H21 Appendix: Bore Construction Requirements

Part A: Groundwater Bores

Pumping Test Specifications

1.0 Scope

This specification outlines the minimum standards for pump testing water bores and reporting test results for water bores situated in the Gisborne region.

2.0 Scope

2.1 A pump test shall be performed in a production water bore to estimate the aquifer transmissivity and aquifer storage coefficient and the specific capacity of the bore. The bore efficiency may also be determined.

2.2 A pump test must be performed for all new bores.

3.0 Types of Pump Testing

3.1 The two most common methods of pump testing are outlined below. In general these will be the only testing methods acceptable to the Council. If the production bore being tested is unable to be tested by one of these methods, other means of testing must first be approved by the Council.

3.2 The testing described below allows useful measurements to be obtained from the production bore and any nearby observation bores. An observation bore is a bore that is also monitored while the production bore is being pumped. It may include other users' bores.

3.3 *Constant Discharge Tests*.

A constant discharge testis one in which the bore is pumped for a certain length of time at a constant rate. Water level measurements are taken at varying time intervals during the period of the test. The best constant discharge tests have at least the following characteristics:

i. Water level measurements are taken at observation bores in addition to levels at the pumped bore.

ii. The bore is pumped at a rate greater than or equal to that required for the production flowrate.

iii. Water level measurements are continued when the pump is switched off at the same intervals as those made when the pump was first started.

iv. The discharge rate is kept constant during the entire period of the pump test. Normal flow variations should be no more than +/- two percent

3.4 *Step Drawdown Tests*

Step drawdown tests are those in which the bore is pumped at different rates (steps) during the period of the test. Measurements are taken at varying intervals, with the most intensive rate being just after the beginning of each step. The best step drawdown tests have the following characteristics:

i. The bore is pumped in five steps. If the planned production flowrate is Q then the steps are 1.25 Q, 1.0 Q, 0.75 Q, 0.5 Q, 0.25 Q.
ii. Water level measurements are taken at other (observation) bores in addition to those in the pumped bore during the drawdown part of the test.
iii. The discharge rate is kept consistent during each step in the pump test. Normal flow variations should be no more than +/- two percent.
iv. The discharge should be recorded at the same time as the water level measurement.

4.0 Measurements Required

4.1 There are a number of measurements common to all pump tests which must be recorded. The three most common are time of measurement, water level and flowrate. For pump tests that are longer than twelve hours records of other pumping in the area, air pressure changes, amount of rainfall, tide times, floods and other phenomena likely to affect the bore water levels should be kept. The easiest method of recording all the information is in tabular form. This information should be kept together with other records for the bore.

4.2 The exact time of each measurement should be noted. All time measurements should be synchronised with a master watch or clock. Watch accuracy should be to within one minute in 24 hours.

5.0 Methods of Discharge Measurement

5.1 The rate of discharge of the pump can be measured by using an in-line flow meter, an orifice weir, a weir box, or a container of a known size. Instruments used for measuring the flowrate should be accurate to within +/-five percent of the actual flow.

5.2 The in-line flow meter should be installed according to the manufacturer's instructions. It must always be running full to read correctly. Most meters show the total flow pumped on a counter. In this case the total pumped at, say, one minute intervals should be noted. Use the difference to calculate the flowrate.

5.3 An orifice weir is a pipe with an accurately machined orifice plate through which the water is discharged into the atmosphere. Just upstream of the plate the pressure head is measured and related to a calibration table for the particular plate. This table may be obtained from a textbook.

5.4 A weir box works similarly. The water level above the weir notch is measured at the weir in the box. This level indicates a particular discharge depending on the type of weir used. Tables are available from textbooks.

5.5 Using a container works like the flow meter method. Measure the time it takes to fill the container, say a 200 litre drum, and then calculate the flowrate.

6.0 Methods and Rates of Water Level Measurement

6.1 The static water level is best measured by an electric plumb bob. This is normally a ribbon tape similar to TV – wire; but less susceptible to stretching; with a battery and a light, ammeter, or buzzer attached to make a circuit. When the bared ends touch water the circuit is completed. Normally the tape is marked off, and the depth to water level can be read off at the measurement point on the bore head.

6.2 Measurement of the static water level should be to within an accuracy of +/- 5% or +/- 2mm whichever is smaller. The bore must be pumped in such a way that the water level can be measured in the pumped bore.

6.3 The water level must be measured frequently near the beginning of a test, with intervals decreasing as the test continues. The recommended intervals for the pumped bore and observation bores are as follows:

TABLE ONE
Recommended Intervals for Measuring Drawdown and Recovery in the Pumped Bore During a Pump Test

Time Since Start or End of Test in Minutes	Time Intervals Between Measurements (Minutes)
0 – 10	0.5 – 1
10 – 15	1
15 – 60	5
60 – 300	30
300 – 1440	60
1440 – end of test	480 (8 hours)

TABLE TWO
Recommended Intervals for Measuring Drawdown in the Observation Bores During a Pump Test

Time Since Start or End of Test in Minutes	Time Intervals Between Measurements (Minutes)
0 – 60	2
60 – 120	5
120 – 240	10
240 – 360	30
360 – 1440	60
1440 – end of test	480 (8 hours)

6.4 Ensuring that measurements are made at exactly the right time interval is not as important as noting the exact time of the measurement.

7.0 Other Records

7.1 Some bore water levels are affected by other atmospheric and climatic conditions. Some of these conditions include air pressure, tide times, daily rainfall, river levels or the water level in a nearby drain. As well as noting this information water levels in the pumped bore must also be recorded.

7.2 It is good practice to note the conditions for some days before and after the pump test. This information can be important as the length of the pump test increases. Sometimes corrections must be made to the water level data. Prior to pump testing bores must be shut down for a period of not less than 24 hours.

7.3 Bores used for the test should be shut down and levels measured for some days prior to the test.

8.0 Pumping Methods

8.1 The methods used for pumping or adding water to the production bore shall not prevent the static water level in the bore being measured.

9.0 Disposal of Pumped Water

9.1 The water pumped from a bore during a pump test must be allowed to flow off site in a safe and efficient manner. If the pump test is being conducted in an unconfined aquifer the waste water must not be allowed to drain back into the aquifer.

9.2 In general water should be discharge to waste over 200 metres from the test site in an unconfined aquifer. In a confined aquifer water should be piped to waste at least 100 metres from the test site.

10.0 Length of Pump Test

10.1 Ideally, pumping tests should be continued until equilibrium is reached, that is, until the cone of depression stabilises. This means that the water levels in the observation bores and the pumped bore are steady or fluctuate around a steady average figure. In practice this is rarely possible.

10.2 In confined aquifers, the cone of depression spreads rapidly because no actual dewatering takes place; only a pressure reduction is occurring outward from the bore. Thus, 24 hours is usually sufficient to record enough reliable data for confined aquifers. Aquifers shallower than 20 metres below ground surface should be pumped for up to 72 hours. Many of these shallow artesian aquifers may be connected to water table aquifers overlying them.

10.3 To gain enough information for unconfined aquifers, 72 hours are usually required to dewater the materials within the cone of depression, because of the slow downward percolation of water in many stratified deposits. This time can be reduced if equilibrium conditions are established before 72 hours have elapsed.

10.4 In general, pumping should not be stopped early because the limited data may not reveal the true extent of the aquifer. This condition will usually be relaxed if the water level has stabilised.

10.5 Listed below are the time requirements for pump testing. Water level recovery must be measured for the same period of time, once the pumping is complete.

TABLE THREE
Length of Pump Testing Required for Different Water Uses

Water Use	Bore Depth	
	0 – 20m	>20m
Stock/ Domestic	4 hours	4 hours
Horticultural	72 hours	24 hours
Municipal/ Community/ Industrial	7 days	7 days

10.6 Stock or domestic use is generally less than 100 m^3/day, horticultural use is usually less than 1000 m^3/day while municipal, industrial and community uses are usually greater than 1000 m^3/day.

10.7 Municipal water supply requirements may often dictate substantially longer testing (eg months in the case of towns or cities). For stock or domestic use the quantities of water required are usually so small that drawdown may have stabilised after two or three hours of pumping.

11.0 When to Pump Test

11.1 The best time to pump test is when no other bores in the area which would affect the water level in the production bore are pumping. If other bores are pumping in the area, it may be possible to have them pumped at a constant rate for the entire length of the pump test. Measurements can then be corrected for the effect caused by others pumping. If other pumping cannot be controlled, the test should only be run when the other pumping does not affect the bore being tested.

11.2 A new bore should not be pump tested until it has been completely developed. Development is generally regarded as complete when water pumped from the bore is relatively sand free. Often bores are tested before development is complete, which will make the results of a pump test worthless. During the development phase of bore construction measurements can be made at nearby bores. These may indicate which ones are affected and could be used as observation bores during the pump test.

11.3 It is most important to have information about water levels for some days before and after ('background measurements') the pump test. This data will allow corrections to be made to measurements recorded during the pump test. The time and date that the measurement is made should also be recorded.

12.0 Reporting of Results

12.1 Results shall be reported to the Council at least in tabular and graphical format. Tables shall include the time and date of all measurements. Results in computer readable format may be acceptable. Graphs shall be labelled showing what each axis represents.

12.2 Analysis of results shall be according to standard aquifer pump test analysis methods. The analysis methods shall be noted in the report.

12.3 The report shall include the name of the analyst, a site description, location plan, pumping conditions together with details of the equipment used for the test.

13.0 Conduct of the Pump Test

13.1 The Council shall be given at least 24 hours notice of the start of the test. An officer of the Council may view the arrangements for a pump test.

13.2 Results from pump tests which have not met any or some of these specifications may not be accepted by the Council.

Water Quality Sampling and Analysis Specifications

1.0 Scope

1.1 This specification outlines the minimum standards for the collection of samples of underground waters for chemical and bacteriological analysis. The minimum standards required for these analyses are also covered in this specification.

1.2 Water samples are analysed to aid in aquifer identification and to determine the degree of pollution of underground water. Samples taken some time apart can indicate whether water quality is improving or not.

2.0 Water Quality Sampling

2.1 Sampling shall be carried out in accordance with procedures laid down by the laboratory conducting the water quality analyses.

2.2 In general the bore should have water discharged to waste equivalent to at least one casing volume before a sample is taken. Up to 20 times the volume of water able to be stored in the bore should be discharged before the sample is taken, although this may not always be practicable. The casing volume is the volume contained in the bore between the water surface and the bottom of the lowest screen.

2.3 In the table following this specification a guide is provided to show the volume of water stored in casings of particular diameters and lengths.

3.0 Water Quality Analysis

3.1 Water quality analyses shall be carried out by a IANZ accredited laboratory using standard methods.

3.2 As a condition of a water right application for a take from a new bore two samples must be analysed. The first sample shall be taken just after the start of a pump test being performed to the Council's specification. The second shall be taken just before the completion of the same pumping test.

3.3 The following parameters shall be reported for water samples from bores requiring a water right:

Bacteriological analyses:

- E coli

Chemical analyses:

- pH, temperature, conductivity, total dissolved solids, calcium and magnesium hardness, total iron, chlorides, sulphates, nitrates, dissolved oxygen, dissolved carbon dioxide, manganese, alkalinity, ammonia, dissolved reactive phosphorous.
- Any analysis shall show who collected the sample at the bore head and who conducted the chemical and bacteriological analysis.

Bore Depth	25	50	75	100	125	150	175	200	225	250	275	300	325	350
5	2	10	22	39	61	88	120	157	199	245	297	353	415	481
10	5	20	44	79	123	177	241	314	398	491	594	707	830	962
15	7	29	66	118	184	265	361	471	596	736	891	1060	1244	1443
20	10	39	88	157	245	353	481	628	795	982	1188	1414	1659	1924
25	12	49	110	196	307	442	601	785	994	1227	1485	1767	2074	2405
30	15	59	133	236	368	530	722	942	1193	1473	1782	2121	2489	2886
35	17	69	155	275	430	619	842	1100	1392	1718	2079	2474	2904	3367
40	20	79	177	314	491	707	962	1257	1590	1963	2376	2827	3318	3848
45	22	88	199	353	552	795	1082	1414	1789	2209	2673	3181	3733	4330
50	25	98	221	393	614	884	1203	1571	1988	2454	2970	3534	4148	4811
55	27	108	243	432	675	972	1323	1728	2187	2700	3267	3888	4563	5292
60	29	118	265	471	736	1060	1443	1885	2386	2945	3564	4241	4977	5773
65	32	128	287	511	798	1149	1563	2042	2584	3191	3861	4595	5392	6254
70	34	137	309	550	859	1237	1684	2199	2783	3436	4158	4948	5807	6735
75	37	147	331	589	920	1325	1804	2356	2982	3682	4455	5301	6222	7216
80	39	157	353	628	982	1414	1924	2513	3181	3927	4752	5655	6637	7697
85	42	167	376	668	1043	1502	2044	2670	3380	4172	5049	6008	7051	8178
90	44	177	398	707	1104	1590	2165	2827	3578	4418	5346	6362	7466	8659
95	47	187	420	746	1166	1679	2285	2985	3777	4663	5643	6715	7881	9140
100	49	196	442	785	1227	1767	2405	3142	3976	4909	5940	7069	8296	9621
105	52	206	464	825	1289	1856	2526	3299	4175	5154	6237	7422	8711	10102
110	54	216	486	864	1350	1944	2646	3456	4374	5400	6534	7775	9125	10583
115	56	226	508	903	1411	2032	2766	3613	4572	5645	6831	8129	9540	11064
120	59	236	530	942	1473	2121	2886	3770	4771	5890	7127	8482	9955	11545
125	61	245	552	982	1534	2209	3007	3927	4970	6136	7424	8836	10370	12026
130	64	255	574	1021	1595	2297	3127	4084	5169	6381	7721	9189	10784	12507
135	66	265	596	1060	1657	2386	3247	4241	5368	6627	8018	9543	11199	12989

INSTRUCTIONS FOR USE

The top line shows the diameter of the bore in millimetres. The first column shows the depth of the bore in metres.

Where the intersection of the column showing diameter and the row showing depth meet is the volume of the bore casing in litres.

For water quality sampling the bores should have at least one casing volume removed before a sample is taken. Ideally up to 20 times the volume of the bore should be discharged before the sample is taken, although this may not be practically possible.

Water Bore Construction Specifications

1.0 Scope

1.1 This specification outlines the minimum construction and reporting standards for water bores in the Gisborne region.

1.2 It must be noted that there may be additional reporting requirements if the use of the bore requires a water permit.

2.0 Bore Resource Consent

2.1 A resource consent issued by the Gisborne District Council is required before the drilling of water supply bores may commence. The resource consent shall be available for inspection by Council staff.

3.0 Bore Records and Samples

3.1 A written bore log shall be supplied to the Council on completion of drilling operations. Logs of partially completed holes should also be supplied. The bore log shall record the materials penetrated to the nearest 100 millimetres.

3.2 A casing and screen location record shall be supplied with the bore log. This record shall show the dimensions of each casing and screen section and the location of packers, plugs and seals.

3.3 Bore logs should be supplied to the Council even when insufficient water is available for the required purposes. This will help the Council build up a record of the geology of different parts of its area.

3.4 The results of any other tests on the aquifer formation or the groundwater shall be supplied to the Council. Such testing may include:

- Water quality analyses
- Geophysical logging
- Particle size analyses
- Pumping tests

3.5 Samples of the strata encountered may also be supplied to the Council. Samples should be completely and accurately identified with a label. The location of the bore, the depth from which the sample was taken, the thickness of the material that it represents, and its sequence in the bore log shall be noted on the label.

3.6 All logs provided shall be signed and dated by the person who performs the logging.

3.7 A properly completed New Zealand Water Bore Data Form shall be supplied for the bore.

4.0 Bore Construction, Reconstruction and Maintenance Requirements

4.1 All equipment used for drilling and bore or well construction, and their maintenance, shall be kept clean to prevent the entry of contaminants to groundwater.

4.2 The driller shall have available manufacturers' guidelines and material safety sheets for chemicals, drilling fluid additives, grout materials. This shall include instructions for handling, preparation, use, potential hazards, and disposal requirements for the materials and their containers.

4.3 The construction of the bore shall not allow the leakage of water from one water bearing formation to another. In practice this will mean that some form of grouting will be required to prevent water leakage between water bearing layers at different levels.

4.4 The construction of the bore shall not allow surface water to enter the bore via the bore lining. In practice this requirement will mean that a concrete pad, which slopes away from the bore liner, shall be installed at the bore head.

4.5 Flood waters and ponded surface waters must be prevented from entering the bore liner. A cap which prevents the ingress of water may be fitted to the bore liner. An alternative method is to allow sufficient liner to extend above the highest known or estimated flood level in the location of the bore.

4.6 The bore liner at the bore head shall prevent the egress of water if the bore is a flowing artesian bore.

5.0 Drilling Fluids and Additives

5.1 Drilling fluid must not be discharged directly to water.

5.2 Drilling fluid must be discharged to land, with measures taken to ensure that there is no runoff into surface waterways.

5.3 Water used for drilling fluid shall be free of substances or contaminants that may adversely affect the strength of the grout or grout setting time.

5.4 Bentonite shall contain no added substances that may adversely affect the strength of the grout or grout setting time, or result in a discharge that affects groundwater quality.

5.0 Bore Casing

5.1 All casing materials used (including temporary casing) shall be suitable in terms of its composition, cleanliness, strength and corrosion resistance for site and installation conditions, and the use of the bore,

5.2 Bore casing shall be secure, leak-proof, and suitable to withstand the stress of installation, bore testing and bore use.

6.0 Bore Grouting

6.1 All grout materials used shall be suitable in terms of composition, density, strength and corrosion resistance for the site and installation conditions.

6.2 Grout additives that could leave a residual toxicity in groundwater shall not be used.

6.3 Water used for grouting shall be free of substances or contaminants that may adversely affect the strength of the grout or grout setting time.

6.4 In artesian conditions suitable grouting shall be performed to prevent water leakage between geological formations. Water leakage between water bearing formations is not acceptable.

6.5 When conditions become sub-artesian in some deeper aquifers the possibility exists that water may leak from the higher aquifers into the lower aquifers. Suitable grouting shall be performed to prevent this possibility.

6.6 In practice these requirements will mean that grouting must be performed from the confining layer immediately above the water bearing layer which is being tapped up to ground surface.

7.0 Bore Screen Selection and Installation Procedure

7.1 All screen material (including temporary screen material) shall be suitable, in terms of its composition, cleanliness, strength and corrosion resistance for the site and installation conditions and the use of the bore.

7.2 The selection procedure will take into account the amount of water required, the composition of the formation from which water is being extracted, the likely yield of the formation, and the quality of the water in the formation.

7.3 The screen shall be securely sealed to the casing to prevent entry of rock or soil or gravel pack material into the bore.

8.0 Filter Pack Selection and Emplacement Procedure

8.1 If required, an appropriate filter pack shall be selected and placed in position. This procedure will take into account the amount of water required, the composition of the formation from which water is being extracted, the depth of the bore and the method of bore construction.

9.0 Bore Plumbness and Alignment

9.1 During construction the bore must be kept vertical and straight within practical limits. A reasonable standard of vertical deflection is 1%. Often the type of pump to be installed will require different standards of plumbness and alignment.

9.2 As an example, in a bore 25 metres deep a one percent vertical deflection will mean that the bottom of the bore will be 250 millimetres off-centre compared with the top of the bore.

10.0 Bore Development

10.1 The development of the bore shall remove silts, clays, and residual drilling fluid from the face of the bore and from the aquifer.

10.2 The bore shall be developed to provide maximum specific capacity.

11.0 Pump Testing

11.1 If the bore is to be used for purposes that require a water right to be issued, a pump test shall be carried out that meets the requirements of the Council's pumping test specifications.

11.2 Listed in Table One (below) are the recommended time requirements for pump testing. Water level recovery should be measured for the same period of time, once the pumping is complete. Changes may need to be made to these recommended pumping times in individual circumstances.

TABLE ONE
Time Requirements for Pump Testing in the Gisborne Region

Water Use	Bore Depth	
	0 – 20m	>20m
Stock/ Domestic	4 hours	4 hours
Horticultural	72 hours	24 hours
Municipal/ Community/ Industrial	7 days	7 days

12.0 Bore Disinfection

12.1 The disinfection of a bore for the purposes of maintaining or improving the yield shall be carried out in such a manner as to prevent harmful amounts of chemicals entering the groundwater in the vicinity. All chemicals shall be prepared and used in accordance with the manufacturer's instructions.

12.2 The disinfection of a bore after drilling is completed must be carried out to prevent contamination of lower aquifers by bacteria from other sources, e.g. drill rods, soil, drilling fluid.

13.0 Water Quality Sampling and Analysis

13.1 If the bore is to be used for purposes that require a water permit to be issued, a water quality test shall be carried out that meets the requirements of the Council's water quality testing specifications.

13.2 Any water quality sampling and analysis should be carried out in accordance with the Council's specifications for sampling of bore waters.

14.0 Inspection Requirements

14.1 The Council shall be given 24 hours notice of commencement of the bore construction.

14.2 A representative of the Council may require to be present to observe that the grouting of the bore is satisfactorily performed.

14.3 All bores shall allow for access by Council staff to measure water levels and obtain water samples.

14.4 All bores that are sub-artesian shall have a 25 millimetre diameter inspection hole fitted at the bore head, which shall allow unobstructed access for a probe to measure the water level in the bore.

14.5 All bores that are continuously flowing artesian shall be capped to prevent wastage of water. The cap shall have an access socket fitted which shall allow the fitting of a pressure gauge or piezometer tube for the measurement of the water pressure.

14.6 Bores that are flowing artesian for part of the year and sub-artesian at other times shall have fittings installed as set out in sections 14.2 and 14.3 above.

15.0 Bore Abandonment

15.1 The bore shall be filled and sealed in such a manner as to prevent accidents and to prevent it from acting as a conduit through which water may travel and/or mix with water from other geological formations.

15.2 In general, the following procedure must be followed where a bore is to be abandoned.

15.3 Any casing and screen that is not salvaged shall be perforated with a casing ripper. The upper 1.5 metres of casing shall be completely removed from the borehole.

15.4 The bore shall be sealed by concrete, cement grout, or neat cement and shall be placed from the bottom upwards by a suitable method.

15.5 The upper 1.5 metres shall be filled with topsoil from the surrounding area.