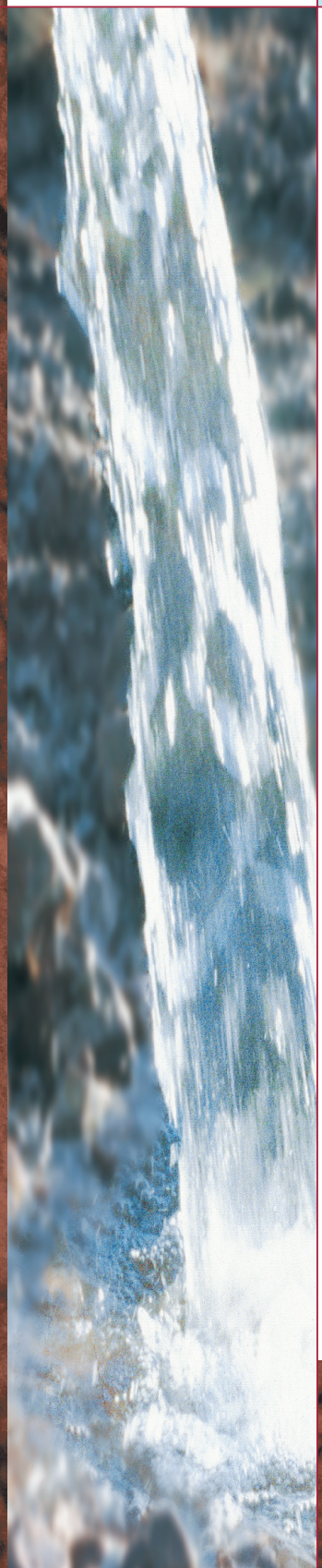
EXPLANATORY NOTE:

This report was produced in March 2004 and describes the modelling of groundwater abstraction for 7.1 GL/a. Since production of this report the Beagle Bay project has been separated into two stages (See Section 11 of PER) and consequently this report applies to Stage 2 of the project. Information on groundwater modelling for Stage 1 of the project is provided in Rockwater's September 2004 report "Addendum to Groundwater Assessment and Modelling to Support Groundwater Licence Application Report."



Rockwater
PROPRIETARY LIMITED

BEAGLE BAY BIG TREE COUNTRY PLANTATION PROJECT

GROUNDWATER ASSESSMENT AND MODELLING TO SUPPORT GROUNDWATER LICENCE APPLICATION

MARCH 2004

REPORT FOR
TROPICAL TIMBER
PLANTATIONS PTY LTD

296.0/04/001

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EXECUTIVE SUMMARY

Tropical Timber Plantations Pty Ltd (TTP) in a joint venture with the Beagle Bay Aboriginal Community (BBC) known as *"Beagle Bay Big Tree Country Project"*, proposes to establish a 1,500 ha plantation to grow high-value tropical timbers (teak, Indian sandalwood, Indian rosewood and African mahogany) near Beagle Bay on the Dampier Peninsula, about 110 km north-east of Broome (Fig 1). The proposed plantation is on 5,000 ha of land leased from the BBC. A groundwater supply of 7.1 GL/a from the underlying Broome aquifer is required for irrigation.

The project is located in the Department of Environment (DoE), Kimberley-Canning Groundwater Management area for which a groundwater management plan has not been prepared. Consequently, because of the size of the groundwater licence being sought by TTP, the DoE has directed TTP to undertake an investigation to determine if suitable groundwater supplies are available before a groundwater licence is issued.

The lease area is located on the Dampier Plateau about 10 km south of Bobby Creek along which there are various mound springs, claypans and riverine vegetation. It is underlain by Cretaceous sedimentary rocks, consisting of the Broome Sandstone overlain by two minor sedimentary formations. Together, the Cretaceous sediments comprise an upper section of interbedded siltstone and sandstone and a lower section consisting mainly of very coarse sandstone and conglomerate. The Cretaceous sediments are about 300 m thick and overlie the Jarlemai Siltstone. The sediments form the northern flank of the Baskerville anticline and dip gently toward the north.

The Broome Sandstone and associated Cretaceous sediments are here referred to as the Broome aquifer. Groundwater in the aquifer originates from rainfall infiltration; based on chloride ratios, the average annual recharge is about 11% of annual rainfall (860 mm). A regional water table occurs in the aquifer with semi-confinement beneath the upper siltstone/sandstone unit. The groundwater flows northward from about 30 m AHD along the Baskerville anticline to 5 m AHD at Beagle Bay. The groundwater is in a defined regional groundwater flow system which discharges around the coast over a saltwater wedge. Water in the aquifer is generally very fresh with a salinity less than 250 mg/L TDS.

Five exploratory bores, comprising four monitoring bores and a test production bore were drilled for the investigation. An additional eight existing bores were located and levelled to supplement the work, and are to be used in a proposed monitoring network.

The test production bore (TTP 02) was pumped for 45 hours at 20 L/s and drawdowns were observed in a monitoring bore (TTM 01) at 118 m distance. The drawdown in the

production bore at the end of the test was 1.66 m and in the monitoring bore it was 0.14 m, indicating a high yielding aquifer.

A numerical groundwater model was prepared based on the data obtained from the field investigation and other available information. The model has two layers to simulate the upper and lower parts of the Broome aquifer and was calibrated in steady-state mode to regional groundwater levels. Groundwater levels were predicted for a 20 year time period for an array of eight bores yielding 35 L/s with one-year stress periods to represent the planned annual pumpage of 7.1 GL/a.

The results of the modelling were:

- predicted drawdowns of greater than 0.6 m will be limited to the lease area;
- drawdowns along Bobby Creek will be less than 0.1 m;
- the estimated throughflow (supported by recharge-estimates) in the flow system is 62 GL/a.

From these results and consideration of the hydrogeology, it is concluded:

1) That after allowing 30% throughflow (19 GL) for environmental water requirements and 10% for other users (6 GL) there are about 37 GL/a available for allocation. Based on these calculations the 7.1 GL/a allocation being requested is readily available.

2) The proposed pumpage will not adversely affect the Beagle Bay Community water supply.

3) The expected modelled drawdown of less than 0.1 m after 20 years will not adversely affect the mound springs along Bobby Creek.

4) The interface between the saltwater wedge and groundwater flow system, if present, may rise by about 4 m along the lower reach of Bobby Creek but will be at depth and will not affect any existing bores.

The hydrogeological and modelling data from this investigation indicate that a supply of 7.1 GL/a is available and that pumping at this rate is sustainable and should have no significant adverse effects. The plantations will be developed in about five stages and a proposed monitoring programme which would be developed in co-operation with the Department of Environment will ensure early warning about any adverse effects and, if necessary, allow time to implement management solutions.

1 INTRODUCTION

1.1 BACKGROUND

Tropical Timber Plantations Pty Ltd (TTP), in a joint venture with the Beagle Bay Aboriginal Community (BBC) known as "*Beagle Bay Big Tree Country Project*", proposes to establish a 1,500 ha plantation to grow high value tropical timbers (teak, Indian sandalwood, Indian rosewood and African mahogany) near Beagle Bay on the Dampier Peninsula, about 110 km north-east of Broome (Fig 1). The proposed plantation is on 5,000 ha of land leased from the BBC. A groundwater supply of 7.1 GL/a from the underlying Broome aquifer is required for irrigation.

The project is to be established in partnership with the BBC. It offers various social and economic benefits, in particular employment and training opportunities for the aboriginal community. The project is pioneering an industry which may be of national significance.

The water requirements for the project have to be approved and licensed by the Department of Environment (DoE). This report has been prepared after consultation with DoE and provides the results of a hydrogeological investigation to support granting of a groundwater licence for the project.

1.2 LOCATION

The TTP Beagle Bay Project is located in an isolated area about 110 km north-east of Broome and 10 km south east of the Beagle Bay settlement. It is located in the West Kimberley region on a lease excised from Aboriginal Reserve 1834. It can be reached via graded roads off the Broome – Cape Leveque Road (Fig 1).

1.3 DEPARTMENT OF ENVIRONMENT REQUIREMENTS

1.3.1 General

One of the factors that attracted TTP to the area was a report by the Geological Survey (Allen, Laws and Commander 1992) that a major fresh groundwater resource of about 100 GL/a was available in the region. This estimate was based on the annual rainfall, relatively uniform geological conditions, some known bore yields and data on water quality.

The project is located in the Kimberley – Canning Groundwater Management Area for which a groundwater management plan has not been prepared by DoE. Consequently, because of the size of the groundwater licence being sought, DoE required TTP to prepare

an investigation programme to determine if adequate groundwater supplies are available after reserving an allowance for the environment and other user requirements.

A report outlining a proposed drilling and testing programme utilising some existing bores for monitoring was submitted to DoE on 13 June 2003 (Rockwater 2003b). The report provoked various discussion about the extent of the aquifer, size of the groundwater resources, and the amount of work which should be justifiably required in a poorly known area. Subsequently, at a meeting between the parties on 15 August 2003 a revised investigation programme was agreed. A report was prepared (Rockwater 2003d), which was accepted by the DoE and an exploration licence issued for the present groundwater investigation.

1.3.2 Existing Groundwater Licence

TTP has an existing groundwater licence (GWL No 100111) which authorises pumping of 100,000 kL/a for the trial project. In 2001/2002 pumpage was 17,200 kL/a and in 2002/2003 was 11,225 kL/a (Rockwater 2003c). A Groundwater Licence Operating Strategy (GLOS), required by DoE, for the trial plantations has also been prepared (Rockwater 2003a). However, a new GLOS Operating Strategy will need to be prepared if the licence is granted for the requested 7.1 GL/a.

1.3.3 Exploration Licence

An exploration licence to construct or alter a well was issued to the landowners (BBC), so that TTP could undertake the work. The licence instrument No CAW1544223(1) is attached in Appendix I.

2 SETTING

2.1 RAINFALL

The project area is located in a semi-arid region characterised by a 'dry season' from April to November in which average monthly rainfall ranges from < 5 to 33 mm, and the 'northern Australian monsoonal season' (four months) from December to March, during which time the average monthly rainfall varies from about 80 to 270 mm. About 90% of the rainfall falls during the monsoon season and originates from the inflow of moist west to north-westerly winds into the monsoonal trough forming thunderstorms and occasional tropical cyclones. Consequently, the location, amount and intensity of rainfall may vary considerably between different years.

The average rainfall for Beagle Bay Community, Country Downs Station (located 25 km south-west of the TTP lease area) and Broome airport – station 003003 - are given in Table 1. The rainfall data show a significant variation arising from location and length of record of the sites.

Table 1 - Average Rainfall (mm) Beagle Bay, Country Downs and Broome Airport (Bureau of Meteorology Data)

	J	F	M	A	M	J	J	A	S	O	N	D	Ann	Years of Record
Beagle Bay Station No 003000	193.5	195.8	147.4	49.5	31.3	12.9	11.3	1.8	1.8	3.6	20.8	92.0	751	81 (some gaps)
Country Downs Station No 003001	266.4	252.3	165.3	48.4	14.1	11.4	6.0	1.2	2.7	11.7	26.2	103.6	895.6	26 (some gaps)
Broome Airport Station No 003003	172.9	182.3	95.6	27.0	28.6	18.4	6.3	1.7	1.5	1.4	8.1	49.1	563.7	63.0

For the purpose of this report, the average rainfall and the average areal potential evaporation have been interpolated from the Bureau of Meteorology Rainfall Atlas and Evaporation Atlas (Bureau of Meteorology 2000 and 2001) and are given in Table 2. The table shows that on average, rainfall only exceeds potential evapotranspiration in January and February and that evapotranspiration is 2.2 times greater than the average annual rainfall.

Table 2 - Average Rainfall and Average Areal Potential Evapotranspiration Bureau of Meteorology Data for TTP Lease Area

	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Average Rainfall	275	250	150	35	30	10	5	< 5	< 5	5	15	80	860
Average Areal Potential Evapotranspiration*	205	185	190	140	115	90	100	120	150	195	210	220	1920

* the evapotranspiration which would take place if there was an unlimited water supply from an area so large that effects of upwind boundary transitions are negligible and local variations are integrated to an area average (Bureau Meteorology, 2001).

2.2 VEGETATION AND LANDUSE

The plantation site is vegetated by a relatively uniform eucalypt woodland with an understory of tussock-forming perennial grasses developed on pindan soils. The woodland has been extensively degraded by a succession of bushfires. About 10 km to the north, along the Bobby Creek drainage line, the vegetation is dominated by melaleuca and near the Beagle Bay Community, circular areas of dense hydrophytic vegetation occur around some mound springs. Mangroves border Beagle Bay and some other areas around the coast. The vegetation patterns can be seen on Figure 2, a rectified satellite image.

Apart from access tracks and the experimental plots, the area around the plantation site is virgin land. A small abandoned nursery is located on Country Downs Station about 15 km to the east, and a number of now-abandoned small orchards and vegetable gardens are located in the vicinity of the Beagle Bay Community.

2.3 TOPOGRAPHY AND DRAINAGE

The lease is located on a dissected plateau, incised by various drainage lines, and slopes downward to the north from about 200 m AHD on Country Downs Station 25 km to the south, to about 5 m AHD around Beagle Bay. Across the lease area the topography slopes downward to the north from about 75 m AHD in the south-west to 45 m AHD in the north.

The major drainage in the area is Bobby Creek. It follows a broad drainage depression and discharges into Beagle Bay. Numerous claypans occur along Bobby Creek and it is likely that it overlies an infilled palaeodrainage line for most of its length, except in the upper reaches. Lake Louisa, in the upper part of the Bobby Creek catchment area is a claypan, possibly formed by discharge from a perched aquifer.

A small un-named drainage line (Fig 3) is located near the western side of the lease, parallel with the Beagle Bay – Cape Leveque Road. Runoff occurs along the drainage after heavy rainfall events and its course is marked by more dense woodland.

2.4 GEOLOGY

2.4.1 Regional Geology

The geology of the region is known from geological mapping, geophysical surveys for oil exploration and data from exploratory oil wells and water bores. The geology of the Pender and Broome Sheets has been described by Gibson (1983 a and b) and a regional description of the geology is given by Yeates et. al. (1984).

The lease is situated in the northern Canning Basin at the north-western end of the Fitzroy Trough. The geology is mainly obscured by eolian sand (Pindan) except around the coastline.

2.4.2 Stratigraphy

The area is underlain by a sequence of sedimentary rocks about 8,000 m thick ranging from Ordovician to Quaternary age. The Jurassic to Quaternary sequence is of present interest and the inferred stratigraphy is listed in Table 3.

Table 3 – Inferred Stratigraphic Sequence in the Beagle Bay Area

Age	Formation	Thickness Approx (m)	Comments
Quaternary	Alluvial deposits Eolian (Pindan) deposits Estuarine deposits Bossut Formation	(?) 5 (?) 10 (?) 5 (?) 20	Sand in drainage lines Eolian sand Clay/silt in tidal and supratidal locations Limestone around coast
Late Cainozoic	Laterite	3	Weathering surface
Early Cainozoic	(?) Palaeodrainage deposits	(?) 30	Inferred sand/clay along infilled drainage lines
Early Cretaceous	Emeriau Sandstone Melligo Sandstone Broome Sandstone	30 30 280	Variable sequence of sandstone, conglomerate and siltstone considered as one unit
Late Jurassic - Early Cretaceous	Jarlemai Siltstone	250	Siltstone/claystone

2.4.3 Structure

The near-surface structure affecting the geological sequence of present interest has been briefly described by Gibson (1983 a, b). A more detailed structural interpretation is given by Laws (1991) who has prepared various structure contour maps for the area. His work shows that an east-west anticline (Baskerville Anticline) extends across the peninsular at about the latitude of Country Downs Station homestead. The lease is located on the northern limb of the anticline and the Broome Sandstone and associated sediments dip gently northward toward an un-named syncline underlying the lower part of Bobby Creek, and Beagle Bay. Some minor faulting probably also occurs but has not been identified.

Early Cainozoic palaeodrainage deposits are inferred to be present in an infilled drainage line along the lower reaches of Bobby Creek and probably also extend beneath Beagle Bay. Flat lying alluvial and eolian sediments conceal the underlying Cretaceous sediments except around the coast.

2.5 HYDROGEOLOGY

2.5.1 Previous Work

The groundwater resources of the Southern Dampier Peninsula (Broome 1:250,000 Sheet) which includes the lease area but not Beagle Bay, have been mapped and described by Laws (1984, 1985 and 1991). However, in the northern part of the peninsula (Pender 1:250,000 Sheet) the groundwater resources have not been mapped and are poorly known.

According to Laws (1991) various aquifers occur at depth beneath the Dampier Peninsula. However, only the near-surface Broome Sandstone and overlying sediments are of present interest. From the available data, the total renewable groundwater resources on the northern Dampier Peninsula are estimated to be about 100 GL/a (Allen, Laws and Commander 1992),

2.5.2 Broome Aquifer

The Melligo and Emeriau Sandstones (Fig 3) are of similar lithology and together are about 60 m thick and are underlain by about 250 m of Broome Sandstone. They are inferred to underlie the lease area and to form the upper sandstone/siltstone sequence encountered in the drilling (Section 4.1), and are in hydraulic continuity with the Broome Sandstone. For convenience the sandstone units are considered to be part of a single aquifer, here referred to as the Broome aquifer, and which extends upward from the top of the Jarlemai Siltstone to the regional water table.

The Broome aquifer consists of lithified (silicified and ferruginised) to unconsolidated, fine to very coarse grained sandstone with interbeds of conglomerate, siltstone and shale. The beds of siltstone are generally 5 to 15 m thick but are locally up to 30 m.

2.5.3 Occurrence of Groundwater

Groundwater in the Broome aquifer originates from the infiltration of a proportion of the annual rainfall to the water table. The infiltration is presumed to occur over the entire Dampier Peninsular but it is likely the percentage varies considerably depending on rainfall intensity, depth to water table, location of drainage lines and the nature of the subcropping Broome aquifer.

The groundwater in the Broome aquifer is unconfined and a regional water table which broadly follows the form of the regional topography extends throughout the region. Locally and at depth in the aquifer, the groundwater may be confined beneath beds of siltstone and fine-grained sandstone. However, there are no known significant vertical head

differences in the aquifer (Laws 1984). In some areas where interbedded siltstone occurs above the regional water table, there are local perched aquifers. In the lease area semi-confined groundwater conditions with local perched aquifers are present.

Groundwater in the aquifer moves in regional groundwater flow-systems controlled by the topography, and the location of recharge and discharge areas. The groundwater moves very slowly to be discharged into the sea, estuaries, claypans and local mound springs. The discharge around the coast occurs over an underlying saltwater wedge which may extend inland for 10 to 15 km (Laws 1991). The lease area is located within a local flow system which has an area of about 1,250 km^2 (Fig 3).

The groundwater in the Broome aquifer is generally very fresh (< 250 mg/L TDS) but may have a slightly higher salinity in the upper siltstone/sandstone sequence in the aquifer and above the saltwater interface between the saltwater wedge and the groundwater flow system. High rainfall recharge, depth to the regional water table and the siliceous nature of the aquifer are factors contributing to the low salinity of the groundwater.

3 INVESTIGATION PROGRAMME

3.1 GENERAL

The number and location of the monitoring bores and test production bore approved by DoE (Rockwater 2003d) are shown in Figure 2.

The drilling construction and testing of the bores was carried out by Drilling Contractors of Australia (DCA) using a B500 mud-rotary drilling rig. The drilling and testing was commenced on 18 November 2003 and was completed on 29 January 2004. Various logistical, weather and equipment problems slowed the progress of the work. Five exploration bores comprising one test-production bore and four monitoring bores with an aggregate depth of 544 m were drilled. Bore construction data are summarised in Table 4 and presented in Appendix II.

3.2 GEOLOGICAL AND GEOPHYSICAL LOGGING

The holes were drilled using mud-rotary methods. Drill cuttings were collected at 3 m intervals and examined on-site by the supervising hydrogeologist and lithological logs prepared (Appendix III).

Table 4 – Summary of Bore Data

Bore Designation	MGA Coordinates		Status	Date Constructed	Depth Drilled (m)	Reduced Level of Datum (mAHD)	Static* Water Level (m below datum)	Static Water Level (m AHD)	Casing Details	Screened or Slotted Interval (m)
	m N	m E								
TTP 02 (C)+	8 112 991.88	470 164.80	Production	November to December 2003	221.3	65.71	52.14	13.57	195 mm ID 219 mm OD uPVC +0.55 to 135.65m	200 mm ID Stainless steel screens 135.83 to 160.05 m
TTM 01 (D)	8 112 995.87	470 046.72	Monitoring	December 2003	85	64.51	50.81	13.70	55 mm ID, 60 mm OD, Class 9 uPVC +0.22 to 83.58m	71.58 to 83.58m 1 mm slotted
TTM 02 (B)	8 112 098.65	474 037.90	Monitoring	December 2003	82	21.67	11.36	10.31	55 mm ID, 60 mm OD, Class 9 uPVC +0.16 to 80.62 m	68.62 to 80.62m 1 mm slotted
TTM 03 (A)	8 116 567.16	467 559.44	Monitoring	January 2004	62	44.22	31.07	13.15	55 mm ID, 60 mm OD, Class 9 uPVC +0.14 to 59.80 m	47.80 to 59.80m 1 mm slotted
TTM 04 (E)	8 122 070.06	464 158.93	Monitoring	January 2004	98	10.05	0.48	9.57	55 mm ID, 60 mm OD, Class 9 uPVC +0.26 to 97.64m	79.64 to 97.64m 1 mm slotted

* Static Water Levels measured on 26 January 2004

\+ Designation of bores (Rockwater 2003d)

Downhole geophysical surveys were run in test production bore TTP 02. They comprised a gamma log and resistivity logs (Fig 4) and were used in conjunction with the lithological log to determine the stratigraphy and groundwater salinity in the test production bore.

3.3 BORE NUMBERING SYSTEM

A specific bore numbering system for the test-production bore and monitoring bores, and existing bores used for monitoring during the investigation, was adopted. The numbering system comprises a prefix TT (Tropical Timber), followed by P for production bore or M for monitoring bore. The bores were then given consecutive numbers and are applied to two production bores (TTP 01 an existing production bore and TTP 02), and twelve monitoring bores (TTM 01 – 12) listed in Table 5.

3.4 BORE LOCATIONS AND LEVELS

The locations and levels of all exploratory and observation bores (Fig 5) were determined by Whelans Survey and Mapping Group Pty Ltd (WSM). Bore sites are located with respect to the Mapping Grid of Australia (MGA) and elevations of bore heads to Australian Height Datum (AHD).

3.4.1 Discrepancy Between Levels

A comparison of levels determined by WSM and topographic contours on the Muntz 1:50,000 topographic sheet showed that the surveyed levels were about 5 to 6 m lower than contours on the topographic maps (Fig 5).

The locations of the bores were checked and found to be accurate. The levelling and standard survey marks (SSMs) used for the survey were checked and no major discrepancy was found. The Department of Land Administration (DOLA) was contacted about the levels of SSM No 187 and SSM No N4S 340 and WSM referred the possible error to Geoscience Australia. An email outlining the problem was sent to Geoscience Australia but WSM do not expect any immediate response.

WSM has also conducted surveys along the Broome – Cape Leveque Road for the Main Roads Department and levels from those and the present survey are consistent and tie together. It is concluded that the contours on the army maps may be in error. Therefore, all levels used in this report are referred to the WSM survey which is internally consistent, and referable to the adopted benchmarks.

Table 5 – Schedule of Monitoring Bores

Bore No.	Alternative Bore Name	MGA Coordinates		Reduced Level of Datum (mAHD)	Static* Water Level (m below datum)	Static Water Level (m AHD)	Open Depth (m below ground)	EC # @ 25°C (µS/cm)	pH
		m N	m E						
TTM 01	D+	8 112 995.87	470 046.72	64.51	50.81	13.70	83.58	420	6.5
TTM 02	B+	8 112 098.65	474 037.90	21.67	11.36	10.31	80.62	430	ND
TTM 03	A+	8 116 567.16	467 559.44	44.22	31.07	13.15	59.80	480	ND
TTM 04	E+	8 122 070.06	464 158.93	10.05	0.48	9.57	97.64	195 @ 79m 210 @ 97m 555 @ 98m	6.8
TTM 05	Bobieding	8 123 175.68	461 271.09	8.32	1.19	7.13	ND	ND	ND
TTM 06	Steven Victor	8 123 490.82	465 084.22	9.63	1.66	7.97	ND	115	6.5
TTM 07	Beagle Bay Village	8 121 697.72	464 163.88	14.00	4.35	10.35	40.8	135	6.5
TTM 08	Army	8 119 032.04	462 183.81	31.07	19.10	11.97	47.5	1140	7.1
TTM 09	Broome Shire	8 125 016.05	475 704.48	12.58	3.34	9.24	41.3	175	6.5
TTM 10	Country Downs	8 110 759.42	478 996.77	51.83	39.80	12.03	129.7	180	65
TTM 11	MRD 11A	8 110 974.05	458 009.99	72.68	55.12	17.56	125	125	6.5
TTM 12	MRD 12A	8 116 883.42	461 571.76	35.87	22.67	12.20	96	140	6.5

* Static Water Levels measured on 26 January 2004
\+ Designation of bores (Rockwater 2003d)
\# EC = Electrical Conductivity

3.5 PRODUCTION BORE (TTP 02)

Bore TTP 02 surface hole was drilled to 6 m depth and lined with 305 mm ID, 324 mm OD, API 5LBS/A53B mild steel casing to 5.88 m depth. The annulus between the casing and the hole was cement-grouted and allowed to cure before drilling resumed.

From 6 m depth, a 216 mm diameter pilot hole was drilled to 221.3 m depth using a tungsten-carbide insert (TCI) bit. The pilot hole was then reamed to 165 m depth and lined with 195 mm ID, 219 mm OD Class 12 uPVC casing from 0.55 m above ground surface to 135.65 m depth, and supported with plastic centralisers at 6 m intervals, and in-line 200 mm ID, 219 mm OD, 304 grade stainless-steel, 0.5 mm aperture, wedge-wire wound screens from 135.83 to 160.05 m depth. The screens are attached to the base of the uPVC casing with a stainless steel cross-over assembly set between 135.65 and 135.83 m depth. The basal screen is fitted with 304 grade stainless steel base plate.

Following casing installation, the annulus between the casing and hole was backfilled with quartz gravel, graded + 1.6 -3.2 mm. The drilling fluid remaining in the bore was replaced with fresh water and a solution of water and mud degrading agents was jetted into the screens. Development was continued, by airlifting at a discharge rate of about 20 L/s, until clean, sand-free water was produced. A bore construction diagram is given in Appendix II, a lithological log in Appendix III and a bore completion summary in Appendix IV.

3.6 MONITORING BORES (TTM 01 TO 04)

Four monitoring bores (TTM 01 to TTM 04) were constructed. TTM 01 was located near the test production bore to monitor water levels during the pumping test and for future long-term monitoring. Bores TTM 02 and TTM 03 were constructed as additional monitoring points to define the regional water table and TTM 04 was drilled to determine the possible presence of a saltwater wedge at Beagle Bay, and for monitoring.

The bores were constructed with a surface conductor hole drilled at 203 mm diamter to about 3 m depth, lined with 154 mm ID, 168 mm OD mild steel casing cemented in place. The holes were then drilled at 140 mm diameter to their designed depth, and lined with 55 mm ID, 60 mm OD, Class 9 uPVC casing with 6 m machine slotted lengths (with end caps) at the end of the casing string.

Following casing installation, the annulus of each bore was backfilled with +1.6 – 3.2 mm gravel graded. The bores were demudded using a 20 mm diameter poly-ethylene pipe and airlifted until clean water was obtained. Bore construction details are given in Appendix II, and bore completion summaries given in Appendix IV.

3.7 ADDITIONAL MONITORING BORES (TTM 05 TO 12)

As part of the DoE approval to undertake the work, additional monitoring bores were required to be identified and used to produce a water table map, and for long-term monitoring.

Available bore data (nine bores) in the DoE data base were obtained but were not usable. Instead, known bores used for road construction by Main Roads Department and Broome Shire, other unused bores around the Beagle Bay Community and on Country Downs Station were located in the field. Their depths were confirmed and the locations and elevations of the bores were surveyed. The location of the bores is shown in Figure 5 and pertinent bore data are listed in Table 5.

3.8 PUMPING TEST PROCEDURES

At the completion of the test production bore (TTP 02), a step-rate test was conducted on 17 December 2003. However, the maximum yield obtainable during initial step-drawdown testing was limited to 17.8 L/s and not 20 L/s as required under the contract conditions. With the approval of TTP, the drilling contractor provided another pump nominally capable of pumping 27 L/s against 60 m head. This pump was used for the pumping tests, but did not meet the rated capacity and produced a maximum yield of 20 L/s against a 56 m head.

The pump used was an electrical submersible pump powered by a portable diesel generator. Discharge rates were measured with an orifice weir and water levels measured using an electrical contact meter.

Water from the pumping test was disposed by surface discharge about 100 m from the site. An existing production bore (TTP 01), about 500 m to the south of the site, was pumped for two to three short periods at low rates during the course of the constant rate test.

3.9 MAPPING MOUND SPRINGS

During the course of the investigation various mound springs were identified and mapped along the lower reaches of Bobby Creek and the approximate areas in which they occur are shown in Figures 2, 2A, 2B and 2C. They generally comprised near-circular areas of dense vegetation surrounded by claypans or low grasses. Areas of free-standing water or wet soils were located within these areas but no significant mounding was noted. Overflow from the springs was not observed and presumably most of the discharging groundwater is

lost by evapotranspiration. During flooding in February 2004 the mound springs were completed inundated by run-off from Bobby Creek.

The mound springs are sites of groundwater discharge from the Broome aquifer. It is inferred that they are sites where groundwater is piped through the overlying alluvium to discharge at the surface. More diffuse and widespread discharge presumably occurs through the overlying alluvium, possibly contributing to the formation of the claypans along Bobby Creek.

4 RESULTS OF DRILLING AND TESTING

4.1 GEOLOGICAL DATA

All the exploratory bores were completed in the Broome Sandstone. The most comprehensive data were obtained from the test-production bore (TTP 02), which was the deepest bore for which there was a sample log and geophysical down-hole surveys.

The test production bore was drilled to 221.3 m but did not intersect the top of the underlying Jarlemai Siltstone. According to data given in Laws (1991) the top of the Jarlemai Siltsone increases from -200 m to -275 m AHD northwards across the lease. On this evidence the base of the sandstone is about 80 m deeper than drilled.

The correlation of the geological sequence encountered in TTP 02 is given in Table 6.

Table 6 – Inferred Geological Sequence in Test Production Bore (TTP 02)

Depth (m)	Formation	Lithology
0 –11	'Pindan'	Red silty sand
11–35	(?) Emeriau Sst	Yellow-grey, poorly sorted, silty sandstone
35 – 72	(?) Melligo Sst	Yellow-brown, siltstone and interbedded sandstone
72 – 221	Broome Sst	Red-brown, very coarse sandstone with interbedded gravel and fine sandstone and thin beds of siltstone

The section from 11 to 72 m consists of a sequence of interbedded siltstone and sandstone which is correlated with the Emeriau and Melligo Sandstones. A similar geological sequence was recorded in TTM 11 and TTM 12 drilled for road construction. The Broome Sandstone is notable for very coarse sandstone and fine conglomerate present in the section from 110 to 180 m.

From the known geological structure (Laws 1991) the sediments dip gently northward from the crest of the Baskerville Anticline. As a result, the siltstone/sandstone section of the aquifer subcrops beneath the lease area and the very coarse sequence of Broome Sandstone subcrops further to the south. This relationship is shown diagrammatically in Figure 6.

4.2 HYDROGEOLOGICAL DATA

4.2.1 Aquifer

In the lease area, the Broome aquifer extends from the water table to the inferred top of the Jarlemai Siltstone and is about 250 m thick. The upper part (Emeriau and Melligo Sandstones) consists of an interbedded sequence of siltstone and sandstone which comprise about 10% of the aquifer. The remainder of the Broome aquifer (Broome Sandstone) consists of coarse sandstone and conglomerate with thin interbeds of siltstone. In TTP 02 the aquifer was about 60% sandstone/conglomerate and 40% siltstone/shale.

4.2.2 Water Table

The downhole geophysical logs (Fig 4) indicate that minor perched aquifers may occur above the regional water table. If correct, they are likely to be of local extent and perched on the beds of siltstone within the sequence.

Uniform vertical heads and hydraulic continuity through the aquifer, as observed by Laws (1985), was observed in TTP 02 and TTM 01 which are 118 m apart, and 221 m and 85 m deep respectively. However, upward heads and local artesian flows occur at the discharge boundary to the flow system, as encountered in several bores and indicated by mound springs along Bobby Creek near the Beagle Bay Community (Fig 2).

The configuration of the water table across the lease area is given in Figure 7. The contours show that the water table ranges from 15 m AHD at the south-western corner to 12 m AHD at the north-eastern corner of the lease. The direction of groundwater flow is north to north-east and the depth to the water table beneath the lease ranges from about 60 m below surface in the south to 30 m in the north.

4.2.3 Aquifer Response to Pumping

Step-rate tests were used to determine the drawdown at different pumping rates and to select the pumping rate for the constant rate test. The bore was pumped at 10.1, 15 and 17.8 L/s during the first test and at rates of 17.8, 19 and 20.1 L/s in the second test. The

results of the step-rate tests are shown in Figure 8. The very low drawdowns indicate that the bore has a high efficiency and is capable of producing at least 30 L/s with a pump inlet setting 84 m below the casing flange (bore datum).

A constant-rate pumping test of 20 L/s was run on bore TTP 02 for 48 hours on 27 to 29 January 2004. During the test, water levels were measured in the test-production bore and in observation bore (TTM 01) about 118 m north-west of the production bore.

The static water level in the production bore at the beginning of the test was 52.3 m below datum and the drawdown at the end of the test was 1.66 m; in the observation bore the static water level was 51.03 m below datum and the maximum drawdown was 0.14 m.

The water level in the production bore recovered to the initial static water level within 65 minutes and in TTM 01 it recovered to within 0.01 m of the static water level within 75 minutes.

On commencement of the test the drawdown response in the monitoring bore was small and instantaneous. The water level response is consistent with a leaky-artesian aquifer where a significant proportion of the pumpage is contributed from overlying confining beds. However, on a regional scale, the Broome aquifer is an unconfined aquifer (Laws 1991).

4.2.4 Aquifer Parameters from Pumping Test

The time-drawdown data from the pumping test measured in TTM 01 were analysed by the Jacob method and by the leaky-artesian method; and TTP 02 by the Jacob method. The Jacob analyses are shown plotted in Figure 9, and the results summarised in Table 7. The transmissivities of 7,200 m^2/d and 6,300 m^2/d (TTP 02) are in close agreement but higher than any other known pumping test results from the Broome aquifer. However, the derived hydraulic conductivity results are reasonable based on the coarse nature of the sediments comprising the aquifer and the very small measured drawdowns. The storativity of 1.21 x 10^4 derived for TTM 01 appears rather low.

Table 7 – Results of Pumping Test Analyses compared with Results from Laws (1985)

Bore	Transmissivity	Hydraulic Conductivity (m/d)	Storativity	Method	Comment
TTM 01	7,200	29*	1.21×10^{-4}	Jacob	-
TTP 02	6,300	25	-	Jacob	-
TTP 01	2,750	11*	1.37×10^{-3}	Leaky Artesian	-
HCL Series	1,500–3,000	12–23	-	-	Laws (1985) p8

* Aquifer assumed to be 250 m thick

The leaky artesian analysis of TTM 01 is shown plotted on Figure 10. The estimated transmissivity of 2,750 m^2/d is considerably less than obtained by the Jacob method but is within the range (1,500 to 3,000 m^2/d) recorded by Laws (1985). The derived hydraulic conductivity of 11 m/d for an aquifer thickness of 250 m appears rather low considering Laws (1985) found a range of 12 to 23 m/d and noted that in local areas the hydraulic conductivity may reach 400 m/d (Laws 1987). A storativity of 1.37×10^{-3} was derived from the result and is in the correct order of magnitude for a leaky artesian aquifer.

The transmissivity and storativity values derived by the two methods of analyses show considerable variation, suggesting problems with the layout of the pumping test and/or that the analyses used do not fulfil the required assumptions. Nevertheless, the very coarse nature of a large proportion of the aquifer, and the low groundwater gradients south of the lease area indicate the Broome aquifer has a relatively high transmissivity.

4.2.5 Specific Yield

The specific yield for the Broome aquifer could not be determined from the pumping test and is not known to have been derived or measured for the aquifer. A value of 0.10 is arbitrarily adopted.

4.2.6 Groundwater Recharge

Groundwater recharge was calculated indirectly from the ratio of chloride in rainfall divided by the chloride in groundwater beneath the lease area. The estimate is based on chloride in rainfall data (Hingston and Galitis 1976) and water analyses from TTP 01 (current operating bore) and TTP 02 (test production bore), listed in Table 8. The method assumes the aquifer does not contribute or capture any chloride other than from rainfall and that the different concentrations of chloride in rainfall and groundwater result from evapotranspiration losses.

Chloride in rainfall is low in the Kimberley region and is about 3 mg/L in the lease area (Hingston and Gailitis 1976). The chloride in the groundwater from TTP 01 is 31 mg/L and in TTP 02 is 34 mg/L, say 33 mg/L. Based on these data, the average annual recharge is 3/33 x 100 = 11%.

Laws (1987), from a consideration of chloride ratios and a flow net interpretation, estimated the recharge to be 4 to 5% near Broome. The different recharge estimates possibly reflect the higher rainfall in the lease area.

Based on the geological interpretation (Fig 6) and the wide separation of regional water table contours the principal recharge area may occur where the very coarse middle section of the Broome aquifer subcrops immediately north of the Baskerville anticline (Fig 3).

4.2.7 Saltwater Wedge

A saltwater wedge is inferred to underlie the area bordering Beagle Bay. As part of the investigation TTM 04 was drilled to 98m, 35 m deeper than the community water-supply bore to test for the presence of the wedge. Electrical conductivity measurements down the test hole showed that at the bottom the groundwater salinity was about 500 mg/L TDS and the interface had not been reached.

The water table map (Fig 7) shows that the water table beneath the Beagle Bay Community lies at about 7.5 to 10 m AHD. Based on the Ghyben-Herzberg principal the interface with the saltwater wedge should be about 40 times the elevation of the water table and theoretically would be at an approximate depth of about 300 to 400 m below the water table and somewhat shallower in the discharge area. The base of the Broome aquifer is about –325 m AHD (Laws 1991) and based on these considerations, it is uncertain whether the toe of the wedge underlies the Beagle Bay Community (Fig 6). Based on similar considerations, the saltwater wedge is not likely to be present beneath the lease area.

4.2.8 Groundwater Quality

Analyses for the existing production bore on the plantation (TTP 01) and for the test production bore (TTP 02) are given in Table 7.

Table 8 – Major Ion Analyses for TTP 01 and TTP 02

Analyte	TTP 01 29 May 2003 (mg/L)	TTP 02 28 January 2004 (mg/L
pH (pH units)	6.0	5.8
Electrical conductivity @ 25°C (micro siemens/cm)	120	130
Total Dissolved Solids (as NaC1)	80	85
Hardness (equivalent $CaCO_{3)}$	15	15
Iron (soluble)	<0.05	0.05
Sodium	16	20
Potassium	<0.05	0.6
Calcium	1.2	0.6
Magnesium	2.8	3.4
Chloride	32	34
Bicarbonate	10	15
Sulphate	<1	2
Nitrate	2.6	2.8
Silica	45	32
Total Phosphorus	<0.05	<0.05

The results of the analyses show that the groundwater is slightly acidic and has very low salinity. The principal constituents are silica, chloride and sodium. The groundwater has a natural nitrate level of 2.8 mg/L and a very low concentration of sulphate, and has been used successfully for the irrigation of the trial plots.

The groundwater temperature measured during the pumping test on TTP 02 was 33.8^{o}C.

5 PROPOSED GROUNDWATER PUMPAGE

5.1 GROUNDWATER REQUIREMENTS

TTP has applied for a groundwater allocation of 7.1 GL/a. This comprises the following components:

- plant requirements
- exceptional season requirements
- system losses
- infrastructure requirements

The plantation is proposed to be irrigated by trickle irrigation. The plant requirements have been determined in the trial plots but will require further refinement as more experience is gained about the requirements of the plantations. In addition to a base-supply, additional water application may be needed in periods of drought and to meet seasonal conditions such as an extended dry season, abnormal easterly winds, or extended periods of high ambient temperatures. Allowances are required to meet losses from the irrigation system (Irrigation Industry Standard of system efficiency is 90%) and a further 10% more than plant requirements may be required. Water is also required for domestic purposes, gardening, fire-fighting, and dust suppression and will increase as the plantation is developed.

The approximate annual and monthly water requirements for the project as it is developed are given in Table 9.

Table 9 – Estimated Water Requirements

YEAR No	YEAR (June to July)	NEW PLANTINGS/ ANNUM (ha)	TOTAL PLANTINGS (ha)	WATER REQUIRED FOR YEAR 1 PLANTINGS (GL/ANNUM)	WATER REQUIRED FOR YEAR 2 PLANTINGS (GL/ANNUM)	WATER REQUIRED FOR YEAR 3 PLANTINGS (GL/ANNUM)	WATER REQUIRED FOR YEAR 4 PLANTINGS (GL/ANNUM)	WATER REQUIRED FOR YEAR 5 PLANTINGS (GL/ANNUM)	ESTIMATED TOTAL WATER REQUIRED (GL/ANNUM)	AVERAGE DAILY PUMPING RATE/ANNUM (kL)	AVERAGE DAILY PUMPING RATE/ NINE MONTHS (kL)
1	2004-2005	300	300	1.5	0	0	0	0	1.5	4,110	5,474
2	2005-2006	300	600	1.5	1.5	0	0	0	3	8,219	10,949
3	2006-2007	300	900	1.5	1.5	1.5	0	0	4.5	12,329	16,423
4	2007-2008	300	1200	1.3	1.5	1.5	1.5	0	5.8	15,890	21,168
5	2008-2009	300	1500	1.3	1.3	1.5	1.5	1.5	7.1	19,452	25,912
6	2009-2010	0	1500	1.3	1.3	1.3	1.5	1.5	6.9	18,904	25,182
7	2010-2011	0	1500	1.3	1.3	1.3	1.3	1.5	6.7	18,356	24,453
8	2011-2012	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
9	2012-2013	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
10	2013-2014	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
11	2014-2015	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
12	2015-2016	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
13	2016-2017	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
14	2017-2018	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
15	2018-2019	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
16	2019-2020	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
17	2020-2021	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
18	2021-2022	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
19	2022-2023	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723
20	2023-2024	0	1500	1.3	1.3	1.3	1.3	1.3	6.5	17,808	23,723

Years 1 to 3 - 1.1 GL/annum/300ha plus 15% for drought (one in four year event) = 1.265; plus 10% inefficiency; plus 0.1 GL/annum contingency = 1.4915 (say 1.5 GL/annum)
Years 4 to 20 - 0.96 GL/annum/300ha (ie trees older 4 years and older) plus 15% for drought (one in four year event) = 1.104; plus 10% inefficiency; plus 0.1 GL/annum contingency = 1.3144 (say 1.3 GL/annum)

5.2 LOCATIONS OF PRODUCTION BORES

The locations of proposed production bores and the current groundwater contours are shown in Figure 7. The bores will be located approximately 1 km apart at right angles to the direction of groundwater flow to maximise interception of groundwater throughflow. They are also located on a central corridor through the proposed plantation to facilitate access, minimise infrastructure costs and to enable transfer of water in the event of pump or bore problems.

Presently, eight production bores, each with a capacity of 35 L/s are planned. Further testing and construction of higher-yielding bores may reduce the number of bores required.

5.3 PUMPING REGIME

The annual volume of water required will gradually increase from 1.5 GL in year 1 to 7.1 GL at year 5 and then decrease to 6.5 GL at year 8. After full development annual water requirements should remain stable, excepting for any exceptional seasonal requirements (Table 9).

The groundwater pumpage and irrigation will be undertaken in the early morning to avoid evaporation losses.

6 COMPUTER MODELLING

6.1 CONCEPTUAL MODEL

The lease area is located within part of a regional flow system (Fig 3) in the Broome aquifer. The aquifer thickens toward the north and is about 250 m thick beneath the area. The regional direction of groundwater flow is predominantly northward toward Bobby Creek and beneath the lease area the water table falls from about RL 15 to RL 12 m AHD (Fig 7).

The Broome aquifer comprises mainly interbedded, very coarse sandstone, conglomerate and siltstone dipping to the north, as shown in the diagrammatic cross section (Fig 6). Beneath the plantation area and to the north the siltstone forms a discontinuous confining layer, probably with local overlying, perched aquifers. To the south the underlying highly permeable part of the formation subcrops and can be directly recharged (Figs 3 and 6).

From pumping test data approximate aquifer parameters are: transmissivity 3,000 to 7,000 m^2/d, hydraulic conductivity 11 to 25 m/d, and storativity 1.21 x 10^{-4}. The specific yield is assumed to be 0.10. These provide a guide for the model and may have to be modified to achieve model calibration.

Annual recharge based on chloride ratios is 11% of the average annual rainfall of 860 mm and is estimated to be 95 mm. Most recharge to the aquifer probably occurs to the south where the coarse sandstone and conglomerate of the Broome aquifer is inferred to subcrop (Fig 3).

The plantation is to be developed in stages. Groundwater requirements will vary monthly depending on seasonal conditions and will be increased as each stage is developed and then decrease and be relatively constant until assumed harvesting after 20 years.

6.2 MODEL DESCRIPTION

The model utilises Processing Modflow Pro version 7.0.18, which incorporates MODFLOW, the industry-standard finite-difference groundwater modelling software designed by the US Geological Survey (Harbaugh, et. al. 2000).

It has a rectangular grid of 50 rows and 54 columns and two layers that covers an area of 71.2 km east–west and 47.1 km north–south centred on the project site. Model cells are generally 1,400 x 940 m in size, reducing to 1,000 x 940 m in the project area. Layer 1 represents the upper part of the Broome aquifer that contains more siltstone, extending from near (and south of) the project site, to the north. Layer 2 represents the bulk of the formation, which is mostly coarse-grained sandstone.

6.3 MODEL PARAMETERS

Initial model parameters were based on values determined in the bore TTP 02 pumping test, and were varied in model calibration, as described in Section 9.3 of this report. The adopted parameters are listed in Table 4, below.

Table 10 – Adopted Model Parameters

	Hydraulic Conductivity (m/d)		Storage Coefficient	Specific Yield
	Horizontal	Vertical		
Layer 1	10	0.5	N/A	0.1
Layer 2	15-25	1	0.00012	0.1

Recharge is 62 mm/year in general, with some low-lying areas with 20 mm/year, and a small area with 95 mm/year. Recharge was assumed to be zero in groundwater discharge areas near the coast. The recharge rates incorporate any evapotranspiration losses in low-lying areas.

The shape of the water-table contours (Figure 3) indicate that there is some groundwater discharge to Bobby Creek, and MODFLOW's Drain package was used to simulate discharge to the creek.

6.4 MODEL CALIBRATION

The model was calibrated in steady-state mode to the regional groundwater levels shown in Figure 3. Values of horizontal and vertical hydraulic conductivity, and recharge rates, were varied until a close correspondence was achieved between calculated and measured groundwater levels (Figure 11).

6.5 MODEL RUN AND RESULTS

The model was run for 20 years with one-year stress periods to represent the planned annual rates of extraction given in Table 9. It was assumed that extraction would be from eight bores, evenly-spaced across the project area, with each bore pumping one-eighth of the annual total.

Predicted water-level drawdowns after 20 years for each of the model layers are shown in Figures 12 and 13. They indicate how the effects of the extraction will be localised within the borefield, and decrease toward Bobby Creek to the north.

7 RESULTS OF MODELLING

7.1 PREDICTED DRAWDOWNS

The model predicts the drawdown in Layer 1 at the water table (siltstone/sandstone sequence); and in Layer 2 which is semi-confined, (mainly sandstone sequence), which receives leakage from Layer 1. The layers are in hydraulic continuity and consequently the modelled drawdown is similar for both layers except in the lease area affected by leakage, and to the south where the confining layer is absent.

The results of the modelling show the development of a shallow cone of depression exceeding 0.6 m concentrated beneath the lease area, and that the drawdown decreases to 0.1 m close to Bobby Creek (Figs 12 and 13). The model accounts for variation in rainfall recharge but not any increased recharge across the plantation area which may occur when

the lease is cleared to establish the plantations. The results are believed to be conservative and effects are likely to be less than predicted.

7.2 EFFECT ON BEAGLE BAY WATER SUPPLY

The modelling indicates that after 20 years pumping the drawdown at Beagle Bay will be about 0.1 m.

There are two production bores (1/82 and 1/83) used for Beagle Bay Water Supply. The bores are 64.8 and 73 m deep with rest water levels 3.10 m and 3.27 m below top of casing, respectively. Bore 1/82 has been tested at 160m^3/d with a pumping water level of 4.7 m and bore 1/83 tested at 1,011 m^3/d with a pumping water level of 14.67 m. An additional 0.1 m of drawdown caused by pumping from the plantations will not effect the yields from the bores, or the pump settings.

7.3 EFFECT ON SALTWATER INTERFACE

The theoretical maximum rise in the interface below the Beagle Bay Water Supply bore based on a drawdown of 0.1 m is about 4 m and will remain well below the bores (Fig 6). The wedge may move inland a short distance as a new dynamic equilibrium is established in response to the pumping. However, no adverse affects on existing bores are likely to occur. The saltwater wedge is not present beneath the lease area and the bores will not be affected.

7.4 EFFECT ON MOUND SPRINGS

The modelled drawdown in the Broome aquifer where the mound springs are located along Bobby Creek is less than 0.1 m (Figs 12 and 13). The potentiometric head in the aquifer in this area is about 7.5 to 10 m AHD (Fig 3) and in low-lying areas along Bobby Creek the head is up to 3 m above ground level and artesian flows, maintaining the mound springs, occur where there are favourable geological conditions and the groundwater is piped to the surface.

Water levels in the mound springs will vary depending on seasonal, atmospheric and tidal conditions affecting loading on the aquifer. In addition, they will be directly affected by any nearby flowing artesian bores such as the bore maintaining the swimming hole north of the Beagle Bay Community. A decline of less than 0.1m superimposed on the natural and locally imposed water level variations should have negligible effect on the mound springs.

7.5 ESTIMATED THROUGHFLOW

The regional throughflow in the flow system past the 15 m water table contour for the capture zone of the flow system (Fig 11) was calculated from the model and is :

L1 = 8,400 m^3/d = 3 GL/a
L2 = 162,500 m^3/d = 59 GL/a
62 GL/a

An alternative method of estimating recharge over the flow system recharge zone was also undertaken. Based on a recharge zone of 750 km^2 for the flow system upstream of the 15 m water table contour (Fig 11), annual rainfall of 860 mm and recharge of 11%, the estimated recharge across the capture zone is 71 GL. This is in reasonable agreement with the model calculation and supports the throughflow estimate.

It should be noted that the total throughflow of the flow system is greater than estimated because recharge downstream from the 15 m water table contour is not included, and is additional to the throughflow.

7.6 GROUNDWATER CAPTURE ZONE AND TRAVEL TIMES

The predicted extent of the groundwater capture zone and travel times for groundwater flow directly intercepted by the proposed pumpage are shown in Figure 14. The capture zone extends south to the Baskerville anticline and has an area of about 155 km^2, about 12% of the flow system (Section 2.5.3).

The travel time for groundwater to move from the plantation area to Bobby Creek with no pumpage is about 200 years and with pumpage, about 250 years in L1 and 290 years in L2 (Fig 14).

7.7 ENVIRONMENTAL WATER REQUIREMENTS

Environmental water requirements (EWR) are a proportion of the groundwater throughflow required to maintain surface water flows and groundwater dependent vegetation, and to minimise movement of the saltwater interface. The DoE applies a figure of 30% of throughflow for environmental water requirements as used in the Land and Water Resources audit (WRC 2000).

In the lease area groundwater in the flow system is generally too deep (30 to 60 m) to be accessed by most vegetation except from any perched aquifer. In the discharge area along

Bobby Creek groundwater dependent vegetation borders Bobby Creek and occurs around mound springs.

Movement of the saltwater interface is likely to be minimal (Fig 3) and to be spread over a wide area.

Accepting that the environmental water requirements are 30% of the throughflow estimate, the EWR for the flow system is about 19 GL/a.

7.8 RESERVATION FOR OTHER USERS

The DoE requires 10% of the throughflow to be reserved for other users. The only significant user is the Beagle Bay Water Supply. Some small satellite communities and Country Downs (stock water) also pump from the aquifer but are too distant to be affected. The Beagle Bay Community currently has a groundwater licence for 0.1 GL (100,000 kL/a). Annual pumpage is less than the licensed allocation and no major increase in annual pumpage is expected.

Based on 10% of the throughflow the volume of groundwater reserved for other users is about 6 GL/a and is well in excess of any likely water requirement for the Beagle Bay Community, or planned water requirements in the region.

7.9 GROUNDWATER AVAILABLE FOR ALLOCATION

The estimated throughflow (supported by recharge estimates) in the flow system is 62 GL/a; after an allowance of 19 GL/a (30%) for environmental water requirements, and 6 GL/a (10%) for other groundwater users, a groundwater resource of about 37 GL/a is available for allocation The allocation of 7.1 GL/a being sought comprises about 17% of the groundwater estimated to be available for allocation.

8 PROPOSED MONITORING PROGRAMME

If the groundwater licence application is approved, a groundwater monitoring programme to protect the groundwater resources and to ensure prompt investigation of any detrimental effects will be developed. The details of the monitoring programme will be provided in a revised Groundwater Licence Operating Strategy, and developed in co-operation with DoE. The programme will be based on, but not restricted to, the programme outlined in Table 11.

Table 11 – Outline for Proposed Monitoring Programme

Parameter	Sampling Sites	Frequency	Comments
Pumpage	All production bores	Monthly	Recorded by calibrated cumulative flow meters
Water Levels	Production bores	Monthly	–
	Monitoring bores (TTM 01 – TTM 12)	3 - Monthly	Some bores may be monitored more frequently
Salinity	Production Bore	Monthly	By conductivity meter
	Monitoring bore (TTM 04)	3 - Monthly	Conductivity profile to test presence of interface
Major Ion Analysis	Production bores	Annual	All major ions
Agro-chemical Analysis	Production bores	2 - Yearly	Scan for agro-chemicals and insecticides

9 CONCLUSIONS

The results of a groundwater drilling and testing programme, interpretation of available data and groundwater modelling have shown that the proposed location of TTP plantations is in a flow system within the Broome aquifer which has about 37 GL/a of groundwater available for allocation.

Modelling of the pumpage effects for a 20 year time-period at a maximum pumping rate of 7.1 GL/a shows that the capture zone extends over an area of about 155 km^2, and a cone of depression greater than 0.6 m depth is limited to the lease area.

The modelling also shows that effects of pumpage are likely to extend northward to Bobby Creek where 20-year drawdowns are estimated to be less than 0.1 m. These small drawdowns are not considered likely to adversely affect the Beagle Bay water supply or local mound springs and groundwater dependent vegetation along Bobby Creek. A small rise in the depth of the salt/fresh water interface may result, but is not likely to affect any existing bores.

The results of this investigation indicate that a supply of 7.1 GL/a is available and that pumpage is sustainable and should have no major adverse effects. A further safeguard is that the plantations will be developed in stages over about five years and with the monitoring system in place should provide early warning, and allow time to modify the pumping regime if necessary.

Dated:

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Yeates, A.N. Gibson, D.L., Towner, R.R. and Crowe, R.W.A., 1984: Regional geology of the onshore Canning Basin Western Australia in the Canning Basin WA: Geological Society of Australian and Petroleum Exploration Society of Australia Proceeding p25 -55.

FIGURES

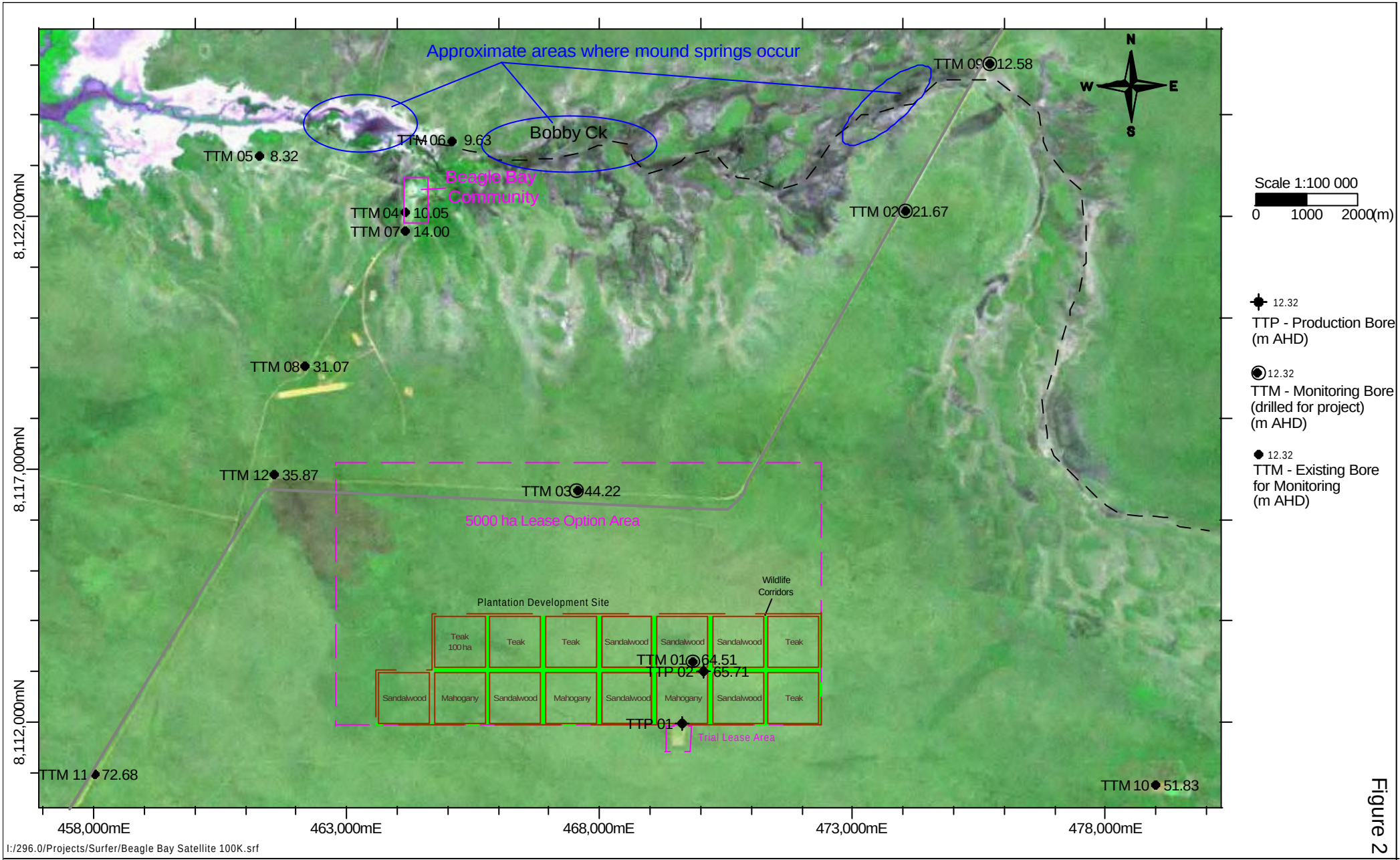
Figure 1

I:/296.0/Projects/Surfer/Beagle Bay Location Map.srf

CLIENT:	Tropical Timber Plantations
PROJECT:	Beagle Bay Project
DATE:	March 2004
Dwg. No:	296.0/04/1-1

LOCALITY MAP

Rockwater Pty Ltd



I:/296.0/Projects/Surfer/Beagle Bay Satellite 100K.srf

Figure 2

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

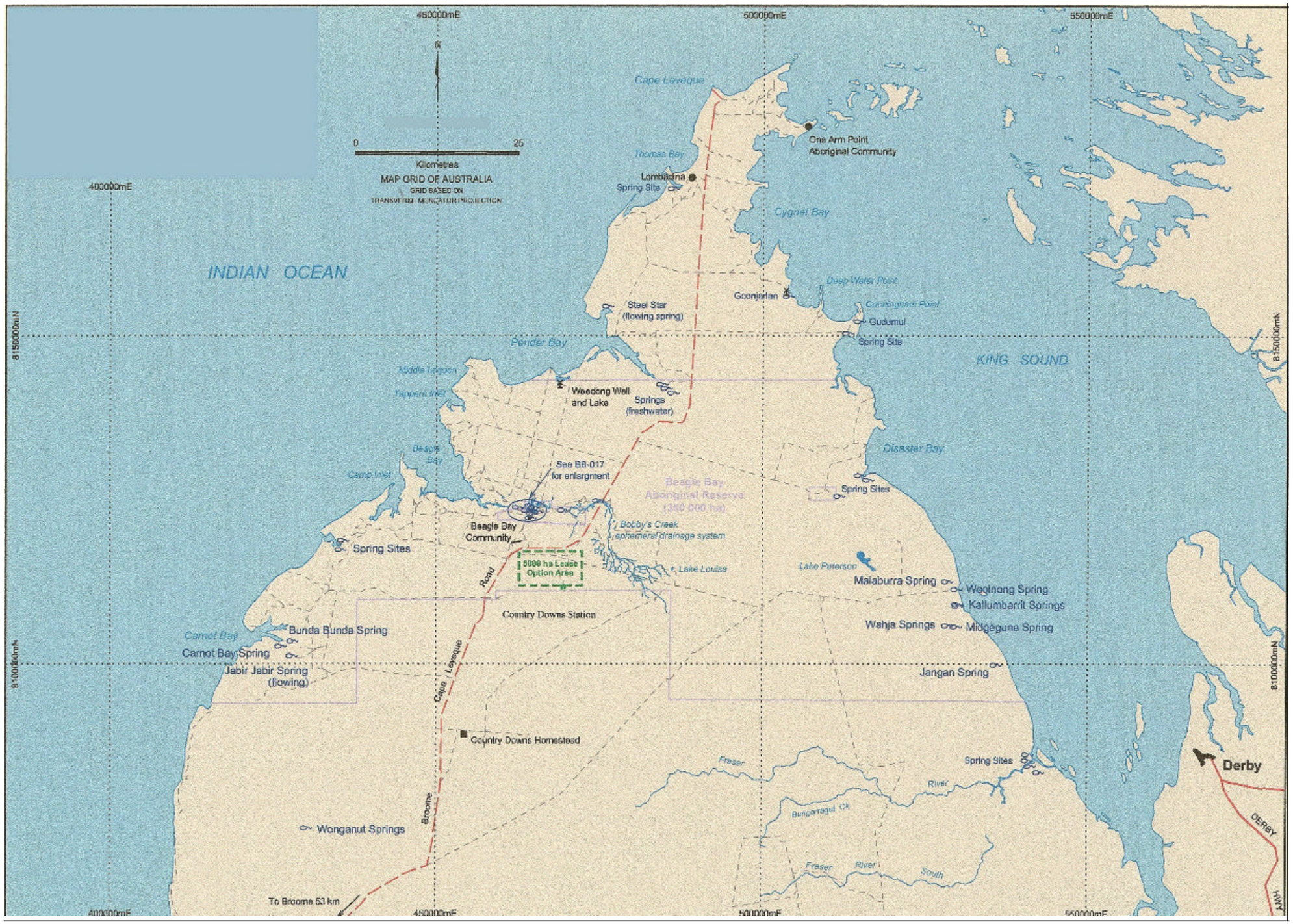
DATE: March 2004

Dwg. No: 296.0/04/1-2

SATELLITE IMAGE WITH LOCATION OF LEASE AREA AND BORES

Rockwater Pty Ltd

Figure 2A



MOUND SPRINGS
NORTHERN DAMPIER
PENINSULA

I:/296.0/Projects/Surfer/Mound Springs Peninsula.srf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

DATE: March 2004

Dwg. No: 296.0/04/1-2A

Rockwater Pty Ltd

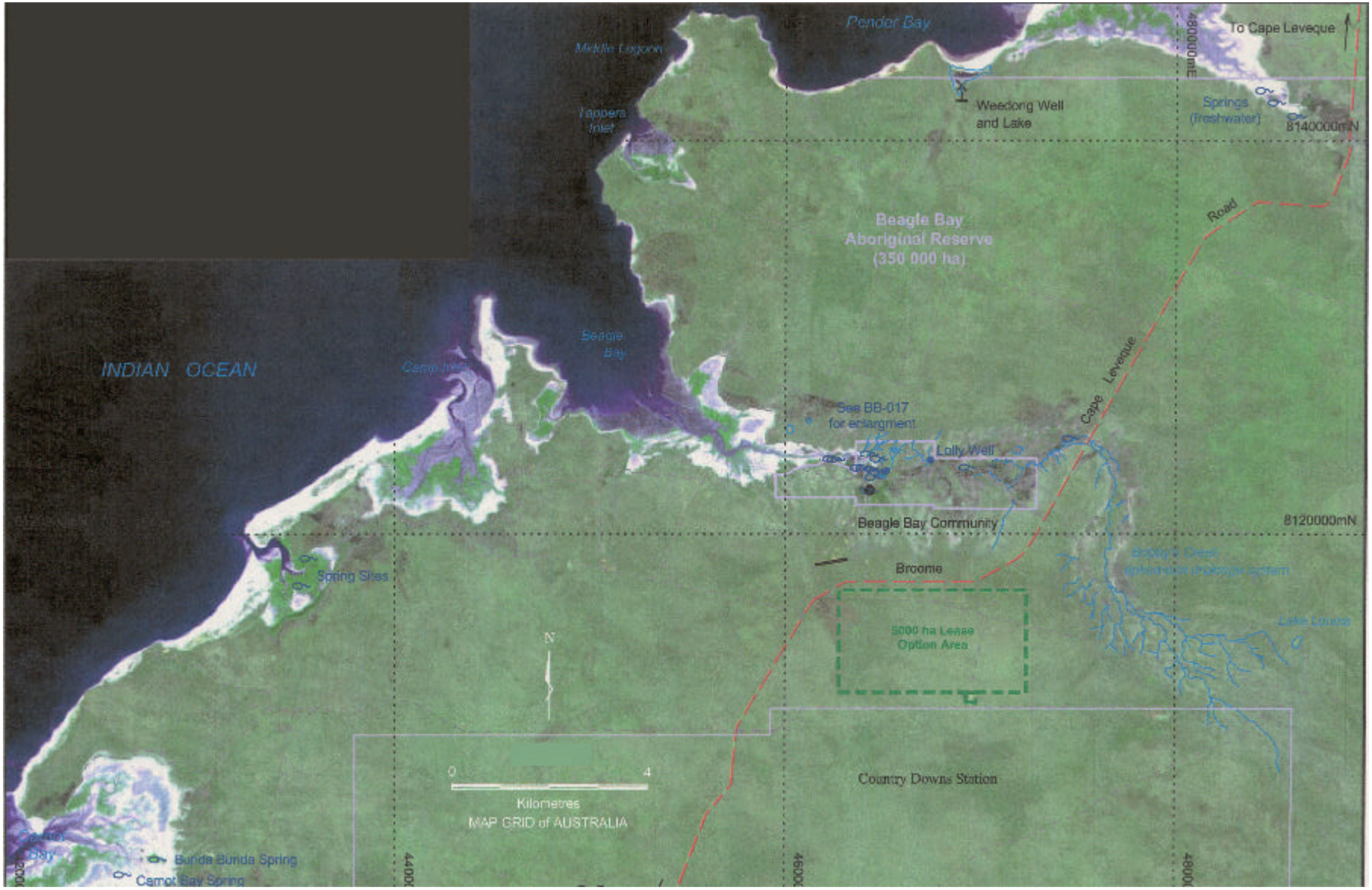


Figure 2B

I:/296.0/Projects/Surfer/Mound Springs Beagle Bay.srf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

DATE: March 2004

Dwg. No: 296.0/04/1-2B

MOUND SPRINGS
BEAGLE BAY REGION

Rockwater Pty Ltd

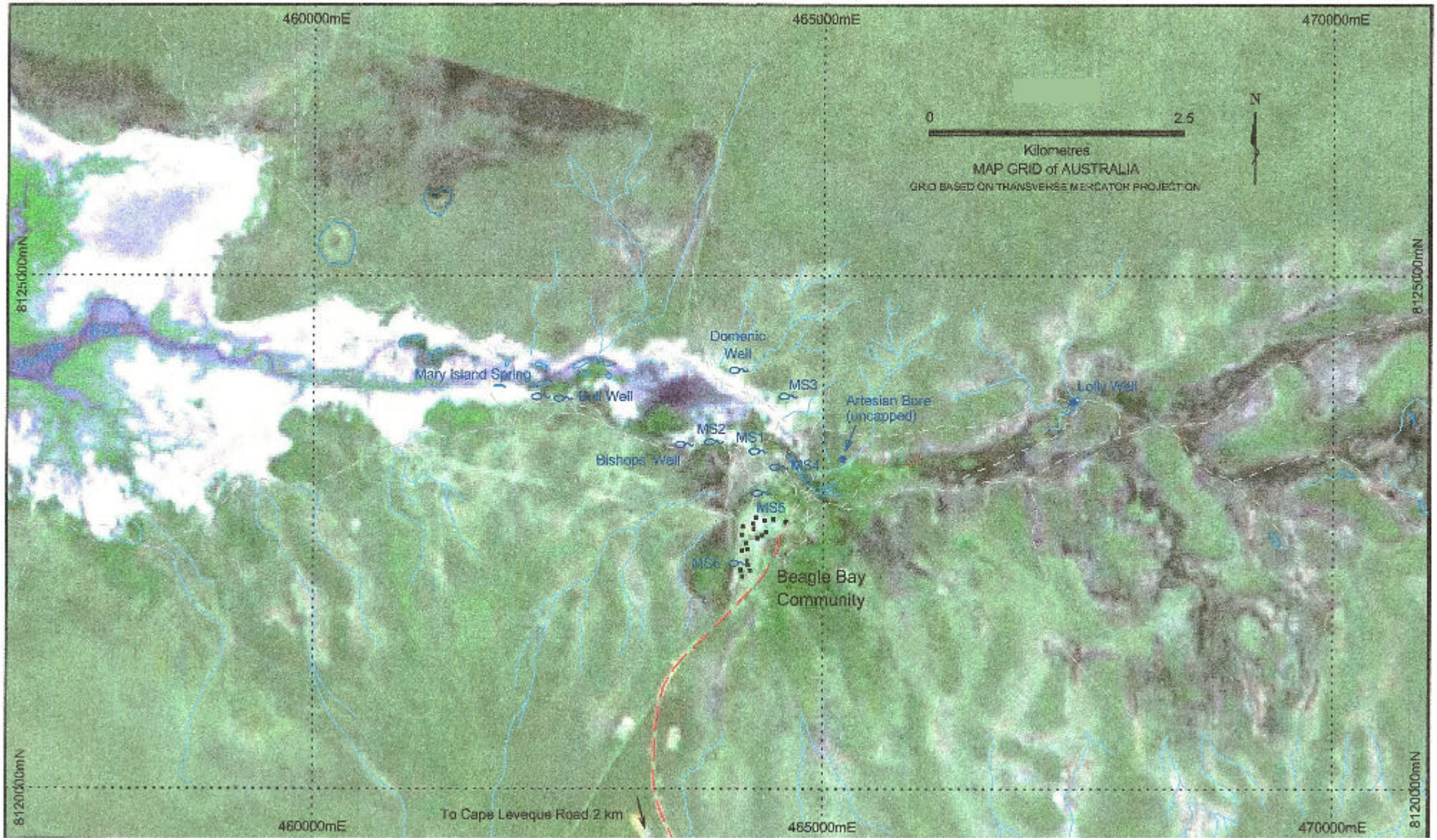


Figure 2C

I:/296.0/Projects/Surfer/Mound Springs Bobby Crk.srf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

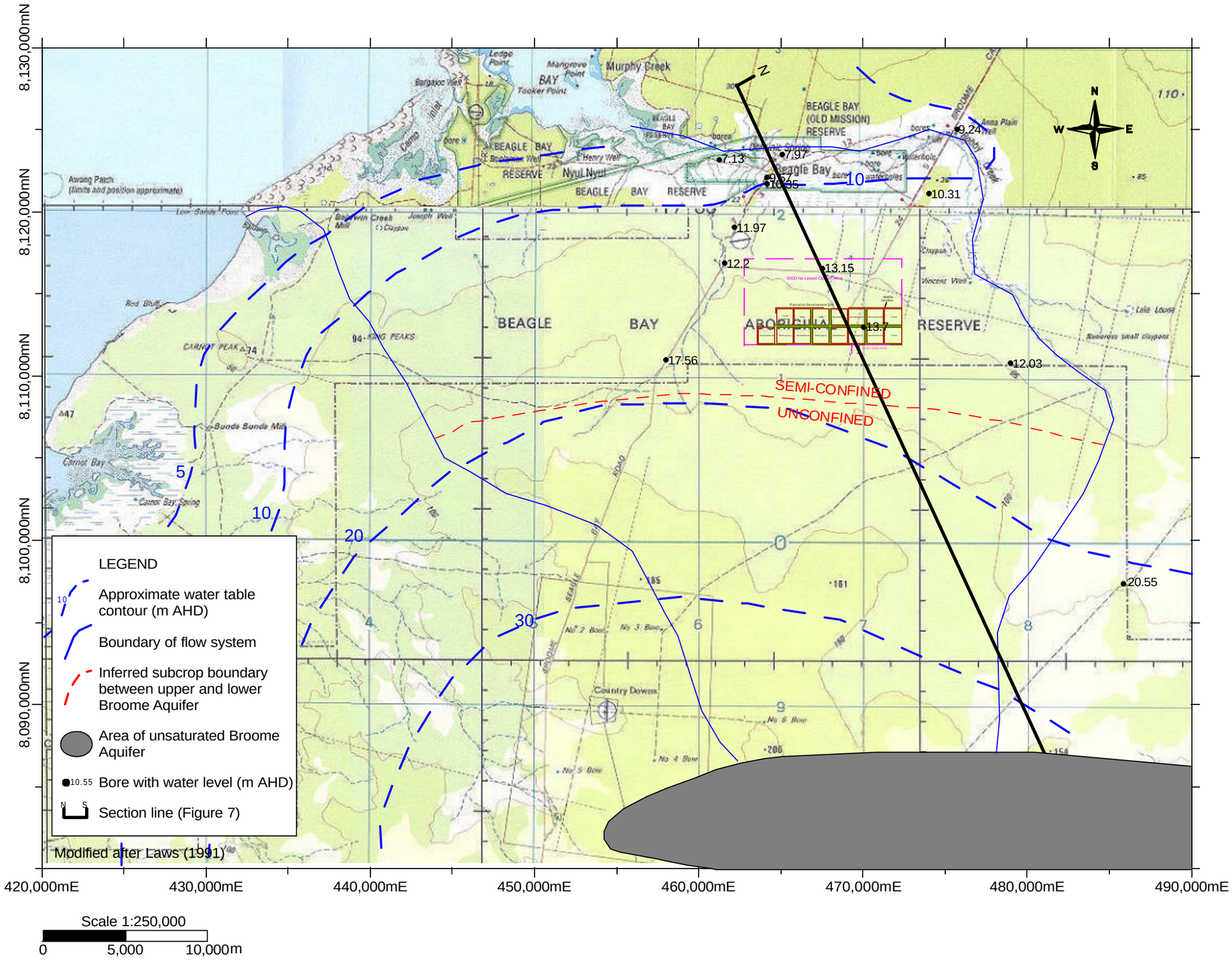
DATE: March 2004

Dwg. No: 296.0/04/1-2C

MOUND SPRINGS
BOBBY CREEK AREA

Rockwater Pty Ltd

Figure 3



HYDROGEOLOGICAL SETTING

I:/296.0/Projects/Surfer/Beagle Bay Hydro 250K.srf

CLIENT: Tropical Timber Plantations

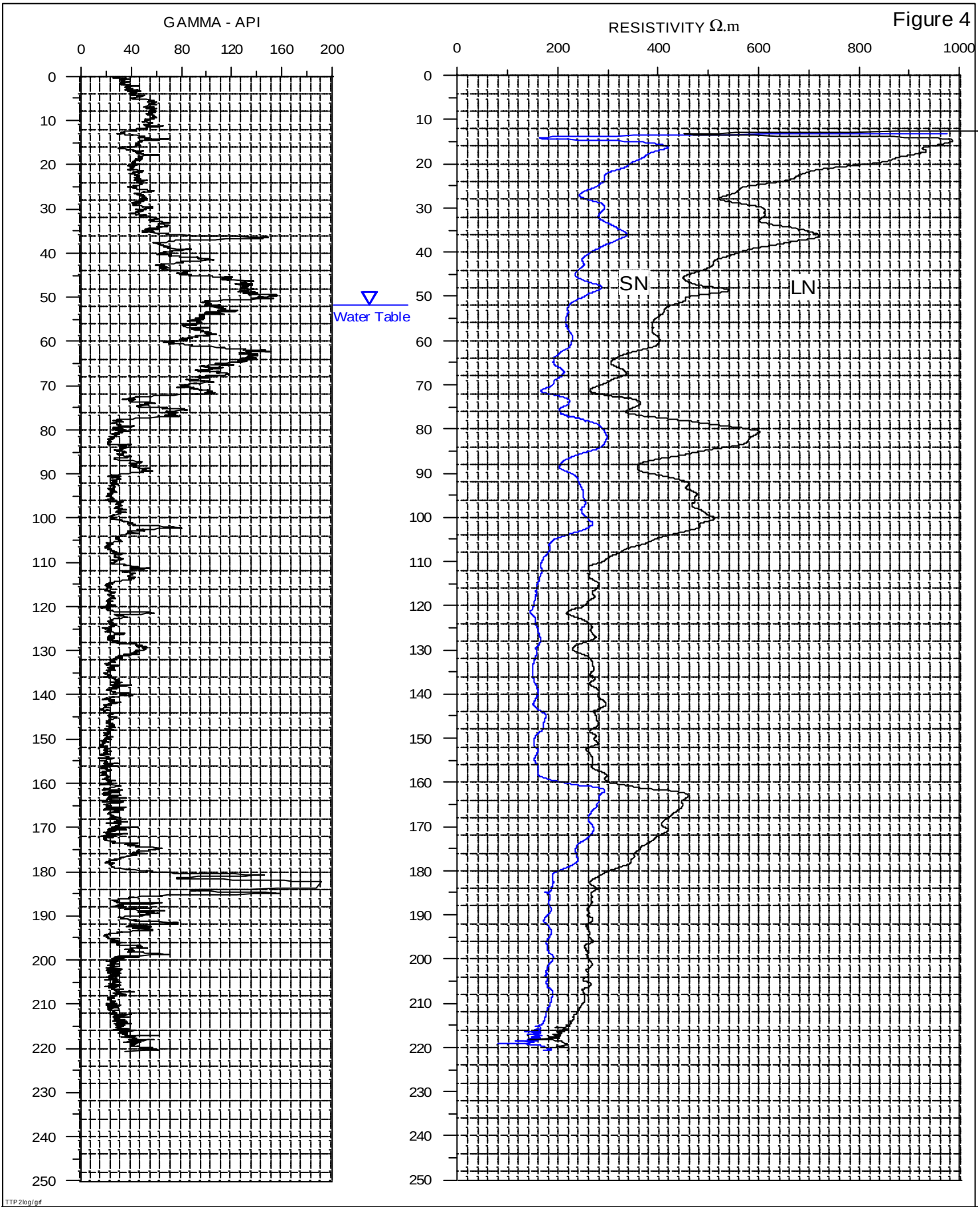
PROJECT: Beagle Bay Project

DATE: March 2004

Dwg. No: 296.0/04/1-3

Rockwater Pty Ltd

Figure 4



TTP 2log/gif

Client: Tropical Timber Plantations

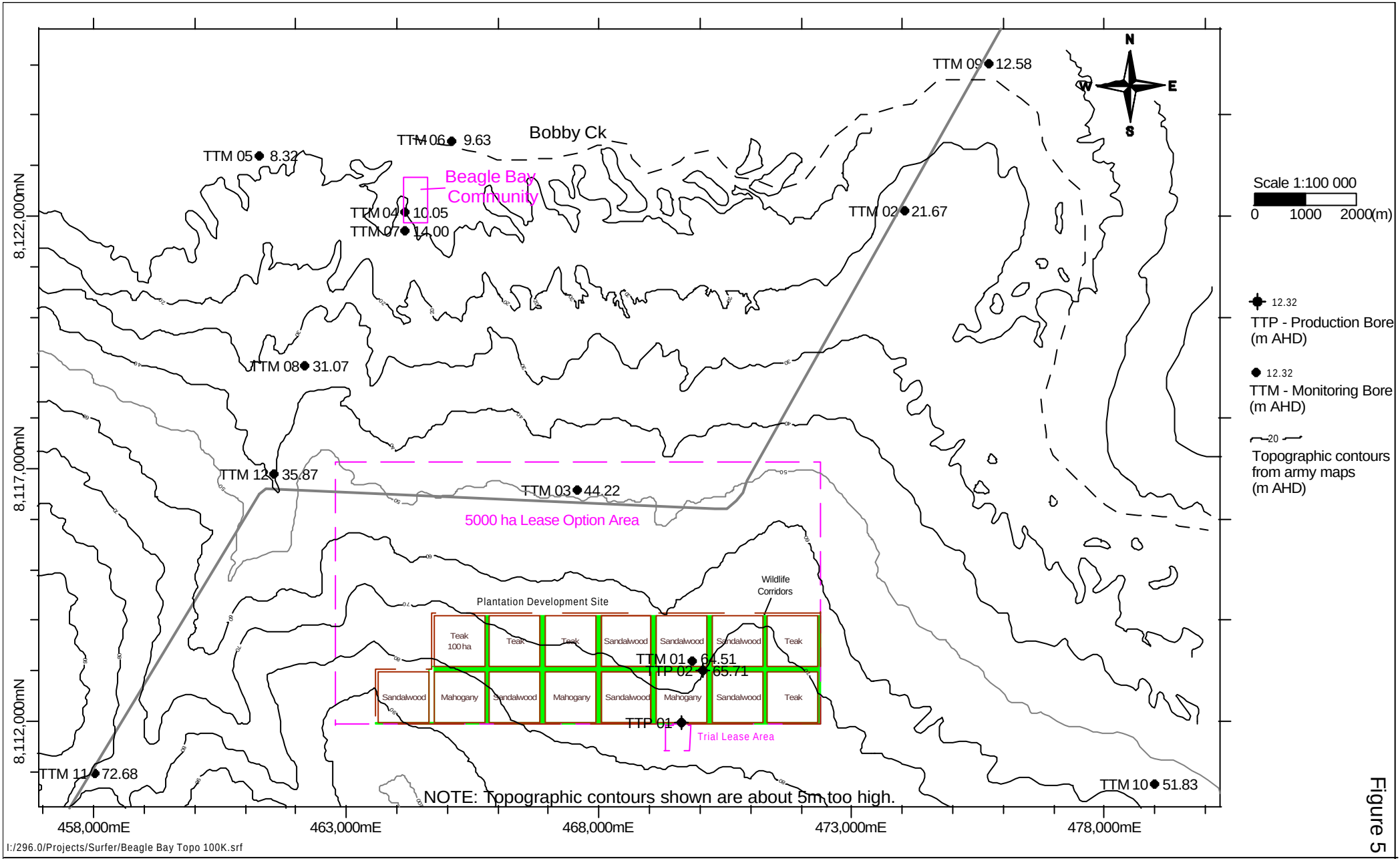
Project: Beagle Bay Project

Date: March 2004

Dwg. No.: 296.0/04/1-4

DOWNHOLE GEOPHYSICAL LOGS FOR TTP 02

Rockwater Pty Ltd



I:/296.0/Projects/Surfer/Beagle Bay Topo 100K.srf

Figure 5

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

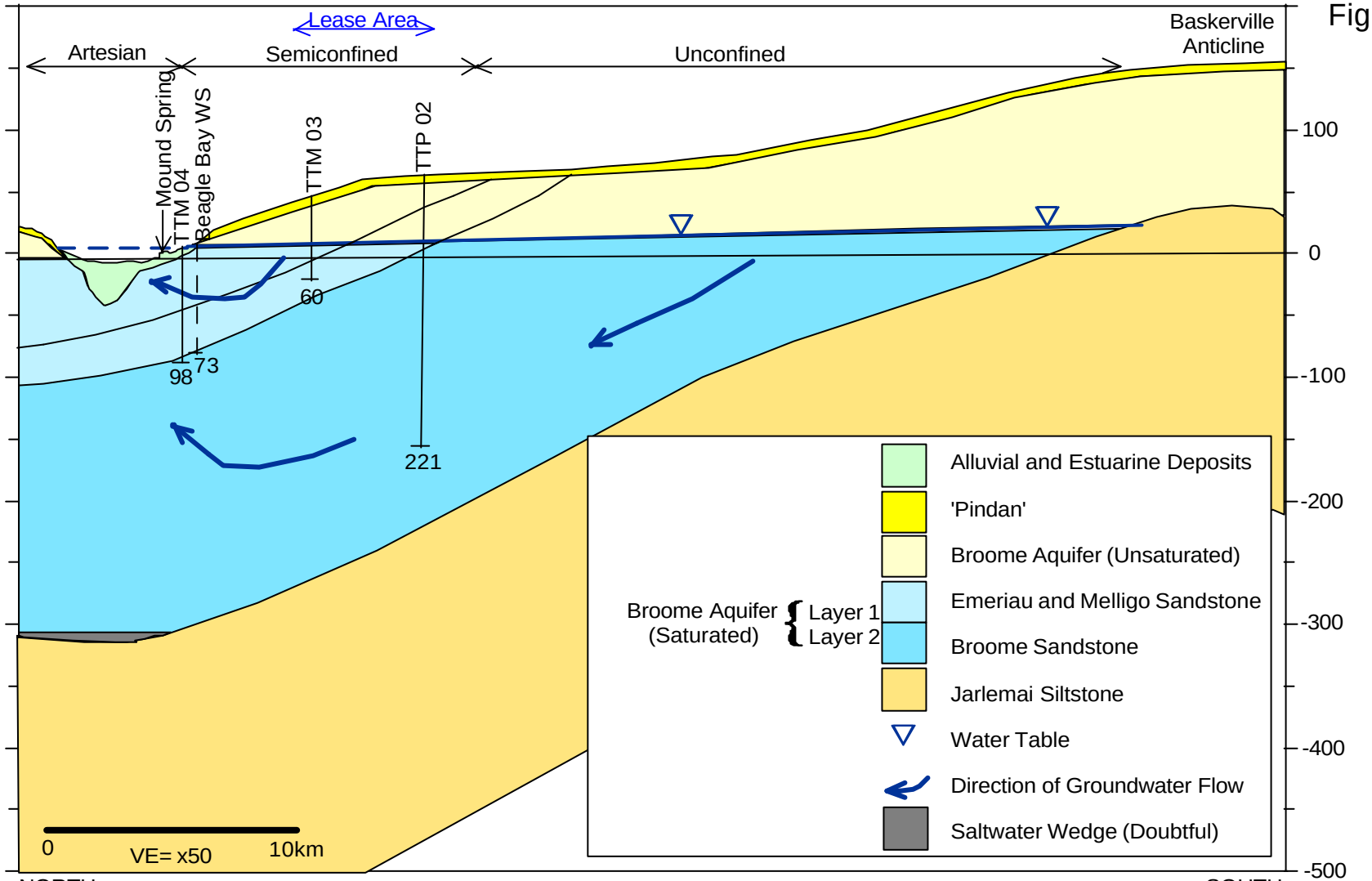
DATE: March 2004

Dwg. No: 296.0/04/1-5

TOPOGRAPHY AND ELEVATION OF BORE HEADS (m AHD)

Rockwater Pty Ltd

Figure 6

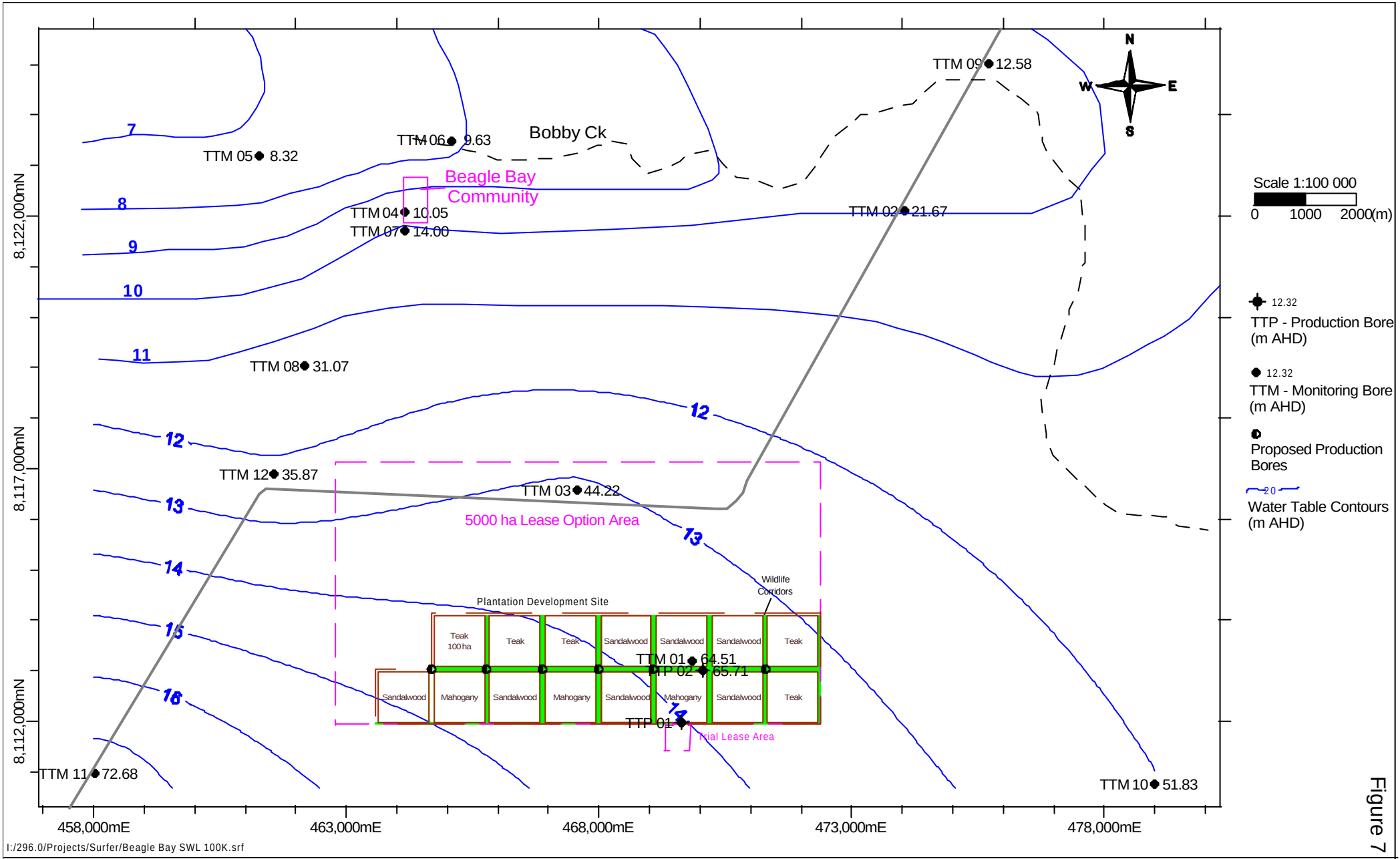


I:/296-0/Projects/Surfer/Hydro Cross Section.srf

CLIENT:	Tropical Timber Plantations
PROJECT:	Beagle Bay Project
DATE:	March 2004
Dwg. No:	296.0/04/1-6

HYDROGEOLOGICAL CROSS-SECTION

Rockwater Pty Ltd



I:/296.0/Projects/Surfer/Beagle Bay SWL 100K.srf

Figure 7

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

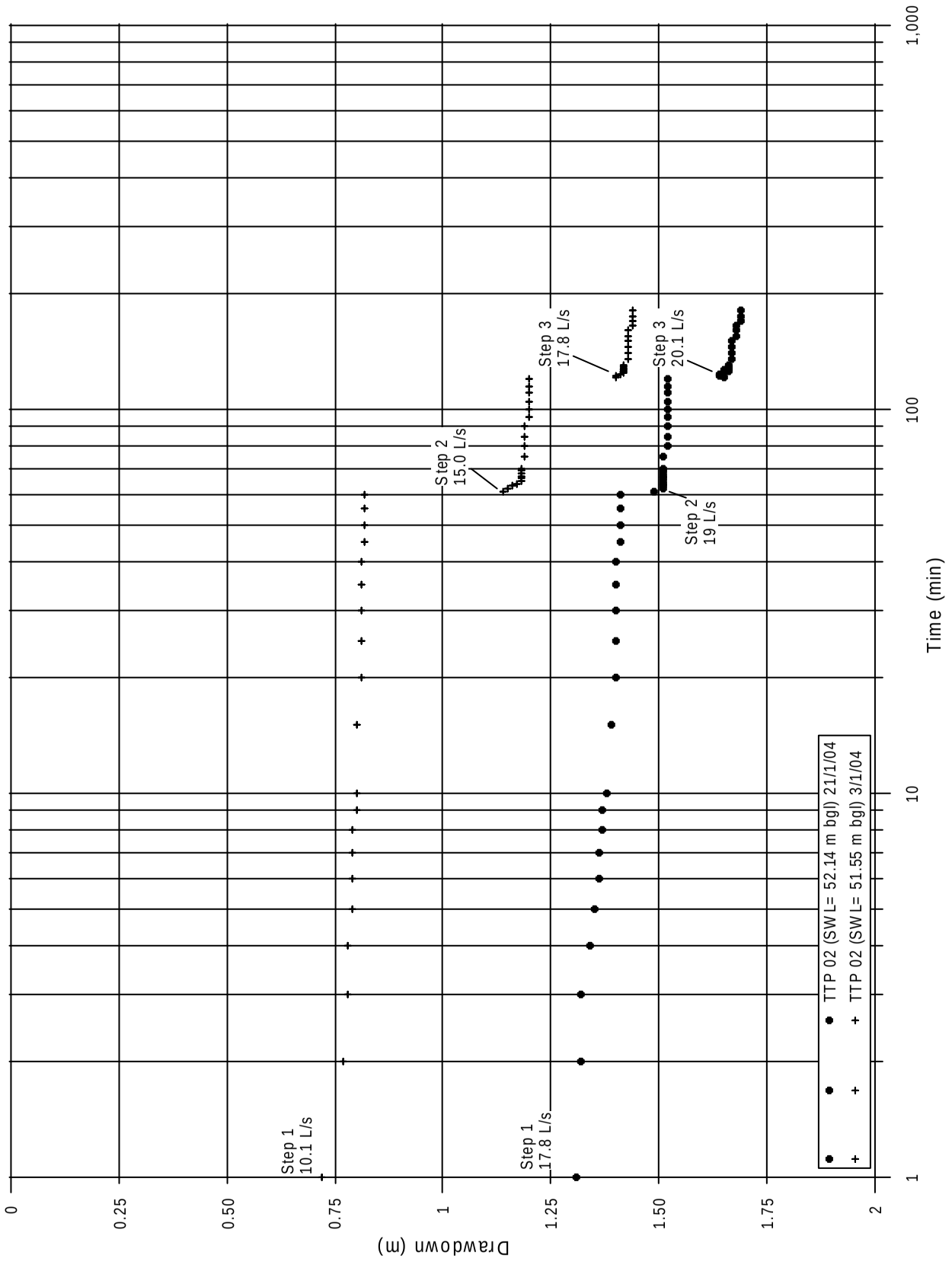
DATE: March 2004

Dwg. No: 296.0/04/1-7

WATER TABLE CONTOURS (JAN 2004) AND PROPOSED PRODUCTION BORES

Rockwater Pty Ltd

Figure 8



296-0/Projects/Grapher/TTP 2 pumping test.xls/TTP 2 step rate test.grf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

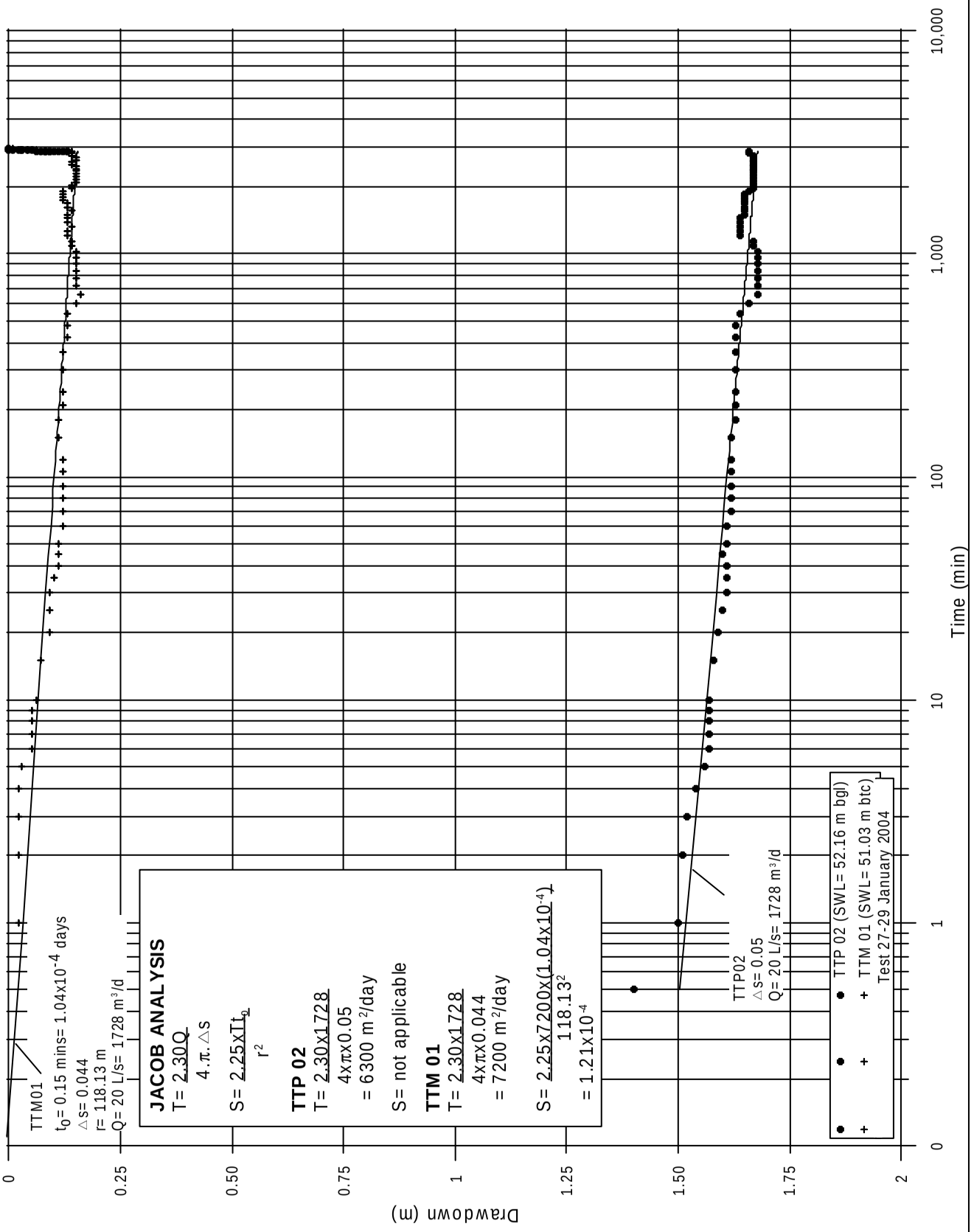
DATE: March 2004

DWG NO.: 296.0/04/1-8

BORE TTP 02 STEP-RATE PUMPING TESTS

Rockwater Pty Ltd

Figure 9



296-0/Projects/Grapher/TTP 2 pumping test.xls/TTP 2 constant rate jacob.grf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

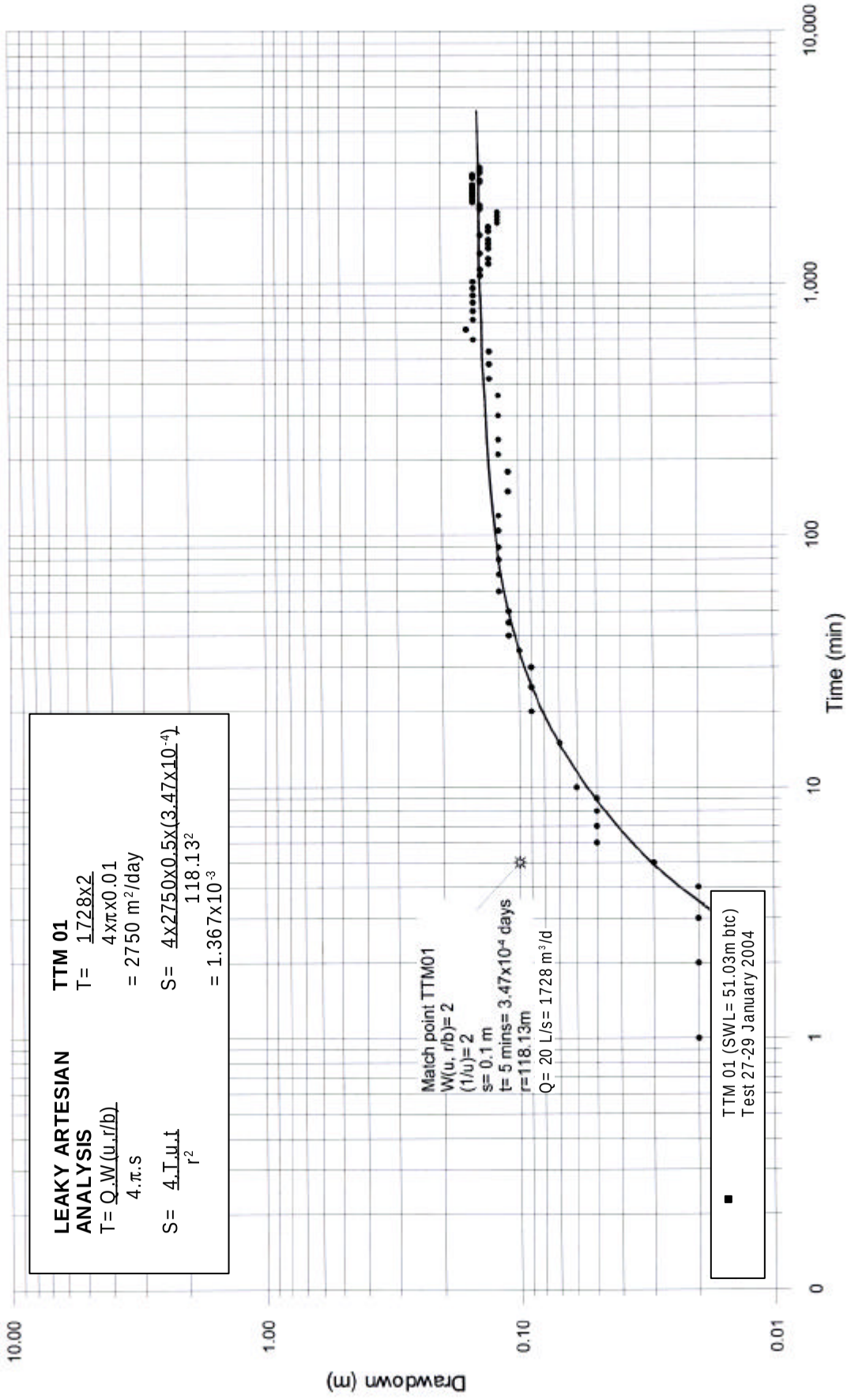
DATE: March 2004

DWG NO.: 296.0/04/1-9

TIME-DRAWDOWN JACOB ANALYSES BORES TTP 02 AND TTM 01

Rockwater Pty Ltd

Figure 10



296-0/Projects/Grapher/TTM1 pumping test.xls/TTM01 leaky aquifer.grf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

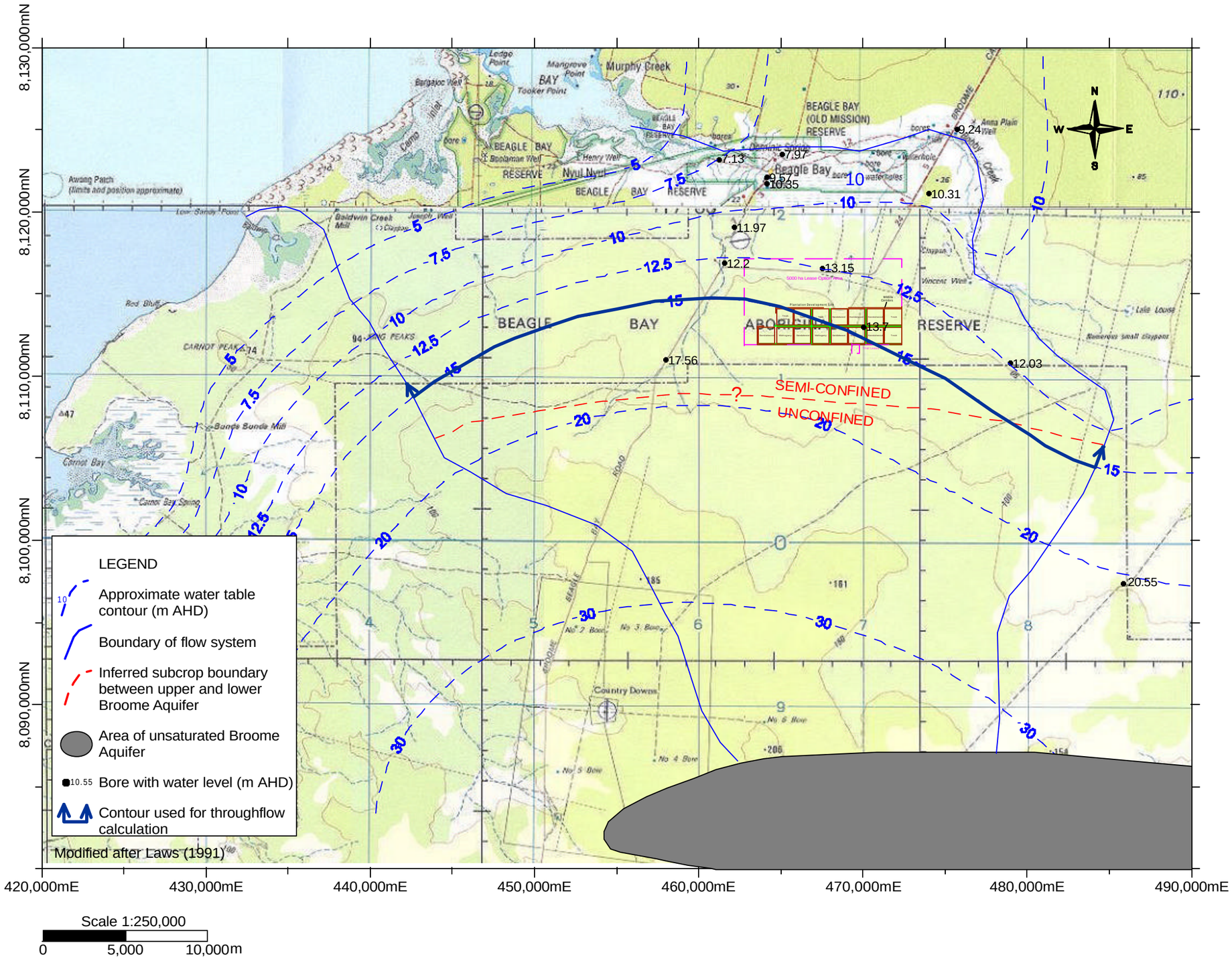
DATE: March 2004

DWG NO.: 296.0/04/1-10

TIME-DRAWDOWN LEAKY-ARTESIAN ANALYSIS BORE TTM 01

Rockwater Pty Ltd

Figure 11



MODEL CALCULATED GROUNDWATER LEVELS AND MEASURED VALUES (m AHD)

I:/296.0/Projects/Surfer/calcsswls.srf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

DATE: March 2004

Dwg. No: 296.0/04/1-11

Rockwater Pty Ltd

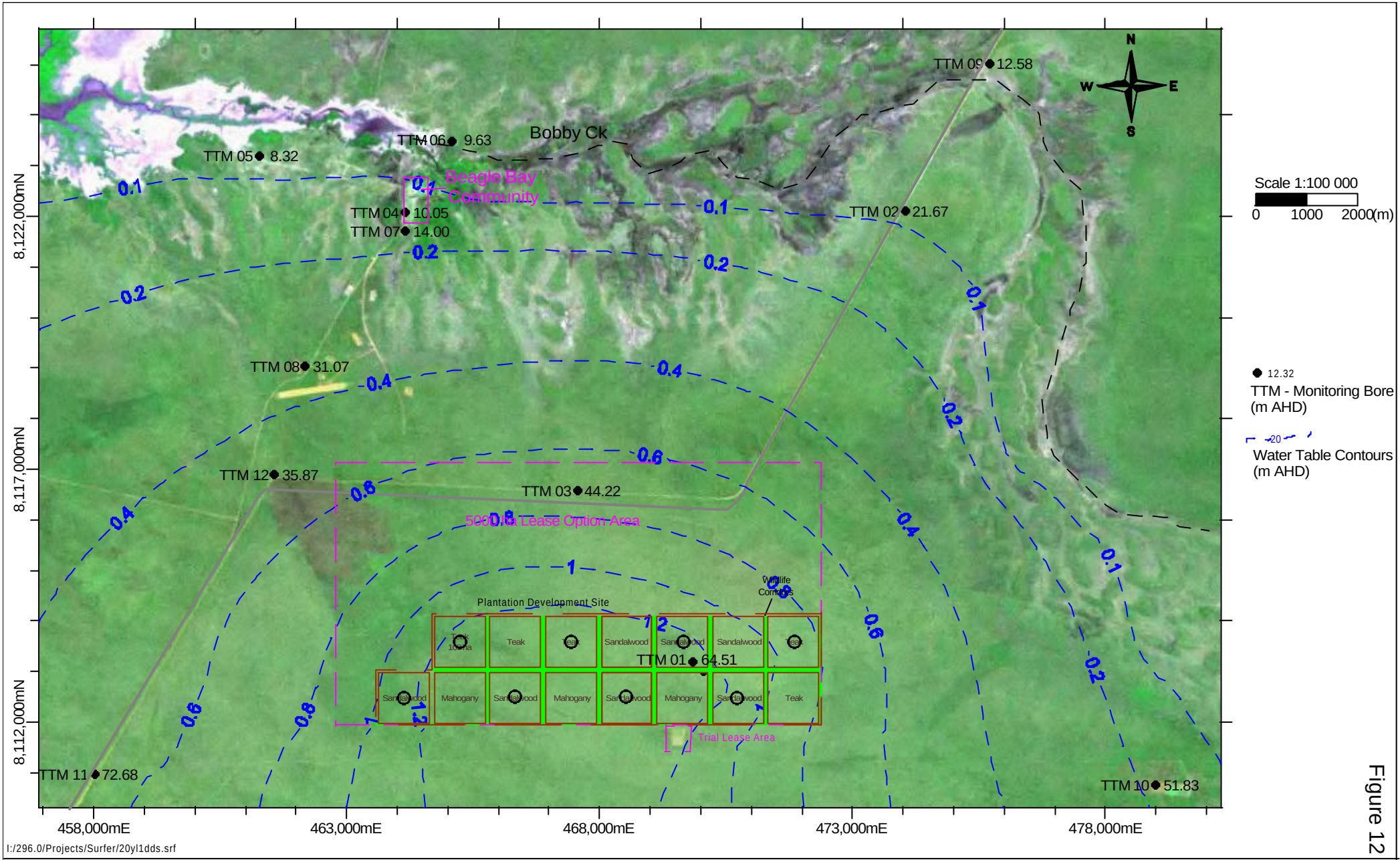


Figure 12

CLIENT: Tropical Timber Plantations

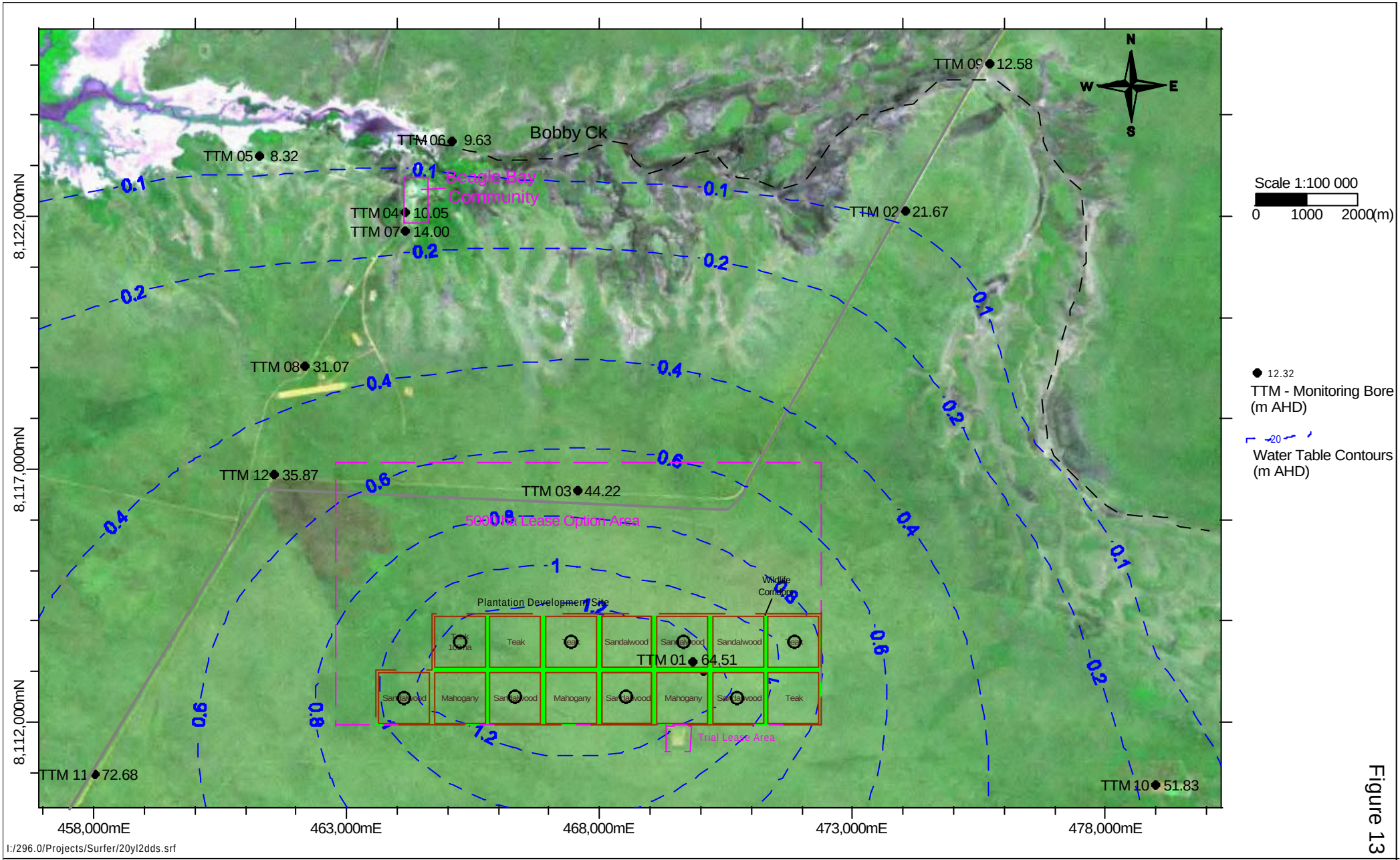
PROJECT: Beagle Bay Project

DATE: March 2004

Dwg. No: 296.0/04/1-12

MODEL-CALCULATED GROUNDWATER LEVEL DRAWDOWNS (m) AFTER 20 YEARS PUMPING, LAYER 1

Rockwater Pty Ltd



I:/296.0/Projects/Surfer/20yl2dds.srf

Figure 13

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

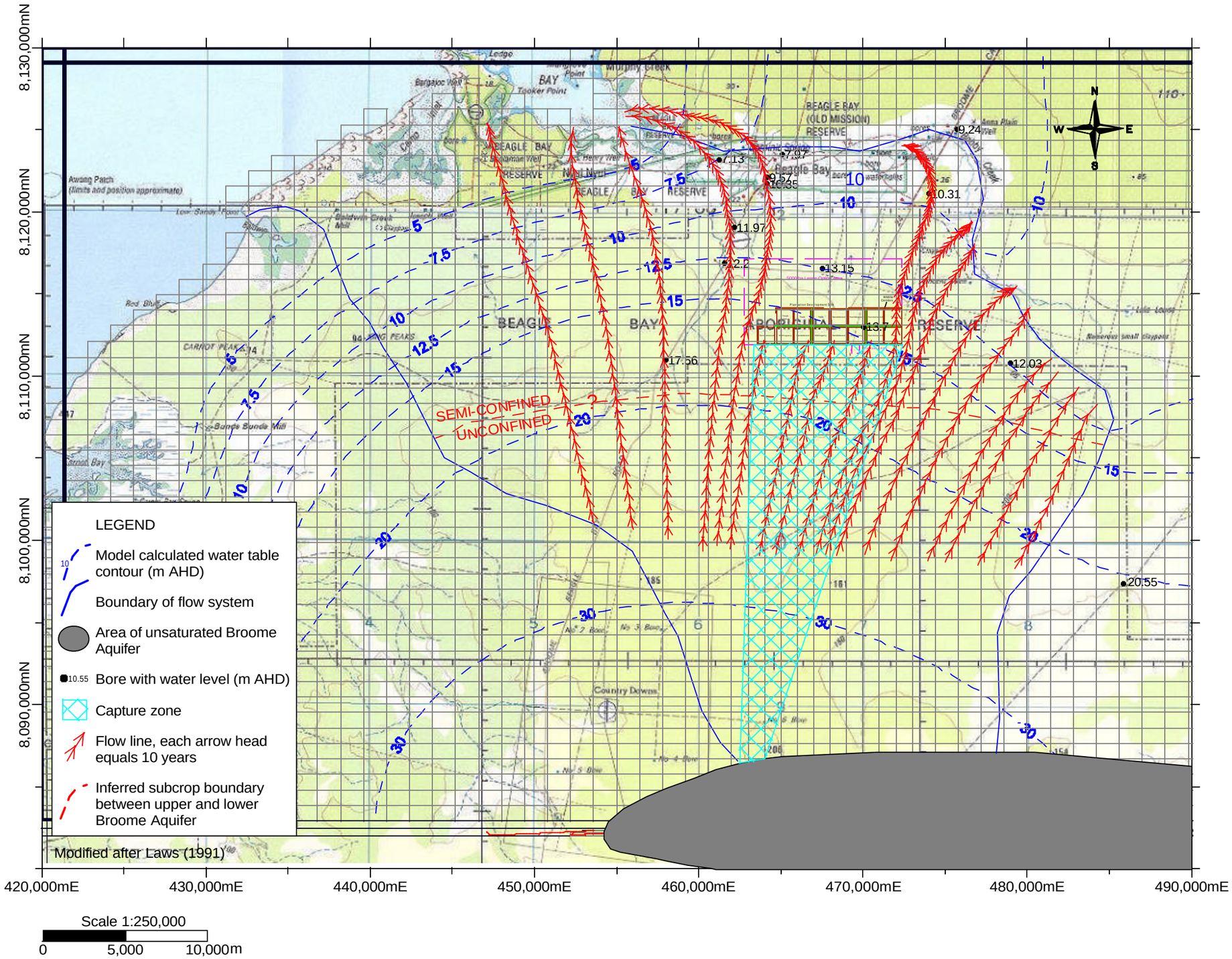
DATE: March 2004

Dwg. No: 296.0/04/1-13

MODEL-CALCULATED GROUNDWATER LEVEL DRAWDOWNS (m) AFTER 20 YEARS PUMPING, LAYER 2

Rockwater Pty Ltd

Figure 14



GROUNDWATER CAPTURE ZONE AND TRAVEL TIMES

I:/296.0/Projects/Surfer/flow-lines.srf

CLIENT: Tropical Timber Plantations

PROJECT: Beagle Bay Project

DATE: March 2004

Dwg. No: 296.0/04/1-14

Rockwater Pty Ltd

APPENDICES

APPENDIX I

DEPARTMENT OF ENVIRONMENT
EXPLORATION LICENCE

Department of Environment

RECEIVED
09 FEB 2004

Your ref:

Our ref:

Enquiries: NWK1862-02

Direct tel: Andrey Riedmann
91440214

Grant Bolton
Rockwater Pty Ltd
PO Box 201
WEMBLEY WA 6913

Dear Grant

COPY OF BEAGLE BAY CAW 154233

Following a telephone discussion with John Brennan, please find enclosed copies of the letter and licence to construct an alter wells.

Yours sincerely

Andrey Riedmann
Natural Resource Management Officer
4 February 2004

WESTERN AUSTRALIAN environment AWARDS

North West Region
Lot 980 Cherratta Road KIE
Karratha Western Australia 6714
PO Box 836 Karratha Western Australia 6714
Telephone (08) 9144 2000 Facsimile (08) 9144 2610
www.environ.wa.gov.au www.wrc.wa.gov.au

Department of Environment

Your ref:

Our ref:

Enquiries: NWK1862-02_KTD1153

Direct tel: Rebecca Blyton

9144 0216

Jane Lawford
Chairperson
Beagle Community Inc
PO Box 326
BROOME WA 6726

Dear Jane

ISSUE OF A *LICENCE TO CONSTRUCT OR ALTER WELL/INVESTIGATE GROUNDWATER RESOURCES:* CAW154223
EXPIRES ON: 31 DECEMBER 2003
PROPERTY LOC: PORTION OF BEAGLE BAY RESERVE

Please find enclosed your Exploration Licence, authorising you to investigate groundwater resources, subject to certain terms, conditions or restrictions.

Read the conditions of your licence carefully. If you do not understand your licence, contact the Commission immediately. There are penalties for failing to comply with all of the conditions. If you are aggrieved by a decision of the Commission, you can appeal to the Minister for the Environment and Heritage within 21 days of receiving this notice. An appeal after 21 days will only be accepted if the Minister considers it would be equitable to do so. A statutory fee is payable on lodgement of an appeal. For more information on appeals contact:

The Appeals Convenor - Environmental Protection Act
Allendale Square 13th Floor, 77 St Georges Tce, Perth 6000
Phone: 9221 8711, Fax 9221 8244

This licence is for investigation of the groundwater resource only. It allows you to conduct test drilling to support the preparation of a Hydrogeological Report. Your Hydrogeolocial Report must be submitted with future applications for a *Licence to Take Water*. Reports submitted to the Commission must follow the format of the attached guidelines and include all data from the investigation program.

After completion of the investigation, should you wish to submit an application for a *Licence to Take Water*, a thorough assessment of the proposal and the Hydrogeological Report will be

WESTERN AUSTRALIAN environment AWARDS

North West Region
Lot 980 Cherratta Road KIE
Karratha Western Australia 6714
PO Box 836 Karratha Western Australia 6714
Telephone (08) 9144 2000 Facsimile (08) 9144 2610
www.environ.wa.gov.au www.wrc.wa.gov.au

conducted by the Commission. It is important to realise that the outcome of the assessment cannot be guaranteed and may not always result in a *Licence to Take Water* being granted.

It is your responsibility to ensure that legal access is acquired and maintained on all land where investigation works will be conducted.

If the water from the wells is being improperly used, is being wasted or is having a harmful effect, the Commission may direct the closing of the wells. For further information, please read the enclosed pamphlet *What are my obligations as a licence holder?.*

If you have any questions, please contact the Karratha Office on 9144 2000.

Compliance with the terms, conditions or restrictions of this licence does not absolve the licensee from responsibility for compliance with the requirements of all Commonwealth and State legislation.

Yours sincerely

Owen Bennett
Natural Resource Management Officer
North West

22 September 2003

File No: NWK1862-02

Water and Rivers Commission
Government of Western Australia

Instrument No. CAW154223(1)

LICENCE TO CONSTRUCT OR ALTER WELL

Granted by the Commission under section 26D of the Rights in Water and Irrigation Act 1914

Licensee(s)	Beagle Bay Community Inc	
Description of Water Resource	Canning-Kimberley Canning - Broome	
Location of Well(s)	Portion of the Beagle Bay Aboriginal Reserve 1834	
Authorised Activities	**Activity**	**Location of Activity**
	Construct as outlined in the Groundwater Investigation Program exploratory well(s).	Portion of the Beagle Bay Aboriginal Reserve 1834
Duration of Licence	From 24 September 2003 to 31 December 2003	

This Licence is subject to the following terms, conditions and restrictions:

1 The licensee shall comply with revised Groundwater Investigation Program as prepared by Rockwater Pty Ltd and approved by the Water and Rivers Commission on 9 September 2003, including any modifications to revised Groundwater Investigation Program as approved during the term of the licence.

2 That prior to a production bore licence being issued the licensee demonstrates that the required groundwater will be available for abstraction without causing harmful effects on the aquifer or other users.

3 That on completion of the exploratory drilling programme the licensee shall submit two copies of a hydrogeological assessment of the groundwater source, prepared by a competent hydrogeologist.

4 The hydrogeological assessment report should be compiled in accordance with the Water and Rivers Commission publication "Guidelines for Hydrogeological and Monitoring Reports Associated with Groundwater Licensing".

5 The well must be constructed by a driller having a current class 2 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or other certification approved by the Water and Rivers Commission as equivalent.

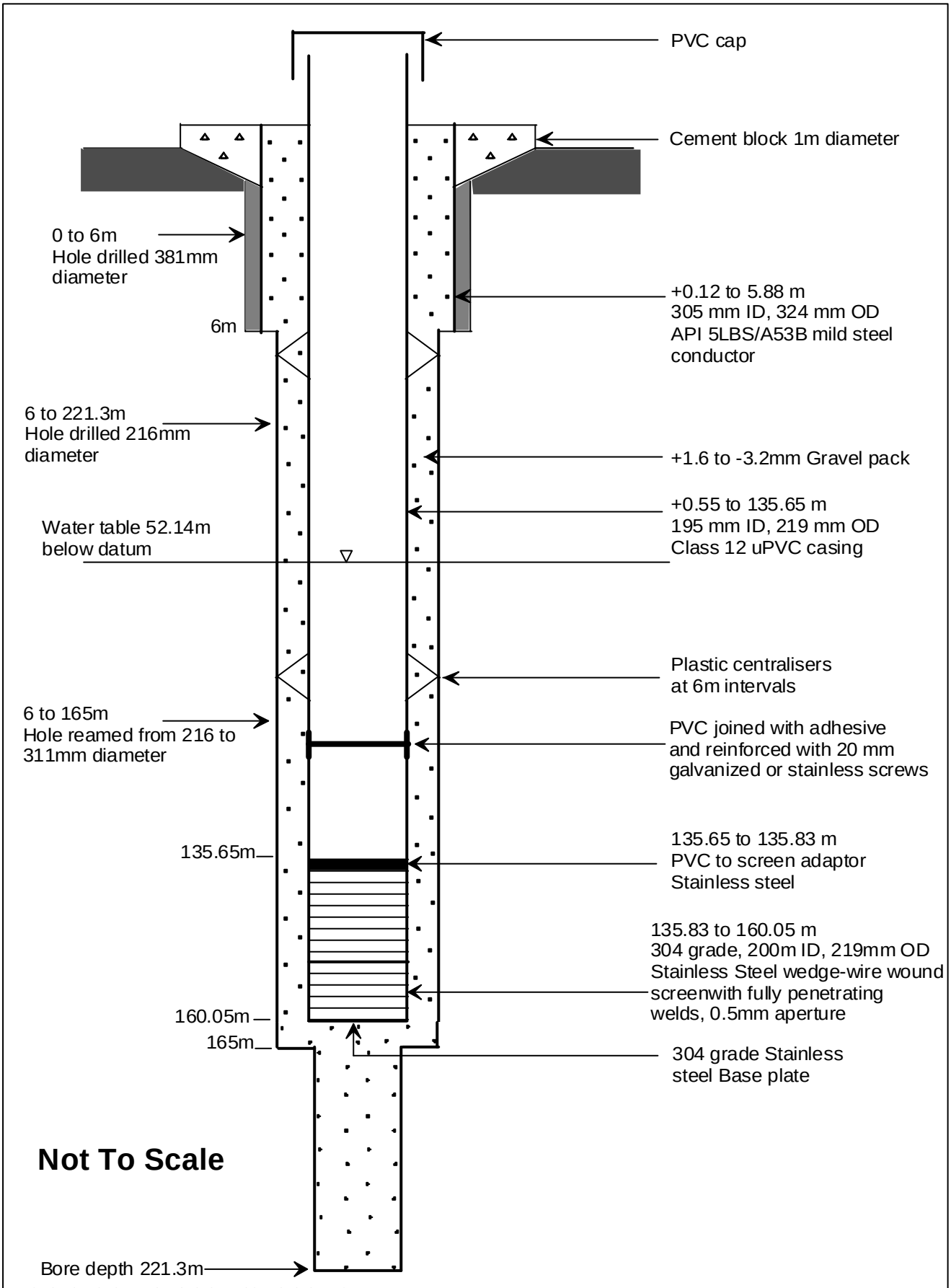
6 The licensee is required to provide to the Water and Rivers Commission a completed ' Particulars of Completed Bore Hole Form ' on completion of the approved drilling programme.

End of terms, conditions and restrictions

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000.

APPENDIX II

BORE CONSTRUCTION DIAGRAMS



296.0/Projects/Grapher/proposed productionbore2.xls/Procductionbore.grf

Client: Tropical Timber Plantations

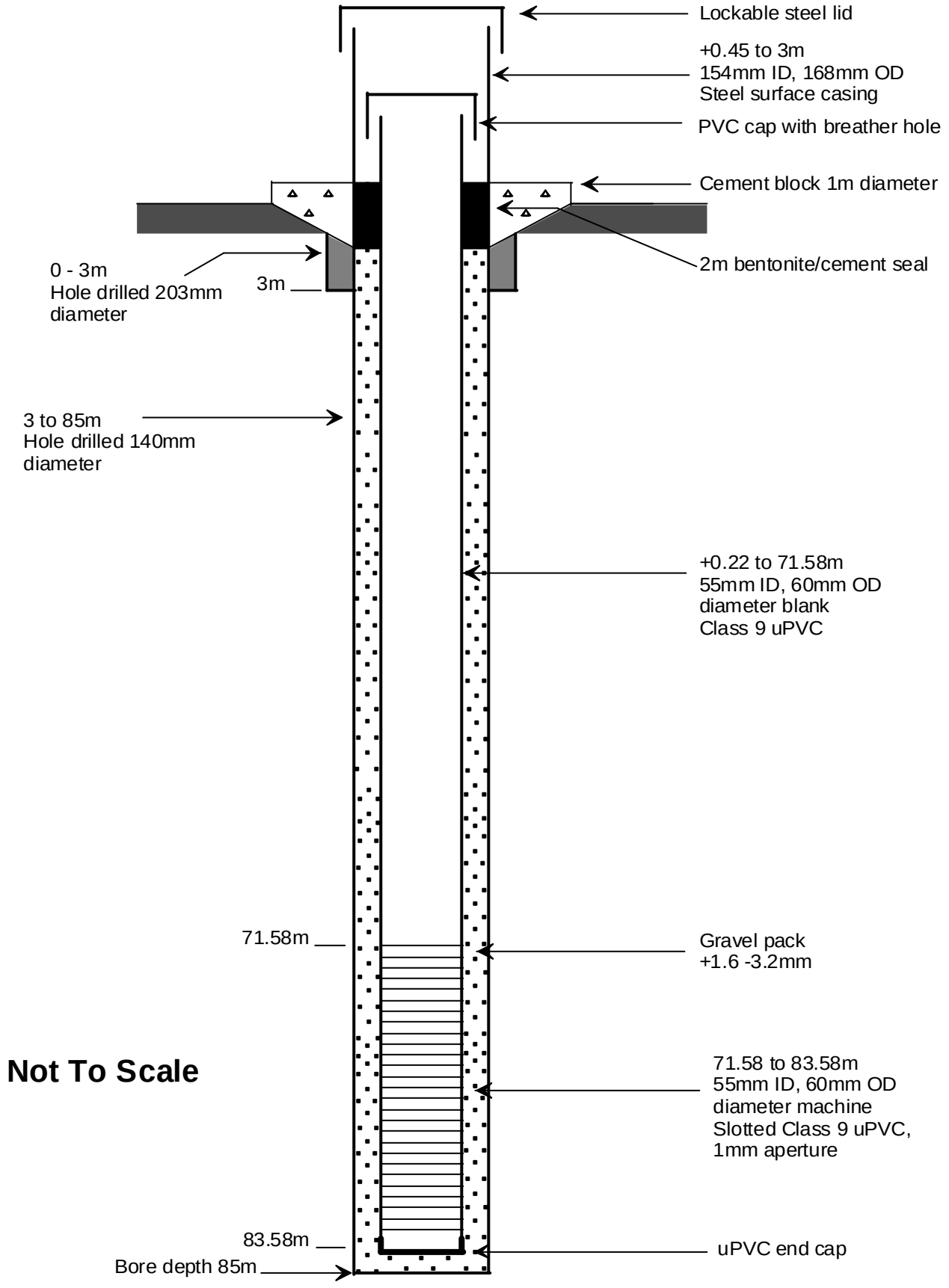
Project:: Beagle Bay Project

Date: March 2004

Dwg No: 296.0/04/Appendix II-1

PRODUCTION BORE TTP 02 DIAGRAM

Rockwater Pty Ltd



296.0/Projects/Grapher/proposed productionbore1.xls/BoreTTM1.grf

Client: Tropical Timber Plantations

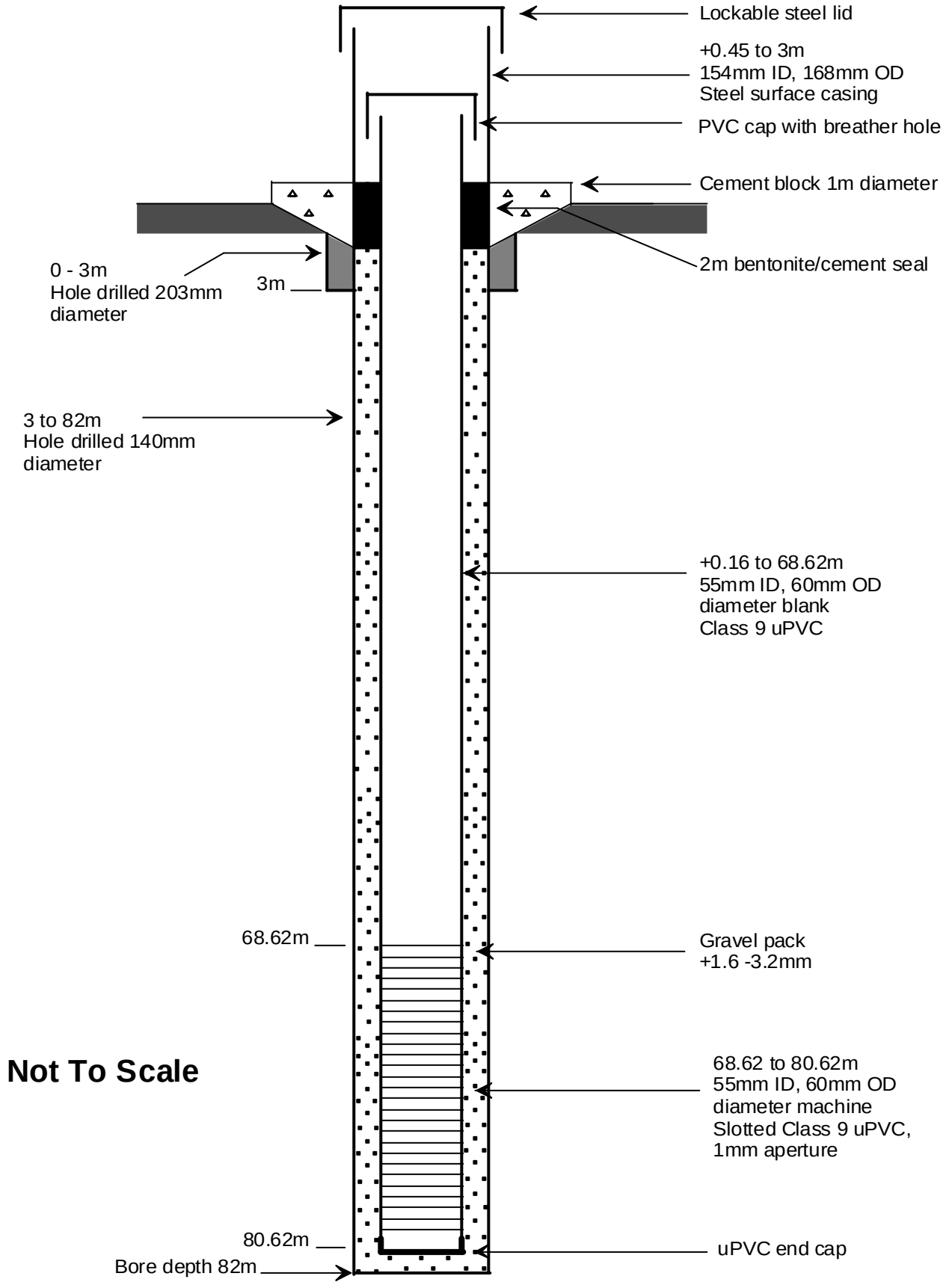
Project:: Beagle Bay Project

Date: March 2004

Dwg No: 296.0/04/Appendix II-2

MONITORING BORE TTM 01 DIAGRAM

Rockwater Pty Ltd



296.0/Projects/Grapher/proposed productionbore1.xls/BoreTTM2.grf

Client: Tropical Timber Plantations

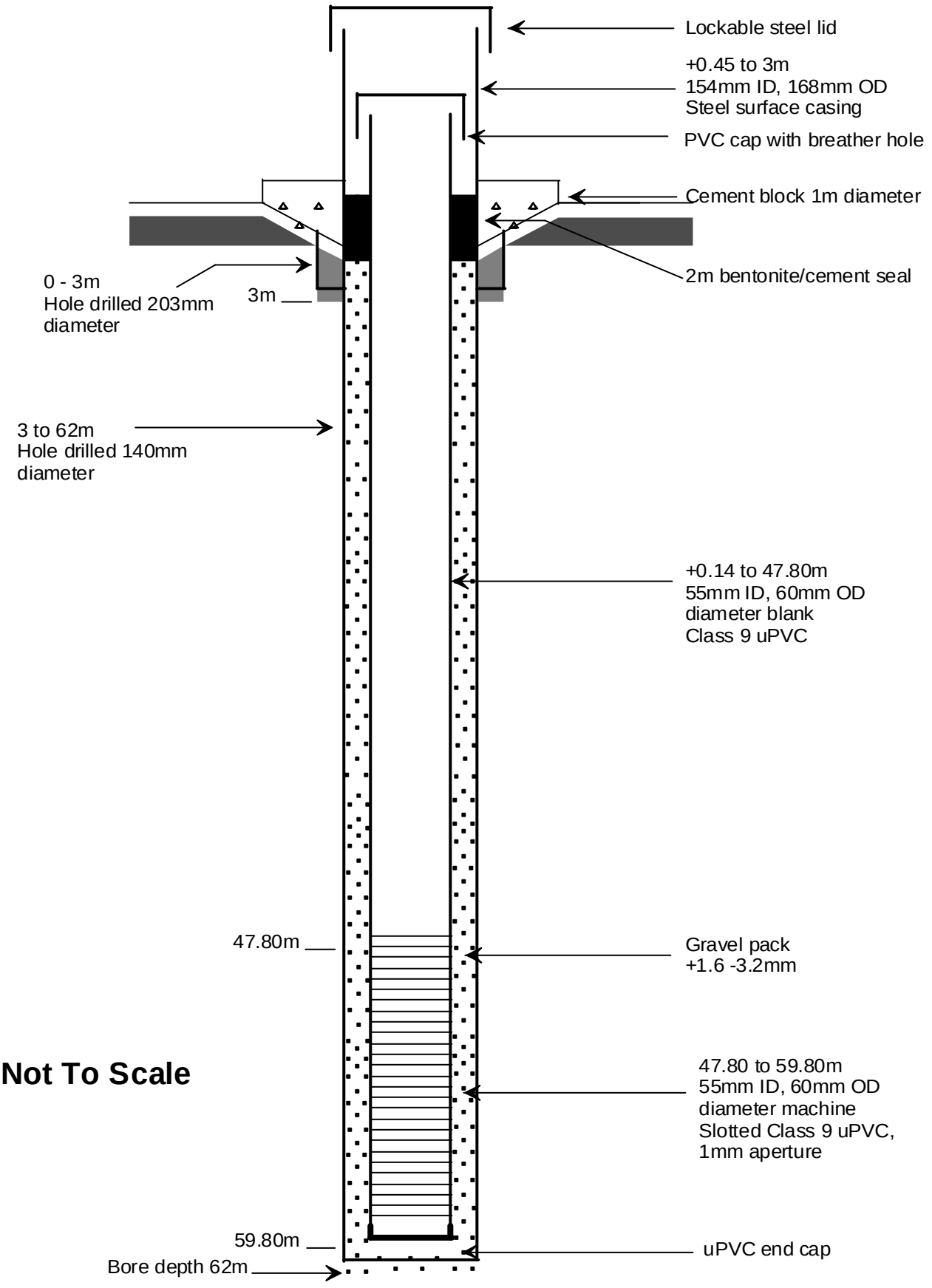
Project:: Beagle Bay Project

Date: March 2004

Dwg No: 296.0/04/Appendix II-3

MONITORING BORE TTM 02 DIAGRAM

Rockwater Pty Ltd



296.0/Projects/Grapher/proposed productionbore1.xls/BoreTTM3.grf

Client: Tropical Timber Plantations Pty Ltd

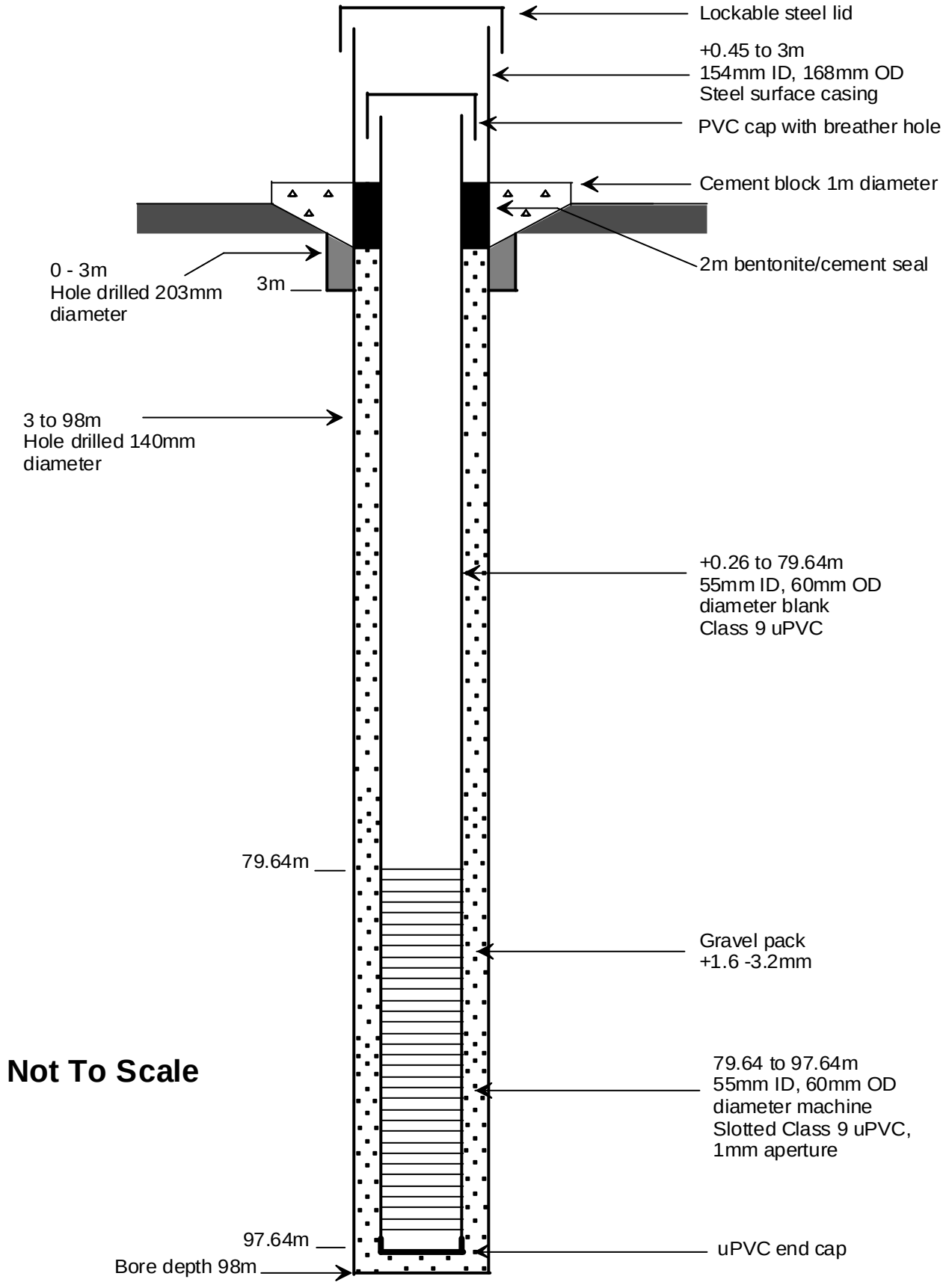
Project:: Beagle Bay Project

Date: March 2004

Dwg No: 296.0/04/Appendix II-4

MONITORING BORE TTM 03 DIAGRAM

Rockwater Pty Ltd



296.0/Projects/Grapher/proposed productionbore1.xls/BoreTTM4.grf

Client: Tropical Timber Plantations

Project:: Beagle Bay Project

Date: March 2004

Dwg No: 296.0/04/Appendix II-5

MONITORING BORE TTM 04 DIAGRAM

Rockwater Pty Ltd

APPENDIX III

LITHOLOGICAL LOGS

Bore TTP 02

Depth (m)	Lithology
0 to 10	SILT: red brown poorly sorted pindan, very fine to medium grained quartz interbedded, unconsolidated
10 to 12	SAND: cream, grey-brown, poorly sorted, medium to very coarse grained angular quartz, unconsolidated
12 to 17	SAND/SILT, red brown, grey, poorly sorted very fine to very coarse grained angular quartz, unconsolidated
17 to 18	CLAY: cream white, minor sand, trace of fossilised wood
18 to 21	SANDY SILT: red brown, grey, poorly sorted, silt to very coarse grained angular quartz and iron, unconsolidated
21 to 35	SAND: Clayey, cream grey, brown, buff, very poorly sorted, silt to very coarse grained angular quartz, feldspar in a clay matrix
35 to 38	SAND: Pale brown, buff, poorly sorted, very fine to granule sized angular quartz, trace of clay
38 to 42	CLAY/SILT: Cream grey, brown, sandy
42 to 45	SAND: Pale grey, brown, poorly sorted, very fine to very coarse angular to subrounded quartz, unconsolidated
45 to 48	SILTY CLAY: Cream white, sandy
48 to 60	SAND/SILT: Buff, cream brown, poorly sorted, very fine to very coarse grained subrounded to angular quartz, interbedded with silt
60 to 72	SILTSTONE: Cream brown, buff
72 to 93	SANDSTONE: Cream grey, poorly sorted, subangular to subrounded very fine to granules sized weakly cemented quartz, trace of interbedded siltstone
93 to 96	SANDSTONE: Pale brown, moderately sorted, very fine to medium grained subangular to subrounded quartz, weakly cemented
96 to 102	SANDSTONE: Pale grey, brown, poorly sorted, angular to subrounded very fine to granule sized quartz, weakly cemented
102 to 108	SANDSTONE: Red brown, grey, poorly sorted, fine to granule sized angular to subrounded quartz, traces of garnet, weakly cemented
108 to 114	GRAVEL: Red brown, grey, well sorted, 4 – 6 mm quartz gravel, weakly cemented
114 to 122	SANDSTONE: Pale brown, grey, poorly sorted, very fine to granule sized, subangular to subrounded quartz, weakly cemented
122 to 130	GRAVEL: Pale grey, cream, brown, very poorly sorted, very fine to 8 mm pebbles of angular to subrounded quartz, weakly cemented
130 to 136	SILTSTONE: Pale grey, white, minor interbedded sandstone, weakly cemented
136 to 140	SANDSTONE: Pale grey, red brown, buff, very poorly sorted, very fine to pebble sized quartz, weakly cemented
140 to 160	SANDSTONE: Red brown, grey, poorly sorted, very fine to very coarse grained subangular to rounded quartz, traces of garnet, weakly cemented
160 to 163	GRAVEL: Pale grey, sandy, poorly sorted, Fine to pebble sized subangular to rounded quartz, weakly cemented
163 to 180	SANDSTONE: Pale grey, brown, poorly sorted, very fine to very coarse grained subangular to rounded quartz, weakly cemented, minor pebbles
180 to 216	SILTSTONE: Cream, grey, buff brown, minor sand, weakly cemented.
216 to 221	SILTSTONE: Mid mauve grey, weakly cemented

Bore TTM 01

Depth (m)	Lithology
0 to 18	SAND: Silty, red brown poorly sorted pindan, fine to medium grained quartz, unconsolidated
18 to 30	SILT/SAND: Pale brown, buff, cream white, poorly sorted, silt to coarse grained angular quartz, interbedded with white siltstone, weakly cemented
30 to 33	SILT: Pale grey, white, red brown, trace of sand, weakly cemented
33 to 39	SAND: Buff cream, brown, poorly sorted, very fine to coarse grained quartz, weakly cemented
39 to 60	SILT/SAND: Pale brown, cream grey, white, minor sand interbeds, weakly cemented
60 to 72	SILTSTONE: Pale grey, white, moderately sorted, trace of interbedded sandstone, weakly cemented
72 to 83	SANDSTONE: Pale grey, brown, buff, poorly sorted, very fine to coarse grained subangular to subrounded quartz, weakly cemented
83 to 84	SILTSTONE: Pale grey, cream white, weakly cemented

Bore TTM 02

Depth (m)	Lithology
0 to 3	SAND: Yellow grey, brown, moderately sorted, very fine to medium grained subangular to subrounded quartz
3 to 24	SAND: Red brown, poorly sorted pindan, silt to coarse grained iron and quartz, unconsolidated
24 to 36	SAND/SILT: Red brown, poorly sorted, very fine to very coarse grained subangular to subrounded quartz in silt, weakly cemented
36 to 72	SILTSTONE: Cream, yellow brown, moderately cemented
72 to 81	SANDSTONE: Pale grey, buff, poorly sorted, very fine to very coarse grained subangular to subrounded quartz, weakly cemented

Bore TTM 03

Depth (m)	Lithology
0 to 18	SAND: Red brown, silty and sandy pindan, unconsolidated
18 to 36	SILTSTONE: Cream, pale brown, weakly to moderately cemented
36 to 42	SANDSTONE: Pale grey, moderately sorted, medium to coarse grained subrounded to rounded quartz, weakly cemented
42 to 60	SANDSTONE: Pale grey, poorly sorted, very fine to coarse grained subangular to subrounded quartz, minor interbedded siltstone (51 – 57 m)

Bore TTM 04

Depth (m)	Lithology
0 to 2.8	SAND: Pale grey, white, well sorted, silt to fine grained subrounded grains, unconsolidated
2.8 to 6	CLAY: Brown grey, silty
6 to 10	GRAVEL/CLAY: Brown, grey, poorly sorted subrounded gravel (laterite) in a silty clay matrix
10 to 21	SILTSTONE: Cream, buff, grey, brown, trace of very fine sandstone, weakly cemented
21 to 25	SANDSTONE: Pale grey, brown, poorly sorted, subrounded to angular very fine to granule sized quartz, weakly cemented, minor siltstone
25 to 36	SILTSTONE: Grey, brown, sandy in part, weakly cemented
36 to 43	SANDSTONE: Brown, grey, buff, poorly sorted, very fine to very coarse grained subangular to subrounded quartz, weakly cemented
43 to 44	SILTSTONE: Cream, brown, sandy
44 to 51	SANDSTONE: Yellow brown, poorly sorted, very fine to very coarse grained subangular to subrounded quartz, weakly cemented
51 to 54	SANDSTONE: Pale grey, poorly sorted, very fine to granule sized, subangular to subrounded quartz, weakly cemented, minor interbedded siltstone, trace rounded quartz pebbles
54 to 57	SANDSTONE: Grey brown, buff, poorly sorted, fine to coarse grained subangular to subrounded quartz, weakly cemented
57 to 63	SANDSTONE/SILTSTONE: Cream, grey brown, interbedded, gravely sandstone and siltstone or sand in silt matrix?
63 to 69	GRAVEL: Pale grey, dark grey, cream, red brown, poorly sorted silt to 20 mm pebbles quartz and ironstone, weakly cemented in silt matrix
69 to 72	SANDSTONE: Pale grey, poorly sorted, very fine to very coarse grained subangular to subrounded quartz, weakly cemented
72 to 78	SANDSTONE/GRAVEL: Poorly sorted, very fine to pebble sized subangular to subrounded quartz, weakly cemented
78 to 84	SANDSTONE: Pale brown, grey, buff, poorly sorted, very fine to coarse grained subangular to subrounded quartz, weakly cemented
84 to 87	SANDSTONE/GRAVEL: Pale grey, brown, cream grey, poorly sorted, very fine to pebble sized subangular to subrounded quartz, weakly cemented
87 to 90	SILTSTONE/GRAVEL: Cream grey, pale grey, very poorly sorted subangular to subrounded quartz gravel, weakly cemented in a siltstone matrix
90 to 93	SANDSTONE: Pale brown, grey, poorly sorted, very fine to coarse grained subangular to subrounded quartz, weakly cemented
93 to 96	SANDSTONE/GRAVEL: Pale grey, brown, poorly sorted very fine to pebble sized quartz, weakly cemented
96 to 97.85	SANDSTONE: Dark brown, moderately sorted, fine to medium grained subangular to subrounded quartz, very hard ferruginous cementation

APPENDIX IV

BORE COMPLETION DATA

TTP 02 BORE COMPLETION DATA

Project:	Tropical Timber Plantations Pty Ltd
Bore No:	TTP 02
Location:	
MGA Coordinates:	8 112 991.88 mN, 470 164.80 mE
Status:	Production Bore
Date Commenced:	23/11/2003
Date Completed:	9/12/2003
Drilling Contractor:	Drilling Contractors of Australia (DCA)
Drilling Rig:	B500 Rotary rig
Depth Drilled:	221.3 m
Drilling Details:	0 to 6 m, 381 mm diameter mud-rotary 6 to 221.3 m, 216 mm diameter mud-rotary, Tungsten-carbide insert (TCI) bit
Reaming Details:	6 to 165 m, 216 mm to 311 mm diameter, mud-rotary
Casing Details:	+0.12 to 5.88 m, 305 mm ID, 324 mm OD API 5LBS/A53B mild steel conductor casing +0.55 to 135.65 m, 195 mm ID, 219 mm OD Class 12 uPVC casing (plastic centralisers at 6 m intervals) 135.65 to 135.83 m, uPVC to screen stainless steel adaptor 135.83 to 160.05 m, 304 grade, 200 mm ID, 219 mm OD Stainless steel wedge-wire wound screen with fully penetrating welds, 0.5 mm aperture
Reference Point Description:	Top of uPVC casing
Height of Reference Above Ground:	+0.55 m
Reference Point Elevation:	65.71 m AHD
Gravel Pack Interval:	0 to 165 m, +1.6 to 3.2 mm graded gravel
Static Water Level (26/1/2004):	52.14 m below datum, 13.57 m AHD
Final Water Salinity:	N.D.

TTM 01 BORE COMPLETION DATA

Project:	Tropical Timber Plantations Pty Ltd
Bore No:	TTM 01
Location:	
MGA Coordinates:	8 112 995.87 mN, 470 046.72 mE
Status:	Monitoring Bore
Date Constructed:	December 2003
Drilling Contractor:	Drilling Contractors of Australia (DCA)
Drilling Rig:	B500 Rotary rig
Depth Drilled:	85 m
Drilling Details:	0 to 3 m, 203 mm diameter mud-rotary 3 to 85 m, 140 mm diameter mud-rotary
Casing Details:	+0.45 to 3 m, 154 mm ID, 168 mm OD mild steel surface casing +0.22 to 71.58 m, 55 mm ID, 60 mm OD Class 9 uPVC casing 71.58 to 83.58 m, 55 mm ID, 60 mm OD Class 9 uPVC machine slotted casing, 1 mm aperture
Reference Point Description:	Top of uPVC casing
Height of Reference Above Ground:	+0.22 m
Reference Point Elevation :	64.51 m AHD
Gravel Pack Interval:	0 to 85 m, +1.6 to 3.2 mm graded gravel
Static Water Level (26/1/2004):	50.81 m below datum, 13.70 m AHD
Final Water Salinity:	212 mg/L TDS (by electrical conductivity)

TTM 02 BORE COMPLETION DATA

Project:	Tropical Timber Plantations Pty Ltd
Bore No:	TTM 02
Location:	
MGA Coordinates:	8 112 098.65 mN, 474 037.90 mE
Status:	Monitoring Bore
Date Constructed:	December 2003
Drilling Contractor:	Drilling Contractors of Australia (DCA)
Drilling Rig:	B500 Rotary rig
Depth Drilled:	82 m
Drilling Details:	0 to 3 m, 203 mm diameter mud-rotary 3 to 82 m, 140 mm diameter mud-rotary
Casing Details:	+0.45 to 3 m, 154 mm ID, 168 mm OD mild steel surface casing +0.16 to 68.62 m, 55 mm ID, 60 mm OD Class 9 uPVC casing 68.62 to 80.62 m, 55 mm ID, 60 mm OD Class 9 uPVC machine slotted casing, 1 mm aperture
Reference Point Description:	Top of uPVC casing
Height of Reference Above Ground:	+0.16 m
Reference Point Elevation :	21.67 m AHD
Gravel Pack Interval:	0 to 82 m, +1.6 to 3.2 mm graded gravel
Static Water Level (26/1/2004):	11.36 m below datum, 10.31 m AHD
Final Water Salinity:	N.D.

TTM 03 BORE COMPLETION DATA

Project:	Tropical Timber Plantations Pty Ltd
Bore No:	TTM 03
Location:	
MGA Coordinates:	8 116 567.16 mN, 467 559.44 mE
Status:	Monitoring Bore
Date Constructed:	January 2004
Drilling Contractor:	Drilling Contractors of Australia (DCA)
Drilling Rig:	B500 Rotary rig
Depth Drilled:	62 m
Drilling Details:	0 to 3 m, 203 mm diameter mud-rotary 3 to 62 m, 140 mm diameter mud-rotary
Casing Details:	+0.45 to 3 m, 154 mm ID, 168 mm OD mild steel surface casing +0.14 to 47.80 m, 55 mm ID, 60 mm OD Class 9 uPVC casing 47.80 to 59.80 m, 55 mm ID, 60 mm OD Class 9 uPVC machine slotted casing, 1 mm aperture
Reference Point Description:	Top of uPVC casing
Height of Reference Above Ground:	+0.14 m
Reference Point Elevation :	44.22 m AHD
Gravel Pack Interval:	0 to 62 m, +1.6 to 3.2 mm graded gravel
Static Water Level (26/1/2004):	31.07 m below datum, 13.15 m AHD
Final Water Salinity:	N.D.

TTM 04 BORE COMPLETION DATA

Project:	Tropical Timber Plantations Pty Ltd
Bore No:	TTM 04
Location:	
MGA Coordinates:	8 122 070.06 mN, 464 158.93 mE
Status:	Monitoring Bore
Date Constructed:	January 2004
Drilling Contractor:	Drilling Contractors of Australia (DCA)
Drilling Rig:	B500 Rotary rig
Depth Drilled:	98 m
Drilling Details:	0 to 3 m, 203 mm diameter mud-rotary 3 to 98 m, 140 mm diameter mud-rotary
Casing Details:	+0.45 to 3 m, 154 mm ID, 168 mm OD mild steel surface casing +0.26 to 79.64 m, 55 mm ID, 60 mm OD Class 9 uPVC casing 79.64 to 97.64 m, 55 mm ID, 60 mm OD Class 9 uPVC machine slotted casing, 1 mm aperture
Reference Point Description:	Top of uPVC casing
Height of Reference Above Ground:	+0.26 m
Reference Point Elevation :	10.05 m AHD
Gravel Pack Interval:	0 to 98 m, +1.6 to 3.2 mm graded gravel
Static Water Level (26/1/2004):	0.48 m below datum, 9.57 m AHD
Final Water Salinity:	76 mg/L TDS (by electrical conductivity)