6.4 e Groundwater Resource Evaluation Supplemental Report Golders

9 March 2009

ELLA BAY INTEGRATED RESORT

Groundwater Resource Evaluation: Supplemental Report

Submitted to:
Satori Resorts Ella Bay Pty Ltd
Level 6
344 Queen Street
Brisbane Queensland 4000

REPORT

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Bris-Supplemental

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Golder Associates

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1.0 INTRODUCTION

In September of 2008, Satori Resorts Ella Bay Pty Ltd (Satori) commissioned Golder Associates Pty. Ltd. (Golder) to conduct an evaluation of groundwater resources at Ella Bay for the following purposes:

- To investigate groundwater supply feasibility; and
- To determine a sustainable yield that addresses conditions of the Environmental Impact Statement in regards to identifying potential impacts upon the Wet Tropics of Queensland World Heritage Area (WTQWHA), sensitive wetland areas and the Great Barrier Reef World Heritage Area (GBRWHA) that may result from changes in groundwater hydrology. Sensitive wetlands were identified as:
  - the dunal swales located near the Eastern Conservation Covenant; and
  - the Ella Bay Swamp located north of the proposed resort area.

A groundwater investigation program was conducted in November to December 2008 at the Ella Bay site and achieved the following field activities:

- Drilling of 11 groundwater exploration boreholes by air direct circulation to characterise the hydrogeology of the site and locate suitable sites for constructing test production bores;
- The completion of two test production bores: Northwest Production Bore (PB1B) and West production bore (PB3C);
- The completion of two monitoring bores: MB1B-01 and MB1B-02;
- Aquifer hydraulic testing by a 3-day constant rate pumping test of the Northwest bore at 3 L/s and rising and falling head tests of single boreholes;
- Monitoring of groundwater levels; and
- Groundwater sampling during the pumping test.

2.0 RESULTS

2.1 Groundwater Exploration

The greatest groundwater occurrence during drilling was identified within colluvium (silty-gravel) aquifer unit with 2.5 L/s of water produced from PB3C and 2 L/s of water produced from the Northwest bore. Several other groundwater exploration boreholes which intersected the silty-gravel aquifer provided poor yields commonly below 0.5 L/s which indicate that the silty-gravel aquifer hydrogeology is highly variable in nature. Figure 1 is a plan view of the Ella Bay site showing the locations of all groundwater exploration boreholes, monitoring and production bores.

A sustainable rate of 3 L/s was pumped from the colluvium aquifer during the 3-day constant rate pumping test of the northwest bore. A pumping rate greater than 3 L/s was not achievable during the test due to limiting specifications of the submersible pump. A greater pumping rate **may be possible** with a higher-yielding pump or alternately pumping from multiple bores with a combined yield of possibly 4 to 6 L/s. A greater extraction rate from the aquifer would require additional, long-term aquifer testing to prove:

- sustainability of the bore(s), and
- the higher extraction rate would not impact the dunal swales or Ella Bay Swamp.

The general direction of regional groundwater flow across the Ella Bay site is from southwest towards the northern resort area (from the Seymour Ranges to the ocean), and is strongly controlled by topographical elevation and hydraulic gradient between upper and lower slopes. A conceptual hydrogeological model of the site is depicted in a cross-section of the site in Figure 2. The location of Cross-Section A-A' is shown on Figure 1.

The groundwater quality is fresh with a very low Total Dissolved Solids concentration, slightly acidic and soft. Metal concentrations are within the 2004 National Drinking Water Guidelines. Measurements of pH, electrical conductivity (indicator of salinity) and temperature were obtained from discharge at the bore head

throughout the pumping test. These measurements showed no trend of deterioration in quality from saltwater intrusion or quality changes from multi-aquifer mixing.

The West production bore produced extremely silty water due to poor bore construction due to a combination of difficult ground conditions and the drilling method used. The West production bore site can be re-drilled by an alternate drilling method compatible for the ground conditions, which will provide improved water quality, yield and longevity of the bore.

2.2 Groundwater Modelling

A simple one-layered analytical model was developed to predict the decrease (drawdown) in groundwater levels in the silty-gravel aquifer from pumping the Northwest Production Bore over extended periods of time at a constant rate of 3 L/s. The aquifer properties used in the model are based on drilling and test pumping results. The drawdown contours generated from modelling were predicted for time durations of 6 months, 1 year and 2 years. The results from 6 months of pumping are provided in Figure 3. The predictions of groundwater level drawdown **does not** account for rainfall recharge and leakage from other geological units into the aquifer. These results are therefore considered to be a worst case scenario.

A summary of the predicted drawdown results are presented in Table 1.

Table 1: Predicted Drawdown of Groundwater Levels in the Aquifer from Modelling Results

Predicted Drawdown (m)	Northwest Bore	Southern Extremity of Ella Bay Swamp (994m*)	Dunal Swale (1538m*)
6 Months	2.55	0.27	0.18
1 Year	2.63	0.35	0.25
2 Years	2.71	0.42	0.33

Note * Distance in metres from Northwest Bore.

It is important to note that there are several limitations and assumptions of the analytical model which reduces the model confidence. Major limitations include:

- No recharge and discharge conditions of the silty-gravel aquifer are within the model construct. Water levels would partially recover during the wet season due to substantial recharge from intense rainfall events and leakage from surface flow;
- The simple model assumes a homogeneous uniform thickness 1 layered aquifer unit of infinite extent where in fact the aquifer has different hydraulic properties laterally and vertically due to changes in geology.

3.0 GROUDWATER ABSTRACTION ASSESSMENT

3.1 Potential Impact on Wetlands Near Ella Bay Swamp From Long-term Pumping of Northwest Production Bore

There is no direct evidence that the Ella Bay Swamp is hydraulically connected to the silty-gravel aquifer. From groundwater modelling results and extrapolating of test pumping data, the Northwest Production Bore can be pumped continuously for at least 35 days at a flow rate of 3 L/s before potentially producing 0.1 m drawdown in the southern extremity of Ella Bay Swamp. As previously stated this modelling does not account for recharge of the aquifer and can be considered as a worst case scenario.

Trigger groundwater levels have been calculated in monitoring bores (MB1B-01 and MB1B-02) as early warning measures for the influence of drawdown reaching the Ella Bay Swamp area from long-term pumping of the Northwest Production Bore at flow rate of 3 L/s. Proposed trigger groundwater levels for monitoring bore MB1B-01 is 1.45 m of drawdown and for monitoring bore MB1B-02 is 0.82 m drawdown.

3.2 Potential Impact on Dunal Swales Near Eastern Conservation Covenant From Long-term Pumping of Northwest Production Bore

The 3-day pumping test did not influence groundwater levels in the vicinity of the dunal swale wetland as indicated by surveillance of monitoring bore A-MW3 located between the Northwest bore and the dunal swale wetland and monitoring bore A-MW4 located at the western edge of the dunal swale wetland. From review of groundwater modelling results the Northwest Production Bore may be pumped continuously for at least 6 months to 1 year at a flow rate of 3 L/s before potentially producing 0.1 m drawdown at bore A-MW3 and for at least 2 years before potentially producing 0.1 m drawdown at bore A-MW4. As previously stated this modelling does not account for recharge of the aquifer and can be considered as a worst case scenario.

4.0 RECOMMENDATIONS

To promote sustainability of groundwater supply and to minimise potential environmental impacts, Golder recommends the following operational management measures for the production and monitoring bores:

- The discharge line from Northwest Production Bore be fitted with a flow meter;
- Groundwater levels in the Northwest Production Bore and affiliated monitoring bores (MB1B-01 and MB1B-02) are monitored prior to pumping and on a weekly basis throughout the duration of the pumping. Measurements are to be taken from a reference point on the bore headworks and converted to metres Australian Height Datum (AHD) and also metres above ground level. Results are to be entered in a log book.
- The installation of a weather station and automated data logger system on site to record localised rainfall to assist groundwater recharge estimations.
- The Northwest Production Bore may be pumped at a maximum flow rate of 3 L/s for long periods of time up to 35 days and possibly up to flow rates of 4 to 5 L/s for shorter timeframes (a higher pumping rate or longer duration would need to be reviewed and approved by a senior level hydrogeologist);
- Allow for 80% recovery of the static water level between pumping durations; and
- Monitor groundwater levels in monitoring bores A-MW2, A-MW3 and AMW4 at weekly intervals during pumping. Measurements to be taken from a reference point on the bore headworks and converted to metres Australian Height Datum and also metres above ground level. Results to be entered in a log book.
- The pumped volumes from Northwest Bore should be recorded in a log book at least on a monthly basis to quantify yields from the aquifer over time; and
- The stopping and starting times of the pump and flow meter readings at this point are to be recorded in a log book.
- The West Bore may be used as a backup emergency water supply for short periods of time. The bore is likely to silt up and choke the pump or dewater if used for an extended period of time of several days use. The pump should not be positioned at or near the bottom of the bore for this reason. The depth of the bore should be frequently dipped during operations to assess the rate of siltation. This will require the removal of the pump prior to dipping the bottom depth of the bore.
- During operation the water quality of the Northwest Bore is monitored at least every 3 months for pH and electrical conductivity to evaluate trends indicating potential deterioration in water quality. If water is used for drinking purposes then recommend undertaking a comprehensive potability analysis on an annual basis.
- The analytical model provides an estimation for predicting behaviour of the aquifer from pumping and is based on a limited timeframe of test pumping data. Therefore the mode of operations for pumping the Northwest Bore is to be modified according to longterm actual groundwater response (drawdown) r in

monitoring bores. This can only be confirmed by routine monitoring of water levels during pumping operations.

- The monitoring bores (MB1B-01 and MB1B-02) should be monitored during pumping of the Northwest Production Bore such that water levels do not exceed the proposed, aforementioned trigger levels for flow rate of 3 L/s; shut off the pumping bore if proposed trigger levels are exceeded and allow for 80% recovery before resuming pumping.

Report Signature Page

GOLDER ASSOCIATES PTY LTD

Robin Davis
Hydrogeologist

David Whiting
Senior Hydrogeologist

RWD/

A.B.N. 64 006 107 857

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FIGURES

FIGURES

Checked by: .....

Date: 9/3/09

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200 100

NOTE
BASE PLAN DERIVED FROM "SCHLENCKER MAPPING P/L", DRAWING No. ELLABAY_CONTOURS.DXF, DATE 08/07/08

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CLIENT	Satori Resorts Ella Bay Pty Ltd	PROJECT	Ella Bay GW Resource Evaluation
DRAWN	GPG / DATE 06/03/09	TITLE	ELLA BAY SITE PLAN AND BOREHOLE LOCATIONS
CHECKED	*RWD / DATE 06/03/09		
SCALE	1:10,000	PROJECT No	087673031-009
FIGURE No	1	REV No	A
			A3

NOTE: THE * BESIDE THE TYPED INITIALS DENOTES THE ORIGINAL DRAWING ISSUE WAS SIGNED OR INITIALLED BY THAT RESPECTIVE PERSON.

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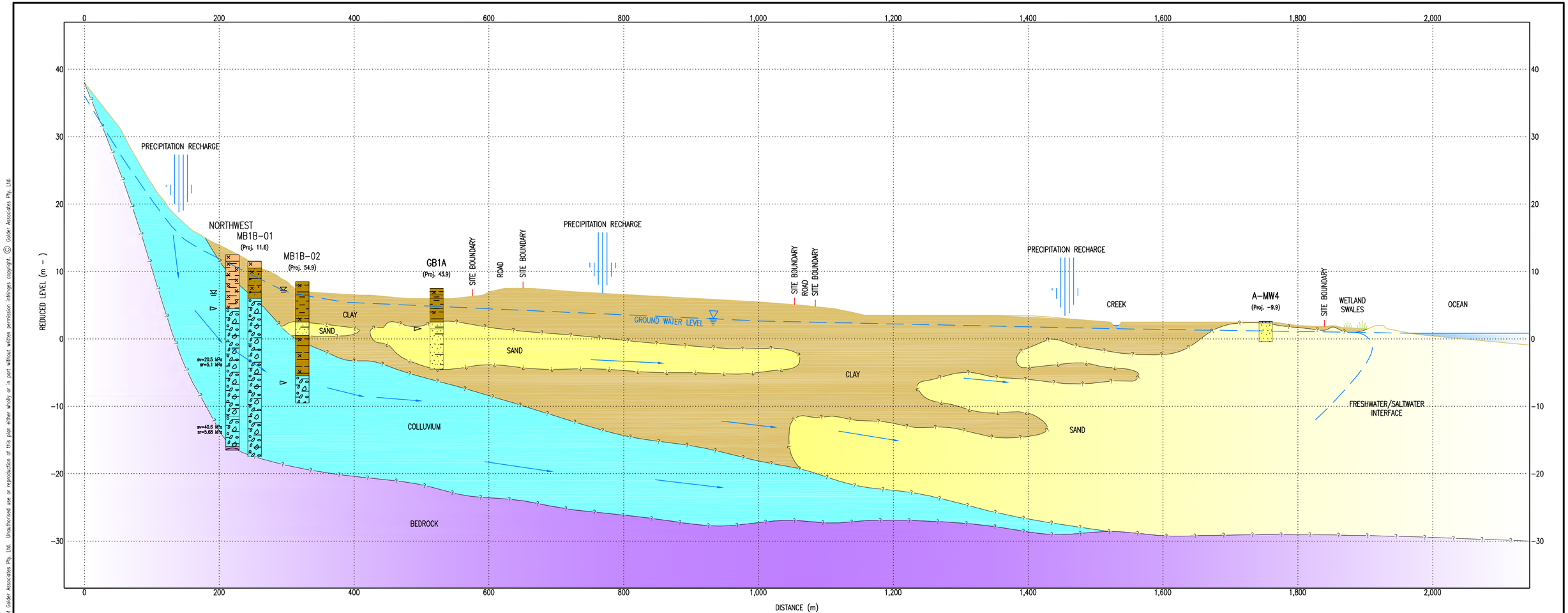

OFFSET FROM CROSS SECTION

BH# (Proj. 5.0)

LEGEND

- TOPSOIL
- Clayey SILT
- Sandy SILT
- CLAY
- Silty CLAY
- Sandy Silty CLAY
- SAND
- Clayey SAND
- Clayey GRAVEL (COLLUVIUM)
- MIXED METAMORPHICS (BEDROCK)
- GROUNDWATER FLOW DIRECTION
- GROUNDWATER LEVEL

CLIENT	Satori Resorts Ella Bay Pty Ltd	PROJECT	Ella Bay GW Resource Evaluation
DRAWN	GPG	DATE	06/03/09
CHECKED	*RWD	DATE	06/03/09
TITLE	HYDROGEOLOGICAL CONCEPTUAL MODELOF CROSS SECTION A-A'		
SCALE	H 1:4000 V 1:200	PROJECT No	087673031-009
FIGURE No	2	REV No	2
			A3+

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1:10000 0 200 400 600 800 1000 m

200 100

NOTE
BASE PLAN DERIVED FROM "SCHLENCKER MAPPING P/L", DRAWING No. ELLABAY_CONTOURS.DXF, DATE 08/07/08

CLIENT: Satori Resorts Ella Bay Pty Ltd		PROJECT: Ella Bay GW Resource Evaluation	
DRAWN: GPG	DATE: 06/03/09	TITLE: PREDICTED DRAW DOWN CONTOURS AFTER 6 MONTHS OF CONTINUOUS PUMPING PB1B AT 3 L/S	
CHECKED: *RWD	DATE: 06/03/09		
SCALE: 1:10,000		PROJECT No: 087673031-009	FIGURE No: 3 REV No: 2 A3

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Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
216 Draper Street
Cairns Queensland 4870
Australia
T: +61 7 4054 8200

Golder Associates