REPT.BK.NO. 78/36

KINGSTON TOWN WATER SUPPLY COMPLETION REPORT FOR WELL NO. 11

- E. & W.S. Department -

A.F. WILLIAMS

Department of Mines and Energy
South Australia —

DEPARTMENT OF MINES & ENERGY
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENGINEERING DIVISION

KINGSTON TOWN WATER SUPPLY
COMPLETION REPORT FOR WELL NO. 11

Client: Engineering & Water Supply Department

by

A.F. WILLIAMS
GEOLOGIST

Rept.Bk.No. 78/36
G.S. No. 6010
DM. No. 397/76
Eng.No. 1977/NA9

CONTENTS

	PAGE
ABSTRACT	1
INTRODUCTION	1
DRILLING AND COMPLETION PROCEDURES	2
GEOLOGY AND HYDROGEOLOGY	2
WELL, AQUIFER TESTING	3
SAFE YIELD	4
WATER QUALITY	4
LEAKAGE THROUGH CONFINING BEDS	5
CONCLUSIONS AND RECOMMENDATIONS	5
REFERENCES	7

TABLES

1. Summary of well details. 1A

APPENDICES

1. Screen selection - Kingston No. 11.

2. Drilling Supervisor's report.

3. Well log.

4. Step drawdown and main test calculations.

5. Full analysis details.

PLANS

Fig. No.		Drawing No.
1	Locality Plan - Kingston area.	S13320
2	Locality Plan - Kingston well field.	78-249
3	Well Construction details.	S13321
4	Drawdown curves for various pumping rates.	S13322
5	Time/drawdown data for constant discharge test.	78-250

BIBLIOGRAPHY INDEX

1 | 4 ACCESSION NUMBER | 10 TYPE OF WORK: 1 | 12 SECURITY | 15 FILE NO.: 1 7 8 / 3 6 | 21 PUBLIC. CODE | 24 SERIAL OR VOLUME NO. | 30 PAGES: 7 | 39 ILLUSTS & MAPS & PLANS: 4 | 41 YEAR: 1978 | 44

POINT LOCATION | 64 LATITUDE OR EAST | 71 LONGITUDE OR NORTH | 79 ZONE

CLIENT:

1 2 | 10 TITLE: KINGSTON TOWN WATER SUPPLY COMPLETION REPORT FOR WELL NO 1 1/E OF W.S. DEPARTMENT (S FEGS)

1 3 | 10 ORGAN. OR COMPANY | 14 AUTHORS: ~~A F~~ WILLIAMS, A F.

1 3 1 | 10 AUTHORS

1 4 | 10 MAP REFERENCES: 6824 ~~6021~~

1 5 | 10 SOUTH EAST ~~KINGSTON~~ | 14 KINGSTON | 18 | 22 | 26 | 30 | 34 39 LICENCE AREA

LOCALITIES

1 3 5 1 | 40 43 47 51 55: 450 / ~~450~~ SECTIONS | 59 62 66 70 74 SECTIONS

LACEPEDE HUNDRED

1 6 | 10 15 MAJOR KEYWORD: ~~KINGSTON~~ HYDROGEOLOGY

34 39: DILWYN FORMATION

58 63: LEAKY AQUIFER ~~LEAKAGE (SUBSURFACE)~~ 498

1 3 6 1 | 10 15: GEOL LOG

34 39

58 63

16 21: WATER SUPPLY

40 45: SAND

64 69: WATER QUALITY

16 21: CABLE TOOL DRILLING

40 45

64 69

KEYWORDS

DRILLING ~~GROUND WATER~~ HUNDRED

22 27: ~~AQUIFER (CONFINED)~~

46 51: SAND SCREENS

WELL ~~DISCHARGE~~ TEST

70 75: WELL COMPLETION REPORT

22 27: WATER ANALYSIS

46 51

70 75

28 33: AQUIFER (CONFINED)

52 5: WATER WELL TESTING/PROD WELL ~~DISCHARGE~~ TEST

28 3: SAFE YIELD

52 5

INDEXED BY . . . . . DATE . . . . . CHECKED Ly DATE 20-7-78

ACCESSION NUMBER REPEATED ON EVERY CARD

DEPARTMENT OF MINES & ENERGY
SOUTH AUSTRALIA

Rept.Bk.No. 78/36
G.S. No. 6010
DM. No. 397/76
Eng.No. 1977/NA9

KINGSTON TOWN WATER SUPPLY
COMPLETION REPORT FOR WELL NO. 11

ABSTRACT

A new production well has been drilled near the south eastern end of the existing well field, to augment the town water supply. Permeable sand was intersected in the confined aquifer at a depth of 58 m and the well has been completed with a stainless steel well screen. Pressure cemented casing has been used to seal off the overlying Gambier Limestone aquifer as a protection against possible contamination by overlying more saline water.

The 42-hour production test showed a safe yield of 1 050 kl/day for continuous pumping; this yield could be increased to 1 300 kl/day for 12-16 hours, allowing for overnight recovery.

Water quality is in the range 750 to 850 mg/l Total Dissolved Solids and appears suitable for most domestic purposes. Checks for groundwater leakage down through the confining layer, by comparison with published type curves, indicate that this possibility is unlikely. Readings taken from a nearby observation well show that only slight interference effects may be expected on the other production wells.

INTRODUCTION

In September, 1976, the Engineering and Water Supply Department requested a new town water supply well to augment Kingston's reticulation scheme. Existing wells are sited east of the town along a road reserve parallel to the Kingston - Naracoorte Railway (Figs. 1 and 2). A site for the new well, known as Kingston No. 11, was selected along this same line and midway between production wells Nos. 6 and 9 as outlined in a review of the well field by Williams (1977). This report describes the drilling, completion and testing of Kingston No. 11.

DRILLING AND COMPLETION PROCEDURES

Drilling commenced on 23/8/77 and was completed on 3/11/77, total depth being 71 m. 203 mm casing was pressure cemented to 57 m in a clay confining layer (see later). Further drilling yielded good aquifer sands from 59 to 67 m - samples of which were sieved and a suitable screen selected (Appendix 1). A completion report by the drilling supervisor appears in Appendix 2 and construction details are shown in Fig. 3. Water levels rose to just above surface on completion, fluctuating continuously through effects of nearby pumping wells.

A summary of well details is given in Table 1.

GEOLOGY AND HYDROGEOLOGY

A summary of the stratigraphic intervals intersected in Kingston No. 11 is as follows:

Interval (m)	Thickness (m)	Unit
0 - 13	13	Pleistocene to Recent soil/calcrete/ limestone, sand and gravel-shelly unconfined aquifer.
13 - 48?	35	Gambier Limestone - bryozoal (fossiliferous) limestone, some silt and marl - unconfined aquifer.
48 - 56	8	Narrawaturk Marl (formerly Lacepede Formation) glauconitic silts, marly, limestone at top - confining bed.
56 - 68	12	Mepunga Formation (formerly Kongorong Sand) - sands and gravels, reasonably clean - confined aquifer.
68 - 71+	3+	Dilwyn Formation? - brown clays - probably close to basement.

TABLE I

SUMMARY OF WELL DETAILS

(all depths below ground level)

Depth:	71 m
Casing:	254 mm ID to 26 m. 203 mm to 57 m pressure cemented to surface. 127 mm casing 51.1 - 59 m. 111 mm ID wire wound sandscreen from 59 - 65.2 m, 2 mm aperture.
Static Water Level:	Just flows
Interval Tested:	59 - 65.2 m
Recommended Safe Yield:	(i) 1 050 kl/day (12 l/sec) (ii) 1 300 kl/day (15 l/sec) for 12-16 hours maximum.
Recommended pump depth:	(i) 40 m (ii) 50 m
Pumping water level:	(i) 38 m after 16 hours (ii) 46 m " " "
Water salinity:	750 - 850 mg/l
Aquifer:	Confined sands

A well log appears in Appendix 3. The confined aquifer interval here is rather more gravelly than that intersected in town water supply wells No. 6 and 9, hence a coarser screen slot width (2 mm) was selected.

WELL, AQUIFER TESTING

A 3 x 100 minute step drawdown and a 42 hour constant discharge test were carried out between 20/10/77 and 26/10/77; results are outlined in Appendix 4. Since well No. 11 is situated within an existing production well field, precautions were taken to avoid interference from nearby wells in operation during the test.

Production well Nos. 4 and 8 (990 m and 1 370 m from No. 11 respectively) were pumped to satisfy township demand rather than the nearer wells, Nos. 6 and 9 (550 m and 450 m from No. 11). Little interference occurred except at the very end of the main test (see Appendix 4, Fig. 4); readings at observation well No. 9A (460 m from No. 11), showed a pressure drop of about 7 kpa over the 42 hour period.

SAFE YIELD

Safe yield of the well is calculated as about 1 050 kl/day (12 l/sec). Fig. 4 shows drawdown vs time for various pumping rates and indicates that above this figure of 12 l/sec, drawdown rises to over 40 m. Since available drawdown is 57 m (before aquifer dewatering occurs) it would be unwise in any one pumping cycle to pump for more than 24 hours at a rate above 1 300 kl/day (15 l/sec). The well could be pumped at 15 l/sec under normal practice i.e. for 12-16 hours/day, with recovery overnight. Recommended pump settings for the two rates of 1 050 and 1 300 kl/day are given in Table 1.

WATER QUALITY

Analysis of confined aquifer water during well testing shows Total Dissolved Solids content as 750 - 850 mg/l. Hardness is rather high at about 250 mg/l and the use of water softeners is recommended. Details of full analyses, carried out by AMDEL, are given in Appendix 5.

LEAKAGE THROUGH CONFINING BEDS

In some areas around Kingston, unconfined aquifer water can be quite saline down to the top of the confining beds. In such a case where the producing aquifer may be only semi-confined, pumping may induce downward movement of this saline water as head reversals of up to 30-40 m may occur. Therefore the unconfined aquifer was sampled at regular intervals with casing following just behind the bit. Results showed similar quality water to the confined aquifer from about 8 m below surface with the exception of uppermost water which exceeded 7 000 mg/l. A sample taken after bailing for 15 mins from a depth of 48 m shows similar chemical characteristics to those from the confined aquifer taken during the well testing, although overall hardness is less (see Appendix 5). In addition, to check for leakage, the main test drawdown data, minus well losses, were plotted on log/log paper and compared with type curves for semi-confined aquifer given in Kruseman and De Ridder, 1970 (p.82). This method gives the behaviour of a hypothetical observation well and the result (Fig. 5) shows the curve still rising after 18 hours and $^{r}/_{B}$ less than 0.1. If leakage was significant the curve should flatten out earlier giving an $^{r}/_{B}$ value greater than 1.

CONCLUSIONS AND RECOMMENDATIONS

Well testing of Kingston No. 11 showed it to have a safe yield of 1 050 kl/day (12 l/sec). Provided it is not pumped for periods greater than 12 - 16 hours, a higher rate 1 300 kl/day (15 l/sec) would be satisfactory. Recommended pump settings for the two rates are 40 and 50 m.

Water quality is 750 - 850 mg/l satisfactory for most garden and domestic usage.

A.F. Williams

AFW:FdeA
4/4/78

A.F. WILLIAMS
GEOLOGIST

REFERENCES

Aaron, G. and Scott, V.H., 1966. Analysis of data from stepwise throtted pump test. J. Hydraulics Div. A.C.S.E., 92 : 95-99.

Hazel, C.P., 1973. Lecture notes on Groundwater Hydraulics. Publ. by Irrigation and Water Supply Commission, Queensland.

Kruseman, G.P. and De Ridder, N.A., 1970. Analysis and Evaluation of pumping test data. Publ. by International Institute for Land Reclamation and Improvement. Wageningen, Netherlands.

Williams, A.F., 1977. Groundwater Resources for South East town water supplies. Review No. 1 - Kingston S. Aust. Dept. Mines RB 77/23 - unpublished.

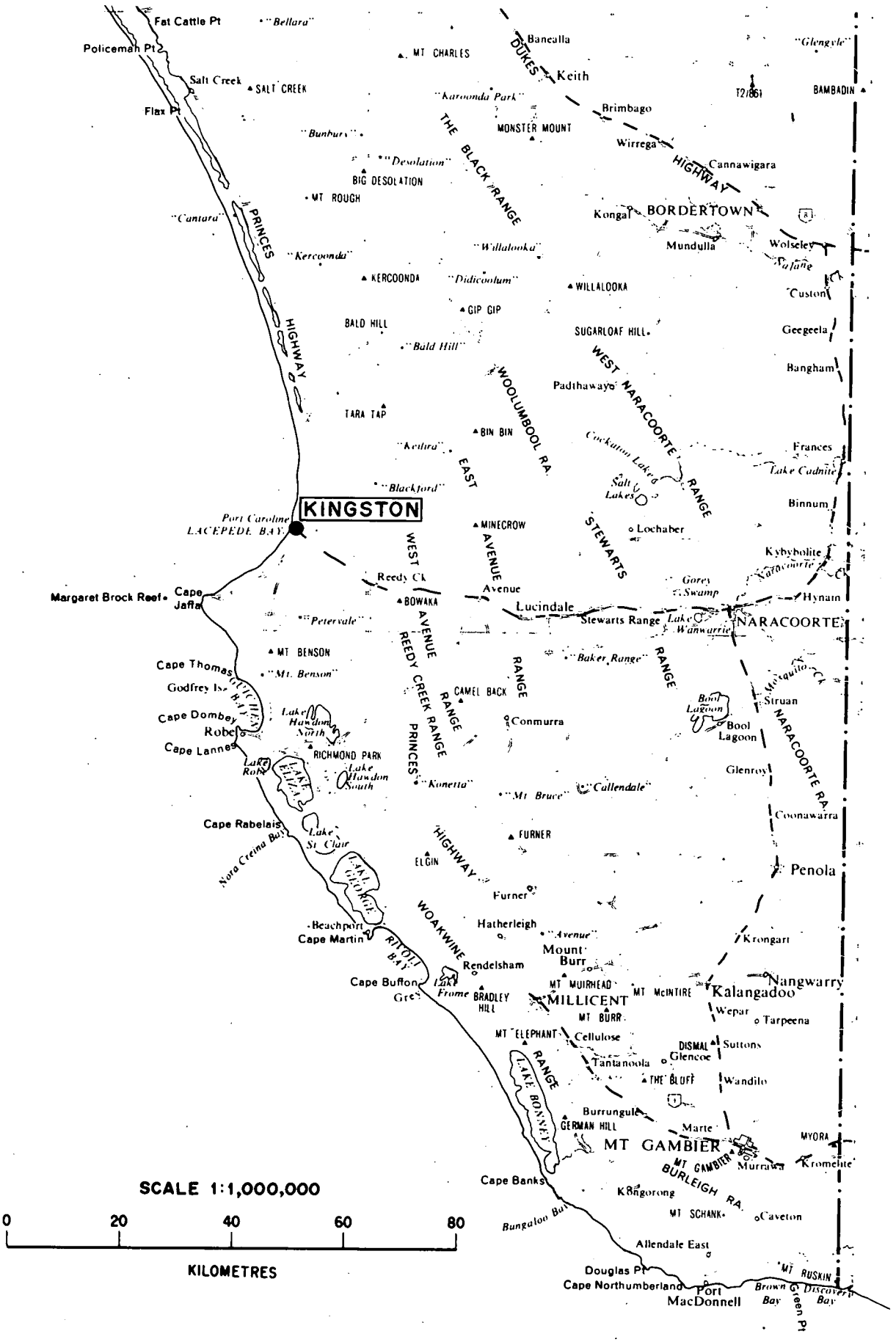


FIG. 1

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE AS SHOWN
COMPILED A.F.W.	KINGSTON TOWN WATER SUPPLY INVESTIGATION	DATE 29/3/78
DRN R.H. CKD	LOCALITY PLAN	PLAN NUMBER S 13320

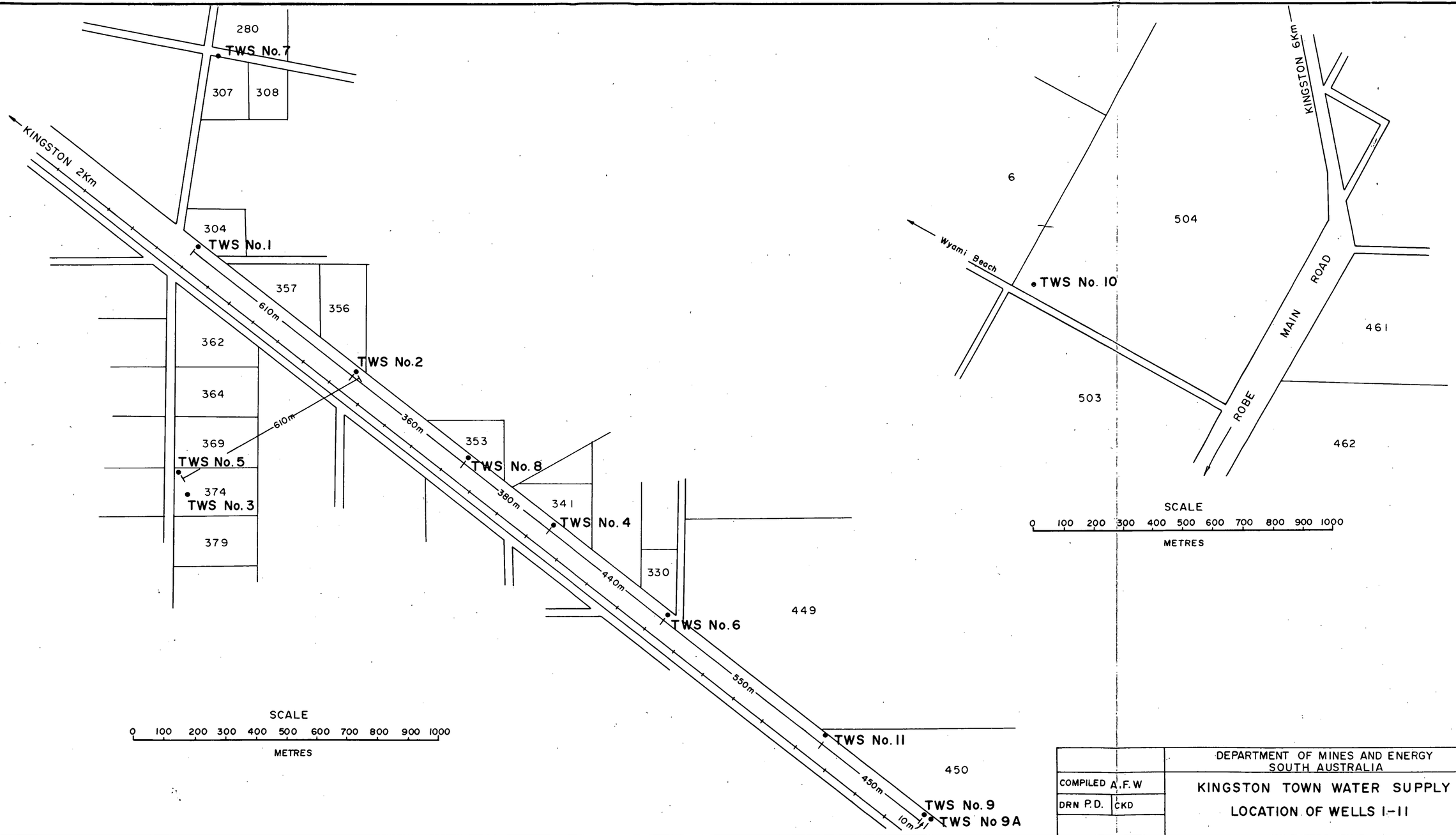
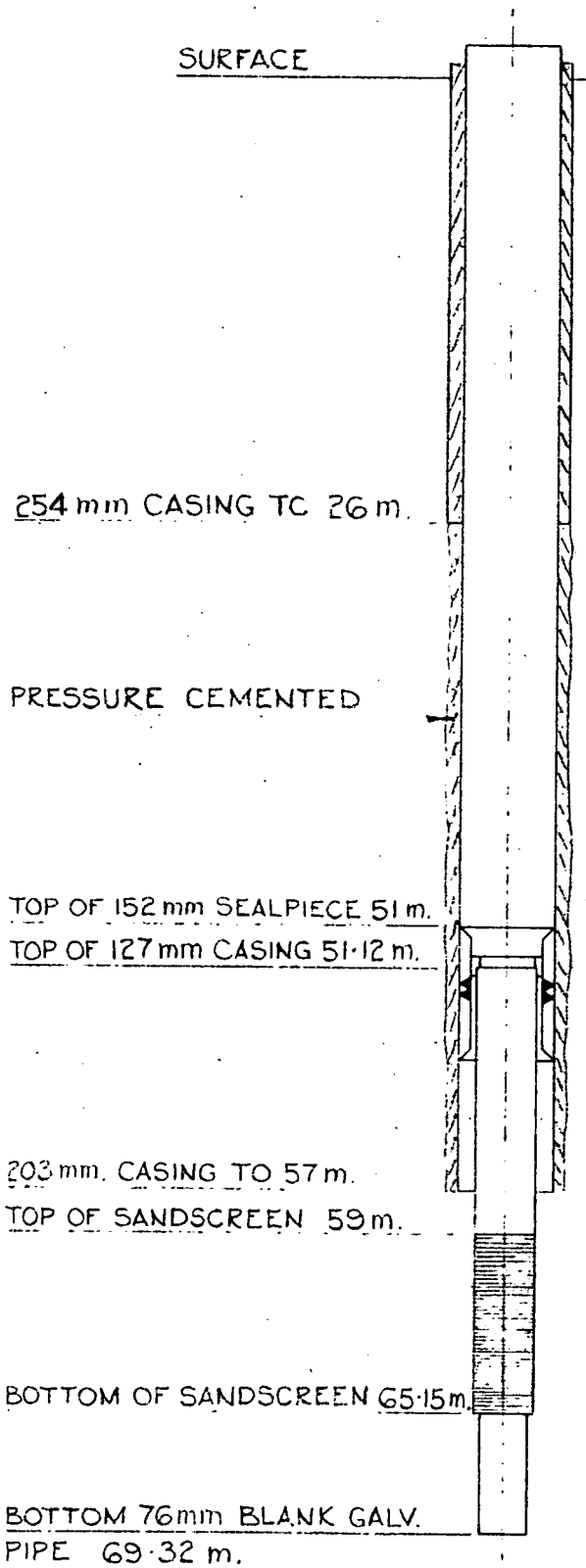


FIG. 2.

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE 1:10,000
COMPILED A.F.W	KINGSTON TOWN WATER SUPPLY	DATE 28/3/78
DRN P.D. CKD	LOCATION OF WELLS 1-11	PLAN NUMBER 78 – 249



DETAILS OF ASSEMBLY

127 mm CASING	1·52 m, 6·46 m
SCREEN (2 SECTIONS) INC. COUPLINGS	6·15 m.
BLANK 76 mm. GALV. PIPE	4·15 m.
TOTAL LENGTH	18·28 m.
LESS THREAD	18·20 m.

DETAILS OF SCREEN

TYPE - "SURESCREEN" - WIRE WOUND STAINLESS STEEL.

LENGTH - 2 SECTIONS.
(1) 3·10 m. INC. COUPLING.
(2) 3·05 m. " "

O.D. - 124 mm. COUPLING 136 mm.
I.D. - 111 mm.
APERTURES - 2 mm.

SEAL PIECE 127 mm. TO 203 mm.

SIZE - 152 mm. CASING.
LENGTH - 1·65 m.
FLARED TO 180 mm. BOTH ENDS WITH SEAT FOR 127 mm. CASING AND RUBBER SEALS TO 203 mm. CASING.

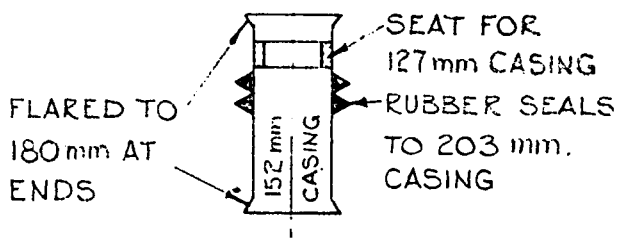


FIG. 3.

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale: N.T.S.
Compiled:	KINGSTON TOWN WATER SUPPLY WELL NO.11	Date: 28 - 3 - 78
Drn. R.B. Ckd.	WELL CONSTRUCTION DETAILS	Drg. No. S 13321

500—11.76 H1081 O

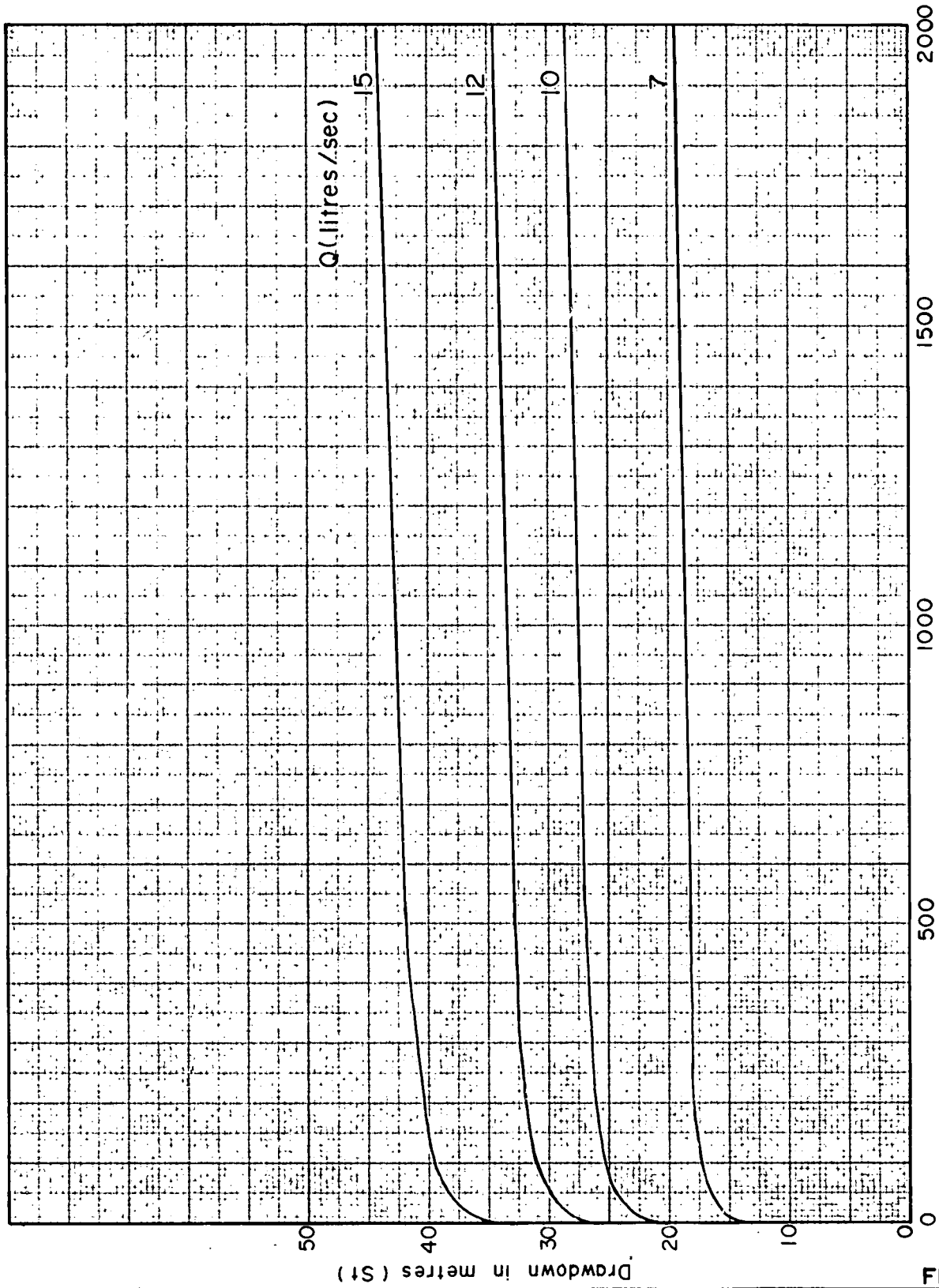
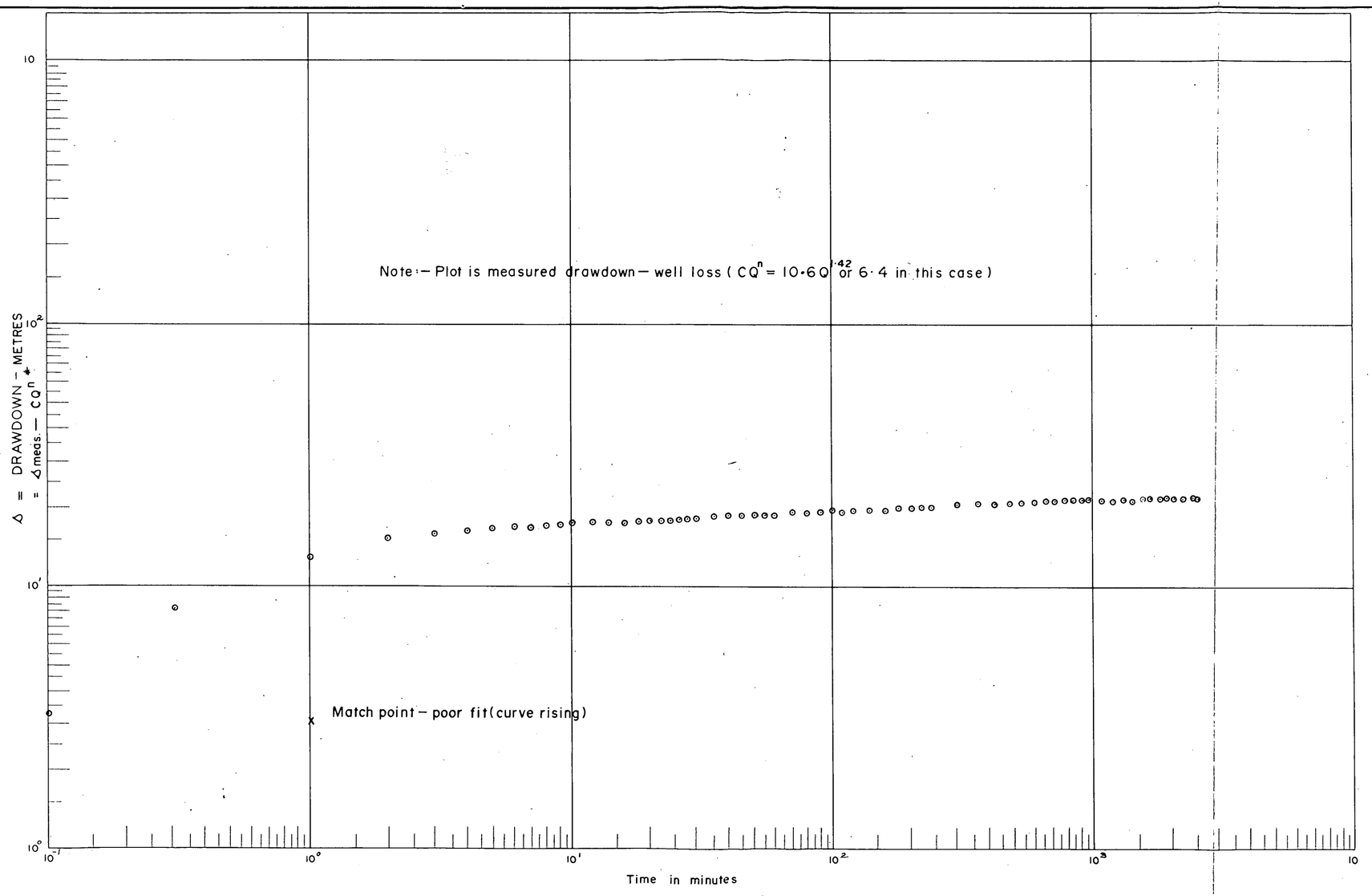


FIG. 4

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: A.F.W	KINGSTON TOWN WATER SUPPLY WELL NO. II	Date: 28 / 3 / 78
Drn. P.D | Ckd.	DRAWDOWN CURVES AT VARIOUS PUMPING RATES	Drg. No. S 13322

P.F. N°S 7852 M



Δ = RECOVERY (RESIDUAL) - FEET

BOREHOLE STATE N°6824002WW00844 TYPE OF PUMP LINE SHAFT (DEUTZ)
DEPTH TO WATER LEVEL
AT TEST START 0·34 m (L) * DISCHARGE STARTED AT 1435 ON 20·10·77
" STOPPED AT 1935 ON 20·10·77
PUMP INTAKE DEPTH 45·50 m (L) AQUIFER FROM 56 m TO 68 m (L)
AVAILABLE DRAWDOWN 45·16 m (L) HOLE DEPTH 71 m (L)

BASIC EQUATIONS

$$T = \frac{Q}{4\pi\Delta} Wu \qquad S = \frac{4Tut}{r^2}$$

In which
T = Transmissivity $(L^3/t/L)$
Q = Pumping Rate (L^3/t)
Δ = Drawdown (L)
Wu = function of u
S = Storage Coefficient (dimensionless)
t = time (t)
r = Distance to observation hole (L)

DATA

Q m^3/day	Δ	t mins	Wu	r/B	u	1 day $8{\cdot}64 \times 10^4$ SEC
1012	3·1	1	1	0·05	0·01	

CALCULATIONS

Match point from non steady state leaky artesian type curves, (Illinois State Water Survey).

$$T = \frac{1012 \times 1}{4\pi \times 3{\cdot}1} = 30 m^3/day/m$$

$r/B = 0{\cdot}05$

* L = unit of Length
t = time unit

FIG. 5

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES - SOUTH AUSTRALIA	D.M. 397 / 76
COMPILED: A.F.W	KINGSTON TOWN WATER SUPPLY WELL NO.11 MAIN TEST DATA — LOG DRAWDOWN LESS WELL LOSS VERSUS LOG TIME	DATE: 28/3/78
DRN: P.D. CHD:		DRG NO 78 - 250

APPENDIX I

SCREEN SELECTION

Screen Selection - Kingston No. 11 (MA 98)

Interval (mm)	% thro' T10 ie. 2.6 mm	% thro' T14 ie. 1.17 mm	% thro' T20 ie. 0.83 mm	40% retained size (mm) (approx)	90% retained size (mm) (approx)	Coefficient of uniformity
58-59	31	44	56	1.2	0.35	3.4
59-60	69	78	85	2.7	0.5	5.4
60-61	56	65	74	3.3	0.4	8.3
61-62	38	46	60	1.6	0.3	5.3
62-63	33	44	62	1.2	0.35	3.4
63-64	57	66	75	2.3	0.3	7.7
64-65	50	62	76	2.2	0.4	5.5
65-66	30	42	55	1.2	0.2	6.0
66-67	7	12	17	0.44	0.18	2.4

Coefficient of uniformity (excluding 66-67 m interval) = 6 (approx.)

Overlying bed firm (black clay) therefore a slightly conservative aperture size to retain 40% of aquifer sand over the majority of the screen length was selected.

Two alternatives arise:

i. T14 screen from 58-66 m interval (aquifer fines after 66 m and terminates at 69 m).

ii. T10 screen from 59-65 m interval.

Alternative i.

Screen aperture opening to retain 40% is 1.17 mm (50 thou)
Screen type - Standard Pattern Mark II - 127 mm diameter
Transmitting capacity of screen - 33.9 m^3/hr/m at entrance velocity of 0.05 m/sec.
i.e. 6 510 m^3/day for 8 m screen length.
But required entrance velocity is 0.01 m/sec as aquifer permeability is 6.8 $m^3/day/m^2$ (see RB 77/23, Appendix 2)
i.e. desired pump rate is $6\,510 \times \frac{0.01}{0.05}$
i.e. 1 300 m^3/day (15 l/sec)

Alternative ii.

Screen aperture opening to retain 40% is 2.03 mm (80 thou)
Screen type - as above
Transmitting capacity = 42.2 m^3/hr/m
Desired pump rate = $42.2 \times 24 \cdot 6 \cdot \frac{0.01}{0.05}$
= 1 220 m^3/day (14 l/sec)

Alternative ii is preferred as decreased drawdown related to screen effects is likely.

Actual pumping rates here are minimal as permeability used is that of the undeveloped aquifer. Higher pumping rates (eg. 20-25 l/sec) should be possible providing proper development procedures are carried out and drawdown is not too excessive.

APPENDIX 2

DRILLING SUPERVISORS REPORT

DM.397/76

TO THE CHIEF DRILLING & MECHANICAL ENGINEER:

Through the Drilling Engineer

Completion of Drilling - TWS Well No. 11 (Temp. No. MA98) - E. & W.S. Department - Kingston S.E. - Permit No. 1648

A 203 mm TWS well was constructed adjacent section 450 in the hundred of Lacepede.

The hole was drilled 254 mm to 58 m and lined with 254 mm steel casing to 26 m. 203 mm casing was inserted to 57 m effective length and pressure cemented to surface, 227 gallons of cement grout was used, 5 - 1 mix. After drilling out the cement plug 152 mm casing was installed and the confined formations were sampled at 1 m intervals to 69 metres. Whilst taking a tube sample at 69 m the sampling tool became sand locked and took 3 days to recover.

At the request of the regional geologist the hole was then extended to 71 metres.

A stainless steel sandscreen was installed from 59 m to 65.16 m with 127 mm Aust. swell joint casing from 51.12 m to the top of the screen. The 152 mm casing was then removed and a 152 mm seal piece was seated at 51 m to seal between 127 mm and 203 mm casings.

Development of the screen was carried out initially by surging and bailing and complated by airlifting and surging the face of the screen for 61 hours.

Pump testing included 3 x 100 minute step draw down tests followed by a 2 520 minute continuous test and recovery.

A sketch of the well and screen is attached.

Details of the well are as follows:

Commenced	23/8/77
Completed	3/11/77
Depth drilled	71 m
Depth at completion	65.15 m
254 mm Aust. casing	Surface to 26 m
203 mm " (pressure cemented)	Surface to 57 m
152 mm sealpiece (127mm - 203mm)	51 m
127 mm Aust. Casing	51.12 m to 59 m
124 mm Sandscreen	59 m to 65.15 m
76 mm Tail pipe	65.15 m to 69.32 m
Developed for	61 hours
Continuous pump test	42 hours
Average pumping rate	10 l/sec

Maximum Drawdown	28.16 m
Approval	$22 000
Estimated cost	$21 000
Machine hours	265
Permit No.	1648

W D Wilson

W.D. WILSON
DRILLING SUPERINTENDENT

15/11/77

APPENDIX 3

WELL LOG

PROJECT: KINGSTON TOWN WATER SUPPLY NO. 11

MINES DEPARTMENT — SOUTH AUSTRALIA
ENGINEERING DIVISION

WATER WELL LOG

HOLE NO: MA 98

UNIT / ~~STATE~~ NO 6624-002-WW 844

DM 397/76

LOCATION OR COORDS:

Adj. SEC 450 HD. LACEPEDE

EL Surface m

EL Ref. Point m Datum

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL TESTED From:	INTERVAL TESTED To:	SUPPLY kilolitres/day*	SUPPLY Test Length (hrs)	SUPPLY Method	TOTAL DISSOLVED SOLIDS milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis No:
	56.0	Flows	59	65	840	Start	Pumped	822 (F)	W — 7035/77
	"	"	"	"	"	0.16	"	770	7036/77
	"	"	"	"	"	1.67	"	770	7037/77
	"	"	"	"	"	16.7	"	765	7038/77

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE
0	0.6		LIMESTONE FILL		
0.6	0.8		CLAY TOPSOIL	Grey, calcareous	
0.8	2		CALCRETE	Hard, well cemented, brown, shelly and some white limestone.	Pleistocene
2	40		LIMESTONE, SAND	Mostly carbonate, fossiliferous, weakly cemented.	"
4	10		SAND	Similar to above, marly, glauconitic at base.	"
10	13		GRAVEL	Shells to 20mm, rest carbonate grains.	"
13	48		LIMESTONE	Fossiliferous, grey, fine to coarse, silty and marly. Flint.	GAMBIER LIMESTONE OLIGO-MIOCENE
48	50		LIMESTONE	Very marly, pale green, glauconitic	? NARRAWATURK MARL,
50	56		SILT	As above, fossiliferous	EOCENE
56	58		SAND	Fine to gravel (15mm), quartz, 20% silt and clay, soft.	? MEPUNGA FORMATION EOCENE

DEPTH CORE SAMPLE	CASING Dia(mm)	CASING From(m)	CASING To(m)
	254 (steel)	0	26
	203 (steel)	0	57

REMARKS:

Permit 1648

*NOTE: 110 kl / day = 1000gals / hr.

DRILL TYPE: CABLE TOOL

CIRCULATION: WATER

SHEET 1 OF 2

COMPLETED: 3.11.77

LOGGED BY: A.F.W.

DATE: 15.2.77

PROJECT: KINGSTON TOWN WATER SUPPLY NO. 11

MINES DEPARTMENT — SOUTH AUSTRALIA
ENGINEERING DIVISION

WATER WELL LOG

HOLE NO: MA 98

UNIT / ~~STATE~~ NO 6624-002-WW 844

DM 397/76

LOCATION OR COORDS:

Adj. SEC 450 HD. LACEPEDE

EL Surface m

EL Ref. Point m Datum

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL TESTED From:	INTERVAL TESTED To:	SUPPLY kilolitres/day*	SUPPLY Test Length (hrs)	SUPPLY Method	TOTAL DISSOLVED SOLIDS milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis No:
	56.0	Flows	59	65	840	30	Pumped	819 (F)	W— 7039/77
	2.0	2.0	2	3	–	–	Bailed	7 000	5980/77
	8.0	2.0	8	9	–	–	"	935	5981/77
	48	2.0	47	48	–	–	"	827 (F)	5986/77

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE	DEPTH CORE SAMPLE	CASING Dia(mm)	CASING From(m)	CASING To(m)
58	62		GRAVEL	Quartz, brown, some feldspar. Pebbles to 15mm.	? MEPUNGA FORMATION EOCENE				
62	68		SAND, GRAVEL,	As above, gravelly 63-65m.	"				
68	71		SILT	Clayey, brown, some fine quartz.	"	71			

REMARKS: Permit 1648

*NOTE: 110 kl / day = 1000gals / hr.

DRILL TYPE:

CIRCULATION:

SHEET 2 OF 2

COMPLETED:

LOGGED BY:

DATE:

APPENDIX 4

STEP-DRAWDOWN AND MAIN TEST CALCULATIONS

CONTENTS

	PAGE
Three Stage drawdown test.	1
Main well test.	2
Table	
1. Main test drawdown data corrected for reduction in pump rate.	1A
Figs.	**Drawing**
1. Three stage drawdown test.	78-251
2. Plot of St/Q vs Q for t=1, 10 mins.	S13323
3. Plot of St/Q-B vs Q for t=10 mins	S13324
4. Main drawdown and recovery test	78-252
5. Main drawdown test - recalculated data based on Q = 1012 m^3/day.	78-253
6. Plot of Q/T for all tests.	S13325

1. Three Stage Drawdown Test

A 3 x 100 minute continuous test was carried out on 20/10/77 at pumping rates of 0.39, 0.49, 0.78 m^3/min. Results are plotted on Fig. 1 from recalculated data (graphical technique - see Hazel, VIII - 16, 1973).

The basic well equation is as follows:

$$St = (a + b \log t)\, Q + cQ^n$$

where a, b, c and n are constants (see Hazel VII-16). To obtain n (which should equal 2 if the well is properly developed) and c in the equation, the procedure was as follows:

1. Plot values of St/Q vs Q for t = 1, 10 mins on ordinary graph paper

Stage	Q(m^3/min)	St=10	St=10/Q	St=1	Q early	St=1/Q early
I	0.39	14.2	36.4	13.1	0.4	32.8
II	0.49	18.6	38.0	17.1	0.51	33.5
III	0.78	30.4	39.0	27.6	0.79	34.9
Main Test	0.70 (t= 0 to 10 recalculated)	27.3	38.86			

2. Drawdown curves or straight lines through each of the sets of points (note- main test data included- see later). These lines should be parallel (see Fig. 2).

3. Read for say t=10, the intercept (a+b log t = B) on the St/Q axis - i.e. 29.6 in this case.

4. Plot $St/_Q$-B vs Q on log-log paper which should give a straight line of slope n-1 and intercept on the $St/_Q$-B axis of c

St=10/Q	B	$St=10/_Q$-B	Q
36.4	29.6	6.8	0.39
38.0		8.4	0.49
39.0		9.4	0.78
38.9		9.3	0.70

From Fig. 3, it can be seen that n - 1.42 and c - 10.6.
Referall back to Fig. 2 shows:

$a + b \log t_{=10} = 29.6$
$a + b \log t_{=10} = 25.6$ or $a = 25.6$ since $\log 1 = 0$
and therefore $b = 29.6 - 25.6 = 4$
i.e. equation is $St = (25.6 + 4 \log t)Q + 10.6Q^{1.42}$

2. Main well test

A 42 hour constant discharge test was carried out from 24-26/10/77 with a subsequent 12 hour recovery period. Actual results are shown on Fig. 4. Unfortunately pumping rates changed significantly at the start from 1 012 m^3/day for 0-5 mins to 848 m^3/day from 5-2 520 mins - 20% reduction (see also Fig. 4 for average pump rates). All drawdowns after t=5 mins are in fact less than they should be had the pump rate been maintained at 1 012 m^3/day. Corrected drawdown values for this initial rate are shown on Fig. 5 (actual calculated values are on Table 1).

Comparison of drawdowns in this corrected plot with those obtained through the well equation are in reasonable agreement (within 3%) as follows.

time after start (mins)	Corrected D/D (m)	Calculated D/D (m)
10	27.2	27.1
100	29.6	29.9
1 000	32.0	32.7
10 000	34.4 (extrap.)	35.5

3. Long term safe yield

The long term safe yield of the well can be obtained by multiplying the test rate by the ratio of the available drawdown to the extrapolated drawdown at 100 000 mins during the test.

$$Qs = Qa \frac{Sa}{Se}$$

where Qs = longterm safe yield

Qa = test pumping rate

Sa = available drawdown less an allowance for well interference and seasonal variation (say 2 m) ie. pump depth (40 m) - 2 m = 38 m

Se = extrapolated drawdown from main test curve

ie. $Qs = 1\,012 \quad \frac{38.0}{36.8}$

$= 1\,045\ m^3$/day (12 l/sec)

(Note larger value as Sa is greater than Se)

A higher discharge rate for shorter periods of pumping up to 1 000 min (approx. 16hrs) may be calculated assuming a pump setting of 50 m and drawdown of 32 m with Q = 1 012 m^3/day. If a conservative figure of 5 m is allowed for possible interference effects and longterm water level fluctuations:-

$$Qs = Qa \frac{\text{available DD} - 5\text{ m}}{\text{Extrapolated DD}}$$

$$= 1\ 012\ \frac{50-5}{32}$$

$$= 1\ 423\ m^3/day\ (16.47\ l/sec)$$

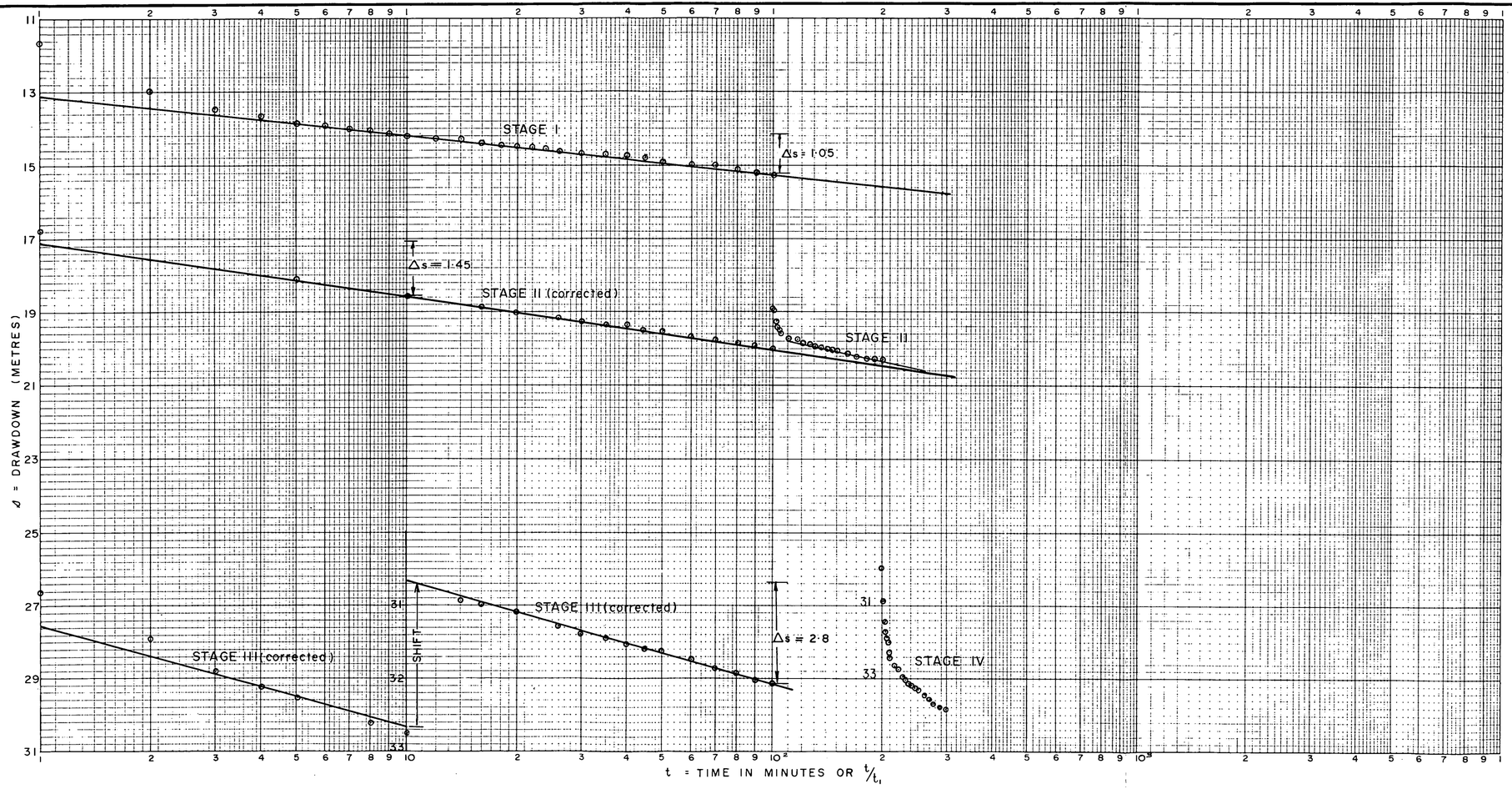
A slightly more conservative figure of 15 l/sec is considered to be a safe discharge rate for periods upto 16 hrs provided recovery occurs between pumping periods.

4. Discussion

A plot of pump rates and transmissivity (Fig. 6) shows a linear relationship between the two such that as Q increases, T decreases, this suggests difficult entry conditions into the well.

Table 1. Main test drawdown data corrected for reduction in pump rate from 1012 m^3/day to 848 m^3/day after t=5 mins (see Aaron & Scott, 1966)

1. Time in mins. after start when pumping at Q_2 (848 m^3/day) commenced.	2. Time in mins. after pumping at =(848 m^3/day)	3. D/D corresp. to time in column 2 but at rate Q1	4. Mult Column 3 by correction factor of $\frac{164}{1012}$ ie. 0.16	5. Meas. value of D/D at time shown in column 2 ie. when pump rate Q2	6. Corrected D/D (4+5)
6	1	21.55	3.45	23.07	26.52
7	2	22.15	3.54	23.22	26.76
8	3	22.50	3.60	23.37	26.97
9	4	22.75	3.64	23.49	27.13
10	5	22.95	3.67	23.60	27.27
12	7	23.25	3.72	23.78	27.50
14	9	23.45	3.75	23.92	27.67
16	11	23.60	3.78	23.96	27.14
18	13	23.75	3.80	24.04	27.84
20	15	23.90	3.82	24.13	27.95
22	17	24.00	3.84	24.21	28.05
24	19	24.10	3.86	24.29	28.15
26	21	24.20	3.87	24.35	28.22
30	25	24.35	3.90	24.46	28.36
35	30	24.50	3.92	24.60	28.52
40	35	24.60	3.94	24.69	28.63
45	40	24.75	3.96	24.79	28.75
50	45	24.85	3.98	24.87	28.85
55	50	24.95	3.99	24.96	28.95
60	55	25.05	4.01	25.03	29.04
70	65	25.15	4.02	25.17	29.19
80	75	25.30	4.05	25.28	29.33
90	85	25.40	4.06	25.38	29.44
100	95	25.50	4.08	25.47	29.55
120	115	25.65	4.10	25.65	29.75
140	135	25.80	4.13	25.80	29.93
160	155	25.90	4.14	25.94	30.08
180	175	26.00	4.16	26.05	30.21
200	195	26.10	4.18	26.18	30.36
220	215	26.20	4.19	26.28	30.47
240	235	26.25	4.20	26.40	30.60
300	295	26.45	4.23	26.59	30.82
360	355	26.65	4.26	26.76	31.02
420	415	26.75	4.28	26.89	31.19
480	475	26.90	4.30	27.04	31.34
540	535	27.00	4.32	27.14	31.46
600	595	27.10	4.34	27.20	31.54
660	655	27.15	4.34	27.25	31.59
720	715	27.25	4.36	27.29	31.65
780	775	27.30	4.37	27.33	31.70
840	835	27.40	4.38	27.36	31.74
900	895	27.45	4.39	27.39	31.78
960	955	27.50	4.40	27.41	31.81
1080	1075	27.60	4.42	27.43	31.85
1200	1195	27.70	4.43	27.45	31.88
1320	1315	27.75	4.44	27.52	31.96
1440	1435	27.85	4.46	27.62	32.06
1560	1555	27.90	4.46	27.73	32.19
1680	1675	27.95	4.47	27.78	32.25
1800	1795	28.05	4.48	28.01	32.50
1920	1915	28.10	4.50	28.10	32.60
2040	2035	28.15	4.50	28.16	32.66
2160	2155	28.20	4.51	-	-
2280	2275	28.25	4.52	28.18	32.70
2400	2395	28.30	4.53	28.10	32.63
2520	2515	28.35	4.54	27.78?	32.32



BOREHOLE STATE/UNIT No.6824002WW00844 — TYPE OF PUMP LINE SHAFT (DEUTZ)

REF. PT. .....(m) above ground — LENGTH OF TEST 5 hours

AQUIFER FROM 56 TO 68 (m) — DEPTH WATER LEVEL AT TEST START (ℓ_2) 0·34 (m)

HOLE DEPTH 71 (m) (backfilled to 68 m) — DEPTH PUMP INTAKE (ℓ_1) 45·5 (m)

* AVAILABLE DRAWDOWN 45·16 (m)

EQUATIONS

$$T = \frac{0.183 \times Q}{\Delta s} \qquad S = \frac{2.25 \times T t_o}{r^2}$$

In which

T = Transmissivity (m^3/day/m) — S = Storage Coefficient

Q = Pumping Rate (m^3/day) — t_o = Zero drawdown time (mins)

Δs = Drawdown per log cycle (m) — r = Distance to Observation Bore (m)

1 day = 8.64×10^4 secs.

DATA

	Q m^3/day	Δs	t_o	$Q/\Delta s$
STAGE 1 —	560	1·05		530
" 2	710	1·45		490
" 3	1050	2·80		375
MAIN TEST	1010	2·40		420

CALCULATIONS

$$T = \frac{0.183 \times 560}{1.05} = 100\ m^3/day/m \quad \text{Stage 1}$$

$$T = \frac{0.183 \times 710}{1.45} = 90\ m^3/day/m \quad \text{Stage 2}$$

$$T = \frac{0.183 \times 1050}{2.80} = 70\ m^3/day/m \quad \text{Stage 3}$$

$$T = \frac{0.183 \times 1010}{2.4} = 80\ m^3/day/m \quad \text{MAIN TEST}$$

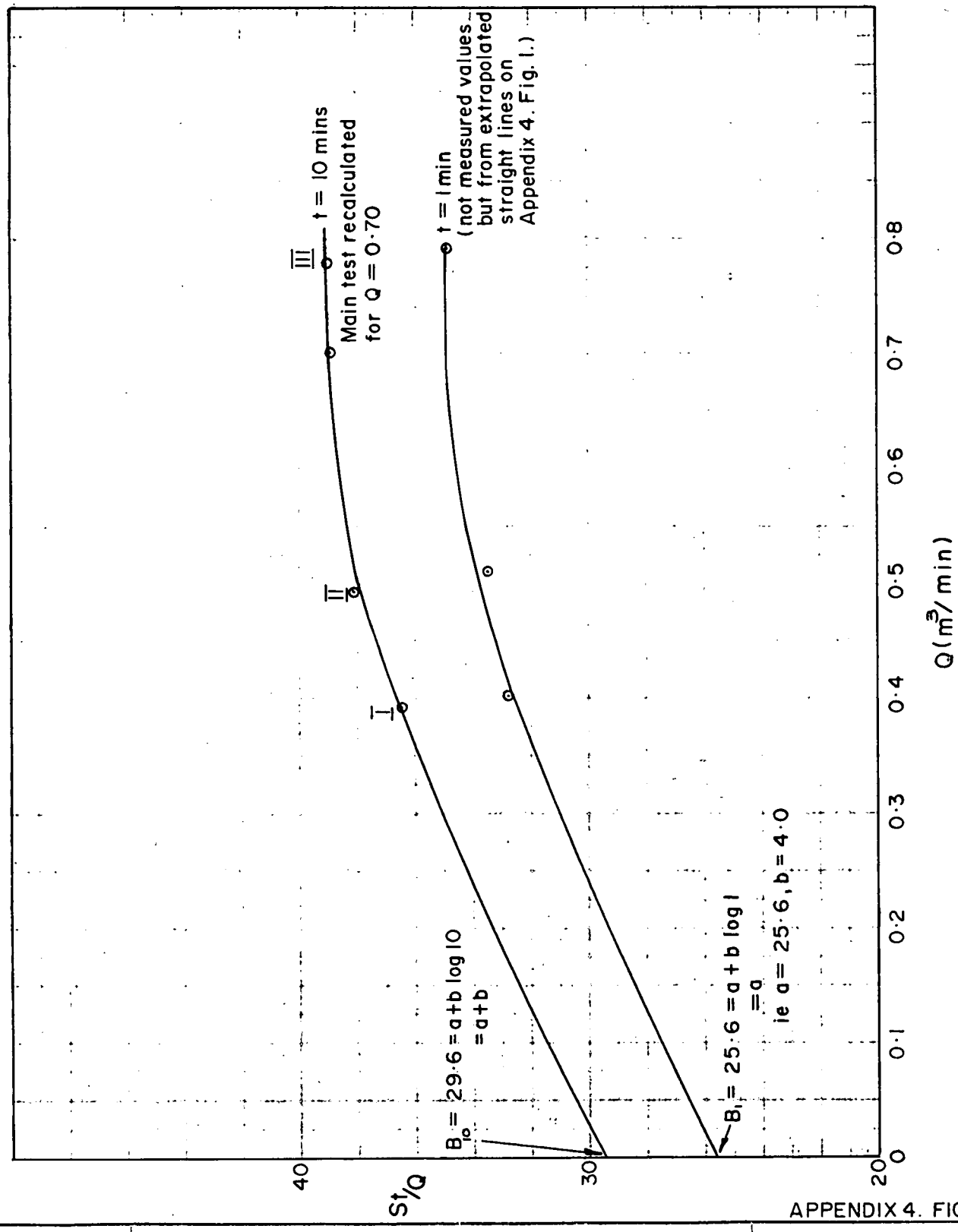
(See Appendix 4 Fig. 4.)

* Available drawdown = $\ell_1 - \ell_2$

APPENDIX 4 FIG. 1

ENGINEERING DIVISION	DEPARTMENT OF MINES — SOUTH AUSTRALIA	D.M.
COMPILED A.F.W.	KINGSTON TOWN WATER SUPPLY WELL NO. 11	DATE 28/3/78
DRN P.D. CKD	3 STAGE DRAWDOWN TEST	PLAN NUMBER
	20/10/77	78 — 251

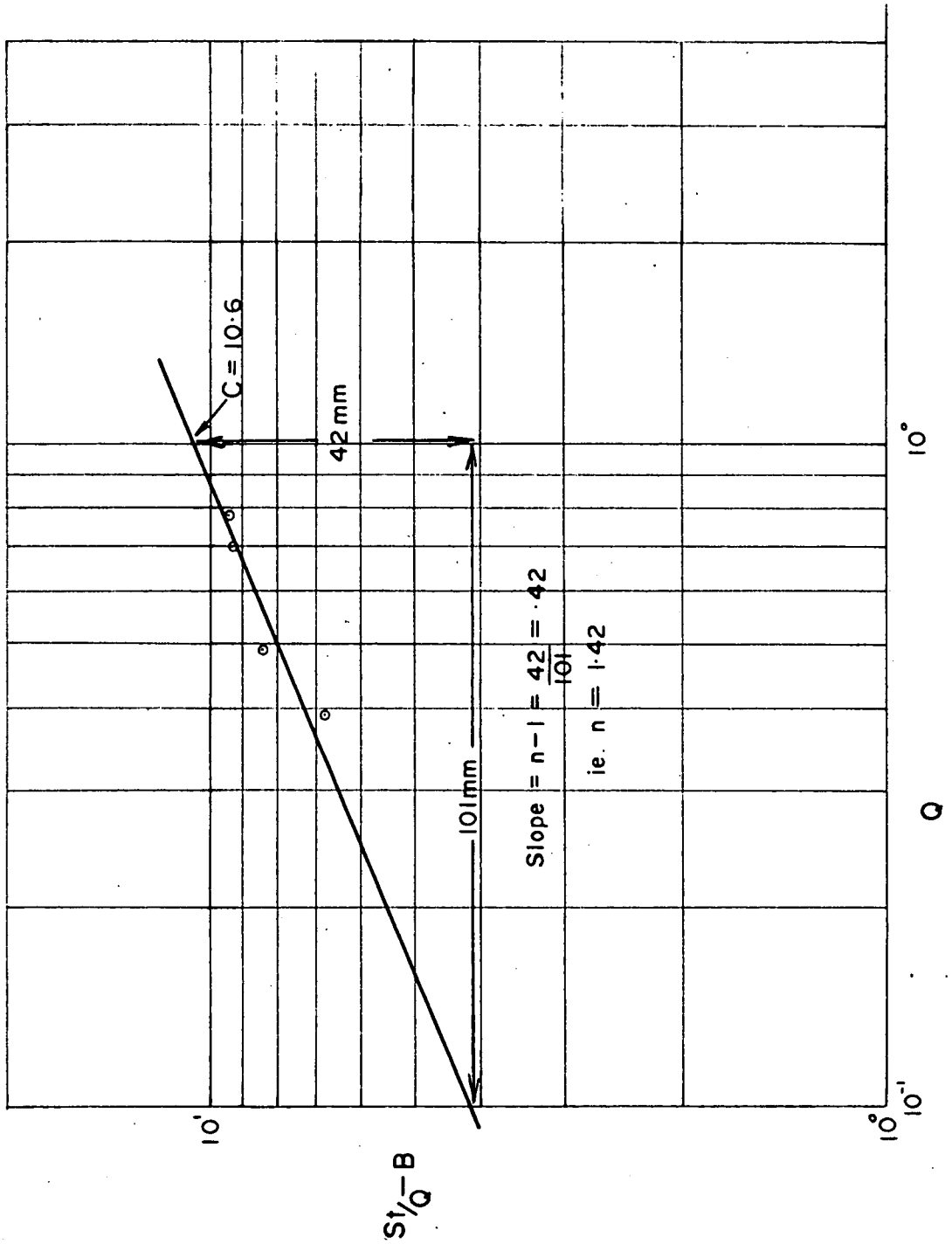
P.F. No. 69—953 MH



APPENDIX 4. FIG.2

	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale:
Compiled: A.F.W	KINGSTON TOWN WATER SUPPLY WELL NO.II	Date: 29/3/78
Drn. F.D | Ckd.	PLOT OF St/Q VERSUS Q	Drg. No. S 13323

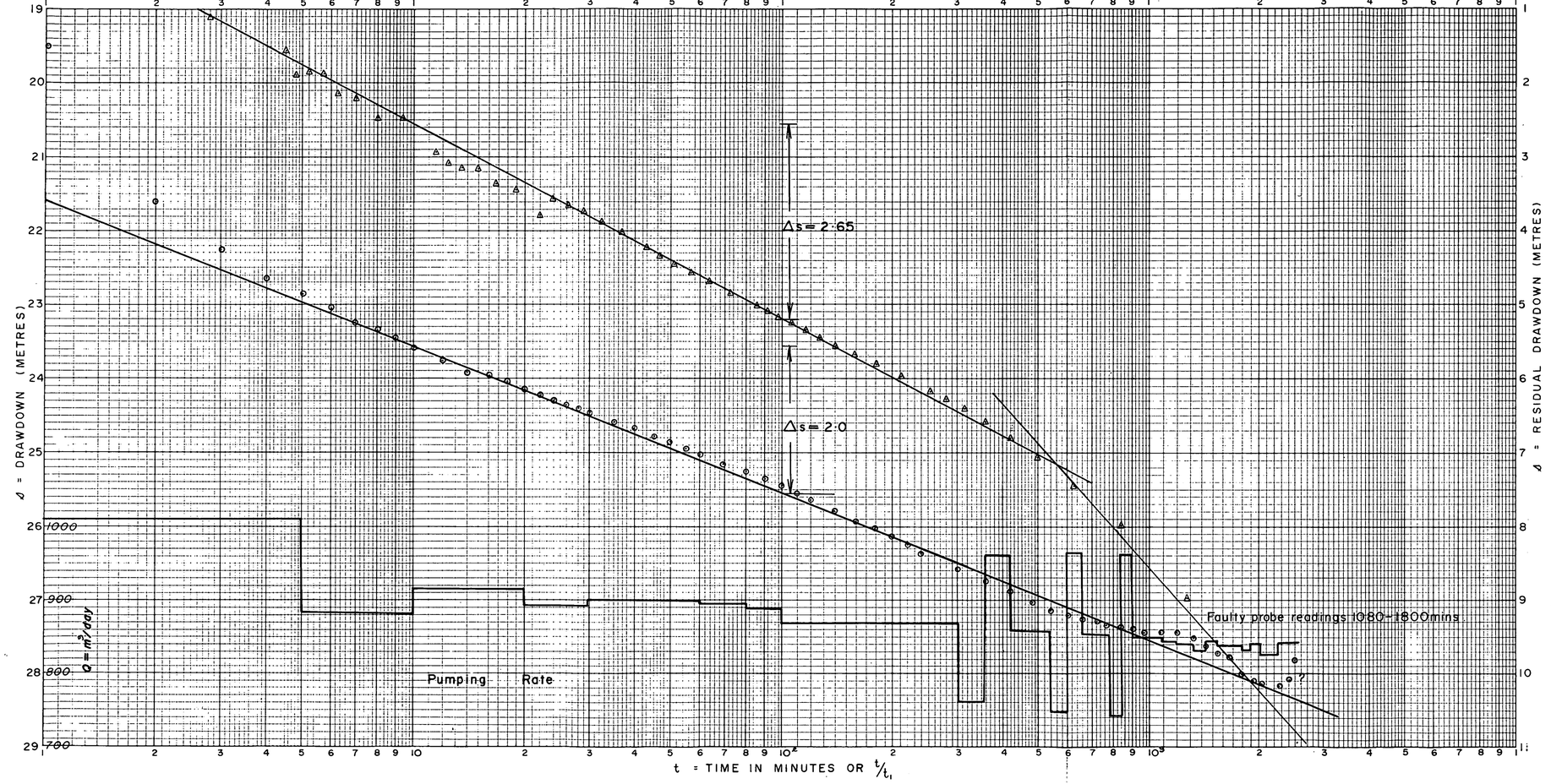
PF. N° S 7852 M



APPENDIX 4. FIG.3

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale:
Compiled: A.F.W	KINGSTON TOWN WATER SUPPLY WELL NO. 11	Date: 29/3/78
Drn. P.D | Ckd.	PLOT OF St/Q − B VERSUS Q	Drg. No. S 13324
	t = 10 mins	

500—6.76 G6584 O



BOREHOLE STATE/UNIT No. 6824002WW00844
REF. PT. ..... (m) above ground
AQUIFER FROM 56 TO 68 (m)
HOLE DEPTH 71 (m)

TYPE OF PUMP LINE SHAFT
LENGTH OF TEST 54 hours
DEPTH WATER LEVEL AT TEST START (ℓ_2) 0·40 (m)
DEPTH PUMP INTAKE (ℓ_1) 45·5 (m)
* AVAILABLE DRAWDOWN 45·1 (m)

EQUATIONS

$$T = \frac{0{\cdot}183 \times Q}{\Delta_\Delta} \qquad S = \frac{2{\cdot}25 \times Tt_o}{r^2}$$

In which

T = Transmissivity (m^3/day/m)
Q = Pumping Rate (m^3/day)
Δ_Δ = Drawdown per log cycle (m)
S = Storage Coefficient
t_o = Zero drawdown time (mins)
r = Distance to Observation Bore (m)
1 day = $8{\cdot}64 \times 10^4$ secs.

DATA

Q(m^3/day)	Δ_Δ	t_o	r
840	2·0	—	

CALCULATIONS

$$T = \frac{0{\cdot}183 \times 840}{2{\cdot}0} = 80\ m^3/day/m \quad (2\ sig.\ figs)\ (D.D)$$

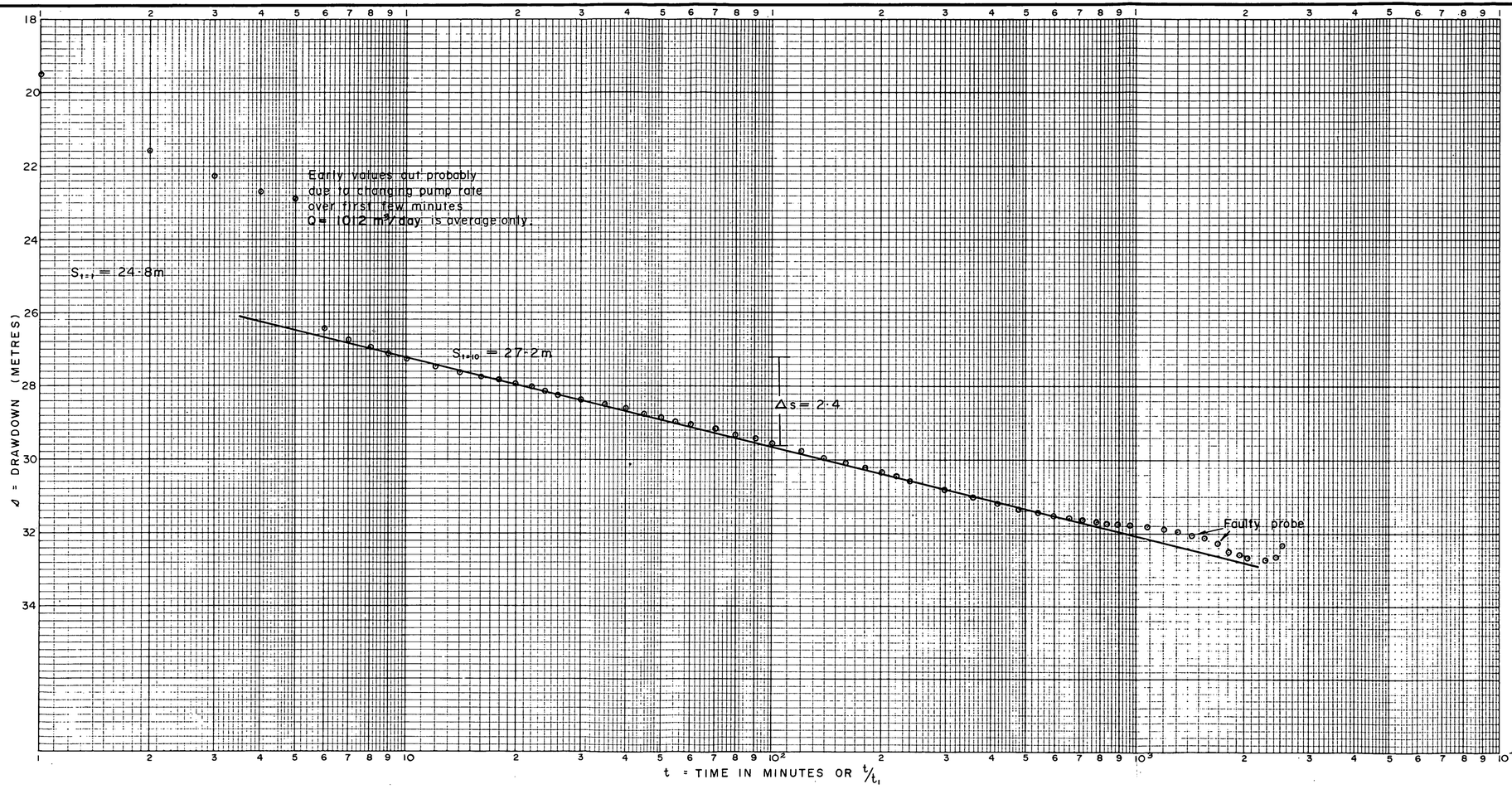
$$T = \frac{0{\cdot}183 \times 840}{2{\cdot}65} = 60\ m^3/day/m\ (Recovery)$$

* Available drawdown = $\ell_1 - \ell_2$

APPENDIX. 4. FIG. 4

ENGINEERING DIVISION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	D.M. 397/76
COMPILED: R. F.	KINGSTON TOWN WATER SUPPLY WELL NO. II	DATE 28/3/78
DRN: P.D. CKD.	MAIN DRAWDOWN-RECOVERY TEST	PLAN NUMBER
	24–26/10/77	78-252

P.F. No. 69–953 MH



BOREHOLE STATE/UNIT No. 6824002 WW 00844 — TYPE OF PUMP LINE SHAFT (DEUTZ)

REF. PT. ..... (m) above ground — LENGTH OF TEST 42 hours

AQUIFER FROM 56 TO 68 (m) — DEPTH WATER LEVEL AT TEST START (ℓ_2) 0·40 (m)

HOLE DEPTH 71 (m) — DEPTH PUMP INTAKE (ℓ_1) 45·5 (m)

* AVAILABLE DRAWDOWN 45·10 (m)

EQUATIONS

$$T = \frac{0{\cdot}183 \times Q}{\Delta_s} \qquad S = \frac{2{\cdot}25 \times T t_o}{r^2}$$

In which

T = Transmissivity (m^3/day/m) — S = Storage Coefficient

Q = Pumping Rate (m^3/day) — t_o = Zero drawdown time (mins)

Δ_s = Drawdown per log cycle (m) — r = Distance to Observation Bore (m)

1 day = $8{\cdot}64 \times 10^4$ secs.

DATA

	Q m^3/day	Δ_s	t_o	r
0–5 mins	1012	2·4	—	
5–2520 mins	848			

CALCULATIONS

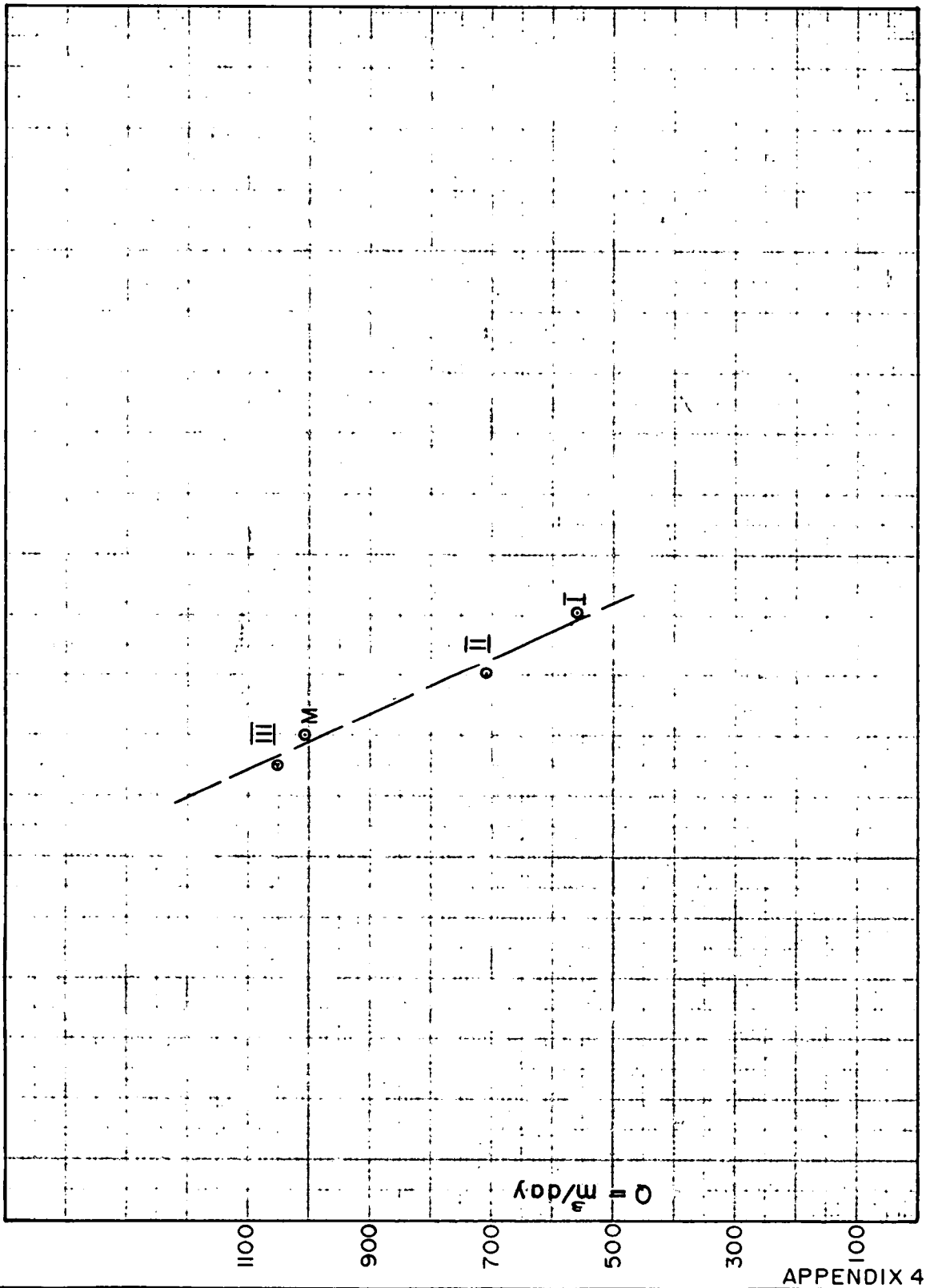
$$T = \frac{0{\cdot}183 \times 1012}{2{\cdot}4} = 77 \text{ or } 80 m^3/\text{day}$$

* Available drawdown = $\ell_1 - \ell_2$

APPENDIX 4. FIG. 5

ENGINEERING DIVISION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	D.M. 397/76
COMPILED: A.F.W	KINGSTON TOWN WATER SUPPLY WELL NO. 11	DATE: 28/3/78
DRN: P.D. CKD.	MAIN DRAWDOWN TEST – RECALCULATED	PLAN NUMBER
	DATA BASED ON Q = 1012 m^3/day	78 – 253

D.F. No. 69–953 MH



APPENDIX 4. FIG.6.

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: A.F.W	KINGSTON TOWN WATER SUPPLY WELL NO.11 PLOT OF Q VERSUS T FOR STAGE AND MAIN TEST	Date: 28 / 3 / 78
Drn. P. D | Ckd.		Drg. No. S 13325

P.F. N° S 7852 M

APPENDIX 5

FULL ANALYSIS DETAILS

WATER ANALYSIS REPORT

SAMPLE No. W5986/77 JOB No. 1069-78

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	27	1.3
MAGNESIUM	(Mg)	13	1.1
SODIUM	(Na)	264	11.5
POTASSIUM	(K)	20	.5
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)		
BICARBONATE	(HCO_3)	398	6.5
SULPHATE	(SO_4)	32	.7
CHLORIDE	(Cl)	269	7.6
FLUORIDE	(F)		
NITRATE	(NO_3)	6	.1
PHOSPHATE	(PO_4)		

TOTALS AND BALANCE				
CATIONS	(me/ℓ)	14.4	DIFF =	.5
ANIONS	(me/ℓ)	14.9	SUM =	29.3

DIFF 100 / SUM = 1.6%

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.)
MICRO-S/cm AT 25 DEG.C 1639.

TOTAL DISSOLVED SOLIDS	MILLIGRAMS PER LITRE mg/ℓ
A. BASED ON E.C.	
B. CALCULATED (HCO_3=CO_3)	827.
C. RESIDUE ON EVAP. AT 180 DEG.C	

TOTAL HARDNESS AS $CaCO_3$	121.
CARBONATE HARDNESS AS $CaCO_3$	121.
NON-CARBONATE HARDNESS AS $CaCO_3$	1.
TOTAL ALKALINITY AS $CaCO_3$	327.
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	

	UNITS
REACTION - pH	7.9
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 79.7%

NAME - E W S Dept.
ADDRESS KINGSTON
DATE COLLECTED 7.9.77
SAMPLE COLLECTED BY: B.W. Chaplin

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. µ-S/cm

OBS. No. -
HOLE No. MA 98, KINGSTON NO. 11
D.M. No. 397/76

SAMPLE COLLECTED 47-48m IE. GAMBIER LIMESTONE UNCONFINED AQUIFER

WATER ANALYSIS REPORT

SAMPLE No. W 7035/77 JOB No. 2230 - 78

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	66	3.3
MAGNESIUM	(Mg)	20	1.6
SODIUM	(Na)	220	9.6
POTASSIUM	(K)	15	0.4
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)		
BICARBONATE	(HCO_3)	376	6,2
SULPHATE	(SO_4)	33	.7
CHLORIDE	(Cl)	270	7.6
FLUORIDE	(F)		
NITRATE	(NO_3)	13	0.2
PHOSPHATE	(PO_4)		

TOTALS AND BALANCE				
CATIONS	(me/ℓ)	14.9	DIFF =	.2
ANIONS	(me/ℓ)	14.7	SUM =	29.6

DIFF 100 / SUM = 0.7%

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C

	MILLIGRAMS PER LITRE mg/ℓ
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	822
B. CALCULATED (HCO_3=CO_3)	
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	247
CARBONATE HARDNESS AS $CaCO_3$	247
NON-CARBONATE HARDNESS AS $CaCO_3$	<1
TOTAL ALKALINITY AS $CaCO_3$	308
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	

	UNITS
REACTION - pH	7.7
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 64.3%

NAME - E. & W. S. Dept.
ADDRESS Kingston
DATE COLLECTED 24.10.77
SAMPLE COLLECTED BY: R. Fennell

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. µ-S/cm

OBS. No.
HOLE No. MA 98 Kingston No. 11
D.M. No. 397/76

SAMPLE COLLECTED AT START OF MAIN WELL TEST

WATER ANALYSIS REPORT

SAMPLE No. W 7039/77 JOB No. 2230 - 78

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	65	3.2
MAGNESIUM	(Mg)	20	1.6
SODIUM	(Na)	221	9.6
POTASSIUM	(K)	15	0.4
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)		
BICARBONATE	(HCO_3)	376	6.2
SULPHATE	(SO_4)	30	0.6
CHLORIDE	(Cl)	270	7.6
FLUORIDE	(F)		
NITRATE	(NO_3)	13	0.2
PHOSPHATE	(PO_4)		

TOTALS AND BALANCE				
CATIONS	(me/ℓ)	14.9	DIFF =	0.3
ANIONS	(me/ℓ)	14.6	SUM =	29.5

$\frac{\text{DIFF } 100}{\text{SUM}}$ = 0.9%

DERIVED AND OTHER DATA

	MILLIGRAMS PER LITRE mg/ℓ
CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C	
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	819
B. CALCULATED (HCO_3=CO_3)	
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	245
CARBONATE HARDNESS AS $CaCO_3$	245
NON-CARBONATE HARDNESS AS $CaCO_3$	<1
TOTAL ALKALINITY AS $CaCO_3$	308
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	

	UNITS
REACTION - pH	7.7
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	
SODIUM TO TOTAL CATION RATIO(me/ℓ)	64.6%

NAME - E. & W. S. Dept.
ADDRESS Kingston
DATE COLLECTED 26.10.77
SAMPLE COLLECTED BY: R. Fennell

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. µ-S/cm

OBS. No.
HOLE No. MA 98 Kingston No. 11
D.M. No. 397/76

SAMPLE COLLECTED 30 HRS AFTER START OF MAIN WELL TEST