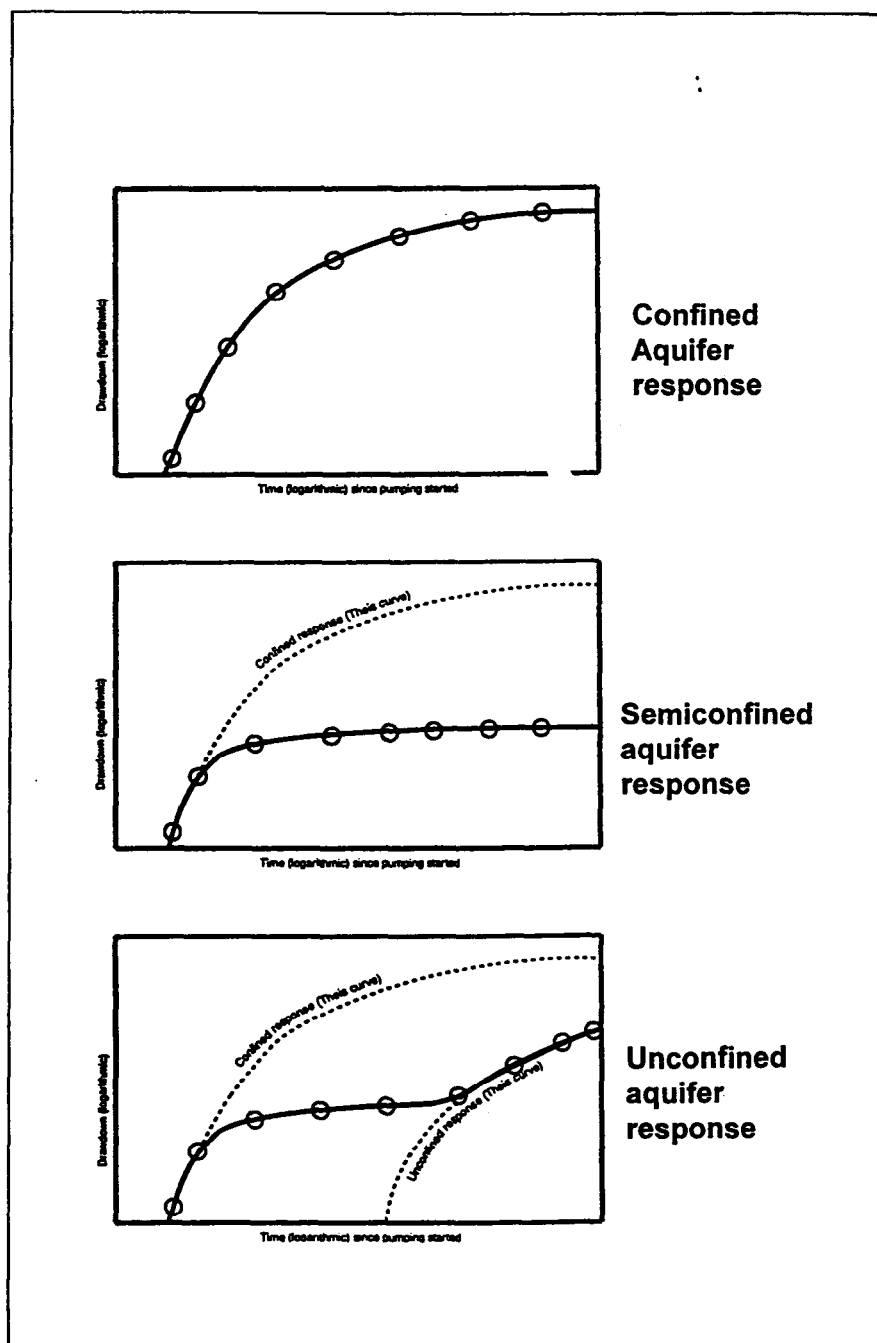


Figure 5.2. Aquifer test data responses to pumping.

6 Analysis methods

The first step in aquifer analysis is to assess the site specific aquifer conditions. The second step is to analyse the test data for the aquifer condition.

As indicated previously, tests may be carried out with or without an observation well. Test analysis completed with an observation well will provide the best assessment of aquifer properties whereas, a single well test is generally used to determine well efficiency.

6.1 Constant discharge aquifer tests with observation well(s)

Table 6.1 summarises several aquifer test analysis methods using an observation well.

6.1.1 Confined aquifer test analyses

A confined aquifer condition is common in the Heretaunga Plains area of Hawke's Bay and aquifer tests may be carried out using constant rate discharge or step drawdown tests (section 6.2.4).

6.1.1.1 Theis method

This classic analysis method serves as a basis for several more complex test methods. The Theis method is described by Fetter (1994, p. 219-224) and Kruseman and de Ridder (1990, p. 61-65). It requires use of a type curve (Reed, 1990, plate 1, fig. 1.2).

The Theis method yields the following aquifer characteristics:

- ♦ Transmissivity,
 - Hydraulic conductivity (when the aquifer thickness is known), and
- ♦ Storativity (with an observation well).

6.1.1.2 Jacob method

This method is easier to use than Theis but is more restricted and is less accurate. It does not require early time test data or a type curve.

The Jacob method is described by Fetter (1994, p. 224-227) and Kruseman and de Ridder (1990, p. 65-70).

The Jacob method yields the following aquifer characteristics:

- ♦ Transmissivity,
 - Hydraulic conductivity (where aquifer thickness is known), and
- ♦ Storativity (with an observation well).

6.1.2 Semi-confined aquifer test analyses

There exists two general semi-confined conditions and methods of analysis. The characteristic of the confining layer is key to distinguishing which method to use.

If the semi-confining layer is compressible, such as a clay or claybound gravel, then the Hantush method of analysis is used. If the semi-confining layer cannot be compressed, such as a basalt or granite, then the Walton method is used.

Because semi-confining layers in Hawke's Bay are typically compressible, the Hantush method is the most common method of analysis.

6.1.2.1 Hantush method

The Hantush method assumes that the confining layer is compressible, such as a clay or claybound gravel. This method is described by Fetter (1994, p. 236-237) and Kruseman and de Ridder (1990, p. 90-93). and requires use of a type curve (Reed, 1980, plate 1, fig. 5.2).

This method yields the following aquifer characteristics:

- ♦ Transmissivity,
 - Hydraulic conductivity (where aquifer thickness is known), and
- ♦ Storativity (with an observation well).

6.1.2.2 Walton Method (Hantush-Jacob equation)

The Walton method assumes that the semi-confining layer is incompressible (not common in Hawke's Bay). Results from using this method for a semi-confined aquifer may be more valid than results from the Theis method, but they are less valid than re-

Aquifer Test Guidelines

Condition	Confined		Semiconfined		Unconfined	
			Confining layer does not compress	Confining layer does compress		
Assumptions ¹	1-7; u < 0.05	1-7	1-9		1, 3-7; 10	1-7, late data
Analysis method ³	Jacob	Theis	Walton (Hantush-Jacob equation)	Hantush	Neuman	Theis
Method uses ^{2,3}	Straight line	Type curve				
		(Reed)	(Walton)	(Reed)	(Neuman)	(Reed)
Reference ³	Fetter (p. 224-227)	Fetter (p. 219-224)	Fetter (p. 229-232)	Kruseman and de Ridder (p. 90-93)	Fetter (p. 237-241)	Fetter (p. 219-227)
Solves for ⁴	T, K, S	T, K, S	T, K, K', S	T, K, S, K' S'	T, K _v , K, S, S _v	T, K, S

¹Assumptions

1. Infinite aquifer
2. Isotropic/homogeneous aquifer
3. Uniform aquifer thickness
4. Steady state in aquifer before pumping
5. Well fully penetrates aquifer
6. Pumping well has insignificantly small diameter
7. Simultaneous: water removed from aquifer as aquifer head declines
8. Vertical leakage through confining layer, into aquifer
9. Water level constant in aquifer that is source of leakage
10. Little drawdown compared to aquifer thickness

²Type curves may be found in report given in parentheses.

³References

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⁴Terms

- K = hydraulic conductivity (aquifer thickness required)
- T = transmissivity
- S = storativity
- K' = vertical hydraulic conductivity of semiconfining layer (confining layer thickness required)
- S' = storativity of the semiconfining layer
- S_v = specific yield (late storativity)
- K_h = horizontal hydraulic conductivity (aquifer thickness required)

- K_v = vertical hydraulic conductivity (aquifer thickness required)
- r = distance to pumping well
- t = time since pumping began

$$u = \frac{r^2 S}{4Tt}$$

Table 6.1. Constant rate discharge aquifer tests with observation wells

sults obtained from use of the Hantush method. This method is described in Fetter (1994, 229-232) and Kruseman and de Ridder (p. 81-84) and requires use of a type curve.

The Walton method yields the following aquifer characteristics:

- ♦ Transmissivity
 - Hydraulic conductivity (where aquifer thickness is known) and
- ♦ Storativity (with an observation well).
- ♦ Vertical hydraulic conductivity of the confining layer (where confining layer thickness is known)

6.1.3 Unconfined aquifer test analyses

An important unconfined aquifer exists in the western portion of the Heretaunga Plains area of Hawke's Bay. When unconfined test data is plotted on log-log paper, the test data shows an early (initial) Theis curve followed by a flatter curve (delayed yield) which is then followed by a second (late) Theis curve. These phases are shown in Figure 5.2.

The early time Theis curve may occur within the first few minutes of extraction as initial groundwater is withdrawn from storage. The slightly flatter curve (middle time data) represents a temporary groundwater equilibrium condition during which withdrawals originate largely from recharge. The second or late Theis curve represents groundwater withdrawn from storage resulting in dewatering of the aquifer.

Unconfined aquifer test analysis may be carried out using the Neuman Method, which when compared to the Theis method, is more difficult to use but is more accurate and comprehensive.

6.1.3.1 Neuman method

The Neuman method utilises all test data (early through late time data) (Figure 5.2).

As described by Fetter (1994, p. 237-241) and Kruseman and de Ridder (1990, p. 102-106), the Neuman method requires use of a type curve and yields the following aquifer characteristics:

- ♦ Transmissivity,
- ♦ Storativity for early time (requires an observation well),

- ♦ Specific yield for late time (requires an observation well),
- ♦ Isotropy (K_h/K_v) (where aquifer thickness is known),
 - Vertical hydraulic conductivity (where aquifer thickness is known), and
 - Horizontal hydraulic conductivity (where aquifer thickness is known).

6.1.3.2 Theis method

The Theis method is typically used for confined aquifer analysis, but may also be used for late time unconfined test data. Though the Theis method is relatively simple to apply, care must be taken to exclude the middle time data. Because early time data is not used, it is not possible to calculate isotropy (K_h/K_v).

This method yields the following aquifer characteristics:

- ♦ Transmissivity,
 - Hydraulic conductivity (where aquifer thickness is known), and
- ♦ Specific yield (with an observation well).

6.2 Single well tests

Single well tests are more common than aquifer tests with observation wells. The obvious advantage of a single well test is that observation wells are not required.

Single-well test methods may be used for an aquifer pre-test to determine an optimal pumping rate for the well. A common single well test is the step drawdown test used to determine well efficiency (ie. such as whether the selected well screen is suited to the lithology).

Table 6.2 summarises single well tests. Some disadvantages are:

- ♦ Well losses during the pumping period underestimate aquifer transmissivity for some methods; hence, recovery (rather than drawdown) data is more valid.
- ♦ Storativity cannot be estimated.
- ♦ Only some of the water level measurement data is valid during the recovery portion of the test.
- ♦ Single well test analyses are less suited to the analysis of semi-confined aquifers.

Aquifer Test Guidelines

Test method	Specific capacity	Jacob		Theis	Eden Hazel	Hvorslev
Condition	Non specific	Confined	Semiconfined	Confined, semiconfined, unconfined	Confined	Confined, unconfined
Assumptions ^{1,3}	None	1-7, $t > 25r_w^2/T$	1-7, $t > 25r_w^2/T < b'S/2-OK'$	1-7, $tp > 25r_w^2/T$, $t > 25r_w^2/T$, (see Kruseman and de Ridder for more specific assumptions)	1-7, $u < 0.01$	1-7,
Discharge	Constant	Constant		Recovery following constant discharge	Step drawdown	Instantaneous injection or withdrawal (slug)
Method uses	Ratio calculation (discharge/drawdown)	Straight line method		Type curve	Straight lines method	Straight line method
References ²	Fetter (1994, p. 256-257)	Kruseman and de Ridder (1990, p. 223-225)		Kruseman and de Ridder (1990, p. 194-196 and p. 232-233)	Kruseman and de Ridder (1990, p. 205-209)	Fetter (1994, p. 247-251)
Solves for ³	Specific capacity	T,K		T,K	T,K	K

¹Assumptions

1. Infinite aquifer
2. Isotropic/homogeneous aquifer
3. Uniform aquifer thickness
4. Steady state in aquifer before pumping
5. Well fully penetrates aquifer
6. Pumping well has insignificantly small diameter
7. Simultaneous: water removed from aquifer as aquifer head declines

²References

Fetter, C.W., 1994, Applied Hydrogeology: New York, Macmillan College Publishing, 691 p.
 Kruseman, G.P., and De Ridder, N.A., 1990, Analysis and evaluation of pumping test data: Littleton, Colo., Water Resources Publications, 184 p.

³Terms

K = hydraulic conductivity
 T = transmissivity
 S = storativity
 r = distance to pumping well
 t = time since pumping began
 r_w = casing radius
 b' = confining layer thickness
 K' = confining layer hydraulic conductivity

Table 6.2. Single well tests

6.2.1 Specific capacity

This test is simple, readily understood, but is of limited application. Specific capacity is the ratio of the sustained pumping rate divided by the incurred drawdown.

Specific capacity is rarely constant. For example, specific capacity determined following 1 hour of

pumping may differ (for the same well) from the specific capacity following 6 hours of pumping. Values may range from about 1 to 20 (l/s)/m, with higher values being more desirable. This method is described by Fetter (1994, p. 256-257) and it does not require a type curve.

6.2.2 Jacob analysis

The Jacob analysis can use data recorded during the pumping period because the method is not affected by well losses if discharge is kept constant. The analysis is valid for confined and semi-confined aquifers. This method is described by Kruseman and de Ridder (1990, p. 223-225).

This method yields:

- ♦ Transmissivity and
- ♦ Hydraulic Conductivity (where aquifer thickness is known).

6.2.3 Recovery test and analysis

A recovery test is carried out to determine aquifer characteristics, based on rising water levels (recovery) after the pump is turned off. The recovery analysis uses the average pumping rate during the pumping period and so the recovery data is unaffected by short flow variations during the pumping period. Recovery tests provide a useful check of aquifer test results determined during the pumping (drawdown) period.

The test starts the moment the pump is turned off and continues until water levels stabilise (the best method) or until about 80% recovery of initial static levels are recorded. Water level measurements are made more frequently immediately after the pump is turned off and less frequently with cumulative time. The average pumping rate during the pumping duration is used in recovery analysis equations, it is therefore important to record pumping rate and time throughout the pumping period.

Recovery tests may be carried out following a constant rate discharge test or a specific capacity test. A recovery test is particularly useful in the following circumstances:

- ♦ Drawdown data for the first several minutes of pumping is typically flawed by an irregular pumping rate; therefore, a recovery test can independently analyse the critical early minutes of an aquifer test.
- ♦ The pump failed for several minutes during pumping; therefore, the subsequent recovery data can instead be used for analysis.
- ♦ Test results for the pumping duration seem anomalous; therefore, a recovery test can independently verify aquifer characteristics.

- ♦ Single well tests may produce pumping-caused turbulence in the pumping well and invalid water-level measurements; therefore use of recovery test data recorded after pumping has ended yields valid results.

This recovery analysis may be used for confined, semi-confined, or unconfined aquifers. Test procedures are described in Kruseman and de Ridder (1990, p. 194-197 and p. 232-233).

The Theis recovery analysis yields the following aquifer characteristics:

- ♦ Transmissivity and
- ♦ Hydraulic conductivity (where aquifer thickness is known).

6.2.4 Step drawdown test and analysis

Step drawdown tests and analyses can estimate transmissivity but the estimated value is less accurate than that estimated from a constant rate discharge test. Reduced accuracy is associated with:

- ♦ difficulties in achieving an instant steady pumping rate for each step and
- ♦ the calculated transmissivity being a product of both the well design and aquifer characteristics.

The step drawdown test is based on the Jacob straight-line analysis, for which the superimposed effects of successive pumping rates are analysed. Kruseman and de Ridder (1990, p. 205-209) describe the step drawdown method and note that the Eden-Hazel method is the only step drawdown method that determines transmissivity and does not require a type curve.

This method yields the following aquifer characteristics:

- ♦ Transmissivity and
- ♦ Hydraulic conductivity (where aquifer thickness is known).

6.2.5 Slug test and analysis

For a slug test, a volume of water or a solid impermeable slug is quickly added or removed from a well. The recovery of water levels in the well are recorded following this event.

The slug test is a simple method used to estimate the hydraulic conductivity of the aquifer. Values

may be statistically valid if tests are completed at several wells (within the same aquifer) over a representative aquifer area.

Slug tests are most useful for low transmissivity aquifers, less than $250\text{m}^2/\text{d}$, since water levels may recover too quickly to manually record water recovery. For aquifers of greater transmissivity, transducers and data loggers may be necessary during the slug test.

Slug tests may be used for confined or unconfined aquifers and are described in Kruseman and de Ridder (1990, p. 237-247). Fetter (1994, p. 247-251) describes the fundamental and versatile Hvorslev slug test analysis.

The Hvorslev analysis yields the following aquifer characteristics:

- ♦ Transmissivity (where aquifer thickness is known) and
- ♦ Hydraulic conductivity.

7 Reporting

A test report is the archival record of what happened during the aquifer or well test day. The record should be complete, clear, and accurate.

7.1 Test information

A test report must provide sufficient information to allow for a person who did not participate in the event to re-create the aquifer test conditions. The test report must also include all information that impacted, or was believed to impact, the test results.

A detailed checklist for what should be included in a test report is provided in Appendix 2. More generally, a test report should include:

- Map of the test location,
- Test date,
- Aquifer characteristics,
 - depth,
 - thickness,
 - lithology (well logs for all wells),
- Test results
 - transmissivity, storativity, etc.,
 - water chemistry,
- Test conditions
 - semiconfined, confined, etc.,
 - pumping rate and whether it was maintained,
 - test duration,
 - identification of all wells involved,
- Analysis summary
 - data corrections,
 - analysis methods used,
 - plotted data,
 - detailed calculations leading to determinations of aquifer characteristics,
 - discussion of data and analysis reliability,
- References for all cited information,
- Records
 - aquifer test summary form (Appendix 2),
 - data forms (Appendix 2),
 - well completion information (well logs, etc.) for each participating well.

the reliability of all aquifer tests. A rating form for aquifer test data is provided in Appendix 2. The rating will be based on:

- **Test type**, with the constant rate discharge test being highly regarded,
- **Test duration**, with longer tests more highly regarded than shorter tests,
- **Test controls**, with technically successful tests (ie. maintained pumping rate) being highly regarded,
- **Reported information**, with tests that offer a complete set of records being highly regarded,
- **Data reasonableness**, with data that fits mathematically-established type curves or lines being highly regarded,
- **Analysis method validity**, with test results that use applicable methods being highly regarded,
- **Corrections applied**, with tests that do not require corrections or tests with successful application of corrections being highly regarded.

7.2 Quality assurance

The Hawke's Bay Regional Council intends to rate

8 References

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Appendix 1 - Example of completed aquifer test data form

Constant Discharge Aquifer Test Data

Observation well bore permit number: Distance from pumping well: ..430...m

Pumping well bore permit number: Pumping rate (average): ..79.03...(l/s)

Persons measuring: John Doe

Initial depth to water:79.66.m

Measuring point description: Top of casing

Page ...1..... of ...1..... pages

Date	Clock time (24-hour)	Time into test (min)		Depth to water (m)	Uncorrected drawdown (m)	Drawdown correction (m)	Corrected drawdown (m)	Pumping rate (l/s)	Person measuring (initials)	Comments
		Pumping	Recovery							
09/10/96	1040	-20		79.697	0.001	0			SM/RS	
	1050	-10		79.696	0	0			SM/RS	
	1055	-5		79.695	-0.001	0			SM/RS	
	1100	0				0			SM/RS	
		0.5		79.696	0	0	0		SM/RS	
		1		79.696	0	0	0		SM/RS	
		1.5		79.696	0	0	0		SM/RS	
		2		79.698	0.002	0	0.002		SM/RS	
		3		79.7	0.004	0	0.004		SM/RS	
		4		79.703	0.007	0	0.007		SM/RS	
		5		79.712	0.016	0	0.016		SM/RS	
		7		79.729	0.033	0	0.033		SM/RS	
		10		79.751	0.055	0	0.055		SM/RS	
		15		79.782	0.086	0	0.086		SM/RS	
		20		79.803	0.107	0	0.107		SM/RS	
		25		79.818	0.122	0	0.122		SM/RS	
		30		79.831	0.135	0	0.135		SM/RS	
		40		79.846	0.15	0	0.15		SM/RS	
	1200	60		79.865	0.169	0	0.169		SM/RS	
		80		79.875	0.179	0.004	0.183		SM/RS	
	1300	120		79.889	0.193	0.005	0.198		SM/RS	
	1400	180		79.898	0.202	0.014	0.216		SM/RS	
	1500	240		79.897	0.201	0.023	0.224		SM/RS	79.897(RS), 79.898(SM)
	1600	300		79.898	0.202	0.029	0.231		SM/RS	
	1704	364		79.894	0.198	0.034	0.232		TB	new probe
	2100	600		79.915	0.219	0.029	0.248		TB	
10/10/96	50	830		79.918	0.222	0.039	0.261		TB	
	520	1100		79.912	0.216	0.064	0.28		TB	
	1051	1431		79.928	0.232	0.059	0.291		NP/TB	pump off: 1440min
		0.5		79.925	0.229				NP/TB	
		1		79.925	0.229				NP/TB	
		1.5		79.925	0.229				NP/TB	
		2		79.925	0.229				NP/TB	
		3		79.92	0.224				NP/TB	
		4		79.913	0.217				NP/TB	
		5		79.908	0.212				NP/TB	
		7		79.891	0.195				NP/TB	
		10		79.868	0.172				NP/TB	
		15		79.839	0.143				NP/TB	
		20		79.82	0.124				NP/TB	
		25		79.803	0.107				NP/TB	
		40		79.774	0.078				NP/TB	
	1200	60		79.753	0.057				NP/TB	