# APPENDIX B
# GROUNDWATER MANAGEMENT PLAN

## B1. INTRODUCTION

This Groundwater Management Plan (GMP) has been developed for the proposed Rainbow Beach Estate development, between the coastal towns of Lake Cathie and Bonny Hills on the NSW Mid-North Coast.

The GMP has been prepared to provide a specification for a groundwater monitoring program for the site, from the present through the development phase and for a 2 year period following development. The monitoring program may be extended at this time subject to qualified review.

Guidance has been provided on the locations (Section B2), frequency (Section B3) and specification of water level and water quality sampling (Section B4). The data collected should be subject to qualified review at two distinct times: shortly after completion of the construction phase, and; at the end of the (2 year) monitoring program. Guidance is also given in the GMP to assist in preliminary interpretation which to be undertaken immediately after every sampling event to allow for timely checking for any impacts.

This purpose of the GMP is to monitor the impacts to groundwater from the development, with consideration to:

- Protection of Groundwater resources as per the requirements of the NSW State Groundwater Policy Framework Document (DLWC, 1997);
- Protection of the littoral rainforest to the east of the site[1], and;
- Acid Sulfate Soil (ASS) risks.

For the latter case (ASS), monitoring specified here has the purpose of detecting, if possible, the unplanned oxidation of pyrites and any associated impacts to the proposed wetland.

This GMP is not to supersede or replace in anyway the role of the Acid Sulfate Soils Management Plan (ASSMP) that is required to guide management of ASS during the development phase. Similarly, this GMP provides some recommended surface water monitoring actions, but is not to supersede requirements for surface water monitoring at the site.

[1] The other identified protection area, the "Wallum Froglet habitat", is not considered by WRL to be a groundwater dependant issue and hence is not addressed in this GMP.

## B2. MONITORING LOCATIONS

The monitoring program requires sampling and measurements to be undertaken from a consistent suite of locations referred to as the "monitoring network".

The monitoring network will comprise a selection of the existing standpipe piezometers shown in Table B1. Construction works should, to the extent possible, avoid disturbance of these standpipe piezometers. If disturbance cannot be avoided, replacement standpipe piezometers should be installed at the nearest practicable location. The new standpipe should: be installed prior to removal of the old one (to allow cross referencing); be installed in a manner conforming to the specification set out in Section B2.1, and; monitor from the same groundwater body (i.e. screen depth) as the piezometer being replaced.

Selected surface water monitoring locations are also stipulated in this GMP. These are stipulated solely for assisting with the detection of any impacts due to ASS. The locations and sampling requirements for these surface water monitoring may be incorporated into the greater surface water monitoring plans for the site.

**Table B1**
**Monitoring Network**

| | ID | Location (MGA Zone 56 GDA 94) mE | mN | Level of Top of Casing (m AHD) |
|---|---|---|---|---|
| Groundwater | GW1 | 485007.51 | 6506846.14 | 7.700 |
| | GW2 | 485098.96 | 6507099.89 | 5.080 |
| | GW3 | 484758.12 | 6507191.45 | 5.560 |
| | GW4 | 484433.50 | 6507116.48 | 5.510 |
| | GW5 | 484051.05 | 6506894.33 | 5.520 |
| | GW6 | 484401.39 | 6506799.19 | 5.835 |
| | GW7a | 484812.83 | 6506844.88 | 6.345 |
| | GW7b | 484812.84 | 6506842.77 | 6.290 |
| | W3 | 483710.82 | 6506852.09 | 5.200 |
| | W5 | 484862.90 | 6507358.70 | 4.480 |
| | W7 | 484705.53 | 6507300.68 | 4.75 |
| Surface Water | SW2 | Duchess Gully between GW1 and GW7 | | |
| | SW3 | Outlet to Existing Wetland | | |
| | SW7 | Within Southern Quarter of Proposed Wetland | | |
| | SW8 | Within Northern Quarter of Proposed Wetland | | |

# B3. MONITORING PROGRAM

## B3.1 Pre-development

A baseline groundwater characterisation study has already been completed. The results of water quality testing and three instances of water level measurements are published in:

- Laxton, J. and Laxton, E. (2009) *Quality of Ground Water and Surface Water at Bonny Hills, NSW, November 2009*. Report for the St Vincents Foundation.

In addition, monthly water level readings have been undertaken since August 2009 as presented in Table 4 of WRL TR 2009/32.

Monthly water level monitoring (dips) should be continued up until development. An additional single round of water quality should be undertaken from the monitoring network prior to commencement of development.

## B3.2 During Development

Monthly measurements of water levels from the monitoring network should continue throughout the development period.

Quarterly monitoring of water quality should be undertaken from the monitoring network during the construction phase.

In addition, more regular monitoring of selected water quality constituents may be undertaken during the construction (and associated dewatering activities) of the proposed wetland as stipulated in the ASSMP.

## B3.3 Post Development

Following completion of development, the collected groundwater monitoring data should be reviewed by a person qualified in hydrogeology and ASS. Subject to their review and any special concerns, quarterly measurements of water levels and water quality from the monitoring network should be continued for a period of 2 years from completion of development. At the end of this 2 year period, the data should again be subject to a formal review by a person qualified in hydrogeology and ASS. Further monitoring may be recommended subject to the findings of the review.

### B3.4 Summary

The proposed frequency of monitoring and formal review are summarised in Tables B2 and B3 respectively.

**Table B2**
**Monitoring Frequency**

| Period | Water Level Monitoring | Water Quality Monitoring |
|---|---|---|
| Pre-development | Monthly | One additional round prior to commencement of construction |
| During Development* | Monthly | Quarterly |
| Post Development | Quarterly | Quarterly |

* Additional construction-specific water level and water quality monitoring may be stipulated in the ASSMP.

**Table B3**
**Monitoring Formal Review**

| Item | Comment |
|---|---|
| Review 1 | A formal review of all water quality and water level data every 2 years, starting from the commencement of construction, or; at the completion of construction, whichever comes first. |
| Review 2 | A formal review of all water quality and water level data at the completion of the 2 year post – construction monitoring program. |

# B4. MONITORING SPECIFICATIONS

## B4.1 Water Level Monitoring

Manual measurement of water level in standpipes should be undertaken using a dip meter, measuring the distance from the highest point on the PVC casing to the standing water level in the standpipe. The 'dip reading' should then be reduced to an elevation in m AHD with reference to the surveyed elevation of the PVC casing and the time and date of the measurement should be recorded.

## B4.2 Water Quality Monitoring

Routine water quality monitoring will tests for the same constituents from all locations in the monitoring network as set out in Table B4.

**Table B4**
**Water Quality Parameters**

| Parameter Type | Parameters |
|---|---|
| Physical Properties* | pH, EC, Temperature, DO, Eh |
| Major Anions | Cl, $SO_4$, Ca, Mg, Na, K, Alkalinity |
| Trace Metals | Fe (total and soluble), Al (total and soluble), As, Cd, Co, Pb, Mn, Hg, Zn |
| Nutrients | TKN, Total N, Total Phosphorous |

* parameters measured in the field

A recommended water quality sampling procedure is set out below.

1. Preparation

Parameters measuring physical properties should be measured in the field using appropriate probes. The remaining parameters will be testing in laboratory. Pre-treated containers for collection of samples appropriate to the parameters being measured are to be obtained from the laboratory that will analyse the samples.

2. Calibration of Meters

Water quality meters must be calibrated to standard solutions according to the manufacturers instructions at the beginning of each sampling day.

3. Measuring Standing Water Level

If manual measurements of water levels are conducted as part of the water quality sampling, then the standing water level is to be measured prior to sampling.

4. Purging

Groundwater sampling should be completed using an electric submersible pump. The well or borehole is to be sufficiently pumped prior to sampling to ensure that the water sampled is representative of the aquifer (AS/AZS 5667.1:1998). Either the volume of water pumped is to be measured, or a flow rate and amount of time pumping. This can be completed with a bucket of known volume and a stop watch. Changes within field parameters are to be ± 10% prior to sampling, or less than ±0.2 ℃ and at least one borehole volume of water extracted (AS/AZS 5667.11:1998), but a volume of over 5 boreholes is recommended. For low yield bores, the bore may be simply pumped dry once and allowed to recover sufficient volume to complete sampling.

5. Recording Data

A log sheet should be kept for each sampling location, and the following information should be recorded for each locations on each sampling event:

- Standing water level
- Calibration of meters
- Set depth of pump
- Volume of water pumped
- Method of sampling
- Sample appearance at time of collection (colour, clarity and odour)
- Preservation techniques
- Field parameters (pH, EC, DO, Temperature and Eh)
- Any information which may affect the results of the analysis.

6. Sampling

Parameters measuring physical properties should be measured in the field using appropriate probes. Field measurement of Eh and DO should be done with the use of flow cells.

Samples to be measured in the laboratory should be stored in pre-treated containers appropriate to the parameters being measured, as obtained from the laboratory that will analyse the samples.

When taking microbiological samples, disposable latex gloves should be worn to prevent contamination of the sample. Care must be taken not to touch the top of the bottle during removal or replacement of the lid and the cap is never to be placed on any surface. The cap must be replaced tightly as soon as the container is filled, and the sample must be kept chilled until it reaches the laboratory.

It is best that all sample containers are filled to the top without any headspace, taking care not to overfill the bottles as preservative may be lost. Check all bottle caps are tightly

secured. Each sample must be clearly labelled at the time of sampling with the borehole ID and the date of sampling.

7. Preservation and Transport of Samples

Groundwater samples obtained for water quality analysis are to be collected, handled and preserved as per the Standards Association of Australia (1998) 'Water Quality -Sampling Part 1: Guidance on the Design of Sampling Programs, Sampling Techniques and the Preservation and Handling of Samples' Australian/New Zealand Standard AS/NZS 5667.1:1998. These guidelines contain specific protocols and procedures suitable for groundwater quality sampling and analysis.

Filled sample containers are to be kept cold in an esky with ice-packs. Bags of ice are not to be used as melt water can contaminate samples and leak from eskies. Samples for microbiological analysis are to arrive at the laboratory within 24 hours of sampling and must be kept chilled. Packing material is to be used to fill the esky prior to couriering to the laboratory. Samples are to arrive at the laboratory on Thursday afternoon at the latest to ensure that the microbiological analysis can be completed prior to the weekend.

Chain-of-custody documentation as required by the laboratory is to be included in the esky with the samples, and is to include the ID's of each sample and the analysis required.

8. Disinfection

Between each bore, pumping equipment must be disinfected. Chlorination is the most simple method available. A batch of water for disinfection may be made up on site by adding bleach (commercially available sodium hypochlorite solution) to water to obtain chlorine concentrations of 100 mg/L. The amount of bleach required to make 100 L of solution as shown in Table B5:

**Table B5**
**Disinfection Recommendations**

| Bleach strength (% sodium hypochlorite) | Volume of Bleach Required (mL) |
|---|---|
| 3 | 330 |
| 5 | 200 |
| 10 | 100 |
| 12.5 | 80 |

Equipment should be soaked in this solution during transport between sampling locations or for at least 15 minutes prior to rinsing and re-use. Care is also to be taken not place any

equipment on the ground. A plastic sheet or tarpaulin may be used on the ground. Rinse water from a clean town water supply may be used. Water quality meters may be triple rinsed using the water to be sampled.

8. Laboratory Analysis Requirements

Groundwater sample analysis is to be undertaken by a laboratory that is NATA-registered for the analysis conducted. Collectors are to ensure that samples are received by the laboratory within 24 hours. Holding times for bacteriological analysis are not to be exceeded.

9. Quality Control Requirements

Groundwater sampling is to be undertaken by suitably trained personnel, following the procedures laid out in this document. For quality control 5% of samples should be submitted as blind duplicates, and one blank (distilled water) and one spiked sample should be submitted with every 20 samples (Jiwan & Gates, 1992). The blind duplicate to the laboratory is to be labelled with a false bore number.

Standard laboratory practice is that a QA/QC compliance report be provided and that laboratories that are NATA certified for analysis of major ions supply a report of charge balance errors (CBE). Satisfactory CBE <5% should be verified prior to payment of the laboratory invoice. If the CBE is not satisfactory and the samples cannot be re-analysed, fresh groundwater samples will need to be obtained and analysed.

## B5. DATA INTERPRETATION AND RESPONSE

The data collected as part of the monitoring program should be subject to formal review by a qualified specialist as per Table B3. This review will assess general impacts to groundwater levels and quality and should seek to determine if the highest existing beneficial usage category is being maintained. The review should make reference to the characterisation of existing groundwater resources presented Section 3 of WRL TR 2009/32. The monitoring review should also compare observed drawdown against predicted drawdown presented in Figures 26 to 28 of WRL TR 2009/32 and comment on the implications for identified sensitive areas and activation of ASS. The monitoring program may be subject to changes following the findings of the reviews.

If it is found that the developments are reducing the quality of the existing groundwater resources, the following actions may be considered by the reviewer:

- Identify and remove point sources of contamination
- Reinforce community education / awareness
- Review current landuse practices or operation and maintenance of stormwater treatment devices
- Initiate community based projects

A preliminary level of data interpretation should also be undertaken after each sampling event to allow for earlier identification of any impacts. This relates specifically to assessing impacts due to ASS, and requires that monitored values are compared against the trigger preliminary levels presented in Table B6. These are referred to as preliminary as they may be subject to change or reinterpretation following each of the formal review stages.

If any of these trigger levels are exceeded, the first response should be to retest from the sample location in question to confirm the validity of results. If the retesting confirms that the trigger level are exceeded immediate action will be required. The nature of action required will be specific to the observed issue, but may include the following:

- Engagement of a qualified specialist to identify the cause or mechanism of trigger level exceedence and propose appropriate actions.
- Increase monitoring frequency.
- In the case of exceedences during the construction or dewatering phase, comply with response measures as stipulated in the ASSMP.

- For the case of exceedence of trigger levels from samples within the proposed wetland, consider dilution and buffering of surface waters by control of weirs to the existing lake.
- Consider application of lime dosing to buffer water quality within the existing or proposed wetland.
- For the case of groundwater, consider techniques to block or treat the water *insitu*, such as cutoff walls or lime injection.

The application of lime should conform to the requirements of the NSW Acid Sulfate Soils Management Manual.

**Table B6**
**Preliminary Trigger Levels for ASS Impacts**

| **Observation** | **Criteria** |
|---|---|
| Groundwater Levels | • Groundwater levels are below 3 m AHD in more that two standpipes (excluding GW2) for two consecutive monitoring periods, or;<br>• Groundwater levels in GW2 are below 2 m AHD, and are below 3 m AHD in another standpipe for two consecutive monitoring periods. |
| Groundwater Quality | • pH is below 4.5 and the ratio of Cl to $S0_4$ ions is less than 1 in any bore.<br>• Soluble Iron in excess of 40 mg / L is recorded in any location for two consecutive monitoring periods, or;<br>• Soluble iron increases consecutively by more that 50% at any one location for two consecutive monitoring rounds. |
| Surface Water Quality | • pH is below 4.5 and the ratio of Cl to $S0_4$ ions is less than 1 in any surface water location.<br>• Soluble Iron in excess of 40 mg / L is recorded in any location for two consecutive monitoring periods, or;<br>• Soluble iron increases consecutively by more that 50% at any one location for two consecutive monitoring rounds. |