# Contents

# Document History and Status

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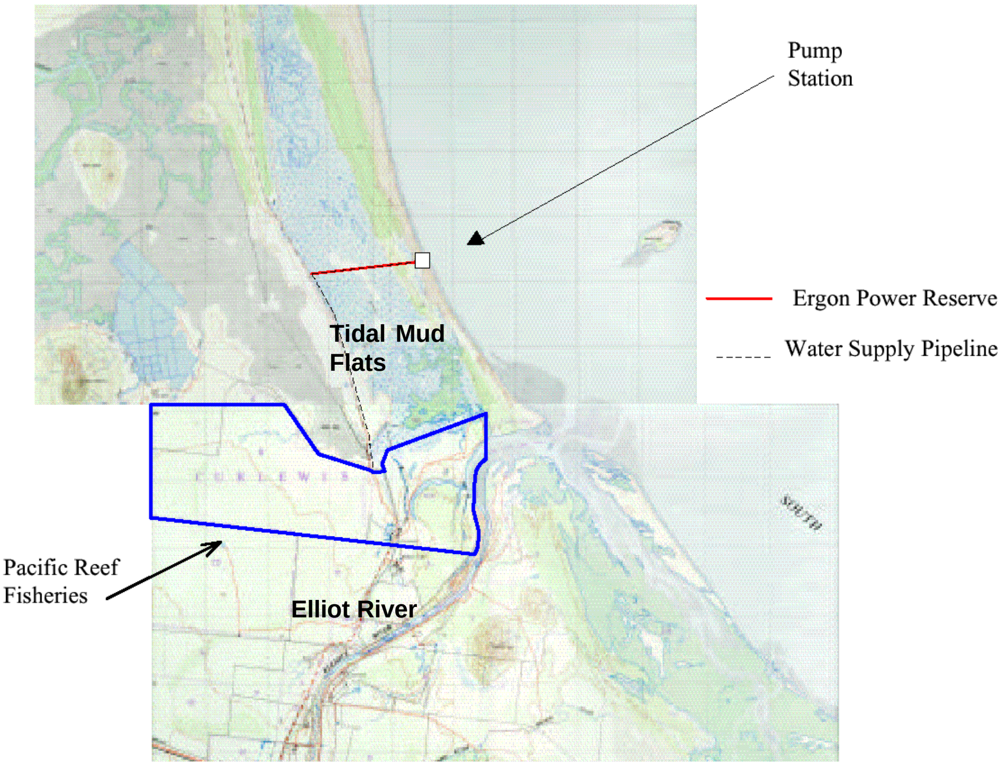
# 1. Hydrogeological Site Description

The proposed prawn farm is located in flat low-lying coastal land immediately west of the Elliot River. The proposed ponds and associated facilities cover an area of more than 350 Ha and are between 4 and 7 km from the coast. The site location is shown schematically in Figure 1-1. Low-lying tidal mud/salt flats are located immediately to the north of the property. The property slopes gently towards the coast and borders the Elliot River to the east. The proposed ponds are located on the western part of the site with a buffer of almost 2 km to the river. The property is currently being used for cattle grazing.

A number of bores have been drilled on the property by the previous owner and on neighbouring properties. Most of these bores have encountered brackish or saline waters that are not of use for domestic, stockwater or irrigation purposes. The nearest existing bores that are currently in use are located to the south of the property. One bore located about 1500m from the property is used to pump about 1.5 L/s for stockwater. Two bore located about 4 km south of the property each produce about 4 L/s for pasture irrigation.

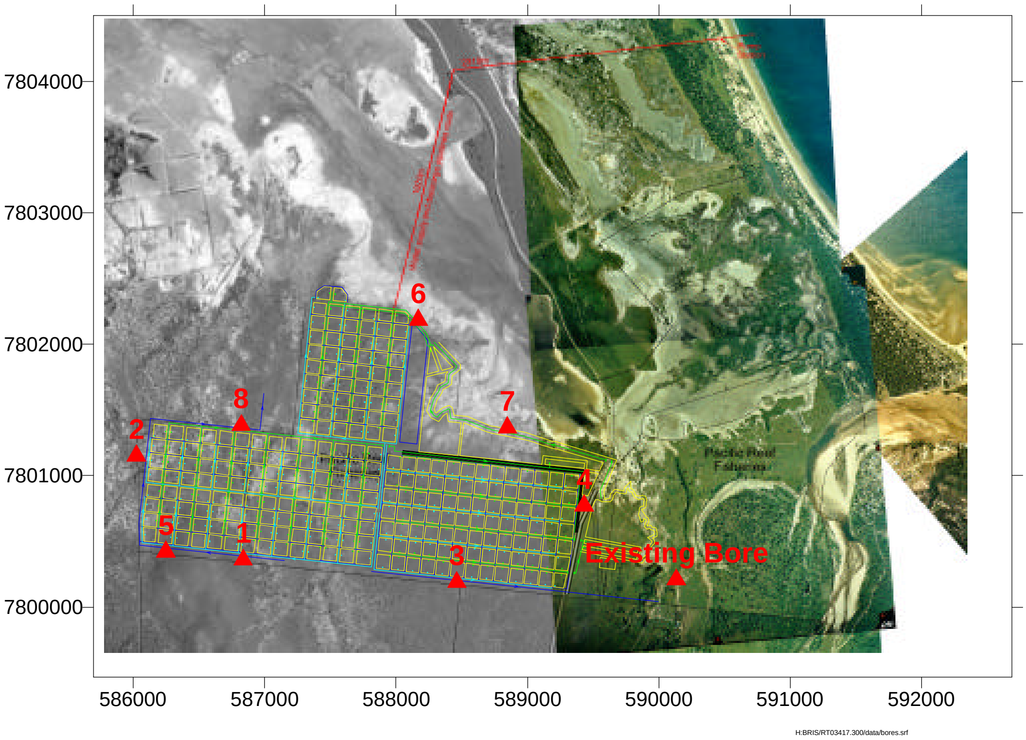
The scarcity in good quality groundwater is reflected in the fact that the location is not included in a specified groundwater protection or groundwater management area. Accordingly there are no existing controls or constraints on groundwater extraction in the area. As a consequence there is little available information on the hydrogeology of the site in the form of reports or data held on the Department of Natural Resources and Minerals (DNRM) groundwater database.

✍ **Figure 1-1 The proposed Pacific Reef prawn farm site**



Detailed site specific information for the current study was obtained from eight shallow bores drilled on the site to investigate the local hydrogeology. The location of these bores in relation to the proposed ponds is shown in Figure 1-2. Also shown in Figure 1-2 is the location of an existing bore drilled by the previous property owner. This bore initially produced a small quantity of fresh water that soon turned saline after pumping. It is no longer in use.

**Figure 1-2 Location of groundwater investigation bores**




Borelogs from seven of the eight bores are presented in Appendix 1.

The logs indicate clays and silts with occasional sands. In some of the bores (notably Bore#6) the water level rose in after a water bearing layer was intersected. These observations suggest the existence of positively pressured confined aquifer conditions.

Water levels in the bores have been measured and a potentiometric surface map generated. This map is presented in Figure 1-3.

**Figure 1-3 Potentiometric surface defined by investigation bores**

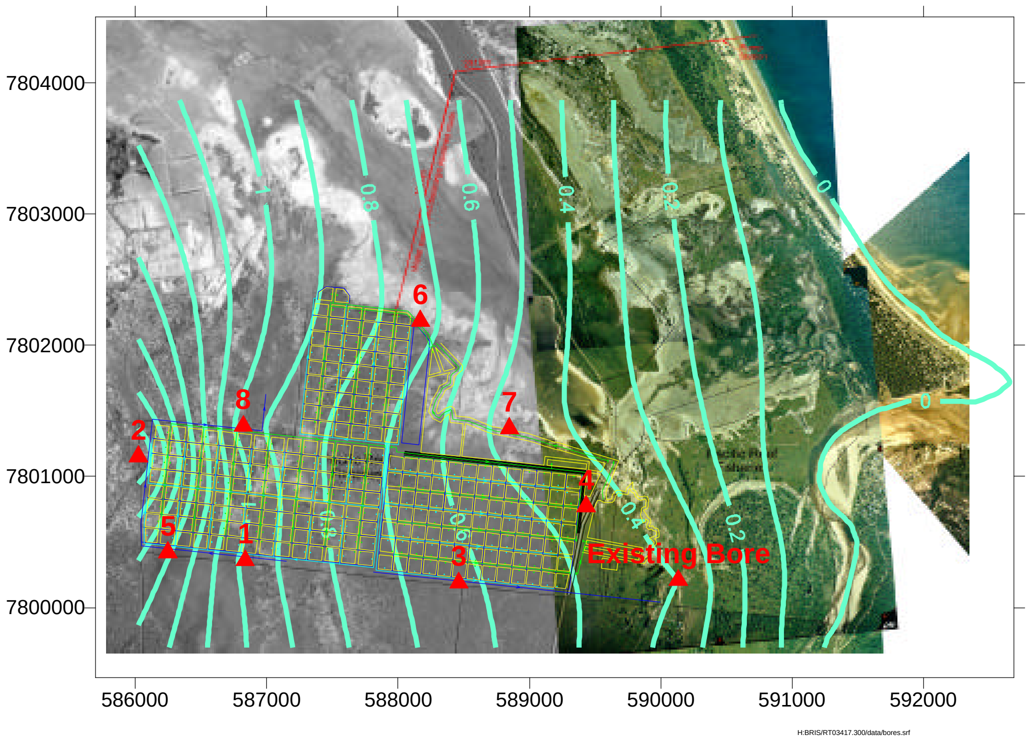
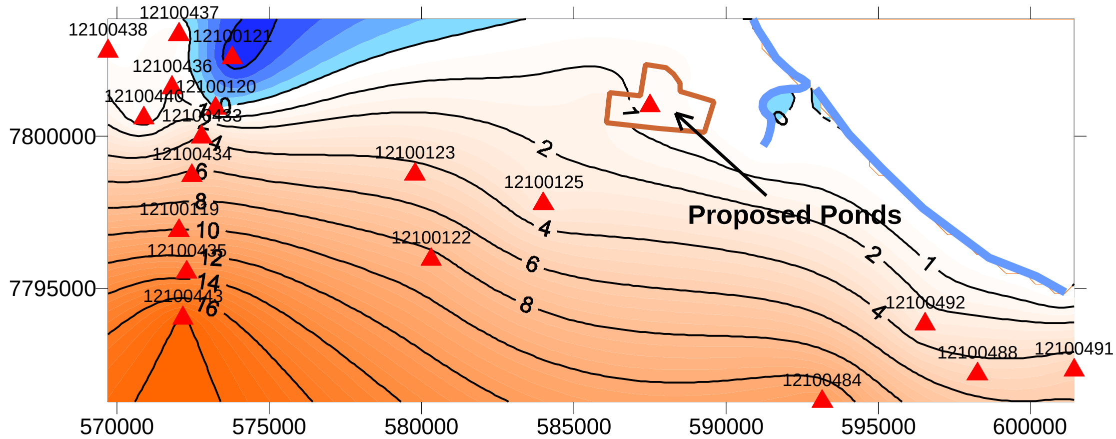



Figure 1-3 indicates that water flows from west to east beneath the site towards the Elliot River and may discharge directly to the river or alternatively to the ocean. An existing bore located on the property was included in the survey and indicates slightly elevated heads in the south-east, possibly reflecting a local shallow perched aquifer. It is understood that isolated pockets of perched fresh groundwater can be found on the eastern part of the property near the Elliot River. Pockets of freshwater are likely to arise from shallow accumulations of rainfall infiltration perched on and surrounded by low permeability sediments that effectively prevent movement of water into the deeper aquifer system. Shallow perched aquifers may also be recharged by the Elliot River under high flow and flood conditions.

The movement of water as indicated by the equipotentials suggest that the groundwater flow net near the site is influenced by surface topography. In particular the hill on the western part of the property coincides with a steepening in the potentiometric gradients that can also be seen in regional potentiometry (refer to Figure 1-4). The potentiometric gradient beneath the hill is approximately 0.7 m/km compared to approximately 0.2 m/km elsewhere.

DNRM have provided information on regional groundwater bores. The location of these bores and the potentiometric contours drawn from their water levels are shown in Figure 1-4.

**Figure 1-4 Regional potentiometric contours**

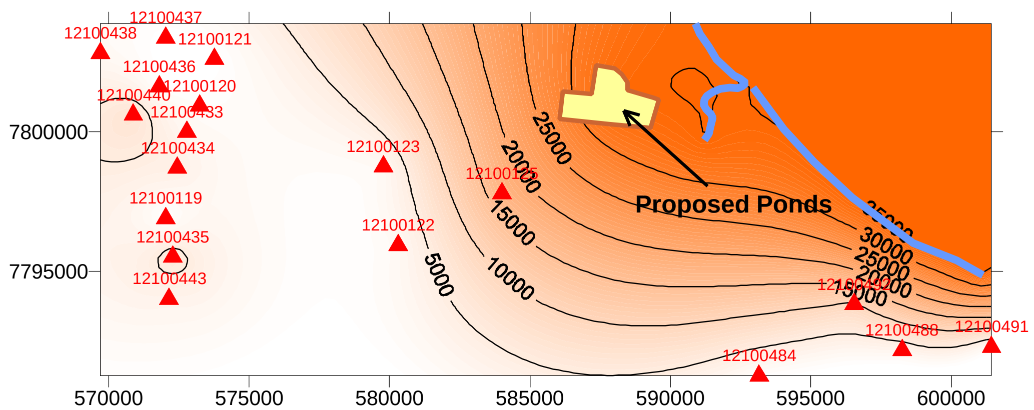



H:BRIS/DATA/RWL/regional_RWL.srf

Figure 1-4 indicates that the regional groundwater gradients are generally south to north indicating a flow of groundwater to the north and north-east. Localised distortion of the potentiometric surface near the proposed prawn farm indicates an easterly flow direction beneath the property. Regions that are colour coded blue in Figure 1-4 indicate areas where the potentiometric surface is below mean sea level. It is assumed that the depressed water table in the north-west is due to groundwater extraction at this location.

The regional groundwater quality is presented in Figure 1-5 as a map of total dissolved solids based on information from the regional bores. Figure 1-5 indicates that the aquifer contains saline water near the coastline, with salinity similar to that of seawater (35 000 mg/L) beneath the site of the proposed ponds. This observation is confirmed by results of laboratory testing of samples collected from the eight investigation bores drilled at the site. Salinities obtained from the investigation bores are presented in Table 1-1.

**Figure 1-5 TDS concentrations [mg/L] in the regional aquifer**




H:BRIS/DATA/salinity/regional_salinity.srf

✍ **Table 1-1 Salinity of investigation bores located at the proposed prawn farm**

| Bore | Date | Conductivity [mS/cm] | Salinity [mg/L] |
|---|---|---|---|
| 1 | 22/08/2002 | 31.4 | 20410 |
| 2 | 22/08/2002 | 33.5 | 21775 |
| 3 | 22/08/2002 | 31.1 | 20215 |
| 4 | 22/08/2002 | 52.1 | 33865 |
| 5 | 22/08/2002 | 30.6 | 19890 |
| 6 | 22/08/2002 | 118 | 76700 |
| 7 | 22/08/2002 | 79.2 | 51480 |
| 8 | 22/08/2002 | 23.7 | 15405 |
| **Average** | | | **32 500** |

Results presented in Table 1-1 indicate variable salinities beneath the proposed ponds ranging from 15 400 mg/L in Bore #8 to 76 700 mg/L in Bore #6. The extremely high salinities found in Bores #6 and #7 suggest an accumulation of salts in shallow sediments near the coast. Irrespective of the origin of the salinity, it is apparent that groundwater beneath the proposed ponds is too saline for domestic, stock water or irrigation purposes.

# 2. EM-34 Survey

As part of the site investigation an EM-34 survey was conducted. The surveys were carried out over three days from 17 to 19 June 2002.

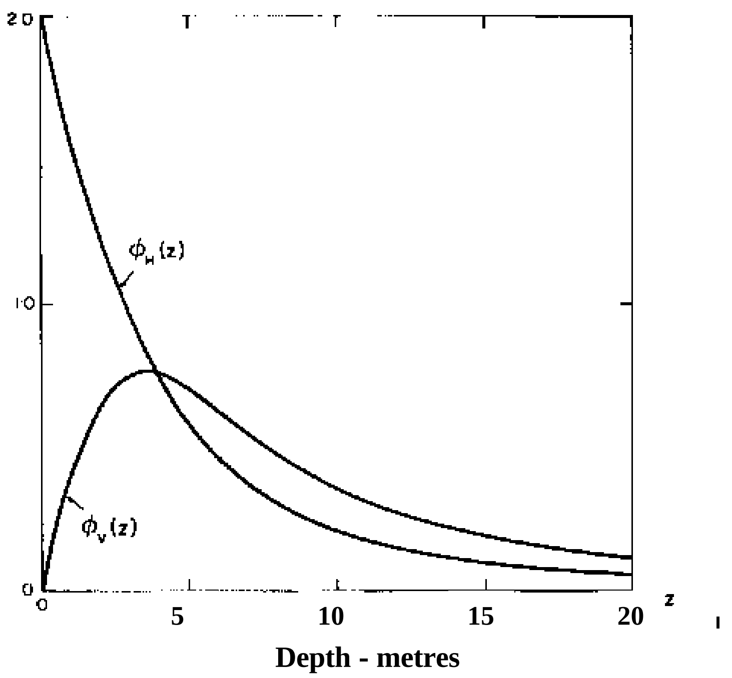
The objective of the surveys was to:

- Find best placement for observation bores for long term groundwater monitoring;
- Locate potential fresh groundwater resources; and to
- Provide baseline site information to assist with hydro-geological characterisation of the site

## 2.1 Method

A Geonics EM-34-3 frequency domain EM system was used. Coils were oriented vertically (horizontal dipole mode) with a coil separation of 10 metres. Readings were taken every 10 metres along east-west lines 200 metres apart. Figure 2.1 (McNeill, 1980) shows how the EM-34 responds to conductivity material at depth. In the configuration used ($?_{H}(z)$) the greatest response comes from the near surface and the relative contribution of deeper material decreases with depth. Thus for these surveys we can assume that the bulk of the conductivity response on the EM-34 is coming from material in the top 7.5 metres. Alternatively one can assume the horizontal dipole measures a cumulative conductivity with greatest influence from the near surface material with minimal contribution below 7.5 metres below surface.

- **Figure 2-1 Depth response of horizontal ($?_{H}(z)$ and vertical $?_{V}(z)$ dipoles for EM-34 (McNeill, 1980) with 10m dipole separation.**



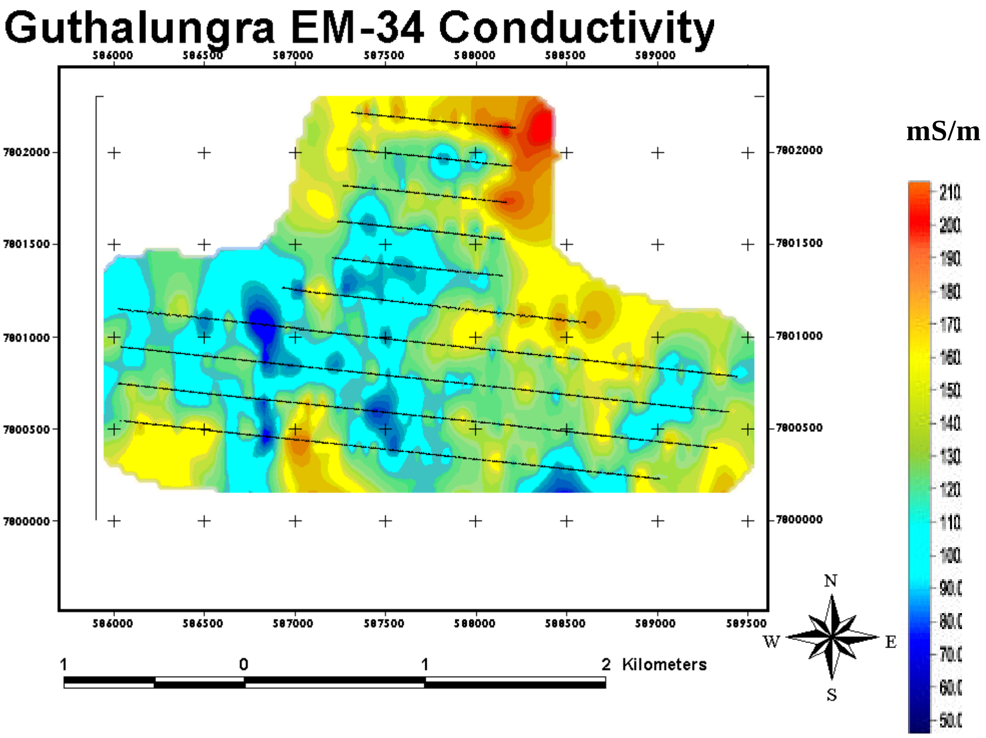
An Omnistar differential GPS receiver was used for navigation along lines and for recording of points every 500 metres along lines. Positional accuracy is considered to be better than +/-10m.

## 2.2 Results and processing

An image of the EM-34 conductivity for the area is presented as figure 3.1.

The image was prepared using CHRIS-DBF software with a grid cell size of 40 metres. This software interpolates the readings between the lines on a cell size of 40m the resulting grid can then be imaged or contour with further interpolation to give a smooth looking change in response across the image. Griding is normally done at around ¼ to 1/5 the line spacing.

**Figure 2-2 EM-34 conductivity from surface to a depth of 7.5m.**




## 2.3 Interpretation

EM-34 conductivity data shows a range of conductivity from around 40 mS/m (400EC) up to a maximum of 225 mS/m (2250 EC). The data is not corrected for non-linearity of the EM-34 response and true conductivity range would be around 50 to 500 mS/m. Recent heavy rain with extensive remaining puddles of surface water indicated the soils were probably fully saturated. The water level in the estuary to the north-east was a few metres below the majority of the survey area.

### High Conductivity Areas

In the field the maximum values were noted to be predominantly over areas of heavy black soil. The highest conductivity corresponds to:

- A saturated clay formation of smectite clays;
- A kaolinite clay with pore water in excess of 10,000 mg/L;
- River sand with water salinity close to seawater; or
- Higher salinity (10,000 to 34,000mg/L) water in a sand/clay mixture.

(Emerson, 1997)

No soil analysis was available but these high conductivities are typically seen over black soil areas in the north of Australia. Therefore at this site the high conductivity is considered to mostly reflect heavy smectite clays which remain highly conductive even during long dry periods due to retained pore water and high cation exchange capacity. The increase in conductivity towards the northeast probably reflects occasional inundation and/or sub-surface infiltration of saltwater

### Low Conductivity Areas

The lowest conductivity corresponds to

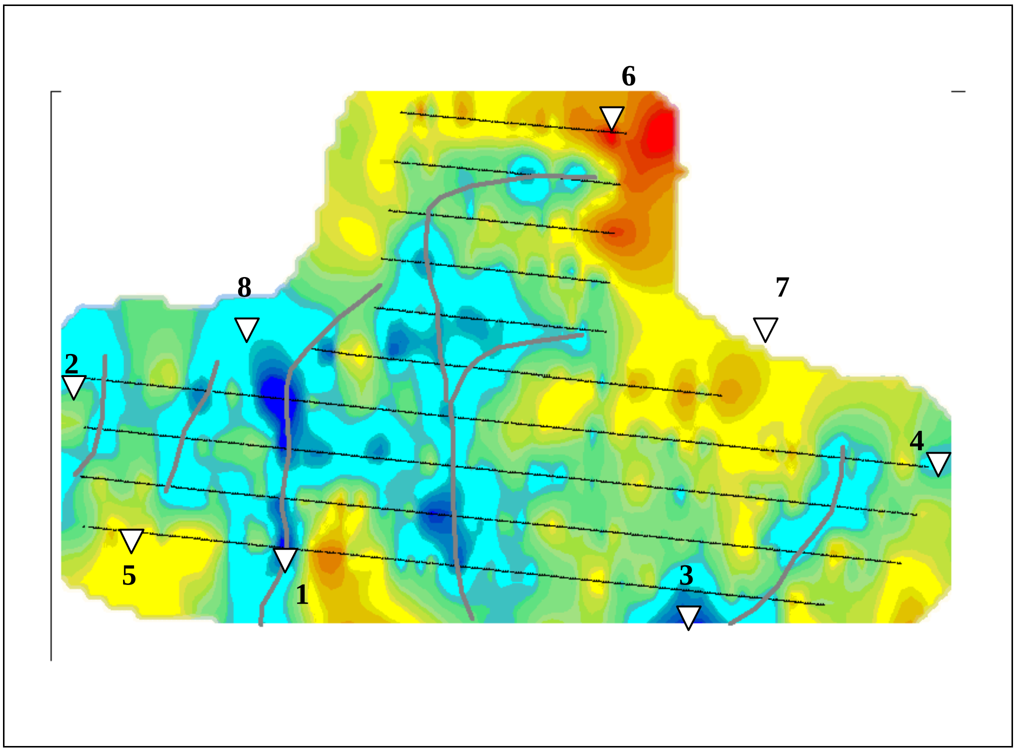
- a river sand with water salinity around 800mg/L.
- a sand clay mix with salinity as low as 200mg/L

Three well defined zones of low conductivity were noted in the field to correspond with more sandy soils. The biggest trees were also noted to occur in the lowest conductivity sections particularly to the western side of the grid. These low conductivity sections are considered to represent alluvial sands deposited in stream channels flowing from the south. They are thus likely to be more permeable sections and possible sources of reasonable quality groundwater.

Sedimentation at this site has resulted in a sand and clay sequence which is reflected at the surface by the presence of sandy and clay soils. The geophysics shows the sands are broader at depth than seen at the surface but the EM-34 has not resolved deeper features. Sandy channels at 5 to 10 metres below surface would probably not be 'seen' with the EM-34 method. The sandy channels at surface may be linked at depth to older sand deposits offset from surface expression and in addition there may be discrete sandy bodies in palaeo-drainage channels.

The sandy channels are likely to carry freshwater into the site from upslope areas to the south and west. If resolution of these channels is a priority then further geophysics could be considered using a time domain EM system. This would produce sections down to depth of around 50m across the site and allow a more accurate groundwater model to be developed.

**Figure 2-3 map of conductivity showing possible pathways for groundwater from south to north and locations of bores that have been drilled.**




The location of bores drilled at the site in relation to the EM-34 survey results is shown in Figure 2-3. An inspection of the borelogs presented in Appendix A suggests that there is not a clear relationship between electrical conductivity and the occurrence of shallow conductive sands. It must be concluded that groundwater and soil salinity is also an important factor controlling electrical conductivity as indicated by the EM-34 results.

The pattern of electrical conductivity obtained from the survey indicates that permeable channels are generally aligned north-south across the prevailing direction of groundwater movement. The effective permeability in the direction of groundwater movement is therefore expected to be lower than that perpendicular to flow.

# 3. Potential Groundwater Impacts

The potential groundwater impacts of the proposed development are associated with the possible leakage of nutrient rich salt water from the ponds and into the underlying aquifer. Once this water has entered the aquifer it will be transported with the groundwater flow and has the potential to spread to neighbouring properties and eventually to the Elliot River where it may cause a deterioration in water quality in the river. There are several factors that will determine whether such impacts will eventuate. These include:

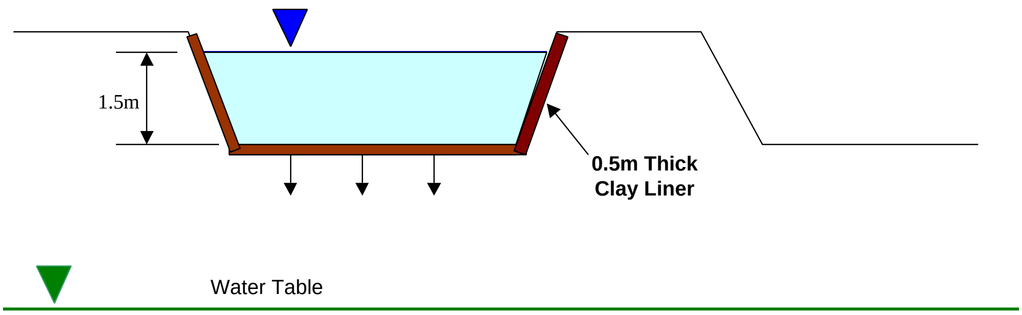
- The rate at which the saline water leaks from the ponds. This factor is dependent on the depth of water in the ponds and the hydraulic conductivity of the sediments that form the base and sides of the pond.
- The velocity of groundwater flow in the aquifer and its potential to transport the saline water to locations where it will impact on neighbouring properties or on the river.
- The salinity of groundwater present in the aquifer and whether it represents a water resource that can be used.

Each of these issues is considered in more detail in the following sections.

# 4. Leakage From Ponds

A typical cross-section through the ponds is shown in Figure 4-1.

**Figure 4-1 Cross Section Through Ponds**




The ponds have been designed with a water level of 1.5 m above the base of the pond. Preliminary permeability tests on six remoulded soil samples from the site (refer to Geotechnical Investigations by Douglas Partners) resulted in hydraulic conductivities between 1E-09 and 3E-11 m/s with an average value of 8.75E-11 m/s.

Application of Darcy's Law to calculate flow across the liner that forms the floor of the ponds is as follows:

$$Q \; ? \; kA\frac{dh}{dz}$$

Where :

$$Q \; ? \; \text{flux of water through the liner}$$

$$k \; ? \; \text{hydraulic conductivity of pond liner}$$

$$? \; 8.75E \; ? \; 11 m/s$$

$$A \; ? \; \text{Area of pond floor} \; ? \; 1.0 ha$$

$$\frac{dh}{dz} \; ? \; \text{Vertical hydraulic gradient within the pond liner}$$

$$? \; 3.0 \; m/m$$

$$Q \; ? \; (8.75E \; ? \; 11)(1E \; ? \; 04)(3.0)$$

$$? \; 0.23 m^3 / day / pond$$

The vertical hydraulic gradient has been determined by assuming a liner thickness of 0.5m and that the entire head drop occurs across the full thickness of liner. The hydraulic conductivity of the liner has been obtained from the average of six measurements of permeability on remoulded soil samples as reported by Douglas Partners (2002).

Leakage rates are expected to further decline as poorly permeable organic matter accumulates on the pond floor during pond operation. Leakage rates will also decline if the water table rises to the level of the pond liner and the sediments immediately beneath the pond become saturated. In this case the hydraulic gradient across the pond liner will decrease below the 3.0m/m that has been assumed in the foregoing calculation and the rate of leakage through the pond liner will decrease.

# 5. Groundwater Transport

Saline water leaking through the pond liners will drain into the underlying aquifer and will be transported away from the ponds by the movement of groundwater. The saline water will undergo dilution and dispersion as it mixes with the groundwater in the aquifer.

The potentiometric contours of Figure 1-3 indicate that groundwater is flowing to the east and is probably discharging into the Elliot River. The environmental impact of the ponds on the local hydrology can therefore be considered in terms of the impact on the salinity and nutrient load of the groundwater in the aquifer and on that of water entering Elliot River.

To estimate the relative magnitude of these possible impacts a simple two dimensional groundwater flow and particle tracking model was developed to simulate the movement of water in the aquifer beneath the ponds. The model was developed in the Visual Modflow modelling environment utilising MODFLOW2000 for the groundwater flow model and Modpath for particle tracking calculations. The model extends from approximately two kilometres upstream (west) of the ponds to the coastline in the east. The Elliot River is included as a General Head Boundary condition that allows groundwater to enter or exit the model according to hydraulic gradients at the boundary. A constant head of 0 mAHD was specified at the coastline thereby constraining the aquifer to discharge at this location. Water enters the model through the upstream (western) boundary defined as a Constant Head Boundary with the head set at 3.0 mAHD, after iterative refinement required to match the potentiometric surface in steady state. All other boundaries are defined as variable head, no-flow boundaries.

Hydraulic conductivity of the sediments was calculated as the average of a series of eight slug tests performed on four of the investigation bores constructed at the site. The results of the slug tests are summarised in Table 5-1. Detailed analyses of the slug test results were carried out using the AQTESOLV well test analysis software package. Graphical presentations of each of the tests are presented in Appendix B.

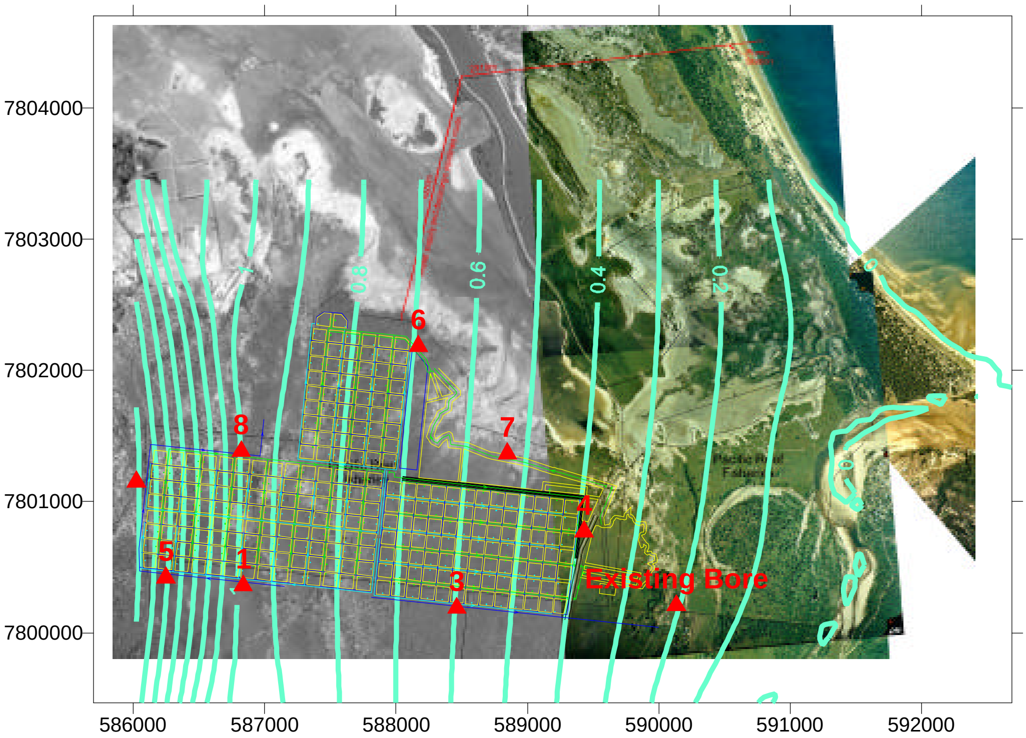
**Table 5-1 Slug test results**

| Bore | Test # | k [m/day] |
|---|---|---|
| 4 | 1 | 0.08 |
| 4 | 2 | 0.08 |
| 6 | 1 | 0.05 |
| 6 | 2 | 0.01 |
| 7 | 1 | 0.08 |
| 7 | 2 | 0.05 |
| 8 | 1 | 0.04 |
| 8 | 2 | 0.04 |
| ***Average*** | | ***0.05375*** |

Slug test results are reasonably consistent and suggest that the aquifer is of low hydraulic conductivity in which water transmission is limited. This result reflects the prevalence of clays and relative scarcity of sands encountered in the drillholes.

The flow model was initially run to steady state and hydraulic conductivities and boundary conditions modified in an attempt to match the measured potentiometric surface as shown in Figure 1-3. The resulting contours of groundwater head predicted by the model are shown in Figure 5-1.

✍ **Figure 5-1 Calculated heads in steady state model**




A comparison between the measured potentiometric surface as shown in Figure 1-3 with the modelled distribution of heads shown in Figure 5-1 suggests that the model reproduces the heads in the aquifer with reasonable accuracy. Accordingly the calibrated model was used to provide the flow field for particle tracking models to assess the movement of saline water in the aquifer beneath the ponds.

## 5.1 Particle Tracking Results

The model was run in transient mode for 100 years model time with the appropriate recharge flux applied to the ponds in order to simulate the calculated leakage from the ponds into the aquifer. The recharge rate was calculated as follows:

$$R \; ? \; Q / A$$

$$Where: R \; ? \; \text{Recharge flux (mm/year)}$$

$$Q \; ? \; \text{Reacharge Rate} \; ? \; 0.23\, m^3 / day / pond$$

$$A \; ? \; \text{Pond Area} \; ? \; 10^4\, m^2$$

$$R \; ? \; 8.4 mm / year$$

This recharge rate was applied to the area covered by the ponds and the salt water storage area and the model run for 100 years. Particle tracking results are presented in

Figure 5-2. Particle traces originating from points distributed around the margins of the ponds and storage area are plotted as arrows showing the travel of water particles over the full 100 years of the model run. In this case the particle traces are extremely limited and are barely visible at the scale of the plot. A magnified view of particle traces on the north east margin of the ponds is presented in Figure 5-3.

The particle trajectories are more clearly visible at the expanded scale of this figure and it can be seen that the predicted movement of particles in the aquifer is less than 100m in 100 years of pond operation.

The result suggests that saline water transport in the aquifer after leakage through the pond liner is expected to be insignificant. The extremely slow migration of saline water in the aquifer beneath the ponds is a direct result of the low hydraulic conductivity of the sediments encountered beneath the proposed site. The results of particle tracking simulations are equally applicable to the migration of dissolved salts and nutrients in the aquifer. It may be concluded that there will be no adverse impacts on the aquifer associated with the leakage of water through the pond liners.

**Figure 5-2 Particle tracking result for 100 years of pond operation**

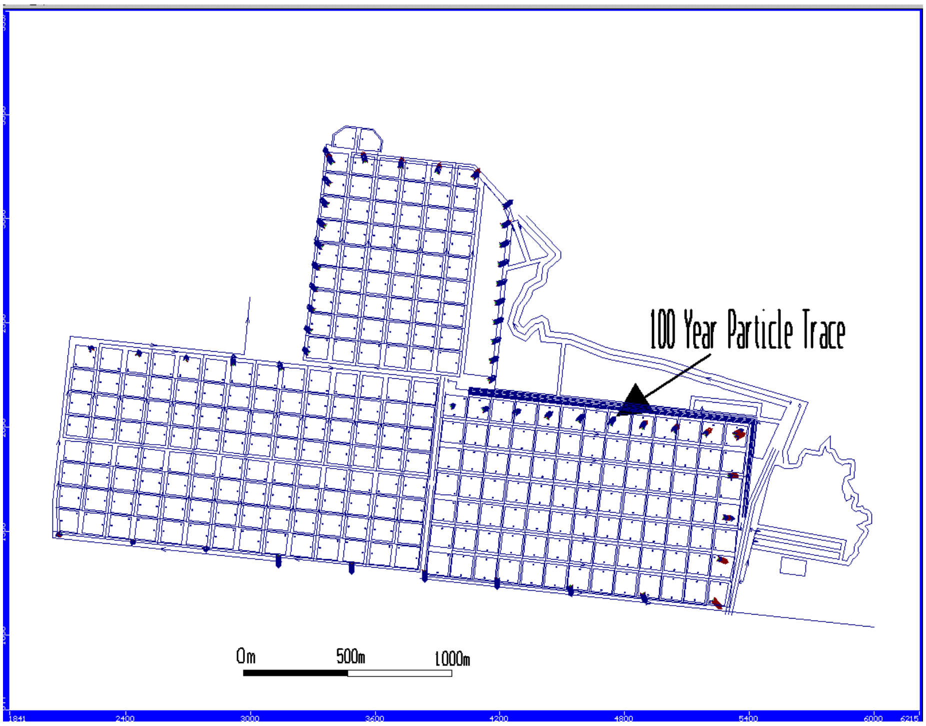
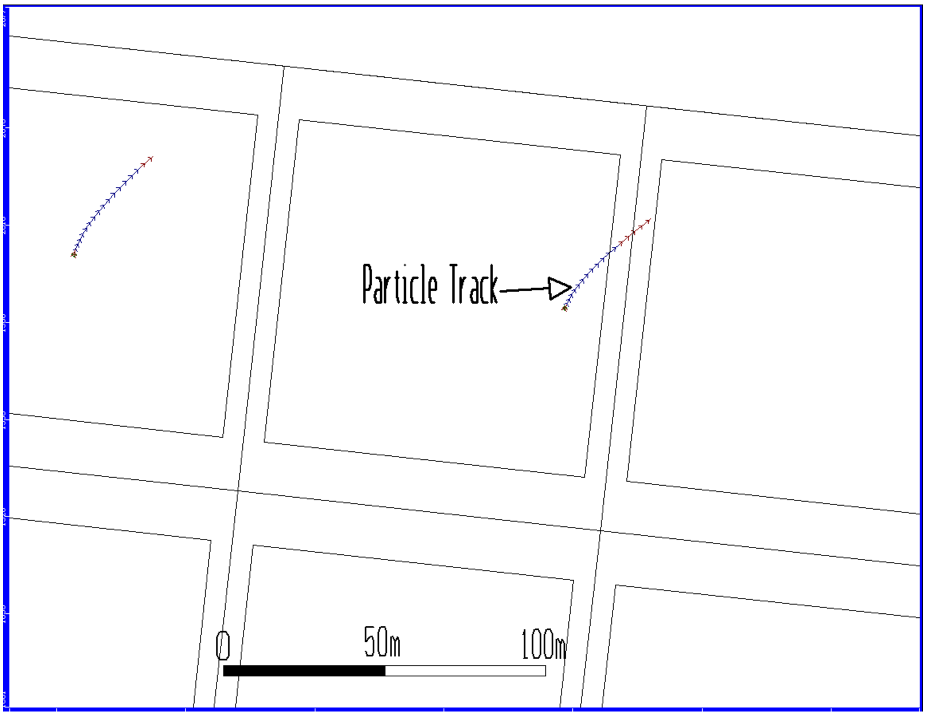


**Figure 5-3 Particle tracking result for 100 years of pond operation – magnified view**



# 6. Receiving Water Quality

As shown in Figure 1-5 and Table 1-1, the aquifer beneath the site contains saline water that is not suitable for use in domestic, stock water or irrigation water supplies. Localised regions of shallow fresh groundwater have been identified on the property to the east of the proposed ponds towards the left bank of the Elliot River. This resource is likely to consist of lenses of shallow perched groundwater located several hundred meters from the proposed ponds. The very presence of perched fresh groundwater in this saline aquifer system indicates the existence of impermeable sediments that prevent the mixing of fresh and saline groundwaters. The effective isolation of these freshwater lenses will help prevent any chance of their contamination from the saline, nutrient rich water leaking from the ponds.

# 7. Conclusions

The potential for adverse groundwater impacts arising from the proposed ponds has been shown to be extremely low. This conclusion reflects a combination of site features that will minimise the potential impacts on the aquifer and other groundwater users. The most important features of the site that have been identified in this respect are:

- The low permeability of the floor and sides of the ponds. Geotechnical investigations carried out at the site indicate that the sediments present at the site will form a low permeability liner to the ponds when reworked and compacted under recommended earthworks construction methods. Leakage rates through this material are therefore expected to be extremely low and have been calculated at 0.23 m3/day/pond.
- The low permeability of the sediments beneath the ponds indicates low groundwater velocities and limited potential for transport of solutes after entering the aquifer. Slug test results carried out on bores drilled at the site confirm an average hydraulic conductivity of about 0.05 m/day. Groundwater flow modelling and particle tracking calculations based on this hydraulic conductivity, calculated leakage rates and on the observed potentiometric gradients at the site, suggest that water entering the aquifer will travel at an average rate of less than 1m per year. Salt water leaking into the aquifer through the compacted pond liners is therefore likely to remain within the property boundaries for at least one hundred years.
- The water present in the sediments beneath the ponds is saline and the leakage of salt water from the ponds is unlikely to cause any further deterioration in groundwater quality.

# Appendix A Bore Logs

SINCLAIR KNIGHT MERZ

**BOREHOLE No. 01**

**Sheet 1 of 1**

| | | | | |
|---|---|---|---|---|
| Client: Guthalungra Prawn Farm | Start Date: 20/8/2002 | Drill method: | Casing/screen dia.: 50mm | Survey datum: |
| Project: | Finish Date: 20/8/2002 | Drilling fluid: | Screen length: 3m | Easting: 586830m |
| Job No: RT03417.300 | Bore location: Guthalungra | Hole diameter: mm | Slot size: mm | Northing: 7800370m |
| Site location: Queensland | Surface condition: | Bore depth: 13.23m | Logged by: , 20/8/2002 | RL TOC: m |
| Driller: Ayr Boring Co. Pty. Ltd. | Rig: | Casing/screen material: PVC | Checked by:, | |

| Ground water | Depth (m) | LITHOLOGICAL DESCRIPTION: Rock/sediment/soil type, unified classification, colour, structure, particle characteristics, minor components | CONDITION: Consistency/ density | CONDITION: Moisture condition | CONSTRUCTION DETAILS: Details | FIELD DATA: Drill method | PID (ppm) | Visual ranking | Odour ranking | Comments | Sample ID | Sample type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | **TOPSOIL** Black clay | | | | | | | | | | |
| | 1 | **SILTY CLAY *(CL)*** Grey | | | | | | | | | | |
| | 2 | **SANDY CLAY *(CL)*** Brown-grey, sandy to silty | | | | | | | | | | |
| | 6.8 | **SANDY CLAY *(CL)*** **Grey** | St | | | | | | | | | |
| ▽ | 7.4 | | | | | | | | | | | |
| | 9.5 | **SANDY CLAY *(CL)*** **Grey** | L | | | | | | | | | |
| | 10.3 | **SILTY SAND *(ML)*** Brown, fine to medium grained | | | 3m screen | | | | | | | |
| | 11.2 | **CLAYEY SAND *(SC)*** Coarse to medium grained | | M | 1m sump | | | | | | | |
| | 13 | EOH @ 13m | | | | | | | | | | |

**VISUAL RANKING**
0 No visible evidence of contamination
1 Slight visible contamination
2 Visible contamination
3 Significant visible contamination

**ODOUR RANKING**
A No Non-Natural odours
B Slight Non-Natural odours
C Moderate Non-Natural odours
D Strong Non-Natural odours

**OTHER ABBREVIATIONS**
PID = Photoionisation detector reading (ppm, V/V)
FR = Fresh rock
SW = Slightly weathered rock
MW = Moderately weathered rock
HW = Highly weathered rock
XW = Extremely weathered rock
RS = Residual soil

**FIELD DATA SYMBOLS**
▼ = SPT Spoon Sample (Pushed)
■ = Undisturbed Tube Sample
● = Disturbed Sample
▯ = Bulk Sample

**GROUNDWATER SYMBOLS**
▼ = Water level (static)
▽ = Water level (during drilling)

**DENSITY (N-value)**

| | | |
|---|---|---|
| VL | (very loose) | <10 |
| L | (loose) | 10 - 20 |
| MD | (medium dense) | 20 - 30 |
| D | (dense) | 30 - 50 |
| VD | (very dense) | >50 |
| CO | (compact) | >50/150mm |

**MOISTURE CONDITION**
D = Dry M = Moist W = Wet

**CONSISTENCY (Su)**

| | | |
|---|---|---|
| VS | (very soft) | < 12 kPa |
| S | (soft) | 12 - 25 |
| F | (firm) | 25 - 50 |
| St | (stiff) | 50 - 100 |
| VSt | (very stiff) | 100 - 200 |
| H | (hard) | > 200 kPa |

SKM ENV 1 PRAWN FARM QLD.GPJ SKM_ENVL1.GDT 24/10/02

**SINCLAIR KNIGHT MERZ**

# BOREHOLE No. 02

**Sheet 1 of 1**

| | | | | |
|---|---|---|---|---|
| Client: Guthalungra Prawn Farm | Start Date: 21/8/2002 | Drill method: | Casing/screen dia.: 50mm | Survey datum: |
| Project: | Finish Date: 21/8/2002 | Drilling fluid: | Screen length: 3m | Easting: 586050m |
| Job No: RT03417.300 | Bore location: Guthalungra | Hole diameter: 159mm | Slot size: mm | Northing: 7801150m |
| Site location: Queensland | Surface condition: | Bore depth: 10.62m | Logged by: , 21/8/2002 | RL TOC: m |
| Driller: Ayr Boring Co. Pty. Ltd. | Rig: | Casing/screen material: PVC | Checked by: , | |

| Ground water | Depth (m) | LITHOLOGICAL DESCRIPTION: Rock/sediment/soil type, unified classification, colour, structure, particle characteristics, minor components | CONDITION: Consistency/ density | CONDITION: Moisture condition | CONSTRUCTION DETAILS: Details | FIELD DATA: Drill method | PID (ppm) | Visual ranking | Odour ranking | Comments | Sample ID | Sample type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | **TOPSOIL** | | | | | | | | | | |
| | 1 | **SILTY CLAY *(CL)*** Yellow brown, with fine sand | | | | | | | | | | |
| | | **SILTY CLAY *(CL)*** Brown, with fine sand | St | | | | | | | | | |
| | 2.4 | **SANDY SILT *(ML)*** Fine grained | | | | | | | | | | |
| ▽ | 6 | | | | | | | | | | | |
| | 6.6 | **SANDY CLAY *(CL)*** Brown | St | | | | | | | | | |
| | 8.4 | **CLAYEY SAND *(SC)*** Fine to medium grained | L | W | 3m screen | | | | | | | |
| | | | | | 1m sump | | | | | | | |
| | 11.2 | EOH @ 11.2m | | | | | | | | | | |

SKM ENV 1 PRAWN FARM QLD.GPJ SKM_ENVL1.GDT 24/10/02

**VISUAL RANKING**
- 0 No visible evidence of contamination
- 1 Slight visible contamination
- 2 Visible contamination
- 3 Significant visible contamination

**ODOUR RANKING**
- A No Non-Natural odours
- B Slight Non-Natural odours
- C Moderate Non-Natural odours
- D Strong Non-Natural odours

**OTHER ABBREVIATIONS**
- PID = Photoionisation detector reading (ppm, V/V)
- FR = Fresh rock
- SW = Slightly weathered rock
- MW = Moderately weathered rock
- HW = Highly weathered rock
- XW = Extremely weathered rock
- RS = Residual soil

**FIELD DATA SYMBOLS**
- ▼ = SPT Spoon Sample (Pushed)
- ■ = Undisturbed Tube Sample
- ● = Disturbed Sample
- ◧ = Bulk Sample

**GROUNDWATER SYMBOLS**
- ▼ = Water level (static)
- ▽ = Water level (during drilling)

**DENSITY (N-value)**

| | | |
|---|---|---|
| VL | (very loose) | <10 |
| L | (loose) | 10 - 20 |
| MD | (medium dense) | 20 - 30 |
| D | (dense) | 30 - 50 |
| VD | (very dense) | >50 |
| CO | (compact) | >50/150mm |

**MOISTURE CONDITION**
D = Dry M = Moist W = Wet

**CONSISTENCY (Su)**

| | | |
|---|---|---|
| VS | (very soft) | < 12 kPa |
| S | (soft) | 12 - 25 |
| F | (firm) | 25 - 50 |
| St | (stiff) | 50 - 100 |
| VSt | (very stiff) | 100 - 200 |
| H | (hard) | > 200 kPa |

SINCLAIR KNIGHT MERZ

# BOREHOLE No. 04

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| Client: Guthalungra Prawn Farm | Start Date: 20/8/2002 | Drill method: | Casing/screen dia.: 50mm | Survey datum: |
| Project: | Finish Date: 20/8/2002 | Drilling fluid: | Screen length: 3m | Easting: 589430m |
| Job No: RT03417.300 | Bore location: Guthalungra | Hole diameter: 159mm | Slot size: mm | Northing: 7800770m |
| Site location: Queensland | Surface condition: | Bore depth: 11.86m | Logged by: , 20/8/2002 | RL TOC: m |
| Driller: Ayr Boring Co. Pty. Ltd. | Rig: | Casing/screen material: PVC | Checked by: , | |

| Ground water | Depth (m) | LITHOLOGICAL DESCRIPTION: Rock/sediment/soil type, unified classification, colour, structure, particle characteristics, minor components | CONDITION: Consistency/density | CONDITION: Moisture condition | CONSTRUCTION DETAILS: Details | FIELD DATA: Drill method | PID (ppm) | Visual ranking | Odour ranking | Comments | Sample ID | Sample type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | **TOPSOIL** Sandy clay | | | | | | | | | | |
| | | **SANDY CLAY *(CL)*** Fine to coarse grained | | | | | | | | | | |
| ▽ | 3 | **CLAYEY SAND *(SC)*** Coarse grained Water struck @ 3.3m | | | | | | | | | | |
| | 5 | **SANDY CLAY *(CL)*** Brown | | M | | | | | | | | |
| | 8.3 | **CLAY *(CH)*** Grey | | W | 3m screen | | | | | | | |
| | 11 | | | | 1m sump | | | | | | | |
| | 11.6 | EOH @ 11.6m | | | | | | | | | | |

**VISUAL RANKING**
0 No visible evidence of contamination
1 Slight visible contamination
2 Visible contamination
3 Significant visible contamination

**ODOUR RANKING**
A No Non-Natural odours
B Slight Non-Natural odours
C Moderate Non-Natural odours
D Strong Non-Natural odours

**OTHER ABBREVIATIONS**
PID = Photoionisation detector reading (ppm, V/V)
FR = Fresh rock
SW = Slightly weathered rock
MW = Moderately weathered rock
HW = Highly weathered rock
XW = Extremely weathered rock
RS = Residual soil

**FIELD DATA SYMBOLS**
▼ = SPT Spoon Sample (Pushed)
■ = Undisturbed Tube Sample
● = Disturbed Sample
◧ = Bulk Sample

**GROUNDWATER SYMBOLS**
▼ = Water level (static)
▽ = Water level (during drilling)

**DENSITY (N-value)**

| | | |
|---|---|---|
| VL | (very loose) | <10 |
| L | (loose) | 10 - 20 |
| MD | (medium dense) | 20 - 30 |
| D | (dense) | 30 - 50 |
| VD | (very dense) | >50 |
| CO | (compact) | >50/150mm |

**MOISTURE CONDITION**
D = Dry M = Moist W = Wet

**CONSISTENCY (Su)**

| | | |
|---|---|---|
| VS | (very soft) | < 12 kPa |
| S | (soft) | 12 - 25 |
| F | (firm) | 25 - 50 |
| St | (stiff) | 50 - 100 |
| VSt | (very stiff) | 100 - 200 |
| H | (hard) | > 200 kPa |

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SINCLAIR KNIGHT MERZ

# BOREHOLE No. 05

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| Client: Guthalungra Prawn Farm | Start Date: 21/8/2002 | Drill method: | Casing/screen dia.: 50mm | Survey datum: |
| Project: | Finish Date: 21/8/2002 | Drilling fluid: | Screen length: 3m | Easting: 586250m |
| Job No: RT03417.300 | Bore location: Guthalungra | Hole diameter: 159mm | Slot size: mm | Northing: 7800420m |
| Site location: Queensland | Surface condition: | Bore depth: 11.94m | Logged by: , 21/8/2002 | RL TOC: m |
| Driller: Ayr Boring Co. Pty. Ltd. | Rig: | Casing/screen material: PVC | Checked by: , | |

| Depth (m) | LITHOLOGICAL DESCRIPTION: Rock/sediment/soil type, unified classification, colour, structure, particle characteristics, minor components | CONDITION: Consistency/density | CONDITION: Moisture condition | CONSTRUCTION DETAILS: Details |
|---|---|---|---|---|
| 0 – 1.3 | **TOPSOIL** Black | | | |
| 1.3 – 3.5 | **CLAY *(CL)*** Brown, silty | St | | |
| 3.5 – 7.8 | **SAND *(SM)*** Brown, fine grained, silty | | D | |
| 7.8 – 11.63 | **SAND *(SM)*** Dark brown, medium to coarse grained, silty. Struck water @ 8m | | W | 3m screen; 1m sump |
| 11.63 | EOH @ 11.63m | | | |

Ground water: water level (during drilling) at approx. 7.2m.

FIELD DATA: Drill method | PID (ppm) | Visual ranking | Odour ranking | Comments | Sample ID | Sample type

**VISUAL RANKING**
0 No visible evidence of contamination
1 Slight visible contamination
2 Visible contamination
3 Significant visible contamination

**ODOUR RANKING**
A No Non-Natural odours
B Slight Non-Natural odours
C Moderate Non-Natural odours
D Strong Non-Natural odours

**OTHER ABBREVIATIONS**
PID = Photoionisation detector reading (ppm, V/V)
FR =Fresh rock
SW =Slightly weathered rock
MW =Moderately weathered rock
HW =Highly weathered rock
XW =Extremely weathered rock
RS =Residual soil

**FIELD DATA SYMBOLS**
= SPT Spoon Sample (Pushed)
= Undisturbed Tube Sample
= Disturbed Sample
= Bulk Sample

**GROUNDWATER SYMBOLS**
= Water level (static)
= Water level (during drilling)

**DENSITY (N-value)**
VL (very loose) <10
L (loose) 10 - 20
MD (medium dense) 20 - 30
D (dense) 30 - 50
VD (very dense) >50
CO (compact) >50/150mm

**MOISTURE CONDITION**
D = Dry M = Moist W = Wet

**CONSISTENCY (Su)**
VS (very soft) < 12 kPa
S (soft) 12 - 25
F (firm) 25 - 50
St (stiff) 50 - 100
VSt (very stiff) 100 - 200
H (hard) > 200 kPa

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SINCLAIR KNIGHT MERZ

# BOREHOLE No. 06

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| Client: Guthalungra Prawn Farm | Start Date: 21/8/2002 | Drill method: | Casing/screen dia.: 50mm | Survey datum: |
| Project: | Finish Date: 21/8/2002 | Drilling fluid: | Screen length: 3m | Easting: 588167m |
| Job No: RT03417.300 | Bore location: Guthalungra | Hole diameter: mm | Slot size: mm | Northing: 7802205m |
| Site location: Queensland | Surface condition: | Bore depth: 11.58m | Logged by: , 21/8/2002 | RL TOC: m |
| Driller: Ayr Boring Co. Pty. Ltd. | Rig: | Casing/screen material: PVC | Checked by: , | |

| Ground water | Depth (m) | LITHOLOGICAL DESCRIPTION: Rock/sediment/soil type, unified classification, colour, structure, particle characteristics, minor components | CONDITION: Consistency/density | CONDITION: Moisture condition | CONSTRUCTION DETAILS: Details | FIELD DATA: Drill method | PID (ppm) | Visual ranking | Odour ranking | Comments | Sample ID | Sample type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | **TOPSOIL** Black clay | | | | | | | | | | |
| ▽ (approx. 1.5) | 1.1 | **CLAY *(CL)*** Brown, some sand | St | | | | | | | | | |
| | 4.4 | **CLAY *(CL)*** Brown-grey, some sand | St | M | | | | | | | | |
| | | | | | 3m screen | | | | | | | |
| | 10 | **CLAYEY SAND *(SC)*** Medium to coarse grained. Water struck @ 10m, rose to 1.52m | | | | | | | | | | |
| | | | | | 1m sump | | | | | | | |
| | 12 | EOH @ 11.98m | | | | | | | | | | |

**VISUAL RANKING**
0 No visible evidence of contamination
1 Slight visible contamination
2 Visible contamination
3 Significant visible contamination

**ODOUR RANKING**
A No Non-Natural odours
B Slight Non-Natural odours
C Moderate Non-Natural odours
D Strong Non-Natural odours

**OTHER ABBREVIATIONS**
PID = Photoionisation detector reading (ppm, V/V)
FR = Fresh rock
SW = Slightly weathered rock
MW = Moderately weathered rock
HW = Highly weathered rock
XW = Extremely weathered rock
RS = Residual soil

**FIELD DATA SYMBOLS**
= SPT Spoon Sample (Pushed)
= Undisturbed Tube Sample
= Disturbed Sample
= Bulk Sample

**GROUNDWATER SYMBOLS**
= Water level (static)
= Water level (during drilling)

**DENSITY (N-value)**
VL (very loose) <10
L (loose) 10 - 20
MD (medium dense) 20 - 30
D (dense) 30 - 50
VD (very dense) >50
CO (compact) >50/150mm

**MOISTURE CONDITION**
D = Dry M = Moist W = Wet

**CONSISTENCY (Su)**
VS (very soft) < 12 kPa
S (soft) 12 - 25
F (firm) 25 - 50
St (stiff) 50 - 100
VSt (very stiff) 100 - 200
H (hard) > 200 kPa

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SINCLAIR KNIGHT MERZ

# BOREHOLE No. 07

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| Client: Guthalungra Prawn Farm | Start Date: 23/8/2002 | Drill method: | Casing/screen dia.: 50mm | Survey datum: |
| Project: | Finish Date: 23/8/2002 | Drilling fluid: | Screen length: 3m | Easting: 588652m |
| Job No: RT03417.300 | Bore location: Guthalungra | Hole diameter: 159mm | Slot size: mm | Northing: 7801095m |
| Site location: Queensland | Surface condition: | Bore depth: 16.5m | Logged by: , 23/8/2002 | RL TOC: m |
| Driller: Ayr Boring Co. Pty. Ltd. | Rig: | Casing/screen material: PVC | Checked by: , | |

| Ground water | Depth (m) | Graphic log | LITHOLOGICAL DESCRIPTION: Rock/sediment/soil type, unified classification, colour, structure, particle characteristics, minor components | CONDITION: Consistency/ density | CONDITION: Moisture condition | CONSTRUCTION DETAILS: Well diagram | CONSTRUCTION DETAILS: Details | FIELD DATA: Drill method | PID (ppm) | Visual ranking | Odour ranking | Comments | Sample ID | Sample type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | **TOPSOIL** Black clay | | | | | | | | | | | |
| ▽ | 1 | | **SAND *(SC)*** Yellow, medium to coarse grained, clay bound | | | | | | | | | | | |
| | 4.4 | | **CLAY *(CH)*** Brown, grey, dry towards bottom, some sandy gravel | St | M | | | | | | | | | |
| | 9 | | | | | | 3m screen | | | | | | | |
| | 11 | | | | | | 1m sump | | | | | | | |
| | 16 | | EOH @ 16m | | | | | | | | | | | |

**VISUAL RANKING**
0 No visible evidence of contamination
1 Slight visible contamination
2 Visible contamination
3 Significant visible contamination

**ODOUR RANKING**
A No Non-Natural odours
B Slight Non-Natural odours
C Moderate Non-Natural odours
D Strong Non-Natural odours

**OTHER ABBREVIATIONS**
PID = Photoionisation detector reading (ppm, V/V)
FR = Fresh rock
SW = Slightly weathered rock
MW = Moderately weathered rock
HW = Highly weathered rock
XW = Extremely weathered rock
RS = Residual soil

**FIELD DATA SYMBOLS**
▼ = SPT Spoon Sample (Pushed)
■ = Undisturbed Tube Sample
● = Disturbed Sample
◨ = Bulk Sample

**GROUNDWATER SYMBOLS**
▼ = Water level (static)
▽ = Water level (during drilling)

**DENSITY (N-value)**
VL (very loose) <10
L (loose) 10 - 20
MD (medium dense) 20 - 30
D (dense) 30 - 50
VD (very dense) >50
CO (compact) >50/150mm

**MOISTURE CONDITION**
D = Dry M = Moist W = Wet

**CONSISTENCY (Su)**
VS (very soft) < 12 kPa
S (soft) 12 - 25
F (firm) 25 - 50
St (stiff) 50 - 100
VSt (very stiff) 100 - 200
H (hard) > 200 kPa

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SINCLAIR KNIGHT MERZ

# BOREHOLE No. 08

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| Client: Guthalungra Prawn Farm | Start Date: 21/8/2002 | Drill method: | Casing/screen dia.: 50mm | Survey datum: |
| Project: | Finish Date: 21/8/2002 | Drilling fluid: | Screen length: 3m | Easting: 586820m |
| Job No: RT03417.300 | Bore location: Guthalungra | Hole diameter: 159mm | Slot size: mm | Northing: 7801370m |
| Site location: Queensland | Surface condition: | Bore depth: 11m | Logged by: , 21/8/2002 | RL TOC: m |
| Driller: Ayr Boring Co. Pty. Ltd. | Rig: | Casing/screen material: PVC | Checked by: , | |

| Ground water | Depth (m) | Graphic log | LITHOLOGICAL DESCRIPTION: Rock/sediment/soil type, unified classification, colour, structure, particle characteristics, minor components | CONDITION: Consistency/ density | CONDITION: Moisture condition | CONSTRUCTION DETAILS: Well diagram | CONSTRUCTION DETAILS: Details | FIELD DATA: Drill method | PID (ppm) | Visual ranking | Odour ranking | Comments | Sample ID | Sample type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0–1.2 | | **TOPSOIL** Black clay | | | | | | | | | | | |
| | 1.2–2.3 | | **SILTY SAND *(SM)*** Brown, fine-grained | | | | | | | | | | | |
| | 2.3–4.5 | | **CLAY *(CL)*** Grey, sandy | St | | | | | | | | | | |
| ▽ 5 | 4.5–7.2 | | **CLAY *(CL)*** Brown, silty, with some fine sand | | | | | | | | | | | |
| | 7.2–7.8 | | **SAND *(SW)*** Yellow, coarse-grained Water struck @ 7.5m, rose to 5.11m | | | | 3m screen | | | | | | | |
| | 7.8–11 | | **CLAY *(CH)*** Yellow brown, hard | St | M | | 1m sump | | | | | | | |
| | 11 | | EOH @ 11m | | | | | | | | | | | |

**VISUAL RANKING**
0 No visible evidence of contamination
1 Slight visible contamination
2 Visible contamination
3 Significant visible contamination

**ODOUR RANKING**
A No Non-Natural odours
B Slight Non-Natural odours
C Moderate Non-Natural odours
D Strong Non-Natural odours

**OTHER ABBREVIATIONS**
PID = Photoionisation detector reading (ppm, V/V)
FR = Fresh rock
SW = Slightly weathered rock
MW = Moderately weathered rock
HW = Highly weathered rock
XW = Extremely weathered rock
RS = Residual soil

**FIELD DATA SYMBOLS**
▼ = SPT Spoon Sample (Pushed)
■ = Undisturbed Tube Sample
● = Disturbed Sample
◧ = Bulk Sample

**GROUNDWATER SYMBOLS**
▼ = Water level (static)
▽ = Water level (during drilling)

**DENSITY (N-value)**

| | | |
|---|---|---|
| VL | (very loose) | <10 |
| L | (loose) | 10 - 20 |
| MD | (medium dense) | 20 - 30 |
| D | (dense) | 30 - 50 |
| VD | (very dense) | >50 |
| CO | (compact) | >50/150mm |

**MOISTURE CONDITION**
D = Dry M = Moist W = Wet

**CONSISTENCY (Su)**

| | | |
|---|---|---|
| VS | (very soft) | < 12 kPa |
| S | (soft) | 12 - 25 |
| F | (firm) | 25 - 50 |
| St | (stiff) | 50 - 100 |
| VSt | (very stiff) | 100 - 200 |
| H | (hard) | > 200 kPa |

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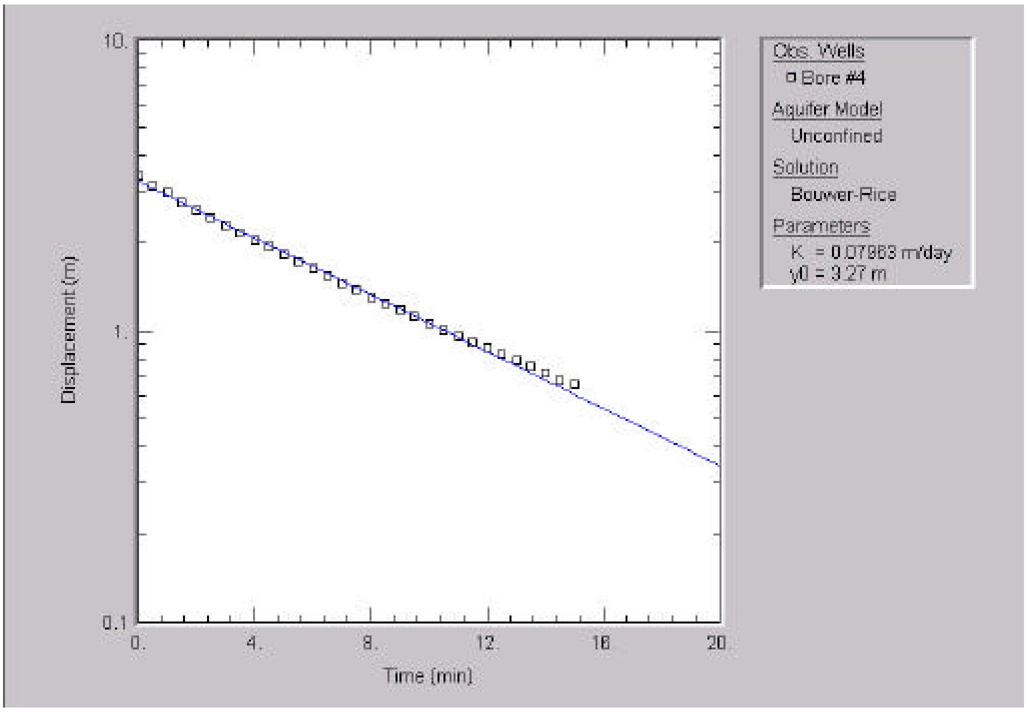
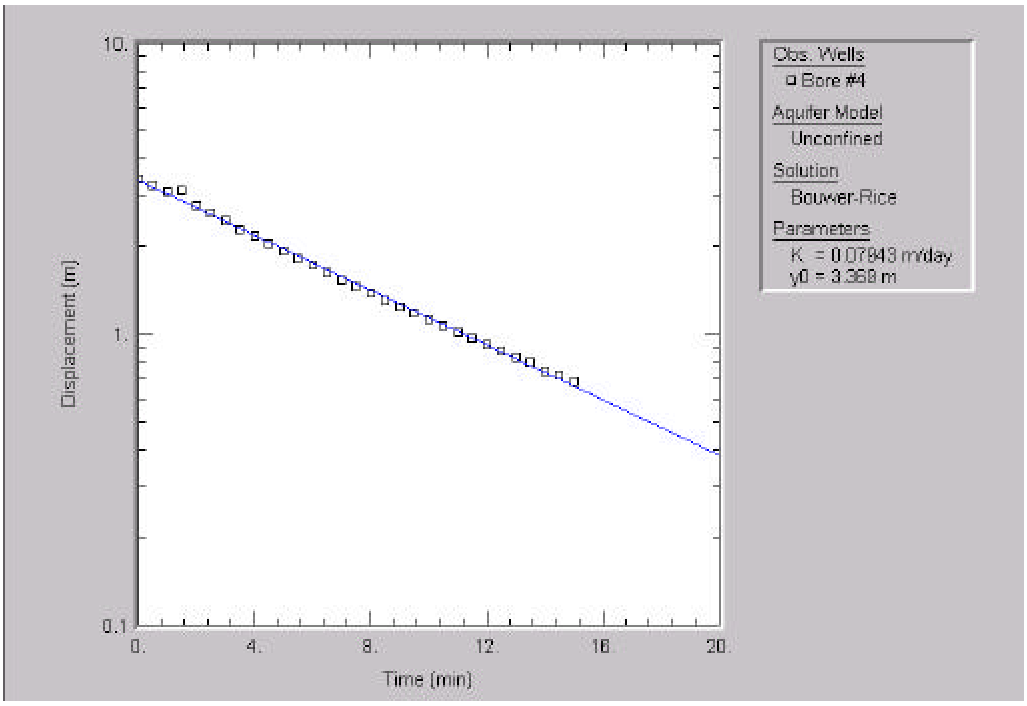
# Appendix B Slug Test Results

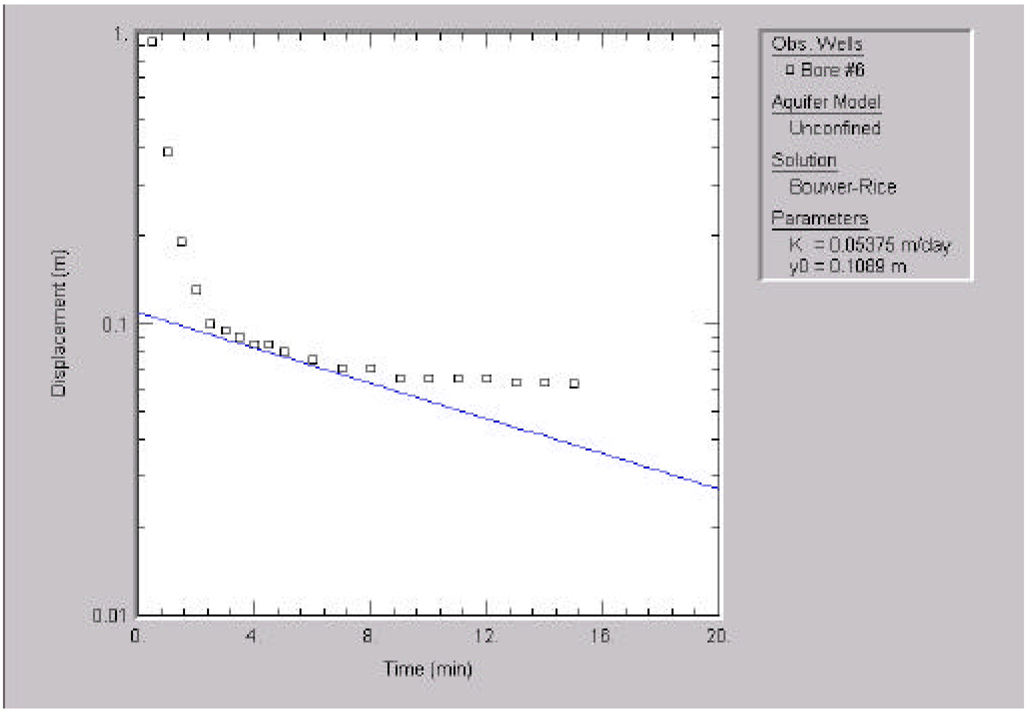
## B.1 Bore #4 Test 1



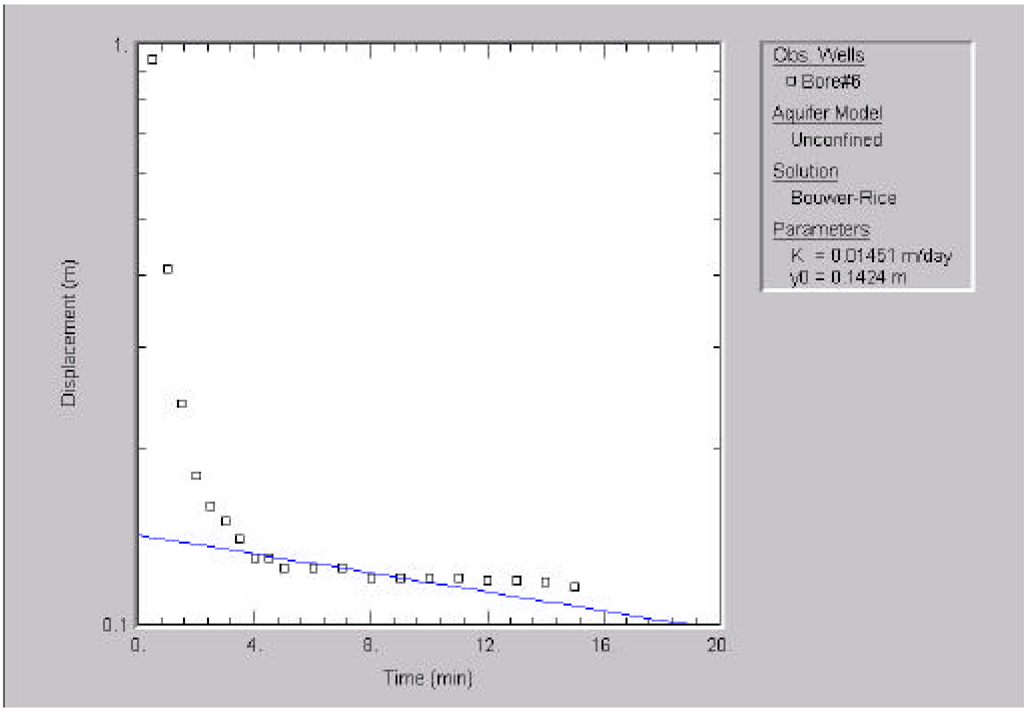

## B.2 Bore #4 Test 2



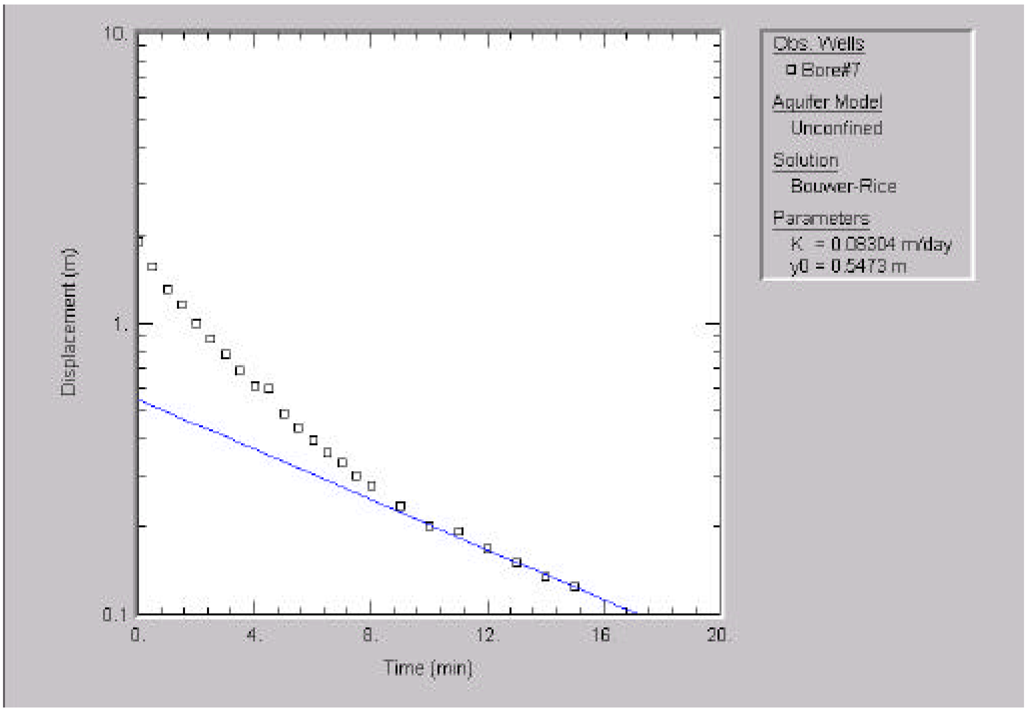
## B.3 Bore #6 Test 1



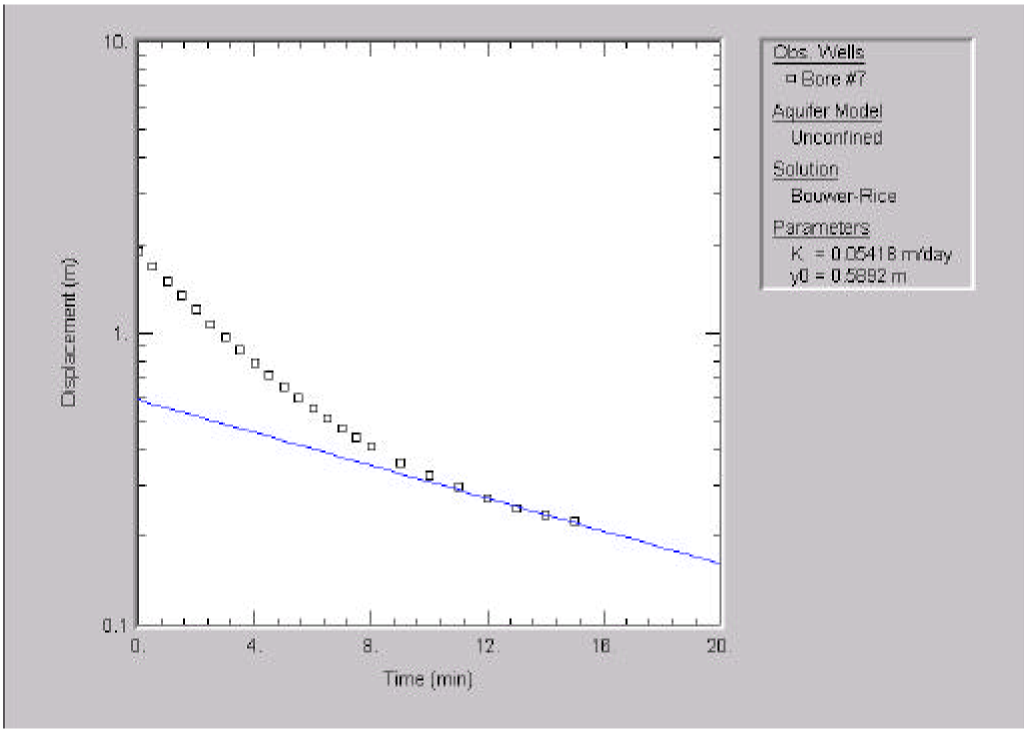

## B.4 Bore #6 Test 2



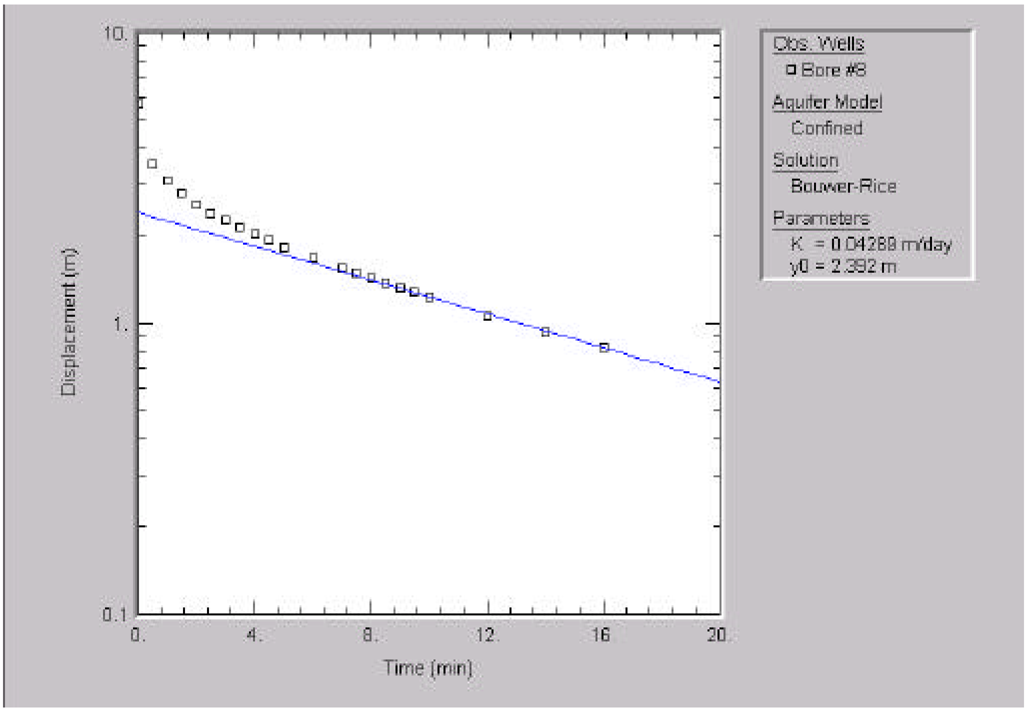
## B.5 Bore #7 Test 1




## B.6 Bore #7 Test 2



## B.7 Bore #8 Test 1




## B.8 Bore #8 Test 2