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REPORT ON

CONCEPTUAL SURFACE WATER AND GROUNDWATER HYDROLOGY MODELS ELLA BAY INTEGRATED RESORT

Submitted to:

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2 Copies - Ella Bay Development Pty Ltd (1 Bound, 1 CD)
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EXECUTIVE SUMMARY

Golder Associates Pty Ltd was commissioned to prepare conceptual surface water and groundwater hydrology models for the proposed Ella Bay Integrated Resort (Development Zone). The objective of this report was to assess potential impacts upon internal and adjacent water courses, wetlands and beach front and surrounding Wet Tropics of Queensland World Heritage Area (WTQWHA) and the Great Barrier Reef World Heritage Area (GBRWHA) and to identify appropriate mitigation measures that could be adopted to address potential changes to surface water flows and groundwater hydrology and discharge of chemicals, nutrients and sediment. Key outcomes and recommendations comprise:

Surface Water Hydrology:

- Approximately 90% of the Development Zone is within a catchment that enters an adjacent wetland swale that flows into Ella Bay during the wet season. This area includes all the proposed resort areas, commercial areas, wastewater treatment area, most residences, most of the access roads and most of the golf course.
- Only 10% of the Development Zone is within the catchment of the WTQWHA wetlands (<5 % of the southern portion of the WTQWHA catchment area). This area includes a low proportion of the residences (< 10%), access roads and golf course. Minor quantities of surface water from the Development Zone flows 500 m through freehold remnant wetlands prior to reaching the WTQWHA wetlands.

Groundwater Hydrology:

- The wetland swale located adjacent to Ella Bay plays an important role in maintaining a natural groundwater divide between seawater and on-shore shallow freshwater aquifers.
- There is no mechanism for northwards and southwards migration and/or interaction of groundwater within the coastal plain of Ella Bay from the Development Zone to the WTQWHA wetlands. The predominant groundwater flow influence within the Ella Bay coastal plain is topography that results in a west to east flow direction.

Hydrology Changes:

- Only minor localised changes to existing surface water and groundwater hydrology will occur from the proposed development by maintaining significant areas of open space, minimising below ground disturbances and hardstand areas and using best practice groundwater extraction and water sensitive urban design (WSUD) techniques.
- The Development Zone primarily comprises existing cleared rainforest and wetland areas. Revegetation of proposed open space areas will reverse some of the existing changes to surface water and groundwater hydrology that would have occurred following clearing.
- Harvesting of surface water from sealed surfaces for water supply purposes will not significantly impact upon surface water or groundwater hydrology.
- Groundwater should not be harvested from shallow alluvial groundwater aquifers to protect wetlands and the freshwater interface adjacent to Ella Bay. Well planned and managed harvesting of groundwater from weathered rock aquifers should present a low risk to shallow groundwater and associated wetlands.
- Subject to maintaining and/or mimicking existing hydrology, the development represents a low risk to adjacent wetland swales and ecological systems. Management of the Development Zone to limit changes to surface water and groundwater hydrology within adjacent wetland areas would, by definition, also protect existing surface water and groundwater discharges to Ella Bay and the Reef Lagoon.

- In accordance with standard development practice, detailed investigation, assessment and modelling of surface water and groundwater hydrology and design of required mitigation measures shall be undertaken as part obtaining approvals and/or operational works permits for each stage of development.
- Changes to surface water and groundwater hydrology identified as potential risks to wetland areas by detailed assessment during each stage of development can be readily mitigated by a range of practical design and/or construction management strategies.

Sediment:

- In relative terms the Development Zone comprises a large area. The adoption of a staged construction program over a 10 to 15 year period will, however, limit actual ground disturbance at any time to areas no greater in size than other typical coastal projects undertaken in Far North Queensland.
- Erosion and Sediment Control Plans (ESCP) for each stage of construction area, down to single lot scale, will be prepared by appropriate personnel and approved by Council as part of Operation Works Permit processes. Auditing of erosion and sediment control implementation and a comprehensive water quality monitoring program are required during and following construction.
- Planned revegetation works within open space areas will reduce existing sediment erosion from cleared areas and also provide additional sediment interception capacity during construction works.
- At the completion of construction works the Development Zone should produce less sediment loading to creeks and wetlands than is currently occurring due to farm use.

Nutrients:

- Water quality monitoring completed to date has identified that surface water and groundwater within the Development Zone contain elevated nutrient concentrations sourced from surrounding rainforest/wetland areas and farm activities.
- Potential nutrients generated by completed development present a very low risk to surface water and groundwater quality within WTQWHA wetland areas located to the north.
- In accordance with standard development practice, detailed investigation, assessment and modelling of nutrient generation and uptake shall be undertaken as part obtaining approvals for each stage of development.
- Potential nutrient impacts identified by detailed assessment during each stage of development can be readily mitigated by a range of practical design and/or construction management strategies to protect creeks and wetland areas that flow directly to Ella Bay.

Contaminants

- Potential contaminants include fuel transport and storage, small scale domestic and commercial chemical use and storage, termite treatments, general litter and road sediment. Mitigation of potential impacts will be primarily achieved by appropriate storage and use, with secondary containment using WSUD techniques.

Acid Sulphate Soils

- Areas to be disturbed below 5 m AHD shall be subject to an acid sulfate soil investigation and management, where identified, in accordance with Queensland State Planning Policy 2/02. Timing for investigations shall be tied to approval of each stage of development.

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1.0 INTRODUCTION

1.1 Background

White Beech Pty Ltd on behalf of Ella Bay Development Pty Ltd commissioned Golder Associates Pty Ltd (Golder) to prepare conceptual surface water and groundwater hydrology models from the proposed Ella Bay Integrated Resort to be located within an existing cattle farm, approximately 10 km north east of the township of Innisfail, Queensland (refer to Figure 1, Site Location Plan).

The proposed Ella Bay Integrated Resort (the '*Development Zone*') is located inside a freehold property (the '*Site*') that contains the cattle farm as indicated on Figure 2. The topography of the area forms a natural amphitheatre outside the Site comprising:

- Ella Bay National Park rainforest and wetlands that are part of the Wet Tropics of Queensland World Heritage Area (WTQWHA) to the north, west and south.
- Ella Bay that fronts the off-shore boundary of the Great Barrier Reef World Heritage Area (GBRWHA) to the east.
- Little Cove Development within rainforest to the south east.

The Master Plan for the Development Zone shown in Appendix A includes the following key elements:

- Low to medium density resorts, units and a day spa facility located along the eastern boundary adjacent to Ella Bay over a distance of approximately 1.7 km.
- A community recreation centre, sports academy and international school.
- An 18-hole golf course surrounded by residential house lots and 3 to 4 storey unit blocks.
- An on-site sewerage treatment plant located in the north eastern corner of the property.

It is understood that remaining areas of the Site, that predominantly comprise remnant rainforest and wetlands, located outside the Development Zone to the north ('*Northern Freehold Area*'), east ('*Eastern Freehold Area*') and south west ('*Western Freehold Area*') will be protected by legal covenant or inclusion within the adjacent National Park.

The Terms of Reference for an Environmental Impact Statement for the Development Zone and subsequent correspondence from relevant referral authorities identified a need to describe the following potential impacts upon the WTQWHA and GBRWHA that may result from:

- Changes to surface water flows and groundwater hydrology.
- Discharge of chemicals, nutrients and sediment.

1.2 Scope of Work

The scope of works for this Conceptual Surface Water and Groundwater Model Report comprised:

- A desktop review of available information to prepare a conceptual model of surface water and groundwater hydrology of the Site and surrounding areas.
- Utilising the conceptual surface water and groundwater hydrology model to identify water connections and interchange between the Site, adjacent wetlands and Ella Bay.
- Identifying potential risks to impact upon water quality with the Site and for impacted water migrate to adjacent wetlands and Ella Bay.
- An assessment of potential management strategies that could be implemented to mitigate potential risks to water quality within adjacent wetlands and Ella Bay.
- Preparation of a technical report describing the conceptual models, potential risks to water quality, wetlands and Ella Bay, the assessment of suitable mitigation and management strategies and recommendations for further studies and management systems may be necessary during detailed design and construction stages.

Please note that this Conceptual Surface Water and Groundwater Hydrology Model Report utilises and includes a range of existing information contained in the following reports prepared by Golder Associates:

- '*Geotechnical Studies, Proposed Eco-Tourist Resort, Ella Bay, Queensland*', 95670148(A), September 1995 (Golder 1995).
- '*Preliminary Environmental And Geotechnical Investigation, Ella Bay Development Far North Queensland*', 001-06673041-R1, November 2006 (Golder 2006).
- '*Water Quality Monitoring – Ella Bay*', 002-077673018-R2, June 2007 (Golder 2007).

2.0 SITE DESCRIPTION

2.1 Rainfall and Evaporation

The Site is located in Far North Queensland where the climate is dominated by a high rainfall, hot 'wet' seasons between December and April and a low rainfall, cooler 'dry' seasons between May and November.

Average and peak rainfall and average temperature data for Innisfail and average evaporation data for Ingham are summarised below.

Month	Rainfall (mm)				Average Temperature (^{O}C)
	Monthly Average	Monthly Maximum	Daily Maximum	Monthly Evaporation	
January	506.6	1581.6	531.1	170.5	30.8
February	593.3	1515.2	435.1	156.8	30.6
March	659.3	1650.5	395.5	148.8	29.6
April	466.5	1063	520.7	117	28.3
May	299.7	1652.5	214.4	102.3	26.4
June	189.1	527.4	203.2	84	24.5
July	134.5	505.7	92.5	89.9	24.1
August	119.9	536	310	108.5	25.1
September	84.6	426.2	161	135	26.7
October	82.6	461.5	342.1	170.5	28.4
November	155.5	997.2	336.2	171	29.7
December	262.8	1303.6	539	179.8	30.8
Total	**3551**	**-**	**-**	**1634.1**	**-**

2.2 Topography and Drainage

2.2.1 General

Figure 2 shows an aerial photograph with 5 m topography contours that includes the Site, Development Zone and adjacent areas, including Ella Bay National Park and Ella Bay. This figure indicates the extent of cleared land, key drainage pathways, associated remanent vegetation within the Development and adjacent rainforest, wetlands and beach frontage.

On a regional scale, the Site and adjacent Ella Bay National Park are part of a sequence of relatively small, localised coastal range catchments that are separate to surrounding major catchment areas that comprise:

- North Johnstone River to the west that flows into the Johnstone River at Innisfail.
- Johnstone River to the south that flows into the Coral Sea between Flying Fish Point and Coquette Point, approximately 6 km south of the Site.
- Russell River to the north that flows into the Coral Sea with the Mulgrave River approximately 20 km north of the Site.

2.2.2 Ella Bay

Ella Bay is fronted by an almost continuous beach dune that extends from Heath Point in the south, past the Site, to Cooper Point in the north. As shown on Figure 3, from the south eastern corner of the Site northwards to an isolated hill within the WTQWHA, located approximately two thirds of the distance to Cooper Point, Ella Bay fronts a single, lightly curved, coastal dune with a maximum elevation of approximately 2 m AHD that is approximately 25 m to 50 m wide ('*Southern Ella Bay Beach Dune*').

There are no permanent surface water drainage pathways within the Southern Ella Bay Beach Dune. There are, however, two intermittent surface water discharge zones shown on Figure 3 comprising:

- '*Southern Beach Discharge*' located adjacent to the north-eastern corner of the Development Zone.
- '*Northern Beach Discharge*' located at the northern end of the Southern Ella Bay Beach Dune

Both discharge locations are characterised by the presence of semi-permanent and relatively short lengths of surface water (< 200 m) located within a wetland swale behind the Southern Ella Bay Beach Dune (refer Figure 3).

Basic surface water quality measurements (pH and electrical conductivity) were taken following the 2007 wet season (24 June 2007) at three locations within the wetland swale located behind Southern Ella Bay Beach Dune (refer Figure 2):

- EBSW4 Approximately 500 m north of the southern boundary of the Site.
- EBSW5 Adjacent to the northern Development boundary within flowing water.
- EBSW6 Approximately 100 north of the Site boundary (WTQWHA).

The results, summarised in Table 1, indicate higher electrical conductivity within the wetland swale than measured in surface water and groundwater to date within the Site, however, the results were within or just above the freshwater aquatic ecosystem guidelines and significantly below seawater concentrations. This suggests that freshwater conditions could be predominant within the wetland swale located behind Southern Ella Bay Beach Dune during and immediately following 'wet' season periods.

Based upon the surface elevations and site observations, it is also evident, however, that the entire length of the wetland swale located behind the Southern Ella Bay Beach Dune would regularly receive sea water inundation during certain weather conditions such as king tides and storm surges.

The following observations were also made with respect to surface water flows and levels at various locations within the wetland swale:

- Within the WTQWHA, north of the Site at EBW6, the surface water level in the wetlands appeared to remain relatively constant. There was no flow evident and there were no water line or vegetation markings to indicate identifiable lowering of the water level with low tide that occurred during the site visit.
- In the southern section of the wetland swale at EBW4, water was flowing along the wetland swale to the north. Water line and vegetation markings indicated a regular water level variation of approximately 0.5 m.

- As noted above, a creek was flowing strongly from the Site, northwards along the wetland swale and discharging across the beach into Ella Bay. Water level and vegetation markings indicated a regular water level variation of approximately 1 m in this area.

2.2.3 Adjacent Areas – Up Gradient

The Site is located below the Seymour Range that forms a natural amphitheatre. Key features of adjacent areas up gradient of the Site include:

- Three sections of relatively steep forested ranges with elevations to over 200 m AHD to the south (Little Cove Development property), south west and north west (WTQWHA).
- Sub-catchment areas with headwaters located within the WTQWHA that flow into the Site from the south and west between the above three sections of steep ranges.

2.2.4 Development Zone

As indicated on Figure 2, most of the Development Zone has been cleared, except immediately adjacent to creeks, larger drainage channels and low-lying wetland areas. Approximately 75% of the Development Zone comprises relatively level land with elevations between 3 m AHD and 10 m AHD. The remainder comprises either:

- Gentle foothills sloping between 10^o and 20^o with localised steeper areas sloping between 30^o to 70^o, particularly adjacent to creeks, gullies and towards adjacent elevated ranges.
- Low-lying (< 2 m AHD) wetland areas located adjacent to the northern and eastern boundaries.

Photographs of Site topography, drainage and vegetation are shown in Appendix B.

There are two main creeks within the Site that both have sub-catchment areas that extend beyond the Site boundary into the WTQWHA to the west and south. These two creeks join near the centre of the Site and flow eastwards towards Ella Bay ('*Farm Creek*'). Minor tributaries that enter the two main creeks within the Development Zone generally have sub-catchment boundaries that are predominantly located within the extent of the Site.

There are two minor creeks located within the Development Zone that do not enter the Farm Creek catchment area of the Site. These separate minor creeks, with sub-catchment that include cleared land and adjacent rainforest, are located in the north western and south eastern corners of the Development Zone.

Drainage from relatively level and cleared areas of the Development Zone generally occurs as sheet-flow into creeks, gullies and low-lying wetlands within the Development Zone.

Surface water flows that discharge from the Development Zone comprise:

- Farm Creek that flows into the Eastern Freehold Area of the Site. This creek comprises the majority of surface water flow from the Site and adjacent up gradient catchment areas.
- The minor creek and sub-catchment area located within the south eastern corner of the Development Zone that flows into a low-lying wetland and subsequently into the Eastern Freehold Area.
- Localised sheet-flows from low-lying cleared areas of the Development Zone into the Eastern Freehold Area.
- The minor creek and sub-catchment area located within the north western corner of the Development Zone that flows into the Northern Freehold Area of the Site.
- Localised sheet-flows, from cleared areas into the Northern Freehold Area.

2.2.5 Adjacent Areas – Down Gradient East

Surface water discharge from the Development Zone into the Eastern Freehold Area and adjacent beachfront land enters a low-lying (< 2 m AHD) continuous wetland swale located behind the Southern Ella Bay Beach Dune that extends along most of the eastern boundary of the Site ('*Farm Wetland Swale*'). The Farm Wetland Swale intermittently flows out to Ella Bay through the Southern Beach Discharge.

During a site visit undertaken on 24 June 2007 at low tide, Farm Creek was flowing strongly from the Site, northwards along the Farm Wetland Swale for a distance of approximately 200 m, before flowing eastwards out the Southern Beach Discharge (refer to Site Photographs in Appendix B). Open water within the Farm Wetland Swale extended northwards from the Southern Beach Discharge for a further distance of approximately 100 m adjacent to the Northern Freehold Area of the Site.

2.2.6 Adjacent Areas – Down Gradient North

Surface water discharge from the Development Zone northwards into the Northern Freehold Area is primarily associated with the minor creek sub-catchment area located in the north western corner. In addition there are three densely vegetated north-south trending wetland swales, located between remnant sand dunes that commence just inside or adjacent to the northern boundary of the Development Zone.

The minor creek and the two eastern wetland swales appear to extend across the full width of the Northern Freehold Area of the Site into the adjacent WTQWHA. The sub-catchment area of the western swale that extends the greatest distance into the Development Zone appears to be limited within the Site boundary.

Within the WTQWHA, beyond the Site, the catchments discharge into a large widespread, low-lying (< 2 m AHD) wetland that extends the full width of the Ella Bay coastal plain from the base of the Seymour Range to the Southern Ella Bay Beach Ridge. The primary outflow for this section of the WTQWHA wetlands appears to be the Northern Beach Discharge.

It is noted that vegetation mapping of the Northern Freehold Area of the Site and adjacent WTQWHA that is shown in the Environmental Impact Statement (Section 4) identify distinct vegetation communities within the lower-lying wetland swales that are considered to be of-concern (Melaleuca swamp forest) and adjacent elevated areas of remnant sand dune ridges that contain areas that are considered to be endangered (i.e. Mesophyll vine forest).

2.3 Regional Geology and Soils

Regional geological mapping of the Site and surrounding area is shown on Figure 4.

The basement rock of the Ella Bay area that also outcrops along surrounding hills and ranges is mapped as the Barnard Metamorphics Formation that comprises interbedded sequences of schist, quartzite, arenite, phyllite, greenstone and gneiss.

Within the area of the Development Zone, the basement rock is generally overlain by quaternary-aged swamp and lacustrine deposits of silt, mud, clay, and sand. The coastal frontage of the site is mapped as quaternary-aged sand dune and beach ridge deposits.

Regional agricultural soil mapping of the Site and surrounding area is shown on Figure 5.

Four distinct soil units have been mapped within the Development Zone that generally correlates to the regional geology above. Description of the soil units are provided below.

Soil Unit	Symbol	Geological Origin	Description
Hull	Hu	Quaternary Beach Ridges	Pale to Black coarse sand A1 Horizon with weakly developed A2 Horizon. Brown or pale brown coarse sand B Horizon.
Mission	Ms	Metamorphic (typically on sloping areas with gradients of 5% to 10%)	Red brown sandy clay loam A1 Horizon, red sandy clay loam to silty light clay massive B Horizon containing metamorphic rock gravel.
Mountainous	M1	Metamorphic	Residual soils and weathered rock.
Tully	Tu	Quaternary Alluvium	Dark grey/brown silty loam to silty clay loam A1 Horizon, yellow brown silty clay loam to light clay B Horizon grading to sandy sediments at depth.

Three other soil units are also mapped within the Northern Freehold Area of the Site:

- Gulmara (Ga) Similar to Mission above.
- Nind (Nd) Associated with low-lying swamp-lands.
- Sumalea Associated with low-lying swamp-lands.

Observations and shallow subsurface soil investigations carried out within the Site (Golder 2006) were generally consistent with the various mapped geology and soil units shown on Figure 4 and Figure 5, respectively. The only variation was the presence of sands at two borehole locations that may indicate that the Hull Unit beach ridges extend further west than indicated by regional mapping.

2.4 Regional Groundwater

A search of registered groundwater wells by the Department of Natural Resources and Water (NRW) presented in Appendix C did not identify locations within or adjacent to Ella Bay. The two nearest NRW registered wells (78343 and 92901) are located on the other side of the range from Ella Bay and were constructed within basalt formations that are not present within the geology underlying the Ella Bay area or located within the rainfall catchment for the Site.

Golder 1995 identified two existing groundwater harvesting wells in this area:

- A 40 m deep well constructed within weathered bedrock at the prawn hatchery located to the south of Ella Bay. This well yielded approximately 4 L/s.
- A shallow well constructed within alluvial soils used for a residential supply within the Development Zone. This well is no longer in use.

Based upon discussions with the Department of Primary Industries (DPI) at that time, Golder 1995 identified two potential groundwater sources within the proposed Little Cove Development located immediately to the south of the Site:

- An unconfined groundwater system in alluvial deposits in lower areas.
- Fractures within the bedrock on steeper portions and underlying the lower area alluvium.

The DPI at this time (1995) raised concerns with large scale use of the alluvial groundwater system and potential disturbance to the freshwater/saltwater interface. Use of the weathered rock groundwater system was preferred, however, ‘controlled’ pumping would be required to reduce the potential for saltwater intrusion, particularly in lower areas.

Experience with similar conditions in the surrounding region indicate that groundwater within the Site would generally be intersected within 5 m depth across areas of the site underlain by alluvial soils with surface levels less than 10 m AHD.

Groundwater underlying Site areas with topography less than 5 m AHD may correlate to sea levels and be subject to the influence of tidal movements with potentially seasonally high salinity concentrations and minimal beneficial use (i.e. not suitable for irrigation, stock watering, drinking water). As surface levels increase above 5 m AHD groundwater is more likely to be influenced by rainfall recharge with a correlating improvement in water quality that may have some beneficial use.

Groundwater conditions within the metamorphic bedrock formations may vary considerably. In general, the metamorphic rocks are likely to provide localised groundwater storage and extraction capacity in highly fractured zones. Bores within this fractured rock aquifer in the surrounding region are reported to have yields of between 0.5 L/s and 4 L/s. This water is generally considered suitable for most beneficial uses.

Groundwater movement within soils and rock is anticipated to be in a generally eastwards direction in sympathy with site topography, discharging into creeks and the Farm Wetland Swale.

Observations and the shallow groundwater investigations and monitoring carried out within the Site (Golder 2006 and Golder 2007) were generally consistent with the above description, as follows:

- Shallow groundwater inflows were intersected at depths less than 3 m within the alluvium at all lower-lying borehole locations.
- Perched groundwater inflows were also noted at depths less than 3 m within residual soils where surface levels were below 15 m AHD.

Electrical conductivity readings on samples from three groundwater monitoring wells taken prior to (November 2006) and during (May) the 2007 wet season were all low (refer Table 1), indicating freshwater conditions. The well nearest to the ocean was located only approximately 100 m west of the Farm Wetland Swale at the northern end of the Development Zone.

In conjunction with surface water quality test results (refer Table 1), the groundwater results indicate that the influence of tidal movements and intrusion of saline water within the Farm Wetland Swale may be limited to severe weather conditions such as king tides and storm surges.

3.0 CONCEPTUAL CATCHMENT MODEL

Surface water flows from the Development Zone and adjacent areas of the Site are located within the following distinct catchment areas based upon the two discharge points to Ella Bay identified in Section 2.2.2 and shown on Figure 3:

- Southern Beach Discharge: Catchment A Approximate Total Area: 886 ha
- Northern Beach Discharge: Catchment B Approximate Total Area: 836 ha

The northern extent of Catchment B was assumed to be the little hill located on the Ella Bay beach approximately two thirds of the distance to Cooper Point. It should be noted that the overall catchment area for the WTQWHA wetland area is approximately three times as large as Catchment B.

Within the Site each of the two main catchment areas comprises a series of sub-catchments as documented below and shown on Figure 3:

Sub-Catchment	Source Description (in order of flow)	Catchment Area (ha)		Discharge Description
		Source	Overall	
Catchment A – Southern Beach Discharge				
A1 Southern Creek	Little Cove Rainforest WTQWHA Rainforest Free-hold Rainforest Cleared Farmland	2.5 204.5 15 61	283	Catchment A2 (Farm Creek)
A2 Farm Creek	WTQWHA Rainforest Free-hold Rainforest Cleared Farmland Catchment A1	300 45 95 -	440	Catchment A4 (Farm Wetland Swale)
A3 Eastern Creek	WTQWHA Rainforest Little Cove Resort Free-hold Rainforest Cleared Farmland	2 13.5 15 45.5	76	Catchment A4 (Farm Wetland Swale)
A4 Farm Wetland Swale	Catchment A3 Catchment A2 Cleared Farmland Freehold Wetlands Beach Wetlands WTQWHA Wetlands	- - 27.5 24.5 10 5	67	Ella Bay (Southern Beach Discharge)
Catchment B – Northern Beach Discharge				
B1 Northern Creek	WTQWHA Rainforest Free-hold Rainforest Cleared Farmland Freehold Wetlands	28 27 29 18	102	Catchment B4 (Southern Ella Bay NP)
B2 Western Swale	Cleared Farmland Freehold Wetlands	7.5 11.5	19	Catchment B3 (Central Swale)
B3 Central Swale	Catchment B2 Cleared Farmland Freehold Wetlands	- 2 15	17	Catchment B4 (Southern Ella Bay NP)
B4 Eastern Swale	Cleared Farmland Freehold Wetlands	2 21	23	Catchment B4 (Southern Ella Bay NP)
B5 Southern Ella Bay National Park	Catchment B1 Catchment B3 Catchment B4 WTQWHA Rainforest WTQWHA Wetlands	- - - 242 431	673	Ella Bay (Northern Beach Discharge)

4.0 CONCEPTUAL GROUNDWATER MODEL

Based upon the topography of the Site and surrounding area, and the available geological mapping and groundwater investigation data, the following key assumptions on groundwater conditions have been made:

- Boundaries for recharge of groundwater within the Development Zone and surrounding areas would primarily be limited to the surface water catchment boundaries that include the Development Zone.
- The primary mechanism for groundwater flow within the Site and adjacent areas would be the local topography that generally slopes from the steep western and southern ranges down to the lower-lying coastal fringe adjacent to Ella Bay.
- There would be separate but interrelated groundwater systems associated with each of the five main weathered rock and soil units present within the Development Zone and surrounding area.

The steep ranges and underlying metamorphic rock present to the west and south of the Site would act as a natural groundwater divide, with groundwater recharge to the west and south of these steep ranges flowing predominantly towards the North Johnstone and Johnstone Rivers. Groundwater interaction between the minor coastal catchment areas and the adjacent relatively major inland river catchment areas is assessed to be negligible in the context of overall groundwater flow volumes and has not been considered further.

Identified groundwater units are shown on Figure 6 and documented below.

Groundwater/ Geology Unit	General Description	Groundwater Recharge Sources	Groundwater Flow Mechanisms
Unit A Metasediments **(Barnard Metamorphics Formation)**	Weathered to fresh fractured meta-sediment rock.	Rainfall on exposed elevated rock outcrops. Minor inflow from overlying groundwater units at depth.	Secondary flow within open rock fractures.
Unit B Residual Soils/ Colluvium **(Mission Soil Unit)**	Clay soils sourced from in-situ weathered metasediment rock and slope-wash material directly overlying the lower extent of the Barnard Metamorphics Formation.	Rainfall on exposed surfaces located near the base of the steep ranges . Minor inflow from overlying/underlying groundwater units at depth.	Primary flow within pore spaces of clay soils, with some preferential flow along bands of broken rock.

Groundwater/ Geology Unit	General Description	Groundwater Recharge Sources	Groundwater Flow Mechanisms
Unit C Alluvial Clays (Tully Soil Unit)	Alluvial clay soils deposited by surface water flows in low-lying areas below the steep ranges.	Rainfall on level exposed surfaces. Minor inflow from over lying/underlying groundwater units.	Primary flow within pore spaces of clay soils in an easterly direction.
Unit D Swamp Clays (Sumalea/Nind Soil Units)	Wet, unconsolidated clay soils deposited within estuarine and coastal swamp conditions.	Rainfall and surface water flows within the wetland areas. Minor inflow from underlying ground-water units at depth.	Primary flow within pore spaces of clay soils as dictated by the head of surface water present within the wetlands.
Unit E Beach Sands (Hull Soil Unit)	Unconsolidated sand soils deposited within coastal beach ridge environment.	Rainfall on relatively level exposed surfaces and interchange with surface water bodies such as creeks, the Farm Wetland Swale. Minor inflow from underlying ground-water units at depth.	Primary flow within pore spaces within the sand soils. Direction of flow would be dictated by the head of surface water present in the creeks, Farm Wetland Swale and adjacent tidal levels in Ella Bay.

5.0 PRELIMINARY WATER BALANCE AND HYDROLOGY

5.1 Assumptions

A month by month preliminary water balance has been prepared for the Site based upon the Conceptual Surface Water and Groundwater Models.

Key assumptions adopted in preparing the water balance were based upon previous experience in similar topographical, geological and vegetation conditions and included:

- Evapo-transpiration of rainfall is approximately 20% greater than measured evaporation in densely vegetated areas and 10% greater in cleared areas.
- Monthly surface water flows and rainfall recharge of groundwater occurs within the month of rainfall. Actual conditions would comprise a proportion of delayed flows typically in the order of one to two months.
- Adopted maximum ‘wet’ season daily groundwater recharge rates from rainfall are:

  - Unit A (Metasediments) 4 mm/m^2/day
  - Unit B (Residual/Colluvium) 2 mm/m^2/day
  - Unit C (Alluvium) 3 mm/m^2/day
  - Unit D (Swamp Clays) 2 mm/m^2/day
  - Unit E (Beach Sands) 15 mm/m^2/day

- Adopted groundwater recharge rates from creeks and wetlands are:
  - Creeks to Unit C Included in groundwater interchange rates.
  - Creeks/Wetlands to Unit D Included in rainfall recharge rates.
  - Creeks/Wetlands to Unit E 150 mm/m^2/day ('wet' season only)
- Adopted groundwater flow interchange rates between groundwater systems are:
  - Unit A to Unit B 20% of volume
  - Unit B to Unit C 20% of volume ('wet' season only)
  - Unit C to Unit B 20% of volume ('dry' season only)
  - Unit C to Unit E 20% of volume ('wet' season only)
  - Unit C to Creeks 5% of volume ('wet' season only)
  - Unit D to Wetlands 10% of volume ('dry' season only)
  - Unit D to Ella Bay All remaining groundwater recharge
  - Unit E to Unit C 20% of volume ('dry' season)
  - Unit E to Unit D 10% of volume ('dry' season)
  - Unit E to Creeks/Wetlands 10% of volume ('dry' season)
  - Unit E to Ella Bay All remaining groundwater recharge
  - All other potential groundwater unit interchange was considered to be less than 5% of total volumes and was not included in the preliminary groundwater model.

5.2 Average Yearly Estimate

Based upon average yearly climatic conditions, a month by month preliminary water balance for each identified sub-catchment area and groundwater unit has been estimated. A breakdown of the preliminary water balance is presented in Table 2 and summarised below.

This conceptual water balance would require updating and refinement using detailed surface water and groundwater hydrology modelling that would be needed to suit detailed planning and design purposes.

Catchment	Area (Ha)	Rain - Evap (Gl)	Groundwater Migration (Gl)						Surface Water Discharge (Gl)
			Unit A	Unit B	Unit C	Unit D	Unit E	Total	
Catchment A – Southern Beach Discharge									
Catchment A1 (Southern Creek)	283	5.3	0.6	0.5	0.6	0.0	0.1	1.8	3.5
Catchment A2 (Western Creek)	440	8.3	0.8	0.6	0.9	0.0	1.0	3.3	8.4 (A1 + A2)
Catchment A3 (Eastern Creek)	76	1.5	0.1	0.1	0.1	0.0	0.3	0.6	0.8
Catchment A4 (Farm Wetland Swale)	67	1.3	0.0	0.0	0.1	0.0	1.3	1.4	9.1 (A1+A2+A3+A4)
Total	886	16.3	1.5	1.2	1.7	0.0	2.7	7.3	9.1
Catchment B – Northern Beach Discharge									
Catchment B1 (Northern Creek)	102	1.9	0.2	0.2	0.3	0.0	0.0	0.6	1.3
Catchment B2 (Western Swale)	19	0.4	0.0	0.0	0.0	0.0	0.3	0.3	0.0
Catchment B3 (Central Swale)	17	0.3	0.0	0.0	0.0	0.0	0.2	0.2	0.0 (B2 + B3)
Catchment B4 (Eastern Swale)	23	0.4	0.0	0.0	0.0	0.0	0.3	0.3	0.1
Catchment B5 (Southern Ella Bay NP)	673	12.9	1.0	0.7	0.0	0.9	0.9	3.5	10.9 (B1+B2+B3 +B4+B5)
Total	838	15.9	1.2	0.9	0.3	0.9	1.7	4.9	10.9

5.3 Relative Flow - Surface Water

The following relative flow volume descriptions have been adopted to describe the estimated surface water flows calculated by the Preliminary Water Balance within and between each of the sub-catchment areas:

- Minor Less than 5%.
- Low 5% to 20%.
- Moderate 20% to 50%.
- High Greater than 50%.

These relative flow volumes are described below and shown on Figure 3.

Catchments	Source	Flow		Overall Flow Volume	
		'Dry'	'Wet'	'Dry'	'Wet'
Catchment A – Southern Beach Discharge					
Catchment A1 Southern Creek	• Rainforest • Farmland	Low Minor	Low Minor	Low	Moderate
Catchment A2 Farm Creek	• Rainforest • Farmland • Catchment A	Low Minor Low	Moderate Low Moderate	Low	High
Catchment A3 Eastern Creek	• Rainforest • Farmland	Minor Minor	Low Low	Minor	Low
Catchment A4 Farm Wetland Swale	• Farmland • Catchment A2 • Catchment A3 • Wetlands	Minor Low Minor Minor	Minor High Low Minor	Low	High
Catchment B – Northern Beach Discharge					
Catchment B1 Northern Creek	• Rainforest • Farmland • Wetlands	Minor Minor Minor	Low Low Low	Minor	Low
Catchment B2 Western Swale	• Farmland • Wetlands	Minor Minor	Minor Minor	Minor	Minor
Catchment B3 Central Swale	• Catchment B2 • Farmland • Wetlands	Minor Minor Minor	Minor Minor Minor	Minor	Minor
Catchment B4 Eastern Swale	• Farmland • Wetlands	Minor Minor	Minor Minor	Minor	Minor
Catchment B5 Southern Ella Bay NP Wetlands	• Rainforest • Catchment B1 • Catchment B2 • Catchment B4 • Wetlands	Low Minor Minor Minor Low	Moderate Low Minor Minor High	Low	High

5.4 Relative Flow - Groundwater

The same relative flow volume descriptions have been adopted for groundwater as defined in Section 5.3.

Relative groundwater flow volumes are described below and shown on Figure 6.

Groundwater Units	Source/ Outflow	Recharge		Discharge		Overall Flow Volume	
		'Dry'	'Wet'	'Dry'	'Wet'	'Dry'	'Wet'
Unit A Meta-sediments	• Rainfall	Minor	Low	-	-	Minor	Low
	• Unit B	Minor	Minor	Low	Low		
	• Bay	-	-	Minor	Minor		
Unit B Residual/ Colluvium	• Rainfall	Minor	Low	-	-	Minor	Low
	• Creeks	Minor	Minor	Minor	Minor		
	• Unit A	Low	Low	Minor	Minor		
	• Unit C	Low	Low	Minor	Minor		
Unit C Alluvial Clays	• Rainfall	Low	Moderate	-	-	Low	Moderate
	• Creeks	Low	Low	Low	Low		
	• Unit B	Minor	Minor	Low	Low		
	• Unit D	Minor	Minor	Minor	Minor		
	• Unit E	Low	Moderate	Low	Low		
Unit D Swamp Clays	• Rainfall	Minor	Low	-	-	Minor	Low
	• Swale	Low	Low	Minor	Minor		
	• Bay	Minor	Minor	Minor	Low		
	• Unit C	Minor	Minor	Minor	Minor		
	• Unit E	Low	Low	Minor	Minor		
Unit E Beach Sands	• Rainfall	Moderate	High	-	-	Moderate	High
	• Creeks	Moderate	Moderate	Moderate	Low		
	• Swale	Moderate	Moderate	Moderate	Low		
	• Bay	Low	Minor	Moderate	High		
	• Unit C	Low	Low	Low	Moderate		
	• Unit D	Minor	Minor	Low	Low		

5.5 Ella Bay Discharge and Tidal Influence

Discharge of surface water to Ella Bay from Catchment A and Catchment B is intermittent and dependant upon seasonal climatic and tidal conditions. The primary influences on discharge from both catchment areas are considered to be:

- Surface Water Flow Volumes
    - 'Wet' Season High volumes resulting in higher wetland swale levels
    - 'Dry' Season Low volumes resulting in lower wetland swale levels
- Tidal levels within Ella Bay:
    - High Tide Higher wetland levels and lower discharge volumes to Ella Bay
    - Low Tide Lower wetland levels and higher discharge volumes to Ella Bay

Based upon site observations and the Preliminary Water Balance calculations, surface water discharge to Ella Bay is considered to primarily occur during and immediately following the 'wet' season when there is a sufficient volume of water to raise water levels over the Southern Ella Beach Sand Dune and maintain flows regardless of external tidal influences.

Once 'dry' season conditions prevail no surface water discharge to Ella Bay from either catchment area occurs. 'Dry' season creek and wetland flows into both catchments are most likely off-set by continuous subsurface groundwater discharge along the length of the wetland swale through the Southern Ella Bay Beach Dune (Groundwater Unit E).

Inundation of the wetland swale by sea waters during king tides and storm surges would probably occur regularly at intervals during each year, however, the saline water is likely to be flushed from the wetland swale fairly rapidly by continual surface water inflow, particularly during the 'wet' season, and groundwater discharge to Ella Bay.

Observations indicate that the influence of tidal movements within Ella Bay on wetland levels behind the Southern Ella Bay Beach Ridge rapidly decreases with distance from the Southern Beach Discharge. Similar conditions are also likely to occur at the Northern Beach Discharge.

5.6 WTQWHA Wetlands

As noted in Section 5.5, available observation data indicates that tidal movements within Ella Bay have minimal influence upon wetland areas located 100 m to 200 m away from open water within the swales that are directly connected to the Northern Beach Discharge and Southern Beach Discharge. This includes wetland areas immediately adjacent to the Southern Ella Bay Beach Dune.

The Conceptual Groundwater Model (Section 4) and Preliminary Water Balance (Section 5.4) show that groundwater flows also have a minimal influence of the hydrology of the WTQWHA wetlands.

The key influence on surface water flow volumes and levels in the WTQWHA wetlands located within Catchment B are considered to be direct rainfall within the wetlands and surface water run-off from adjacent up gradient rainforest areas located within the WTQWHA.

Seasonal flows within the WTQWHA are briefly described as follows:

- 'Wet' Season High rainfall volumes resulting in higher wetland levels and flow predominantly towards the northern Ella Beach discharge.
- 'Dry' Season Low rainfall volumes resulting in lower wetland levels, with almost no internal flow or discharge to Ella Bay.

A total of approximately 41 hectares of the Development Zone is located within the four southern sub-catchments (B1 to B4) of Catchment B. This is approximately 5% of the total area of Catchment B that includes the southern portion of the WTQWHA wetlands. The Preliminary Water Balance (Section 5.4) indicates that surface water run-off from the three wetland based sub-catchments (B2 to B4) are in total less than 1% of the total surface water flow volume for Catchment B.

5.7 Key Project Outcomes

Surface Water:

- **Approximately 90% of the Development Zone is within Catchment A that enters an adjacent wetland swale that flows into Ella Bay during the wet season. This area includes all the proposed resort areas, commercial areas, wastewater treatment area, most residences, most of the access roads and most of the golf course.**
- **Only 10% of the Development Zone is within Catchment B, that includes WTQWHA wetlands (<5 % of the total Catchment B area). This area includes a low proportion of the residences (< 10%), access roads and golf course.**
- **Surface water within Catchment B area of the Development Zone flows 500 m through remnant wetlands located within the Northern Freehold Area of the Site prior to discharging to the WTQWHA wetlands that are considered to predominantly flow to the Northern Beach Discharge.**

Groundwater:

- **The Farm Wetland Swale located behind the Southern Ella Bay Beach Dune plays an important role in maintaining a natural groundwater divide between seawater in Ella Bay and freshwater within on-shore shallow aquifers.**
- **There is no mechanism for northwards and southwards migration and/or interaction of groundwater within the coastal plain of Ella Bay north of Farm Creek. The predominant groundwater flow influence within the Ella Bay coastal plain is topography that results in a west to east flow direction.**
- **It is considered that there is only minor and localised groundwater interchange between the Development Zone and immediately adjacent sections of the Northern Freehold Area. There would be no groundwater interchange between the Development Area and the WTQWHA.**
- **Groundwater is considered to form only a minor component of the overall hydrology of the WTQWHA wetlands.**

6.0 POTENTIAL IMPACTS AND MITIGATION - HYDROLOGY

6.1 General

The Master Plan for the Development Zone (refer Appendix A) and project description provided in the Environmental Impact Statement were prepared to work within and take advantage of the existing natural topography, drainage and vegetation systems. It is understood that the Development Zone no longer includes any plans to include lakes or require works that would modify the existing creek and wetland systems.

Specific Development Zone elements that will significantly reduce the risk of potential changes to existing surface water and groundwater hydrology conditions within and adjacent to the Site include:

- Maintaining a high percentage open space (i.e. golf course, residential gardens, public parks and gardens, resort gardens, existing and rehabilitated habitat).
- Limiting the extent of hardstand areas (roads, car parks, buildings)
- Management of surface water flow using Water Sensitive Urban Design (WSUD) techniques (porous pavements, unlined swales, gross pollutant traps, wetland treatment and detention) prior to discharge to existing creeks and wetlands.
- Limiting the extent of cut and fill earthworks.
- Limiting the extent of permanent below ground structures.
- Protecting and rehabilitating existing creeks, gullies and the Farm Wetland Swale.
- Protecting and rehabilitating most existing remnant vegetation within the Development Zone.
- Protecting areas of remnant rainforest and wetland vegetation surrounding the Development Zone within the Site (Northern Freehold Area, Western Freehold Area and Eastern Freehold Area.
- Providing a buffer of approximately 500 m between the Development Zone and wetland areas within the WTQWHA.

This approach, in conjunction with appropriate detailed design and construction supervision will inherently:

- Maintain existing surface water flow detention periods, velocities and volumes for:
    - Sheet flow over cleared land to gullies, creeks and wetlands that will contain and be surrounded by remnant and rehabilitated vegetation within the Development Zone.
    - All Gullies and creeks discharging to the Farm Wetland Swale.
    - The Farm Wetland Swale and flow to Ella Bay through the Southern Beach Discharge.

  - Creeks and swales entering the Northern Freehold Area of the Site that subsequently discharges to the WTQWHA wetlands.

- Maintain groundwater recharge and discharge rates to and from each of the Groundwater Units and surface water features (gullies, creeks and wetlands).
- Limit disturbance to or restriction of groundwater flow within the shallow Groundwater Units (Unit C, and Unit E) that are present within the Development Zone.

Specific changes or issues of concern for surface water and groundwater hydrology are discussed in the following Sections.

6.2 Surface water

6.2.1 Farm Wetland Swale

Most surface water flows from the Development Zone discharge into the Farm Wetland Swale located behind the Southern Ella Bay Beach Dune either via Farm Creek or by localised sheet flow within adjacent cleared areas.

The catchment area of Farm Creek predominantly comprises rainforest that will remain undisturbed outside the Development Zone and existing cleared farmland that will predominantly be used for residential housing, golf course and habitat rehabilitation. As noted in Section 6.1, changes to the surface water hydrology of Farm Creek and its subsequent discharge to the wetland swale area is considered to be minimal based upon the nature of the proposed development and subject to use of appropriate WSUD techniques to maintain the existing flow volumes, velocities and detention rates.

Higher density developments (commercial areas, town centre, resorts, etc), are predominantly located within cleared areas of the Development Zone that are subject to sheet flow into the Farm Wetland Swale. Such areas are considered to have the greatest potential for impacting the surface water hydrology of the Farm Wetland Swale.

The Conceptual Catchment Model (Section 3) identified that the Farm Wetland Swale is subject to significant natural variability in flow rates, water levels and salinity. For the purposes of this report it is considered reasonable to assume that the existing ecological systems within the Farm Wetland Swale would have adapted to such ongoing variability. This would need to be confirmed by other relevant studies.

Although it should be the objective during each stage of development to maintain the existing surface water sheet flow hydrology from the Development Zone into the Farm Wetland Swale, some localised changes adjacent to each development area should be acceptable within the context of maintaining overall existing flow rates and volumes. This objective would generally require the use WSUD techniques to mimic existing flow hydrology such as constructed swales to intercept sheet flows currently entering each development area and directing this flow around the development for diffuse discharge into adjacent wetland areas.

As discussed in further detail in Section 7, for water quality purposes it is also anticipated that WSUD techniques for surface water management from the Development Zone into wetland areas would include:

- Bunding along the Development Zone boundary to limit uncontrolled discharge to wetland areas.
- Direction of all flows from each sub-catchment within the Development Zone through some form of constructed sediment/wetland treatment system prior to discharge into creeks and wetland areas.

Management of the Development Zone to limit changes to surface water hydrology within the Farm Wetland Swale would also protect existing surface water discharges to Ella Bay and the larger Reef Lagoon (this is the area of the Coral Sea located between the Queensland coastline and the outer areas of the Great Barrier Reef).

6.2.2 WTQWHA Wetlands

As noted in Section 5.6, the Development Zone comprises only a minor component of Catchment B (5%). Flows from the Development Zone occur within four sub-catchments (B1 to B4) that enter wetlands located within the Northern Freehold Area of the Site and subsequently the WTQWHA wetlands approximately 500 m further to the north.

As noted in Section 2.2.6, The Northern Freehold Area and adjacent WTQWHA contains vegetation communities considered to be of concern (swales) and endangered (sand dunes).

In the absence of specific tolerance information for these wetland vegetation communities it is recommended that the surface water hydrology (flow detention, velocities and volumes) for each of these sub-catchments (B1 to B4) be kept as close as possible to the existing conditions following completion of construction works. This would generally require implementation of a range of solutions that may include:

- Development of detailed water balances for each sub-catchment that takes into account hardstand areas, golf course and residential irrigation, vegetation changes, etc.
- Maintaining existing sub-catchment boundaries following development.
- Use of WSUD techniques to mimic existing flows and water quality.

Specialist advice on the ecosystems of the wetland areas within the Northern Freehold Area should be sought on how to best manage surface water flows into this area during construction periods. It may be appropriate, particularly during ‘dry’ season periods when most construction work is planned, to prevent surface water flows and any potential contaminant sources (refer Section 7) generated within the Development Zone entering down gradient areas of Catchment B within the Northern Freehold Area and the WTQWHA.

6.3 Groundwater

6.3.1 Farm Wetland Swale

As identified in Section 5.7 there is likely to be a relatively high interaction between groundwater within Unit E (Beach Sands) and surface water that plays an important role in maintaining ecology systems within the Farm Wetland Swale and the natural divide between saline waters from Ella Bay, particularly during the low surface water flow 'dry' season.

The proposed resorts located adjacent to the Farm Wetland Swale may include the following elements that have the potential to change the groundwater hydrology of Groundwater Unit E (Beach Sands) at a local level:

- Hardstand areas (roofs, roads, cark parks, swimming pools).
- Water supply from roofs.
- Excavations for swimming pools, ½ basements and lift wells to a maximum depth of 2 m that may potentially act as barriers to groundwater flow.

It is understood that the four northernmost resorts, located either side of Farm Creek, will be constructed on a relatively small scale, with one to two storey structures that do not require basements. Permanent excavations in these four areas would be predominantly for swimming pool construction within a depth of 2 m from the existing ground surface.

As noted in Section 6.2.1, the bulk of rainfall in the resort development areas is likely to be currently lost as surface water sheet flow to the Farm Wetland Swale. Existing recharge of Groundwater Unit E in the lower-lying Site areas adjacent to the Farm Wetland Swale will be controlled by soil saturation, particularly during the 'wet' season. Loss of a limited volume of overall yearly rainfall run-off for water supply harvesting is not considered to have a negative an impact upon groundwater recharge on the basis of:

- Additional recharge from excess surface water run-off from hardstand areas using WSUD techniques (i.e. constructed swales and sediment/wetland treatment systems) rather than traditional stormwater pipelines.
- Use of recycled water sourced from an on-site wastewater treatment plant for watering of open space areas.

It should also be noted that the existing cattle grazing areas have only been cleared in the past century. Previous natural rainforest and wetland vegetation that would have been present across the entire Site would have resulted in significantly higher evapotranspiration rates and resultant lower rate of groundwater recharge than is currently occurring.

The proposed resorts are planned to be set-back from the beachfront and Farm Wetland Swale by a distance of at least 100 m from the highest astronomical tide (HAT). At this distance, the total thickness of Groundwater Unit E (Beach Sands) is likely to be in the order of at least 5 m to 10 m.

Conservatively allowing for an average depth to groundwater from the existing ground surface of only 1 m, the total saturated thickness of Groundwater Unit E (Beach Sands) is likely to be at least 6 m, providing a total cross-sectional area for groundwater flow along the entire front of the Development Zone in the order of at least 10,000 m^2.

Allowing for excavations to a depth of 2 m below the ground surface and, therefore, 1 m below groundwater levels, across 50% the two southern larger scale resorts, the maximum cross-sectional area reduction to shallow groundwater flows in Unit E (Beach Sands) would be less than 250 m^2 out of a total flow area of 10,000 m^2 (2.5%). The high permeability of Unit E soils would compensate for such shallow, localised, non-continuous barriers and any change in overall groundwater flow volumes would be less than 1%.

In the context of the predominant surface water flow volumes to and from the Farm Wetland Swale, minor changes to groundwater flows within Groundwater Unit E (Beach Sands) would not impact upon existing surface water ecological systems or the barrier to saltwater intrusion.

In the event that subsequent detailed planning and design works result in potential reductions to groundwater flow within Unit E (Beach Sands) of greater than say 5%, there are a number of simple and practical management strategies that could be implemented that include the use of WSUD techniques (i.e. constructed swales and wetlands) to increase groundwater recharge to Unit E (Beach Sands) in the areas between the resorts and the Farm Wetland Swale.

Management of the Development Zone to limit changes to groundwater hydrology adjacent to the Farm Wetland Swale would protect existing groundwater discharges to Ella Bay and the Reef Lagoon.

6.3.2 WTQWHA Wetlands

Section 5.7 states that there would currently be only minor groundwater movement and interchange between existing cleared areas of the Development Zone and the wetlands areas located within the Northern Freehold Area of the Site. The 500 m distance between the Development Zone and the WTQWHA boundary would provide a more than adequate buffer to prevent existing groundwater interchange between these areas and also ensure that the existing groundwater hydrology within the WTQWHA wetland areas is not impacted.

6.3.3 Water Harvesting

It is proposed to harvest rainfall from selected sealed surfaces (i.e. building roofs) to provide a significant proportion of potable water supply for the Development Zone. Section 6.3.1 indicates that this water harvesting should have minimal impact upon groundwater recharge.

Harvesting of groundwater for water supply purposes may also be considered for the following uses, subject to undertaking appropriate studies and monitoring to demonstrate that there would be no adverse impacts upon wetland ecosystems and groundwater quality:

- Construction use
- Emergency operational use during extended dry periods.

As identified by Golder 1995, large scale use of the near-surface Groundwater Units [i.e. Unit C (Alluvial Clay), Unit D (Swampland Clay), Unit E (Beach Sands)] for this purpose is not recommended on the basis of the following:

- The storage capacity of shallow soil aquifer is generally limited and may not provide a suitably reliable water supply.
- Dewatering of the shallow soil-based groundwater systems is likely to impact upon vegetation and interconnected surface water systems (i.e. creeks and wetlands), including potential seawater intrusion as identified in Section 5.7.

Only Unit A (Weathered Metasediments) is considered potentially suitable for large scale water supply purposes. Suitable characteristics of this groundwater system include:

- Localised groundwater storage is likely to be relatively large and therefore provide some reliability without resulting in significant drawdown.
- The Conceptual Groundwater Model shows that there are multiple layers of low permeability clay-based groundwater systems (Unit B and Unit C) located between Unit A and sensitive wetland ecosystems that predominantly interact with the higher permeability Unit E (Beach Sands).
- The topography of the site and main recharge source (i.e. elevated hillslopes) may result in sub-artesian groundwater pressure conditions within Unit A.

As noted above, detailed groundwater assessment and modelling is required at the design stage to assess the most appropriate locations and extraction volumes that could be sustained with an acceptable factor of safety against impacting upon such systems. Operation of a large scale groundwater harvesting system within Unit A (metasediments) would also require a comprehensive monitoring program to identify and address potential impacts upon shallow groundwater and surface water systems.

6.4 Key Project Outcomes and Recommendations

Hydrology:

- **Only minor localised changes to existing surface water and groundwater hydrology will occur from the proposed development by maintaining significant areas of open space, minimising below ground disturbances and hardstand areas and using best practice groundwater extraction and water sensitive urban design (WSUD) techniques.**
- **The Development Zone primarily comprises existing cleared rainforest and wetland areas. Revegetation of proposed open space areas will reverse some of the existing changes to surface water and groundwater hydrology that would have occurred following clearing.**
- **Subject to maintaining and/or mimicking existing hydrology, the development represents a low risk to adjacent wetland swales and ecological systems (Farm Wetland Swale and WTQWHA). Management of the Development Zone to limit changes to surface water and groundwater hydrology within adjacent wetland areas would, by definition, also protect existing surface water and groundwater discharges to Ella Bay and the Reef Lagoon.**
- **In accordance with standard development practice, detailed investigation, assessment and modelling of surface water and groundwater hydrology and design of required mitigation measures shall be undertaken as part obtaining approvals and/or operational works permits for each stage of development.**
- **Changes to surface water and groundwater hydrology identified as potential risks to wetland areas by detailed assessment can be mitigated by a range of practical design and/or construction management strategies.**
- **Specialist advice on the ecosystems of the wetland areas within the Northern Freehold Area should be sought on how to most appropriately manage surface water flows into this area during construction periods.**

Water Harvesting

- **Harvesting of surface water from sealed surfaces for water supply purposes will not significantly impact upon surface water or groundwater hydrology.**
- **Groundwater should not be harvested from shallow alluvial groundwater aquifers (Units C & Unit E) to protect wetlands and the freshwater interface adjacent to Ella Bay.**
- **Well planned and managed harvesting of groundwater from weathered rock aquifers (Unit A) should present a low risk to shallow groundwater and associated wetlands.**

7.0 POTENTIAL IMPACTS AND MITIGATION - CONTAMINANTS

7.1 Sediment

7.1.1 Existing Conditions and Potential Impacts

Existing erosion of sediment from farmland and adjacent rainforest and wetland areas is evident in a relatively large scale across the Site and surrounding areas that include:

- Vehicle tracks across paddocks and creek crossings.
- Cattle tracks across paddocks and creek crossings.
- Bare earth adjacent to and within the cattle yards.
- Relatively recent slopewash material adjacent to the boundary between rainforest and cleared land.
- Sediment film over vegetation within the Farm Wetland Swale.
- Areas of relatively recent fine sediment located adjacent to Farm Creek within the Farm Wetland Swale (refer Appendix B Site Photographs, Plate 15).
- Areas of relatively recent fine sediment located along the beach front of the Southern Ella Bay Beach Dune adjacent to the Site.

Potential impacts from existing and future sediment erosion from the Resort Zone entering waterways include:

- Smothering ecosystems within creeks and wetland areas.
- Discharge of sediment to the Reef Lagoon.
- Reduction in visual amenity of completed stages of the development.

7.1.2 Mitigation Strategies

Sediment reduction measures to protect coastal ecosystems and the Reef Lagoon from large-scale sediment sources such as agriculture and smaller-scale sources such as coastal developments have been identified and implemented over a whole of government and industry approach within the past ten years (refer to Section 8).

Well designed and maintained roads, resorts, residences and other open space areas within the Development Zone will mitigate most of the existing sediment impact from the Site identified in Section 7.1.1 and provide additional sediment retention capacity through the use of WSUD techniques (i.e. constructed swales and sediment/wetlands treatment areas). Post construction, this should significantly reduce the overall existing sediment load to creeks, adjacent wetland areas and the Reef Lagoon.

Sediment erosion during each stage of construction works is considered to be the key issue of concern as this will require disturbance of surface soils across most of Site, except adjacent to creeks and other areas where existing vegetation will be retained and rehabilitated. The main potential sediment source during construction is considered to be surface soil stripping for:

- Resort areas located adjacent to the Farm Wetland Swale.
- Development Zone access roads, particularly adjacent to creek crossings.
- Residential construction.
- Wastewater treatment plant area
- Golf course terrain construction.

In relative terms the Development Zone comprises a large area. Is must be recognised, however, that this area will be subject to a staged construction program over a 10 to 15 year period and it includes a substantial proportion of open space. Actual ground disturbance at any time within the development is not likely to be greater in size than other typical coastal projects undertaken in Far North Queensland.

Areas disturbed by construction activities and potentially subject to sediment erosion at any time in the construction cycle would be equivalent in scale to other similar development projects adjacent to coastal areas in North Queensland. An example of the typical scale of construction works at any time is the adjacent approved Little Cove development located immediately south of the Site.

Within the Development Zone it is planned to use WSUD techniques as part of sediment control measures during and following construction through:

- Use of water harvesting and porous paving to reduce run-off from hardstand areas.
- Limit the extent of disturbed areas open at any time.
- Management of surface water using WSUD techniques such as constructed swales, sediment/wetlands treatment areas and gross pollutant traps to reduce flow velocities and provide suitable retention times to trap sediment prior to discharge off-site.
- WSUD techniques will also maximise the direction of surface water sheet flow into natural buffers to waterways that will be provided by vegetation to be retained and rehabilitated adjacent to gullies, creeks and wetlands.

The primary method of erosion and sediment control during construction will be the preparation and implementation of Erosion and Sediment Control Plans (ESCP) for each development area, down to single lot scale, in accordance with the strategies promulgated by the Far North Queensland Regional Organisation of Councils (FNQROC). All ESC Plans will be required to be prepared by appropriately trained and approved personnel in accordance with FNQROC policies as applied by Johnstone Shire Council. This would include review of all ESC Plans as part of each Construction Works Approval to be provided by Council.

Auditing of erosion and sediment control implementation and a comprehensive water quality monitoring program would be required during and following construction.

Subject to implementation of the strategies, sediment discharge to creeks and wetlands is not considered a significant risk to water quality, adjacent wetlands or the Reef Lagoon during or following each stage of construction works.

7.1.3 Northern Wetland Areas

Run-off from the Development Zone into the Northern Freehold Area and subsequently into the WTQWHA wetlands is limited to four relatively small sub-catchments (B1 to B4).

The relatively small size of these catchments within the Development Zone and the flat topography of the coastal plain in these areas give an opportunity to provide additional sediment and other potential contaminant protection to wetland areas by completely redirecting surface water run-off from one or more of these sub-catchments during and potentially following constructions works.

As noted in Section 6.2.2, specialist advice would be required to assess the potential benefits to wetland ecosystems against the reduction in run-off volumes. In practical terms it may only be worth considering the three smallest sub-catchments that directly flow into relatively undisturbed wetland swales.

7.2 Nutrients

7.2.1 Existing Conditions and Potential Impacts

Water quality monitoring completed to date within the Site (Golder 2006 & Golder 2007) identified that:

- Concentrations of nitrogen and phosphorous within both surface waters and groundwater exceed relevant fresh and marine water ecosystem guideline values.
- Elevated nutrient concentrations are present at locations within the Site that are considered to indicate background water conditions entering the Site from the adjacent WTQWHA rainforest.

This information indicates that both surface and groundwater are likely to contain naturally elevated nutrient concentrations sourced from surrounding rainforest/wetlands that would also be augmented by current cattle grazing and pasture fertilising within the Site. The ecosystems of the creeks and wetlands within and adjacent to the Development Zone are therefore likely to have adapted to the current site conditions over considerable periods of time.

Changes to nutrient sources within the Development Zone are anticipated to include:

- Generation of wastewater from residential properties, the resorts and other commercial premises.
- Removal of cattle grazing/pasture fertilising.
- Rehabilitation of some existing cleared land.
- Use of recycled wastewater for irrigation of open space land.
- Use of fertilisers for the golf course, residential gardens, resort gardens and other open space land.

7.2.2 Mitigation Strategies

The Ella Bay Integrated Resort incorporates a fully sealed sewerage collection system to all domestic, commercial, resort buildings that will be connected to an on-site wastewater treatment plant. Subject to appropriate design and operation of the wastewater collection and treatment systems there should be no nutrient impact upon surface and/or groundwater quality from the generation and collection of untreated wastewater.

Potential impacts resulting from any proposed direct release of treated wastewater to surface water systems, Ella Bay and the Reef Lagoon is not within the scope of this report. This issue has been specifically addressed by others within the Environmental Impact Assessment reports. It is understood that a smaller scale wastewater treatment system has recently approved for the adjacent Little Cove Development by the Environmental Protection Agency. It is anticipated that similar water quality discharge requirements would be applied to the Development Zone by the Environmental Protection Agency, Great Barrier Reef Marine Park Authority and other relevant regulatory agencies.

Discharge to water would most likely need to be treated to a tertiary level. Nutrient removal treatment could include the use of engineered artificial wetland systems, however, this would need to be considered within the context of providing suitable storage capacity during the 'wet' season period each year.

The wastewater treatment area is currently planned to be located within the north eastern corner of the Development Zone adjacent to the Farm Wetland Swale. As discussed in Section 7.1.3, to reduce potential risks to wetlands located within the Northern Freehold Area and WTQWHA, it may be appropriate to consider redirecting all surface run-off from the waste water treatment area away from Catchment B.

Impacts upon surface water and groundwater from the use of fertilisers and treated wastewater to maintain parks, gardens and the golf course within the significant open space areas of the Site will be at least partially off-set by the removal of cattle grazing and pasture fertilising.

The Conceptual Surface Water and Groundwater Models indicate that there is currently only localised minor water interaction between the Development Zone and wetlands located within the Northern Freehold Area and almost no interchange within the WTQWHA wetland areas.

Potential nutrient impacts that may occur in these areas would be of a minor nature, localised to the immediate area adjacent to the Development Zone and well within the Northern Freehold Area. Other than identification of a potential opportunity to redirect the relatively small surface run-off volumes from the Development Zone into Catchment B, as discussed in Section 6.2.2, potential nutrient impacts upon the WTQWHA wetland areas located to the north of the Site are not considered to require further assessment.

The key ecosystem of concern in the event of changes to nutrient concentrations in surface waters and/or groundwater is therefore considered to be the Farm Wetland Swale.

Nutrient modelling (Medli or similar program) is required during detailed planning and design stages to provide an accurate assessment of nutrient loadings from existing cattle grazing/fertiliser use, proposed development land and irrigation uses and the impact of potential changes in nutrient concentrations upon this receiving ecosystem. Such nutrient modelling would need to consider and develop a range of appropriate mitigation measures including:

- Determining the level of nutrient removal required for wastewater to be used for irrigation purposes (i.e. irrigation using appropriately treated wastewater is likely to be the most sustainable method of fertilising open space areas).
- Attenuation of nutrient concentrations from irrigation waters within the unsaturated soil profile to protect shallow groundwater quality.
- Adoption of the most suitable irrigation method (surface or subsurface) for application of treated wastewater for the golf course, residential properties, parkland and resort areas to protect surface water quality.

In the event that fertiliser use and irrigation application within the Development Zone are assessed to present a risk to receiving groundwater and surface water ecosystems there are a range practical mitigation strategies that could be implemented:

- Adoption of subsurface irrigation method within key areas of concern.
- Preparation of a site specific management plans for the golf course and resort operations that includes a detailed assessment of nutrient requirements and sources and ongoing monitoring soil and water monitoring to ensure that only the fertiliser required to maintain open space within these properties to a required standard is used.
- Design and operation of the wastewater treatment system to remove nutrient concentrations to a standard acceptable for on-site irrigation application or discharge to wetland areas and the Reef Lagoon.

- Use of pubic information systems to be developed for other environmental issues of concern (such as cassowary management) to inform future residents of the Site of the importance of managing garden fertiliser use.
- Use of WSUD techniques such as constructed swales, external bunding and other drainage control systems to direct surface water generated within the Development Zone into sediment/wetland treatment systems to reduce nutrient concentrations, as required.
- Use of WSUD techniques such as constructed swales, gross-pollutant traps, wetlands and similar treatment systems to remove organic matter from surface run-off generated within both open space areas and remnant/rehabilitated vegetation areas prior to discharge to gullies, creeks and wetlands.

7.3 Contaminants

7.3.1 Existing Conditions

Known potential contaminant sources located within the Site comprise:

- Farm workshops and fuel storage areas located near the entrance to the Site.
- Former cattle dip located near the centre of the Site.

Both these areas will require investigation, assessment and possibly remediation works during the detailed design and construction phases of the development in accordance standard industry practice as documented in the draft 'Guidelines for the Assessment and Management of Contaminated Land in Queensland', 1998.

These existing conditions have not been considered further for this report.

7.3.2 Potential Impacts and Mitigation Strategies

Potential surface water and groundwater contaminant sources that may be present during the development and subsequent operation of the Development Zone that will require mitigation include:

- **Fuel and oil storage.**

  Possibly required for construction equipment, golf course maintenance and emergency electricity generators.

  All such storages should be located within appropriately designed, constructed and maintained facilities in accordance with relevant Australian Standards and Queensland Government licence conditions.

  Consideration should be given to the use of natural gas or liquid petroleum gas for this purpose. Such gas fuel supplies present no risk of contamination to groundwater and/or surface water.

- **Discarded litter and other domestic and commercial wastes.**

  The Development Zone will be serviced by a domestic and commercial waste collection contractor for disposal to licensed facilities located outside the Site area.

  Potential surface water contaminant sources are likely to be limited to minor domestic waste and general litter. Surface water management systems should include the use WSUD techniques such as of gross pollutant traps to intercept this solid waste prior to entering creeks and other surface water systems.

- **Minor localised domestic and commercial chemical storage and use.**

  Use and/or spillage of chemicals within domestic residences and commercial premises are not considered a significant risk to surface water and/or groundwater in the context of the overall size of the Development Zone and receiving rainfall.

  Similar to fertilisers discussed in Section 7.2, pubic information systems to be developed for other environmental issues should be used to inform future residents of the Development Zone of the importance of limiting chemical use and correct storage.

- **Herbicide and pesticide storage and use within the golf course and resorts.**

  The likely use and/or spillage of herbicides and pesticides within the golf course and resort areas are generally not considered a significant risk to surface water and/or groundwater in the context of the overall size of the Development Zone and receiving rainfall.

  Similar to fertilisers discussed in Section 7.2, a site specific management plan for the golf course and the resort operations should be prepared that includes a detailed assessment of herbicide and pesticide requirements ensure that only required amounts of suitable chemicals are used within these properties to maintain the required standard.

- **Road sediment (i.e. oils, fine ground rubber, etc.).**

  The length of the road networks and associated vehicle use within the Development Zone is only a small component of the overall area of the Site.

  To reduce the impact from the limited road sediment on surface water ecosystems, all road run-off should be managed using WSUD techniques such as direction into constructed unlined swales and bunds and sediment/wetland treatment areas prior to diffuse discharge to gullies, creeks and wetlands.

- **Fuel and Chemical Transport.**

  Most chemical transport would be in relatively small overall quantities and comprising individual containers with volumes less than 20 litres. The most significant transport volume would comprise the delivery of fuel for construction purposes and possibly emergency generator supplies.

Given the relatively narrow access to the Development Zone, transport of bulk fuel supplies is likely to be limited smaller volume, non-articulated vehicles. Potential risks associated within such transport to the Site are generally no different to any other small coastal community location along the north Queensland coastline.

Within the Development Zone, the transport of bulk fuel will introduce a new potential risk to the Farm Creek and Farm Wetland Swale.

To reduce the potential impacts from spillage or leakage of liquid fuels during internal transport it is recommended that all road run-off should managed using WSUD techniques such as direction into constructed swales, bunds and sediment/wetland treatment areas that are designed with a capability and sufficient capacity to contain the maximum volume being transported.

- **Termite soil treatments for building construction.**

  All buildings within the Development Zone will require the use of termite protection during construction.

  Use and/or spillage of termite treatment chemicals for this purpose is not considered a significant risk to surface water and/or groundwater in the context of the overall size of the Development Zone and receiving rainfall.

  Where possible, however, the use of non-chemical protection methods such as wire meshes should be considered as an alternative, particularly for the resort buildings located adjacent to the Farm Wetland Swale.

7.4 Acid Sulfate Soils

Investigations completed to date (Golder 2006) indicate that acid sulfate soils (ASS) are not widespread within the Site.

Where ASS material is present and disturbed by excavations, dewatering or fill placement there is a risk to surface and groundwater quality and receiving ecosystems.

To protect water quality and ecosystems all areas of proposed development requiring ground disturbances located below 5 m AHD shall be subject to an ASS investigation and management, where identified, in accordance with Queensland State Planning Policy 2/02.

7.5 Key Project Outcomes and Recommendations

Sediment:

- **In relative terms the Development Zone comprises a large area. The adoption of a staged construction program over a 10 to 15 year period will, however, limit actual ground disturbance at any time to areas no greater in size than other typical coastal projects undertaken in Far North Queensland.**
- **Erosion and Sediment Control Plans (ESCP) for each stage of construction area, down to single lot scale, will be prepared by appropriate personnel and approved by Council as part of Operation Works Permit processes. Auditing of erosion and sediment control implementation and a comprehensive water quality monitoring program are required during and following construction.**
- **Planned revegetation works within open space areas will reduce existing sediment erosion from cleared areas and also provide additional sediment interception capacity during construction works.**
- **At the completion of construction works the Development Zone should produce less sediment loading to creeks and wetlands than is currently occurring due to farm use.**

Nutrients:

- **Water quality monitoring has identified that surface water and groundwater within the Development Zone contain elevated nutrient concentrations sourced from surrounding rainforest/wetland areas and farm activities.**
- **Potential nutrients from the development present a very low risk to surface water and groundwater quality within WTQWHA wetland areas located to the north.**
- **In accordance with standard development practice, detailed investigation, assessment and modelling of nutrient generation and uptake shall be undertaken as part obtaining approvals for each stage of development.**
- **Potential nutrient impacts identified by detailed assessment during each stage of development can be readily mitigated by a range of practical design and/or construction management strategies to protect creeks and wetland areas that flow directly to Ella Bay.**

Contaminants

- **Potential contaminants include fuel transport and storage, small scale domestic and commercial chemical use and storage, termite treatments, general litter and road sediment. Mitigation of potential impacts will be primarily achieved by appropriate storage and use, with secondary containment using WSUD techniques.**

Acid Sulphate Soils

- **Areas to be disturbed below 5 m AHD shall be subject to an acid sulfate soil investigation and management, where identified, in accordance with Queensland State Planning Policy 2/02. Timing for investigations shall be tied to approval of each stage of development.**

8.0 REEF PLAN

The Commonwealth and Queensland Governments in conjunction with a broad range of stakeholders have prepared the Reef Water Quality Protection Plan (Reef Plan, October 2003) that establishes a series of long term strategies with the following key objectives:

- Objective 1 Reduce the load of pollutants from diffuse sources in water entering the Reef.
- Objective 2 Rehabilitate and conserve areas of the Reef catchment that have a role in removing water borne pollutants.

Reef Plan identifies that the Johnstone River and Russell/Mulgrave River Systems within the top 10 high risk catchments. Ella Bay is located between these two catchment systems.

Relevant Strategies from Reef Plan that have the potential to be influenced by the proposed Ella Bay Integrated Resort are identified below:

- Strategy A Self Management Approaches

  Items 3/4 Support & Promote industry-lead development of best management practices.

  The Environmental Impact Statement clearly establishes that the proposed development is planned to provide best management practices for a range of potential environmental issues. With respect to water quality this report identifies that minimal changes to existing conditions are anticipated. Where potential risks or changes have been identified a range of best management practices mitigation measures have been identified to protect surface water ecosystems.

- Strategy B Education and Extension

  Item 4 Develop and implement a community awareness raising campaign.

  The Environmental Impact Statement identifies that a community education campaign is planned for future Ella Bay residents to support appropriate management of Cassowaries. This report identifies that the education campaign should also include education on the use and storage of domestic fertilisers and chemicals to protect surface water and groundwater quality.

- Strategy D Planning for Natural Resource Management and Land Use

  Item 8 Identify and establish nutrient sensitive zones.

  Studies being completed by others are assessing the ecological systems present within the Site and adjacent areas. This report identified two wetland areas (WTQWHA and Farm Wetland Swale) to assess potential interaction and potential impacts upon surface water and groundwater systems. Potential risks and identification of management strategies has been undertaken on the basis of potential nutrient impacts upon these two wetland areas.

Item 9 Acid Sulfate Soils

This report supports the implementation of the State Planning Policy involving Acid Sulfate Soils.

Item 10 Net gain of riparian and wetland areas.

The Environmental Impact Statement identifies that minimal disturbance is planned to existing riparian and wetland areas located within and adjacent to the Development Zone. It is also intended to rehabilitate creek bank and cassowary corridor areas as part of the proposed development.

- Strategy I Monitoring and Evaluation

  Item 6 Implement industry-based water quality monitoring programs.

  A surface water and groundwater monitoring program has commenced within the Development Zone. This program will continue through the planning, design and construction phases of the development to clearly establish base-line water quality conditions and to maintain and enhance these conditions through the use of appropriate design and management.

This report indicates that a well planned, constructed and operated development at Ella Bay will have minimal impact upon surface water and groundwater hydrology and quality and adjacent wetland areas. Planning for the development is primarily based upon protection of immediate adjacent wetland areas within the Northern Freehold Area and the Farm Wetland Swale. The protection of these potentially more sensitive on-shore wetland ecosystems will in turn provide suitable protection for the adjacent area of the Reef lagoon. A range of design and mitigation measures have been identified that will need to be considered and implemented to maintain and, where possible, enhance water quality.

The recommended approach should not only provide adequate protection of water quality, it also actively supports the various strategies for implementation of Reef Plan and its key objectives.

9.0 LIMITATIONS OF THIS REPORT

This report has been prepared in accordance with the agreement between White Beech Pty Ltd and Golder Associates Pty Ltd (Golder Associates). The services performed by Golder Associates have been conducted in a manner consistent with the level of quality and skill generally exercised by members of its profession and consulting practice. No warranty or guarantee of site conditions is intended.

This report is solely for the use of White Beech Pty Ltd, Ella Bay Developments Pty Ltd and relevant government assessment agencies and any reliance of this report by third parties shall be at such party's sole risk and may not contain sufficient information for purposes of other parties or for other uses. This report shall only be presented in full and may not be used to support any other objective than those set out in the report, except where written approval with comments are provided by Golder Associates.

The information in this report is considered to be accurate at the date of issue in accordance to the current conditions of the site. Subsurface conditions can vary across a particular site which cannot be explicitly defined by investigation. Therefore, it is unlikely that the results and estimations expressed in this report will represent the extremes of conditions within the site.

Attached as Appendix D is a document "Important Information About Your Geo-Environmental Report" which should be read in conjunction with this report. We would be pleased to answer any questions about this important information.

GOLDER ASSOCIATES PTY LTD

James Begg
Senior Environmental Engineer

Paul Scells
Principal

JSB/PKS/rlz
J:\3ENV07\077673018\CORRESPONDENCE_OUT\001-077673018\001-077673018-R3-CONCEPT HYDROLOGY MODELS.DOC

Station Name	Sample Date	Sample Season	pH* pH units	EC* µS/cm	Chloride mg/L	Sulphate mg/L	Ammonia Nitrogen mg/L	Total Kjeldahl Nitrogen mg/L	Total Oxidised Nitrogen ** mg/L	Total Nitrogen mg/L	Total Phosphorus (as P)*** mg/L	Arsenic mg/L	Cadmium mg/L	Chromium mg/L	Copper mg/L	Lead mg/L	Nickel mg/L	Zinc mg/L	Mercury mg/L	Aluminium mg/L	Manganese mg/L	Iron mg/L	Total Iron mg/l	Calcium mg/L	Magnesium mg/L
LCSW1	13/11/2006	End of Dry	6.7	70	13	22	<0.05	0.12	<0.05	0.12	**<0.02**	<0.005	<0.0002	<0.002	<0.001	<0.002	<0.002	0.005	<0.0002	<0.05	<0.05	0.49	1.0	2.0	2.3
	22/05/2007	Wet Season	7.0	46	12	2	<0.05	0.15	***0.09***	**0.24**	<0.02	<0.005	<0.0002	<0.05	<0.01	<0.002	<0.05	0.006	<0.0002	**0.16**	0.05	0.22	0.3	2.1	2.0
LCSW2	13/11/2006	End of Dry	6.5	73	12	2	0.05	0.14	<0.05	0.14	**<0.02**	<0.005	<0.0002	<0.002	<0.001	<0.002	<0.002	0.007	<0.0002	<0.05	<0.05	0.55	1.0	2.0	2.3
	22/05/2007	Wet Season	6.9	42	11	2	<0.05	0.11	***0.07***	0.18	<0.02	<0.005	<0.0002	<0.05	<0.01	<0.002	<0.05	<0.005	<0.0002	**0.22**	<0.05	0.19	0.3	2.8	2.2
LCSW3	13/11/2006	End of Dry	6.8	79	15	35	0.07	0.12	***0.15***	***0.27***	**<0.02**	<0.005	<0.0002	<0.002	<0.001	<0.002	<0.002	**0.012**	<0.0002	<0.05	<0.05	<0.05	0.23	1.6	2.0
	22/05/2007	Wet Season	6.9	42	12	2	<0.05	0.12	***0.23***	***0.35***	<0.02	<0.005	<0.0002	<0.05	<0.01	<0.002	<0.05	<0.005	<0.0002	**0.78**	<0.05	<0.05	<0.05	2.8	2.2
EBSW4	24/06/2007	End of Wet	6.4	288	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t
EBSW5	24/06/2007	End of Wet	6.8	155	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t
EBSW6	24/06/2007	End of Wet	5.4	122	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t
MW1	14/11/2006	End of Dry	5.9	42	13	12	<0.05	0.16	***0.06***	**0.22**	***0.34***	<0.005	<0.0002	<0.002	<0.001	<0.002	<0.002	0.006	<0.0002	<0.05	0.06	<0.05	48	0.8	1.5
	22/05/2007	Wet Season	5.8	35	12	2	<0.05	0.2	***0.05***	***0.25***	***0.17***	<0.005	<0.0002	<0.05	<0.01	<0.002	<0.05	<0.005	<0.0002	**0.35**	<0.05	<0.05	<0.05	1.9	1.6
MW2	14/11/2006	End of Dry	5.6	91	14	2	<0.05	0.19	<0.05	0.19	***0.12***	<0.005	<0.0002	<0.002	***0.003***	<0.002	<0.002	**0.012**	<0.0002	<0.05	0.41	<0.05	9.8	0.6	1.8
	22/05/2007	Wet Season	5.7	49	12	<2	<0.05	0.73	<0.05	***0.73***	***0.27***	<0.005	<0.0002	<0.05	<0.01	<0.002	<0.05	<0.005	<0.0002	**0.21**	0.28	<0.05	<0.05	1.7	1.6
MW3	14/11/2006	End of Dry	5.3	86	9	4	0.05	0.27	<0.05	***0.27***	***0.49***	<0.005	<0.0002	<0.002	<0.001	<0.002	<0.002	***0.062***	<0.0002	<0.05	<0.05	<0.05	11	<0.5	<0.5
	22/05/2007	Wet Season	5.0	17	8	2	<0.05	0.51	<0.05	***0.51***	***0.39***	<0.005	<0.0002	<0.05	<0.01	<0.002	<0.05	**0.011**	<0.0002	**0.37**	0.05	1.4	1	0.9	<0.5
ANZECC Water Quality Guidelines 2000, Trigger Values for Fresh Waters 95% Level of Protection			**6.0-8.0[a]**	**20-250[a]**	-	-	**0.9**	-	**0.01[a]**	**0.2-0.3[a]**	**0.01[a]**	**0.024^**	**0.0002**	**0.001^^**	**0.0014**	**0.0034**	**0.011**	**0.008**	**0.0006^^^**	**0.055**	**1.9**	**ID**	**ID**	-	-
ANZECC Water Quality Guidelines 2000, Trigger Values for Marine Waters 95% Level of Protection			***7.0-8.5[b]***	-	-	-	***0.91***	-	***0.03[b]***	***0.25[b]***	***0.02[b]***	***ID***	***0.0055***	***0.0044^^***	***0.0013***	***0.0044***	***0.007***	***0.015***	***0.0004^^^***	***ID***	***ID***	***ID***	***ID***	-	-

Note:
n/t = Not Tested
* = Parameter tested in the field
** = Oxides of Nitrogen (NO_x) trigger value
*** = 2007 Total Phosphorus results tested as Total Kjeldahl Phosphorus
^ = Arsenic (III)
^^ = Chromium (Cr VI)
^^^ = Mercury (inorganic)
a = ANZECC Water Quality Guidelines 2000, Trigger values for Tropical Australia Lowland river ecosystem
b = ANZECC Water Quality Guidelines 2000, Trigger values for Tropical Australia Estuarie ecosystem
ID =Insufficient Data
Results in bold exceed the ANZECC water quality guidelines 2000, trigger values for fresh waters 95% level of protection.
Results in bold italics and underlined exceed the ANZECC water quality guidelines 2000, trigger values for marine waters 95% level of protection.

Golder Associates

TABLE 1
SUMMARY OF WATER TEST RESULTS

Client **Ella Bay Developments Pty Ltd**
Job Title **Conceptual Surface Water and Groundwater Models**
Location **Ella Bay**

Input By: AOB
Date: 11/07/2007
Checked By: PKS
Date: 11/07/2007

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area	**Rate**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
(Ha)	**(mm)**	**Evaporation (mm)**	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
-	-	Upstream Catchments	0	0	0	0	0	0	0	0	0	0	0	0	0
222	120%	Rainforest Rainfall	670,440	899,411	1,067,243	723,942	392,807	196,026	59,096	0	0	0	0	104,429	4,113,394
61	110%	Farmland Rainfall	194,621	256,700	302,328	206,058	114,174	58,987	21,722	336	0	0	0	39,662	1,194,587
0	120%	Wetland Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
-		Groundwater Discharge/(Recharge)	(267,420)	(241,290)	(267,420)	(258,710)	(267,420)	(253,461)	(78,303)	0	0	0	0	(140,515)	(1,774,539)
283	**-**	**Subtotal**	**597,641**	**914,821**	**1,102,151**	**671,290**	**239,561**	**1,552**	**2,516**	**336**	**0**	**0**	**0**	**3,576**	**3,533,442**
Groundwater Flows				**Wet' Season Rainfall to Recharge Limit**				**97%**	**29%**	**0%**	**0%**	**0%**	**0%**	**53%**	
93	4	Unit A Recharge/(Discharge)	103,558	92,398	103,558	99,838	103,558	96,490	21,681	(11,762)	(11,762)	(11,762)	(11,762)	49,358	623,390
71	2	Unit B Recharge/(Discharge)	48,566	44,306	48,566	47,146	48,566	66,034	37,478	24,712	24,712	24,712	24,712	27,876	467,385
119	3	Unit C Recharge/(Discharge)	102,346	91,636	102,346	98,776	102,346	90,937	19,144	(12,950)	(12,950)	(12,950)	(12,950)	50,331	606,064
0	1	Unit D Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	20	Unit E Recharge/(Discharge)	12,950	12,950	12,950	12,950	12,950	0	0	0	0	0	0	12,950	77,700
283	**-**	**Subtotal**	**267,420**	**241,290**	**267,420**	**258,710**	**267,420**	**253,461**	**78,303**	**0**	**0**	**0**	**0**	**140,515**	**1,774,539**
		Catchment Discharge													
283	-	Surface Water - Catchment A2	597,641	914,821	1,102,151	671,290	239,561	1,552	2,516	336	0	0	0	3,576	3,533,442
93	-	Groundwater - Unit A	103,558	92,398	103,558	99,838	103,558	96,490	21,681	(11,762)	(11,762)	(11,762)	(11,762)	49,358	623,390
71	-	Unit B	48,566	44,306	48,566	47,146	48,566	66,034	37,478	24,712	24,712	24,712	24,712	27,876	467,385
119	-	Unit C	102,346	91,636	102,346	98,776	102,346	90,937	19,144	(12,950)	(12,950)	(12,950)	(12,950)	50,331	606,064
0	-	Unit D	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit E	12,950	12,950	12,950	12,950	12,950	0	0	0	0	0	0	12,950	77,700
283	**-**	**Subtotal**	**865,061**	**1,156,111**	**1,369,571**	**930,000**	**506,981**	**255,013**	**80,819**	**335**	**(0)**	**(0)**	**(0)**	**144,091**	**5,307,981**

TABLE 2A

PRELIMINARY WATER BALANCE - CATCHMENT A1

Project **77673018**

Client **Ella Bay Developments Pty Ltd**

Job Title **Conceptual Surface Water and Groundwater Models**

Location **Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area (Ha)	**Rate (mm)**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
		Evaporation (mm)	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
283	-	Upstream Catchments	597,641	914,821	1,102,151	671,290	239,561	1,552	2,516	336	0	0	0	3,576	3,533,442
345	120%	Rainforest Rainfall	1,041,900	1,397,733	1,658,553	1,125,045	610,443	304,635	91,839	0	0	0	0	162,288	6,392,436
95	110%	Farmland Rainfall	303,098	399,779	470,839	320,910	177,812	91,865	33,830	523	0	0	0	61,769	1,860,423
0	120%	Wetland Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
-		Groundwater Discharge/(Recharge)	(541,732)	(504,682)	(541,732)	(529,382)	(541,732)	(386,518)	(116,006)	9,482	9,482	9,482	9,482	(219,828)	(3,343,684)
723	**-**	**Subtotal**	**1,400,906**	**2,207,651**	**2,689,811**	**1,587,863**	**486,083**	**11,534**	**12,178**	**10,340**	**9,482**	**9,482**	**9,482**	**7,805**	**8,442,616**
Groundwater Flows				**Wet' Season Rainfall to Recharge Limit**				**75%**	**23%**	**0%**	**0%**	**0%**	**0%**	**41%**	
130	4	Unit A Recharge/(Discharge)	145,733	130,133	145,733	140,533	145,733	101,533	21,609	(15,467)	(15,467)	(15,467)	(15,467)	50,625	819,762
110	2	Unit B Recharge/(Discharge)	73,485	66,885	73,485	71,285	73,485	81,936	48,122	32,436	32,436	32,436	32,436	33,247	651,672
165	3	Unit C Recharge/(Discharge)	142,796	127,946	142,796	137,846	142,796	113,370	37,289	1,995	1,995	1,995	1,995	52,260	905,080
0	1	Unit D Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
35	15	Unit E Recharge/(Discharge)	179,719	179,719	179,719	179,719	179,719	89,679	8,986	(28,446)	(28,446)	(28,446)	(28,446)	83,696	967,171
440	**-**	**Subtotal**	**541,732**	**504,682**	**541,732**	**529,382**	**541,732**	**386,518**	**116,006**	**(9,482)**	**(9,482)**	**(9,482)**	**(9,482)**	**219,828**	**3,343,684**
		Catchment Discharge													
723	-	Surface Water - Catchment A4	1,400,906	2,207,651	2,689,811	1,587,863	486,083	11,534	12,178	10,340	9,482	9,482	9,482	7,805	8,442,616
130	-	Groundwater - Unit A	145,733	130,133	145,733	140,533	145,733	101,533	21,609	(15,467)	(15,467)	(15,467)	(15,467)	50,625	819,762
110	-	Unit B	73,485	66,885	73,485	71,285	73,485	81,936	48,122	32,436	32,436	32,436	32,436	33,247	651,672
165	-	Unit C	142,796	127,946	142,796	137,846	142,796	113,370	37,289	1,995	1,995	1,995	1,995	52,260	905,080
0	-	Unit D	0	0	0	0	0	0	0	0	0	0	0	0	0
35	-	Unit E	179,719	179,719	179,719	179,719	179,719	89,679	8,986	(28,446)	(28,446)	(28,446)	(28,446)	83,696	967,171
723	**-**	**Subtotal**	**1,942,638**	**2,712,333**	**3,231,543**	**2,117,245**	**1,027,815**	**398,052**	**128,184**	**858**	**0**	**0**	**0**	**227,633**	**11,786,301**

TABLE 2B

PRELIMINARY WATER BALANCE - CATCHMENT A2

Project **77673018**

Client **Ella Bay Developments Pty Ltd**

Job Title **Conceptual Surface Water and Groundwater Models**

Location **Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area	**Rate**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
(Ha)	**(mm)**	**Evaporation (mm)**	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
-	-	Upstream Catchments	0	0	0	0	0	0	0	0	0	0	0	0	0
31	120%	Rainforest Rainfall	93,620	125,593	149,029	101,091	54,851	27,373	8,252	0	0	0	0	14,582	574,393
45	110%	Farmland Rainfall	143,573	189,369	223,029	152,010	84,227	43,515	16,025	248	0	0	0	29,259	881,253
0	120%	Wetland Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
-		Groundwater Discharge/(Recharge)	(116,014)	(110,134)	(116,014)	(114,054)	(116,014)	(58,011)	(18,080)	2,901	2,901	2,901	2,901	(36,754)	(673,475)
76	**-**	**Subtotal**	**121,178**	**204,828**	**256,044**	**139,047**	**23,063**	**12,877**	**6,197**	**3,148**	**2,901**	**2,901**	**2,901**	**7,088**	**782,171**
Groundwater Flows				**Wet' Season Rainfall to Recharge Limit**				**54%**	**18%**	**0%**	**0%**	**0%**	**0%**	**32%**	
24	4	Unit A Recharge/(Discharge)	27,062	24,182	27,062	26,102	27,062	12,854	2,658	(2,698)	(2,698)	(2,698)	(2,698)	6,825	143,012
20	2	Unit B Recharge/(Discharge)	13,341	12,141	13,341	12,941	13,341	11,181	6,933	4,701	4,701	4,701	4,701	4,909	106,931
20	3	Unit C Recharge/(Discharge)	17,809	16,009	17,809	17,209	17,809	13,519	7,147	3,799	3,799	3,799	3,799	5,161	127,667
0	1	Unit D Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
12	15	Unit E Recharge/(Discharge)	57,803	57,803	57,803	57,803	57,803	20,458	1,342	(8,702)	(8,702)	(8,702)	(8,702)	19,859	295,865
76	**-**	**Subtotal**	**116,014**	**110,134**	**116,014**	**114,054**	**116,014**	**58,011**	**18,080**	**(2,901)**	**(2,901)**	**(2,901)**	**(2,901)**	**36,754**	**673,475**
		Catchment Discharge													
76	-	Surface Water - Catchment A4	121,178	204,828	256,044	139,047	23,063	12,877	6,197	3,148	2,901	2,901	2,901	7,088	782,171
24	-	Groundwater - Unit A	27,062	24,182	27,062	26,102	27,062	12,854	2,658	(2,698)	(2,698)	(2,698)	(2,698)	6,825	143,012
20	-	Unit B	13,341	12,141	13,341	12,941	13,341	11,181	6,933	4,701	4,701	4,701	4,701	4,909	106,931
20	-	Unit C	17,809	16,009	17,809	17,209	17,809	13,519	7,147	3,799	3,799	3,799	3,799	5,161	127,667
0	-	Unit D	0	0	0	0	0	0	0	0	0	0	0	0	0
12	-	Unit E	57,803	57,803	57,803	57,803	57,803	20,458	1,342	(8,702)	(8,702)	(8,702)	(8,702)	19,859	295,865
76	**-**	**Subtotal**	**237,193**	**314,962**	**372,058**	**253,101**	**139,078**	**70,888**	**24,277**	**248**	**0**	**0**	**0**	**43,841**	**1,455,646**

TABLE 2C

PRELIMINARY WATER BALANCE - CATCHMENT A3

Project **77673018**

Client **Ella Bay Developments Pty Ltd**

Job Title **Conceptual Surface Water and Groundwater Models**

Location **Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area	**Rate**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
(Ha)	**(mm)**	**Evaporation (mm)**	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
1,082	-	Upstream Catchments	1,522,084	2,412,479	2,945,855	1,726,909	509,146	24,411	18,375	13,488	12,383	12,383	12,383	14,892	9,224,788
0	120%	Rainforest Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
28	110%	Farmland Rainfall	89,334	117,830	138,774	94,584	52,408	27,076	9,971	154	0	0	0	18,206	548,335
39	120%	Wetland Rainfall	124,430	164,120	193,292	131,742	72,996	37,713	13,888	215	0	0	0	25,358	763,753
-		Groundwater Discharge/(Recharge)	(315,263)	(315,263)	(315,263)	(315,263)	(130,343)	(50,584)	(9,078)	12,731	12,731	12,731	12,731	(47,330)	(1,447,468)
67	**-**	**Subtotal**	**1,420,584**	**2,379,165**	**2,962,657**	**1,637,972**	**504,207**	**38,615**	**33,155**	**26,587**	**25,113**	**25,113**	**25,113**	**11,125**	**9,089,408**
Groundwater Flows			**Wet' Season Rainfall to Recharge Limit**				**42%**	**21%**	**7%**	**0%**	**0%**	**0%**	**0%**	**14%**	
0	4	Unit A Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	2	Unit B Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	Unit C Recharge/(Discharge)	(637)	(637)	(637)	(637)	(637)	25,461	25,461	25,461	25,461	25,461	25,461	(637)	148,948
0	1	Unit D Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
67	15	Unit E Recharge/(Discharge)	315,900	315,900	315,900	315,900	130,980	25,123	(16,383)	(38,192)	(38,192)	(38,192)	(38,192)	47,967	1,298,520
67	**-**	**Subtotal**	**315,263**	**315,263**	**315,263**	**315,263**	**130,343**	**50,584**	**9,078**	**(12,731)**	**(12,731)**	**(12,731)**	**(12,731)**	**47,330**	**1,447,468**
		Catchment Discharge													
67	-	Surface Water - Catchment A4	1,420,584	2,379,165	2,962,657	1,637,972	504,207	38,615	33,155	26,587	25,113	25,113	25,113	11,125	9,089,408
0	-	Groundwater - Unit A	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit B	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit C	(637)	(637)	(637)	(637)	(637)	25,461	25,461	25,461	25,461	25,461	25,461	(637)	148,948
0	-	Unit D	0	0	0	0	0	0	0	0	0	0	0	0	0
67	-	Unit E	315,900	315,900	315,900	315,900	130,980	25,123	(16,383)	(38,192)	(38,192)	(38,192)	(38,192)	47,967	1,298,520
67	**-**	**Subtotal**	**1,735,847**	**2,694,428**	**3,277,920**	**1,953,235**	**634,550**	**89,200**	**42,233**	**13,857**	**12,383**	**12,383**	**12,383**	**58,456**	**10,536,875**

TABLE 2D

PRELIMINARY WATER BALANCE - CATCHMENT A4

Project **77673018**

Client **Ella Bay Developments Pty Ltd**

Job Title **Conceptual Surface Water and Groundwater Models**

Location **Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area (Ha)	**Rate (mm)**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
		Evaporation (mm)	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
-	-	Upstream Catchments	0	0	0	0	0	0	0	0	0	0	0	0	0
55	120%	Rainforest Rainfall	166,100	222,827	264,407	179,355	97,317	48,565	14,641	0	0	0	0	25,872	1,019,084
29	110%	Farmland Rainfall	92,525	122,038	143,730	97,962	54,279	28,043	10,327	159	0	0	0	18,856	567,919
18	120%	Wetland Rainfall	57,429	75,748	89,212	60,804	33,691	17,406	6,410	99	0	0	0	11,704	352,501
-		Groundwater Discharge/(Recharge)	(95,249)	(85,919)	(95,249)	(92,139)	(95,249)	(93,300)	(30,851)	0	0	0	0	(54,757)	(642,713)
102	**-**	**Subtotal**	**220,805**	**334,693**	**402,099**	**245,982**	**90,038**	**714**	**527**	**258**	**0**	**0**	**0**	**1,675**	**1,296,791**
Groundwater Flows			**Wet' Season Rainfall to Recharge Limit**					**100%**	**32%**	**0%**	**0%**	**0%**	**0%**	**58%**	
30	4	Unit A Recharge/(Discharge)	33,343	29,743	33,343	32,143	33,343	32,143	8,047	(3,857)	(3,857)	(3,857)	(3,857)	17,719	204,401
25	2	Unit B Recharge/(Discharge)	16,844	15,344	16,844	16,344	16,844	24,017	13,977	9,017	9,017	9,017	9,017	10,334	166,619
47	3	Unit C Recharge/(Discharge)	45,061	40,831	45,061	43,651	45,061	37,140	8,827	(5,160)	(5,160)	(5,160)	(5,160)	26,703	271,693
0	1	Unit D Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	15	Unit E Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
102	**-**	**Subtotal**	**95,249**	**85,919**	**95,249**	**92,139**	**95,249**	**93,300**	**30,851**	**0**	**0**	**0**	**0**	**54,757**	**642,713**
		Catchment Discharge													
102	-	Surface Water - Catchment A4	220,805	334,693	402,099	245,982	90,038	714	527	258	0	0	0	1,675	1,296,791
30	-	Groundwater - Unit A	33,343	29,743	33,343	32,143	33,343	32,143	8,047	(3,857)	(3,857)	(3,857)	(3,857)	17,719	204,401
25	-	Unit B	16,844	15,344	16,844	16,344	16,844	24,017	13,977	9,017	9,017	9,017	9,017	10,334	166,619
47	-	Unit C	45,061	40,831	45,061	43,651	45,061	37,140	8,827	(5,160)	(5,160)	(5,160)	(5,160)	26,703	271,693
0	-	Unit D	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit E	0	0	0	0	0	0	0	0	0	0	0	0	0
102	**-**	**Subtotal**	**316,054**	**420,612**	**497,348**	**338,121**	**185,287**	**94,014**	**31,378**	**258**	**0**	**0**	**0**	**56,431**	**1,939,504**

TABLE 2E

PRELIMINARY WATER BALANCE - CATCHMENT B1

Project **77673018**

Client **Ella Bay Developments Pty Ltd**

Job Title **Conceptual Surface Water and Groundwater Models**

Location **Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area	**Rate**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
(Ha)	**(mm)**	**Evaporation (mm)**	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
-	-	Upstream Catchments	0	0	0	0	0	0	0	0	0	0	0	0	0
0	120%	Rainforest Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
7	110%	Farmland Rainfall	22,334	29,457	34,693	23,646	13,102	6,769	2,493	39	0	0	0	4,551	137,084
12	120%	Wetland Rainfall	38,286	50,498	59,474	40,536	22,460	11,604	4,273	66	0	0	0	7,802	235,001
-		Groundwater Discharge/(Recharge)	(64,200)	(83,865)	(89,850)	(68,475)	(39,405)	(14,733)	(2,962)	3,222	3,222	3,222	3,222	(16,719)	(367,321)
19	**-**	**Subtotal**	**(3,580)**	**(3,909)**	**4,318**	**(4,293)**	**(3,843)**	**3,640**	**3,804**	**3,327**	**3,222**	**3,222**	**3,222**	**(4,365)**	**4,764**
Groundwater Flows			**70%**	**93%**	**100%**	**75%**	**41%**	**21%**	**7%**	**0%**	**0%**	**0%**	**0%**	**14%**	
0	4	Unit A Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	2	Unit B Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	Unit C Recharge/(Discharge)	0	0	0	0	0	6,444	6,444	6,444	6,444	6,444	6,444	0	38,665
0	1	Unit D Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
19	15	Unit E Recharge/(Discharge)	64,200	83,865	89,850	68,475	39,405	8,289	(3,482)	(9,666)	(9,666)	(9,666)	(9,666)	16,719	328,655
19	**-**	**Subtotal**	**64,200**	**83,865**	**89,850**	**68,475**	**39,405**	**14,733**	**2,962**	**(3,222)**	**(3,222)**	**(3,222)**	**(3,222)**	**16,719**	**367,321**
		Catchment Discharge													
19	-	Surface Water - Catchment A4	(3,580)	(3,909)	4,318	(4,293)	(3,843)	3,640	3,804	3,327	3,222	3,222	3,222	(4,365)	4,764
0	-	Groundwater - Unit A	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit B	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit C	0	0	0	0	0	6,444	6,444	6,444	6,444	6,444	6,444	0	38,665
0	-	Unit D	0	0	0	0	0	0	0	0	0	0	0	0	0
19	-	Unit E	64,200	83,865	89,850	68,475	39,405	8,289	(3,482)	(9,666)	(9,666)	(9,666)	(9,666)	16,719	328,655
19	**-**	**Subtotal**	**60,620**	**79,956**	**94,168**	**64,182**	**35,562**	**18,373**	**6,766**	**104**	**0**	**0**	**0**	**12,354**	**372,085**

TABLE 2F

PRELIMINARY WATER BALANCE - CATCHMENT B2

Project **77673018**

Client **Ella Bay Developments Pty Ltd**

Job Title **Conceptual Surface Water and Groundwater Models**

Location **Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area	**Rate**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
(Ha)	**(mm)**	**Evaporation (mm)**	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
		Surface Water Flows													
19	-	Upstream Catchments	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(3,580)	(42,966)
0	120%	Rainforest Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
2	110%	Farmland Rainfall	6,381	8,416	9,912	6,756	3,743	1,934	712	11	0	0	0	1,300	39,167
15	120%	Wetland Rainfall	47,858	63,123	74,343	50,670	28,076	14,505	5,342	83	0	0	0	9,753	293,751
-		Groundwater Discharge/(Recharge)	(51,520)	(51,520)	(51,520)	(51,520)	(36,220)	(14,972)	(3,386)	2,455	2,455	2,455	2,455	(15,544)	(266,384)
17	**-**	**Subtotal**	**(862)**	**16,439**	**29,155**	**2,326**	**(7,982)**	**(2,114)**	**(913)**	**(1,032)**	**(1,126)**	**(1,126)**	**(1,126)**	**(8,071)**	**23,568**
		Groundwater Flows	**100%**	**100%**	**100%**	**100%**	**66%**	**37%**	**12%**	**0%**	**0%**	**0%**	**0%**	**23%**	
0	4	Unit A Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	2	Unit B Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	Unit C Recharge/(Discharge)	0	0	0	0	0	4,479	4,479	4,479	4,479	4,479	4,479	0	26,873
0	1	Unit D Recharge/(Discharge)	2,170	2,170	2,170	2,170	2,170	2,801	2,285	2,024	2,024	2,024	2,024	499	24,532
10	15	Unit E Recharge/(Discharge)	49,350	49,350	49,350	49,350	34,050	7,693	(3,378)	(8,958)	(8,958)	(8,958)	(8,958)	15,045	214,980
10	**-**	**Subtotal**	**51,520**	**51,520**	**51,520**	**51,520**	**36,220**	**14,972**	**3,386**	**(2,455)**	**(2,455)**	**(2,455)**	**(2,455)**	**15,544**	**266,384**
		Catchment Discharge													
17	-	Surface Water - Catchment A4	(862)	16,439	29,155	2,326	(7,982)	(2,114)	(913)	(1,032)	(1,126)	(1,126)	(1,126)	(8,071)	23,568
0	-	Groundwater - Unit A	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit B	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit C	0	0	0	0	0	4,479	4,479	4,479	4,479	4,479	4,479	0	26,873
0	-	Unit D	2,170	2,170	2,170	2,170	2,170	2,801	2,285	2,024	2,024	2,024	2,024	499	24,532
10	-	Unit E	49,350	49,350	49,350	49,350	34,050	7,693	(3,378)	(8,958)	(8,958)	(8,958)	(8,958)	15,045	214,980
17	**-**	**Subtotal**	**50,658**	**67,959**	**80,675**	**53,846**	**28,238**	**12,859**	**2,473**	**(3,487)**	**(3,580)**	**(3,580)**	**(3,580)**	**7,473**	**289,952**

TABLE 2G

PRELIMINARY WATER BALANCE - CATCHMENT B3

Project	**77673018**
Client	**Ella Bay Developments Pty Ltd**
Job Title	**Conceptual Surface Water and Groundwater Models**
Location	**Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area	**Rate**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
(Ha)	**(mm)**	**Evaporation (mm)**	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
-	-	Upstream Catchments	0	0	0	0	0	0	0	0	0	0	0	0	0
0	120%	Rainforest Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
2	110%	Farmland Rainfall	6,381	8,416	9,912	6,756	3,743	1,934	712	11	0	0	0	1,300	39,167
21	120%	Wetland Rainfall	67,001	88,372	104,080	70,938	39,306	20,307	7,478	115	0	0	0	13,654	411,251
-		Groundwater Discharge/(Recharge)	(65,950)	(65,950)	(65,950)	(65,950)	(47,230)	(18,994)	(5,115)	3,146	3,146	3,146	3,146	(18,967)	(341,521)
23	**-**	**Subtotal**	**7,432**	**30,839**	**48,043**	**11,744**	**(4,181)**	**3,247**	**3,075**	**3,273**	**3,146**	**3,146**	**3,146**	**(4,012)**	**108,897**
Groundwater Flows			**100%**	**100%**	**100%**	**100%**	**68%**	**36%**	**13%**	**0%**	**0%**	**0%**	**0%**	**23%**	
0	4	Unit A Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	2	Unit B Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	Unit C Recharge/(Discharge)	0	0	0	0	0	5,712	5,712	5,712	5,712	5,712	5,712	0	34,270
0	1	Unit D Recharge/(Discharge)	3,100	3,100	3,100	3,100	3,100	3,646	2,969	2,566	2,566	2,566	2,566	713	33,090
13	15	Unit E Recharge/(Discharge)	62,850	62,850	62,850	62,850	44,130	9,637	(3,565)	(11,423)	(11,423)	(11,423)	(11,423)	18,254	274,162
13	**-**	**Subtotal**	**65,950**	**65,950**	**65,950**	**65,950**	**47,230**	**18,994**	**5,115**	**(3,146)**	**(3,146)**	**(3,146)**	**(3,146)**	**18,967**	**341,521**
		Catchment Discharge													
23	-	Surface Water - Catchment A4	7,432	30,839	48,043	11,744	(4,181)	3,247	3,075	3,273	3,146	3,146	3,146	(4,012)	108,897
0	-	Groundwater - Unit A	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit B	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	Unit C	0	0	0	0	0	5,712	5,712	5,712	5,712	5,712	5,712	0	34,270
0	-	Unit D	3,100	3,100	3,100	3,100	3,100	3,646	2,969	2,566	2,566	2,566	2,566	713	33,090
13	-	Unit E	62,850	62,850	62,850	62,850	44,130	9,637	(3,565)	(11,423)	(11,423)	(11,423)	(11,423)	18,254	274,162
23	**-**	**Subtotal**	**73,382**	**96,789**	**113,993**	**77,694**	**43,049**	**22,241**	**8,190**	**126**	**0**	**0**	**0**	**14,955**	**450,418**

TABLE 2H

PRELIMINARY WATER BALANCE - CATCHMENT B4

Project **77673018**

Client **Ella Bay Developments Pty Ltd**

Job Title **Conceptual Surface Water and Groundwater Models**

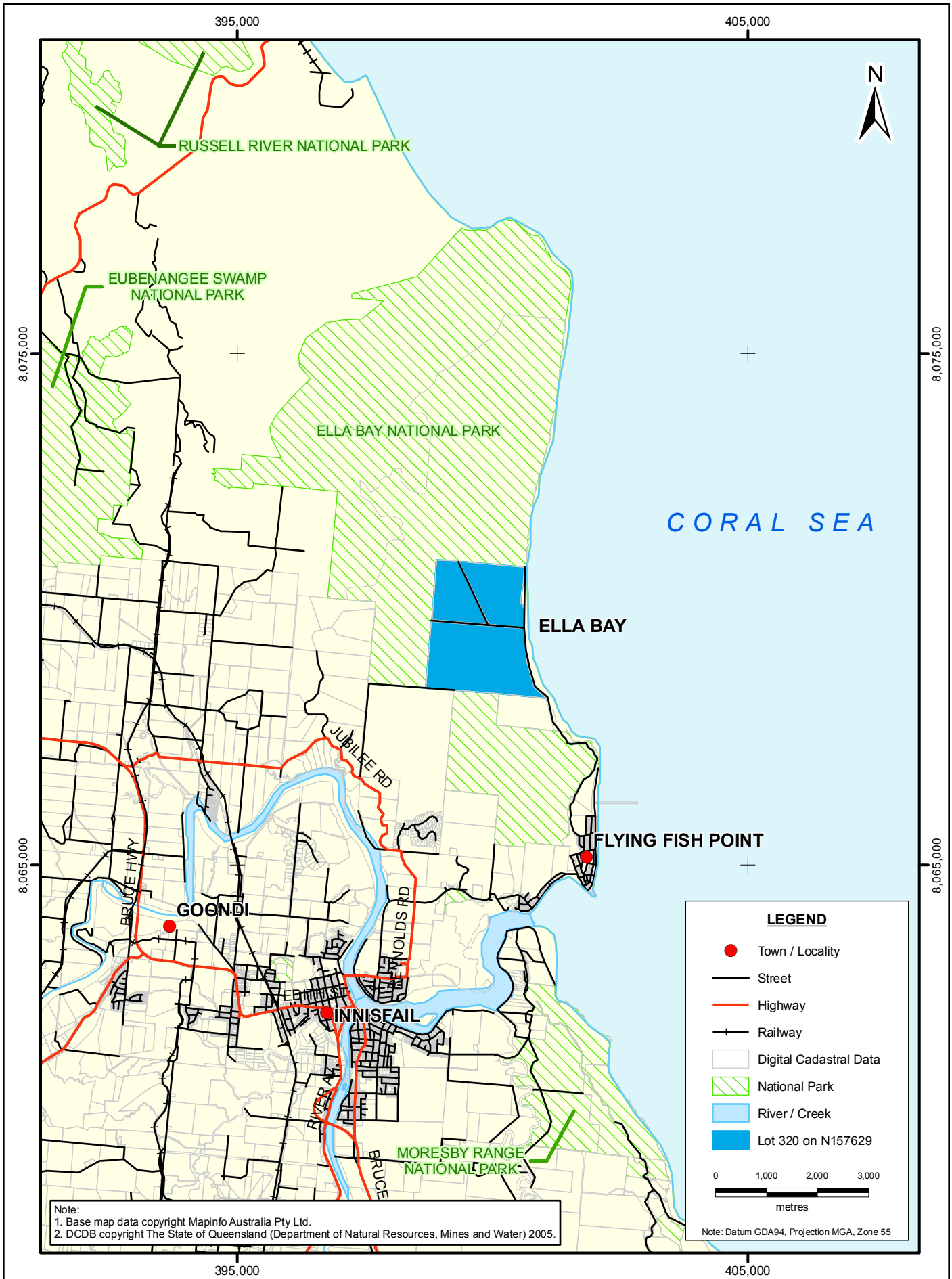
Location **Ella Bay**

			January	February	March	April	May	June	July	August	September	October	November	December	Year
Area	**Rate**	**Rainfall (mm)**	**506.6**	**593.3**	**659.3**	**466.5**	**299.7**	**189.1**	**134.5**	**119.9**	**84.6**	**82.6**	**155.5**	**262.8**	**3554.4**
(Ha)	**(mm)**	**Evaporation (mm)**	**170.5**	**156.8**	**148.8**	**117.0**	**102.3**	**84.0**	**89.9**	**108.5**	**135.0**	**170.5**	**171.0**	**179.8**	**1634.1**
Surface Water Flows															
161	-	Upstream Catchments	223,794	378,062	483,615	255,759	74,033	5,487	6,492	5,825	5,242	5,242	5,242	(14,774)	1,434,020
242	120%	Rainforest Rainfall	730,840	980,439	1,163,391	789,162	428,195	213,686	64,420	0	0	0	0	113,837	4,483,970
0	110%	Farmland Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0
431	120%	Wetland Rainfall	1,375,106	1,813,734	2,136,122	1,455,918	806,703	416,777	153,479	2,371	0	0	0	280,236	8,440,445
-		Groundwater Discharge/(Recharge)	(505,930)	(482,890)	(505,930)	(498,250)	(505,930)	(473,405)	(201,184)	16,495	16,495	16,495	16,495	(399,209)	(3,506,746)
673	**-**	**Subtotal**	**1,823,809**	**2,689,345**	**3,277,198**	**2,002,589**	**803,000**	**162,546**	**23,208**	**24,691**	**21,738**	**21,738**	**21,738**	**(19,910)**	**10,851,688**
Groundwater Flows				**Wet' Season Rainfall to Recharge Limit**				**100%**	**43%**	**0%**	**0%**	**0%**	**0%**	**78%**	
142	4	Unit A Recharge/(Discharge)	156,986	139,946	156,986	151,306	156,986	151,306	56,620	(19,094)	(19,094)	(19,094)	(19,094)	118,248	1,012,004
100	2	Unit B Recharge/(Discharge)	81,094	75,094	81,094	79,094	81,094	79,094	45,754	19,094	19,094	19,094	19,094	67,454	666,153
0	3	Unit C Recharge/(Discharge)	0	0	0	0	0	0	0	0	0	0	0	0	0
400	1	Unit D Recharge/(Discharge)	124,000	124,000	124,000	124,000	124,000	120,797	54,117	797	797	797	797	96,720	894,820
31	15	Unit E Recharge/(Discharge)	143,850	143,850	143,850	143,850	143,850	122,208	44,692	(17,292)	(17,292)	(17,292)	(17,292)	116,787	933,769
673	**-**	**Subtotal**	**505,930**	**482,890**	**505,930**	**498,250**	**505,930**	**473,405**	**201,184**	**(16,495)**	**(16,495)**	**(16,495)**	**(16,495)**	**399,209**	**3,506,746**
		Catchment Discharge													
673	-	Surface Water - Catchment A4	1,823,809	2,689,345	3,277,198	2,002,589	803,000	162,546	23,208	24,691	21,738	21,738	21,738	(19,910)	10,851,688
142	-	Groundwater - Unit A	156,986	139,946	156,986	151,306	156,986	151,306	56,620	(19,094)	(19,094)	(19,094)	(19,094)	118,248	1,012,004
100	-	Unit B	81,094	75,094	81,094	79,094	81,094	79,094	45,754	19,094	19,094	19,094	19,094	67,454	666,153
0	-	Unit C	0	0	0	0	0	0	0	0	0	0	0	0	0
400	-	Unit D	124,000	124,000	124,000	124,000	124,000	120,797	54,117	797	797	797	797	96,720	894,820
31	-	Unit E	143,850	143,850	143,850	143,850	143,850	122,208	44,692	(17,292)	(17,292)	(17,292)	(17,292)	116,787	933,769
673	**-**	**Subtotal**	**2,329,739**	**3,172,235**	**3,783,128**	**2,500,839**	**1,308,930**	**635,950**	**224,392**	**8,196**	**5,242**	**5,242**	**5,242**	**379,299**	**14,358,435**

TABLE 2I

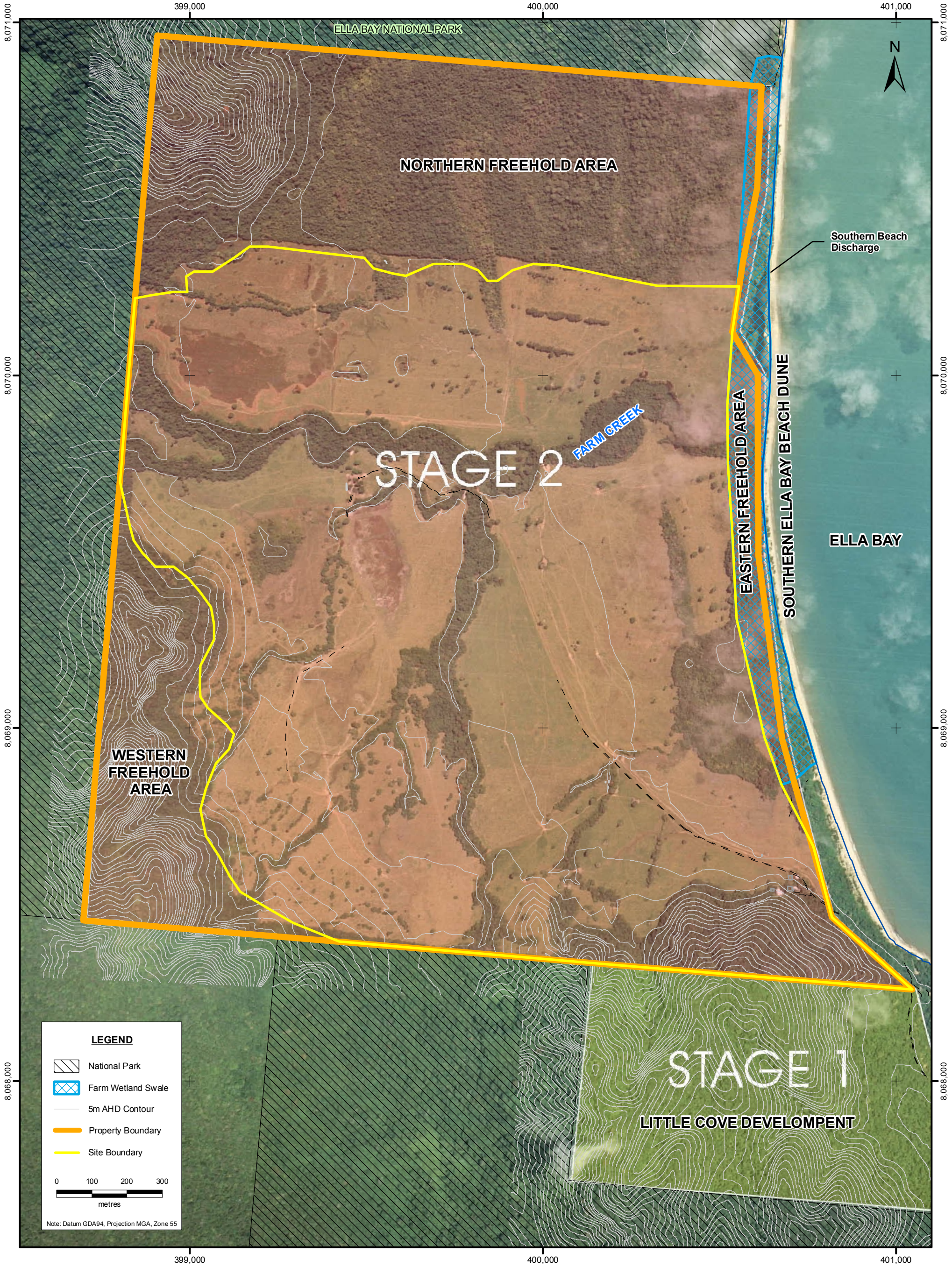
PRELIMINARY WATER BALANCE - CATCHMENT B5

Project	**77673018**
Client	**Ella Bay Developments Pty Ltd**
Job Title	**Conceptual Surface Water and Groundwater Models**
Location	**Ella Bay**



Golder Associates	CLIENT: Ella Bay Developments Pty Ltd	PROJECT: CONCEPTUAL SURFACE WATER AND GROUNDWATER MODELS	
	DRAWN: AOB / DATE: 9/7/07	TITLE: **ELLA BAY DEVELOPMENT SITE LOCATION PLAN**	
	CHECKED: JSB* / DATE: 9/7/07		
	SCALE: 1:100,000	PROJECT No: 001-077673018	FIGURE No: 1 / REV No: R2 / **A4**

File Location: S:\GIS_Jobs\Cairns.07\3env07\077673018_EllaBay\GIS\Projects\ArcGIS\001-077673018-R-Fig01-SiteLocationPlan-Rev2-A4.mxd
Note: The * beside the typed initials denotes the original drawing issue was signed or initialled by that respective person.



Note:
1. Base map data copyright Mapinfo Australia Pty Ltd.
2. Aerial Photography and Survey Plan supplied by John Holland services Pty Ltd.

Golder Associates

CLIENT	Ella Bay Developments Pty Ltd	PROJECT	CONCEPTUAL SURFACE WATER AND GROUNDWATER MODELS
DRAWN	AOB	DATE	11/7/07
CHECKED	JSB*	DATE	11/7/07
TITLE	ELLA BAY DEVELOPMENT SITE LAYOUT PLAN		
SCALE	1:10,000	PROJECT No	001-077673018
FIGURE No	2	REV No	R2
			A3

File Location: S:\GIS_Jobs\Cairns.07\3env07\077673018_EllaBay\GIS\Projects\ArcGIS\001-077673018-R-Fig02-SiteLayoutPlan-Rev2-A3.mxd
Note: The * beside the typed initials denotes the original drawing issue was signed or initialled by that respective person.

N

399,000 400,500 402,000

8,071,500 8,070,000 8,068,500 8,067,000

ELLA BAY NATIONAL PARK

B 5

B 1 B 2 B 3 B 4

NORTHERN FREEHOLD AREA

Northern Beach Discharge

SOUTHERN ELLA BAY BEACH DUNE

Southern Beach Discharge

FARM CREEK

A 2

A 4

WESTERN FREEHOLD AREA

A 1

A 3

EASTERN FREEHOLD AREA

ELLA BAY

LITTLE COVE DEVELOMPENT

399,000 400,500 402,000

LEGEND

- National Park
- Property Boundary
- Site Boundary
- Catchment Area
- A1 Sub-Catchment Boundary

Surface Water Direction and Volume

- High: >50% of total
- Moderate: <50% and >25% of total
- Low: <25% and >5% of total

0 200 400 600 800 1,000

metres

Note: Datum GDA94, Projection MGA, Zone 55

Note:
1. Base map data copyright Mapinfo Australia Pty Ltd.
2. Aerial photography copyright The State of Queensland (Department of Natural Resources and Mines) 2002.

Golder Associates

CLIENT	Ella Bay Developments Pty Ltd	PROJECT	CONCEPTUAL SURFACE WATER AND GROUNDWATER MODELS
DRAWN	AOB	DATE	9/7/07
CHECKED	JSB*	DATE	9/7/07
TITLE	**ELLA BAY DEVELOPMENT INFERRED SURFACE WATER FLOWS**		
SCALE	1:20,000	PROJECT No	001-077673018
FIGURE No	3	REV No	R2
			A3

File Location: S:\GIS_Jobs\Cairns.07\3env07\077673018_EllaBay\GIS\Projects\ArcGIS\001-077673018-R-Fig03-SurfaceWater-Rev2-A3.mxd
Note: The * beside the typed initials denotes the original drawing issue was signed or initialled by that respective person.

399,000 400,000 401,000

8,071,000 8,070,000 8,069,000 8,068,000

ELLA BAY NATIONAL PARK

N

STAGE 2

ELLA BAY

STAGE 1

LEGEND

Site Boundary

National Park

GEOLOGY

PLbs: Barnard Metamorphics

Qaw: Quaternary Swamp and Lacustrine Deposits

Qd: Quaternary Beach Sands

0 100 200 300 400

metres

Note: Datum GDA94, Projection MGA, Zone 55

Note:
1. Base map data copyright Mapinfo Australia Pty Ltd.
2. Geology data copyright The State of Queensland (Department of Natural Resources and Mines) 2005.
3. Aerial Photography and Survey Plan supplied by John Holland Services Pty Ltd.

Golder Associates

CLIENT	Ella Bay Developments Pty Ltd	PROJECT	CONCEPTUAL SURFACE WATER AND GROUNDWATER MODELS
DRAWN	AOB	DATE	9/7/07
CHECKED	JSB*	DATE	9/7/07
TITLE	**ELLA BAY DEVELOPMENT SITE GEOLOGY MAP**		
SCALE	1:10,000	PROJECT No	001-077673018
FIGURE No	**4**	REV No	R2
			A3

File Location: S:\GIS_Jobs\Cairns.07\3env07\077673018_EllaBay\GIS\Projects\ArcGIS\001-077673018-R-Fig04-SiteGeologyMap-Rev2-A3.mxd
Note: The * beside the typed initials denotes the original drawing issue was signed or initialled by that respective person.

399,000 400,000 401,000

8,071,000 8,070,000 8,069,000 8,068,000

ELLA BAY NATIONAL PARK

STAGE 2

STAGE 1

Ga M1 Ms Nd Sl Hu Tu

N

LEGEND

- Site Boundary
- National Park

SOILS

- Ga Galmara
- Hu Hull
- M1 Mountainous
- Ms Mission
- Nd Nind
- Sl Sumalea
- Tu Tully

0 100 200 300

metres

Note: Datum GDA94, Projection MGA, Zone 55

Note:
1. Base map data copyright Mapinfo Australia Pty Ltd.
2. Soils data copyright The State of Queensland (Department of Natural Resources and Mines) 2005.
3. Aerial Photography and Survey Plan supplied by John Holland Services Pty Ltd.

Golder Associates

CLIENT	Ella Bay Developments Pty Ltd	PROJECT	CONCEPTUAL SURFACE WATER AND GROUNDWATER MODELS
DRAWN	ABC	DATE	9/7/07
CHECKED	JSB*	DATE	9/7/07
TITLE	**ELLA BAY DEVELOPMENT SITE SOILS MAP**		
SCALE	1:10,000	PROJECT No	001-077673018
FIGURE No	5	REV No	R2
	A3		

File Location: S:\GIS_Jobs\Cairns.07\3env07\077673018_EllaBay\GIS\Projects\ArcGIS\001-077673018-R-Fig05-SiteSoilMap-Rev2-A3.mxd
Note: The * beside the typed initials denotes the original drawing issue was signed or initialled by that respective person.

LEGEND

Groundwater Units

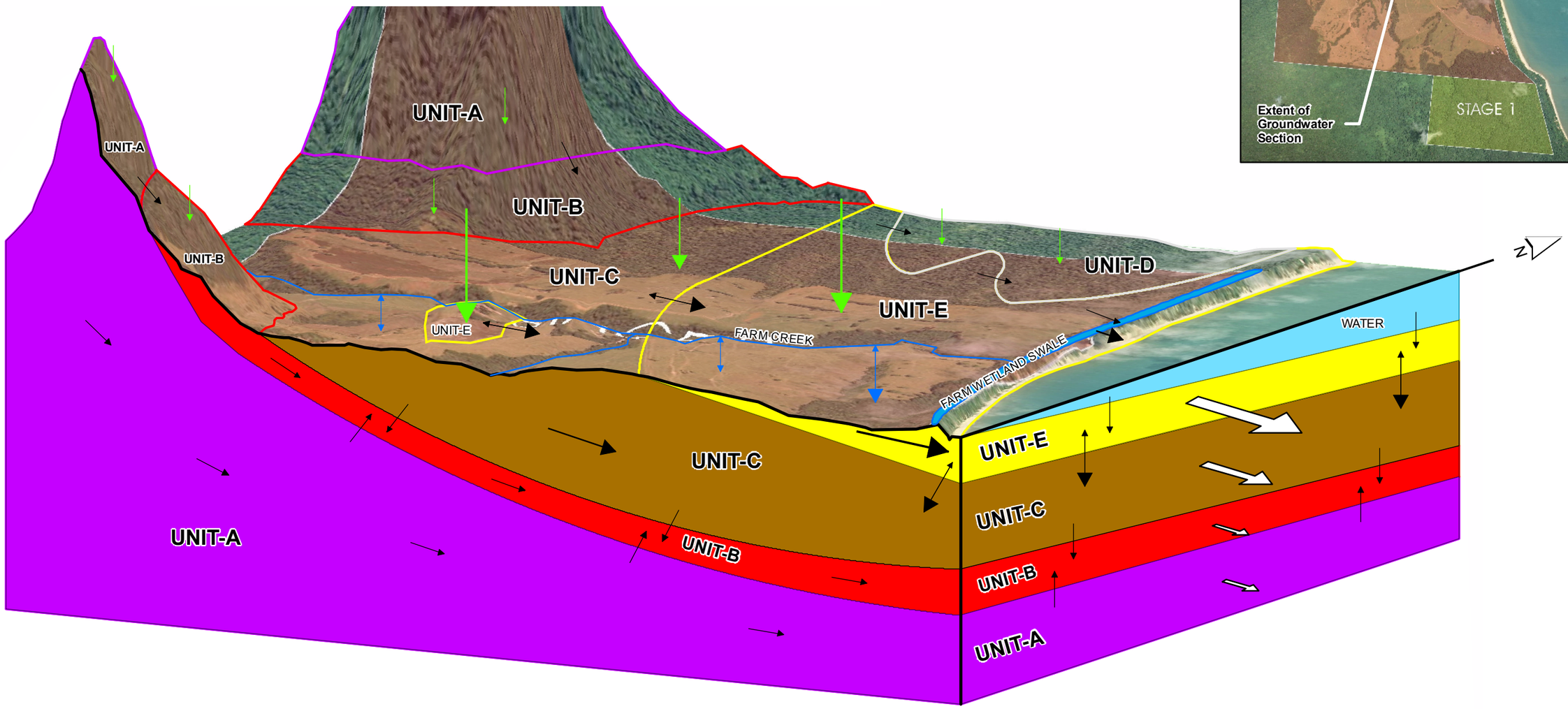
- Lake / Creek
- UNIT A: Meta-sediments
- UNIT B: Residual/Colluvium
- UNIT C: Alluvial Clays
- UNIT D: Swamp Clays
- UNIT E: Beach Sands
- Water

Flow Direction

- Groundwater
- Rainfall
- Surface water interchange
- Off-site discharge

Groundwater Volume

- High: >50% of total
- Moderate: <50% and >25% of total
- Low: <25% and >5% of total



CLIENT: Ella Bay Developments Pty Ltd		PROJECT: CONCEPTUAL SURFACE WATER AND GROUNDWATER MODELS	
DRAWN: AOB	DATE: 9/7/07	TITLE: **INTERNAL GROUNDWATER SECTION**	
CHECKED: JSB*	DATE: 9/7/07		
SCALE: Not To Scale		PROJECT No: 001-077673018	FIGURE No: 6 / REV No: R2 / **A3**

File Location: S:\GIS_Jobs\Cairns.07\3env07\077673018_EllaBay\GIS\Projects\ArcGIS\001-077673018-R-Fig05-GroundwaterSection-Rev0-A3.mxd
Note: The * beside the typed initials denotes the original drawing issue was signed or initialled by that respective person.

APPENDIX A

Master Plan

Ella Bay

phase 2 master plan

June 2006

job no. 045800

John Holland

DBI DESIGN

APPENDIX B

Site Photographs

Plate 1 – South Eastern Site Area

Plate 2 – Central Eastern Site Area

Plate 3 – Central Site Area

Plate 4 – South Western Site Area

Plate 5 – Cleared Hillside, Central Southern Site Area

Plate 6 – Central Western Site Area

Plate 7 – Northern Site Area

Plate 8 – Northern Site Boundary

Plate 9 – Steep, Incised Creek Channel (3 m to 4 m deep)

Plate 10 – Steep Incised Creek Valley (8 m to 10 m deep)

Plate 11 - Steep Incised Creek Valley (8 m to 10 m deep)

Plate 12 – Creek Behind Beach Dune (from the Site)

Plate 13 – Creek Behind Beach Dune (from the beach)

Plate 14 – Creek Behind Beach Dune

Plate 15 – Creek Bank Behind Beach Dune Showing Sediment

Plate 16 – Creek Junction Behind Beach Dune

Plate 17 – Creek Discharging Across Beach Dune

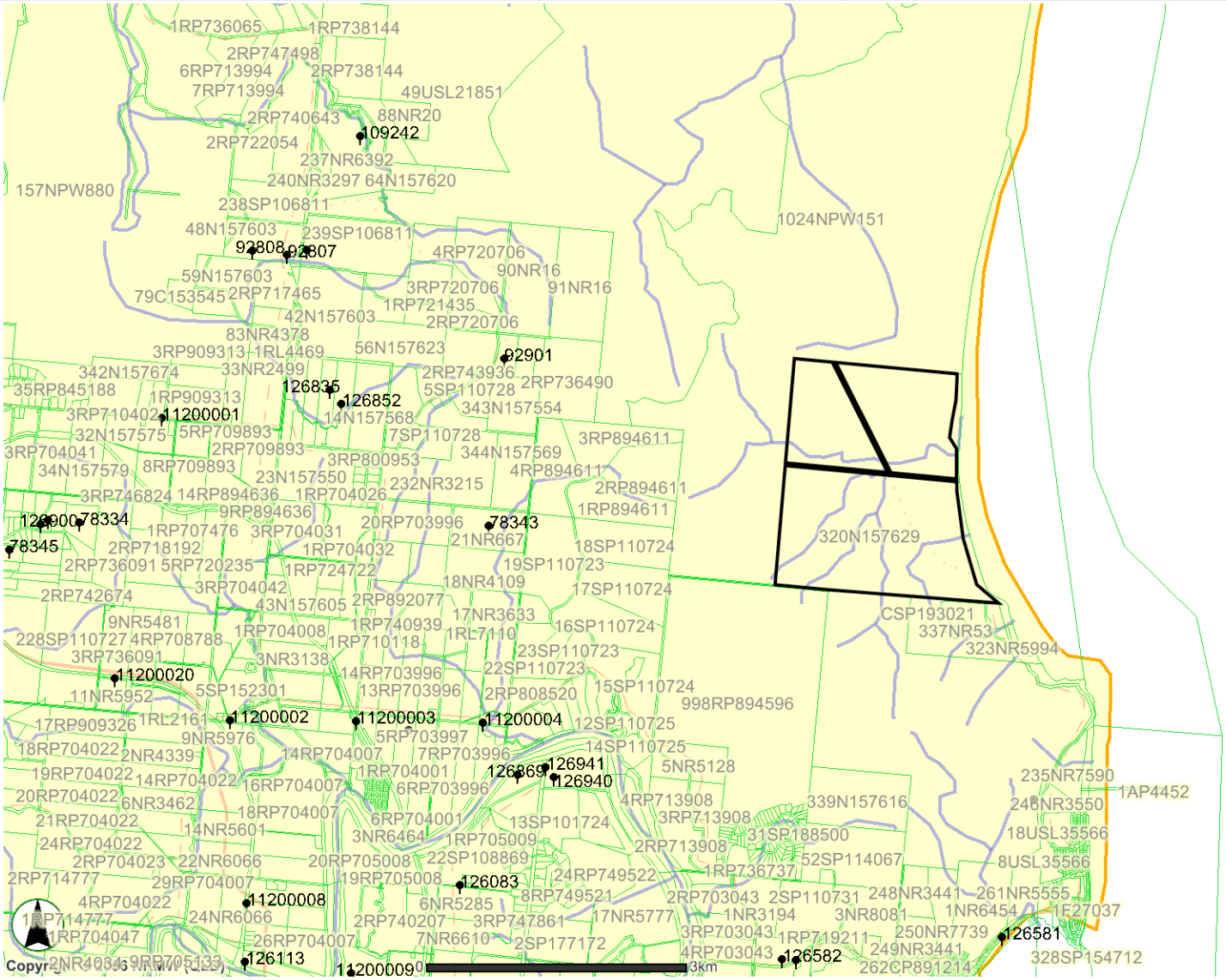
Plate 18 – Ella Bay National Park Boundary

Plate 19 – Melaleuca Wetland Behind Beach Dune in Ella Bay National Park

APPENDIX C

Natural Resources and Water Groundwater Records

Lot 320 N157629	*1:80,000*
	22/05/2007



Legend


DCDB Labels
Watercourses
All QLD Bores
Bore (Validated Location)
Bore (Unvalidated Location)
Include All Reg. Numbers
All Towns
All Roads
Dual Carriageway
Principal Road
Secondary Road
Minor Road
Track
DCDB
Legend
Coastline
Queensland
Other Australian States

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 78343

REGISTRATION DETAILS

		BASIN	1120	**LATITUDE**	17-27-43	**MAP-SCALE**	
OFFICE	Mareeba	**SUB-AREA**		**LONGITUDE**	146-01-03	**MAP-SERIES**	M
DATE LOG RECD		**SHIRE**	4150-JOHNSTONE	**EASTING**	395675	**MAP-NO**	A1-101196
D/O FILE NO.	81-003	**LOT**	21	**NORTHING**	8069050	**MAP NAME**	
R/O FILE NO.		**PLAN**	NR667	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**	L21 NR 667	**ACCURACY**	SKET	**PRES EQUIPMENT**	
				GPS ACC			
GIS LAT	-17.462148962	**PARISH NAME**	2011-GLADY			**ORIGINAL BORE NO**	
GIS LNG	146.017493001	**COUNTY**	NARES			**BORE LINE**	-
CHECKED	Y	**PROPERTY NAME**					
		FIELD LOCATION				**POLYGON**	
						RN OF BORE REPLACE	
FACILITY TYPE	SF	**DATE DRILLED**	14/09/1990			**DATA OWNER**	
STATUS	EX	**DRILLERS NAME**				**CONFIDENTIAL**	
ROLES		**DRILL COMPANY**					
		METHOD OF CONST.	ROTARY PERCUSSION RIG				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	14/09/1990	1	Gravel Pack	10.000	GR	225	0.00	42.70
A	14/09/1990	2	Plastic Casing (unspecified)	5.900	WT	125	0.00	42.70
A	14/09/1990	3	Perforated or Slotted Casing		AP	125	30.50	42.70

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	1.83	CLAY SOIL, RED
2	1.83	4.57	CLAY, BROWN
3	4.57	5.79	BASALT, HARD
4	5.79	7.01	CLAY, BROWN
5	7.01	8.53	BASALT, BROKEN AND CLAY
6	8.53	9.45	BASALT, HARD

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 78343

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
7	9.45	13.41	CLAY, CHOCOLATE *
8	13.41	15.54	BASALT
9	15.54	16.46	BASALT, BROKEN
10	16.46	17.68	BASALT
11	17.68	18.29	CLAY, BROWN
12	18.29	20.42	BASALT, HONEYCOMB * 0.37L/S
13	20.42	22.56	BASALT, HARD
14	22.56	23.16	BASALT, BROKEN * 0.25 L/S
15	23.16	24.69	BASALT
16	24.69	26.21	BASALT, BROKEN * 0.5 L/S
17	26.21	27.43	BASALT
18	27.43	28.96	CLAY, HONEYCOMB * 0.88 L/S
19	28.96	31.09	CLAY, YELLOW SANDY
20	31.09	32.31	QUARTZ AND CLAY *
21	32.31	34.75	SHALE
22	34.75	35.66	SHALE AND BROWN CLAY
23	35.66	36.88	SHALE
24	36.88	39.01	BLUESTONE
25	39.01	39.62	BLUESTONE, BROKEN AND QUARTZ *
26	39.62	42.67	BLUESTONE, HARD
27			DELAI DRILLING
902			14/09/1990 SWL -12.20M
903			14/09/1990 1.76 L/S

AQUIFER DETAILS

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	15.60	16.50	BSLT							FR	UNKNOWN
2	18.30	20.40	BSLT							FR	UNKNOWN
3	24.70	26.20	BSLT							FR	UNKNOWN
4	27.50	29.00	CLAY							SC	UNKNOWN

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 78343

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
5	31.10	32.30	CLAY GBRO							FR	UNKNOWN

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK
A	14/09/1990	-3.72	R											

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 92901

REGISTRATION DETAILS

		BASIN	1120	**LATITUDE**	17-26-44	**MAP-SCALE**	
OFFICE	Mareeba	**SUB-AREA**	NOT	**LONGITUDE**	146-01-08	**MAP-SERIES**	
DATE LOG RECD		**SHIRE**	2060-CAIRNS CITY	**EASTING**	395822	**MAP-NO**	
D/O FILE NO.	515/0004151	**LOT**	1	**NORTHING**	8070883	**MAP NAME**	
R/O FILE NO.		**PLAN**	RP743936	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**		**ACCURACY**	SKET	**PRES EQUIPMENT**	
				GPS ACC			
GIS LAT	-17.445589194	**PARISH NAME**	2011-GLADY			**ORIGINAL BORE NO**	
GIS LNG	146.018970314	**COUNTY**	NARES			**BORE LINE**	-
CHECKED	Y	**PROPERTY NAME**					
		FIELD LOCATION				**POLYGON**	
						RN OF BORE REPLACE	
FACILITY TYPE	SF	**DATE DRILLED**	16/07/1998			**DATA OWNER**	
STATUS	AD	**DRILLERS NAME**	DELAI, MARK ANDREW			**CONFIDENTIAL**	N
ROLES	WS	**DRILL COMPANY**					
		METHOD OF CONST.	ROTARY				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	16/07/1998	1	Plastic Casing (unspecified)	5.900	WT	140	0.00	54.00
A	16/07/1998	2	Perforated or Slotted Casing	2.000	AP	140	24.00	54.00
A	16/07/1998	3	Gravel Pack	7.000	GR	200	8.00	54.00
A	16/07/1998	4	Grout			200	0.00	6.00

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	2.00	RED SOIL
2	2.00	15.00	BROWN CLAY
3	15.00	23.00	VOLCANIC CLAY
4	23.00	47.00	HONEYCOMBE CLAY *
5	47.00	54.00	HONEYCOMBE BASALT *

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 92901

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
6			DRILLER - M.DELAI
7			SWL 16-7-98 -21.0M
8			AIRTEST AT 2.5 L/S FOR 2 HRS

AQUIFER DETAILS

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	23.00	54.00	BSLT	16/07/1998	-21.00	N	POTABLE	2.50	Y	VS	ATHERTON BASALT

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK
A	16/07/1998	-21.00	N											

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 126940

REGISTRATION DETAILS

		BASIN	1120	**LATITUDE**	17-29-13	**MAP-SCALE**	
OFFICE	Mareeba	**SUB-AREA**		**LONGITUDE**	146-01-26	**MAP-SERIES**	
DATE LOG RECD	17/MAY/06	**SHIRE**	4150-JOHNSTONE	**EASTING**	396367	**MAP-NO**	
D/O FILE NO.	RN DRAWER	**LOT**	2	**NORTHING**	8066300	**MAP NAME**	
R/O FILE NO.		**PLAN**	RP705003	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**		**ACCURACY**	GPS	**PRES EQUIPMENT**	
				GPS ACC	30		
GIS LAT	-17.4870363	**PARISH NAME**	2503-JOHNSTONE			**ORIGINAL BORE NO**	
GIS LNG	146.0238838	**COUNTY**	NARES			**BORE LINE**	-
CHECKED	Y	**PROPERTY NAME**					
		FIELD LOCATION				**POLYGON**	
						RN OF BORE REPLACE	
FACILITY TYPE	SF	**DATE DRILLED**	09/03/2006			**DATA OWNER**	
STATUS	EX	**DRILLERS NAME**	BLIESNER, NORMAN			**CONFIDENTIAL**	N
ROLES	WS	**DRILL COMPANY**	INGHAM DRILLING				
		METHOD OF CONST.	ROTARY AIR				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	09/03/2006	1	Polyvinyl Chloride	12.300	WT	223	-0.40	24.00
A	09/03/2006	2	Perforated or Slotted Casing	2.500	AP	223	12.50	18.00
A	09/03/2006	3	Perforated or Slotted Casing	2.500	AP	223	19.00	23.80
A	09/03/2006	4	Gravel Pack	4.000	GR	300		
A	09/03/2006	5	Grout			300	0.00	6.00

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	8.00	CLAY VERY SILTY & SANDY
2	8.00	12.50	CLAY VERY SOFT & VERY SILTY
3	12.50	13.00	SAND FINE *
4	13.00	14.00	CLAY SILTY

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BORE CARD REPORT - PUBLISHABLE

REG NUMBER 126940

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
5	14.00	17.80	SAND FINE WITH CLAY BANDS ***
6	17.80	23.70	SAND GRAVEL & COBBLES CLAY BANDS **
7	23.70	27.00	ASH VOLCANIC

AQUIFER DETAILS

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK
A	09/03/2006	-6.40	N											

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 126941

REGISTRATION DETAILS

		BASIN	1120	**LATITUDE**	17-29-10	**MAP-SCALE**	
OFFICE	Mareeba	**SUB-AREA**		**LONGITUDE**	146-01-22	**MAP-SERIES**	
DATE LOG RECD	17/MAY/06	**SHIRE**	4150-JOHNSTONE	**EASTING**	396249	**MAP-NO**	
D/O FILE NO.	RN DRAWER	**LOT**	2	**NORTHING**	8066408	**MAP NAME**	
R/O FILE NO.		**PLAN**	RP705003	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**		**ACCURACY**	GPS	**PRES EQUIPMENT**	
				GPS ACC	30		
GIS LAT	-17.4860964	**PARISH NAME**	2503-JOHNSTONE			**ORIGINAL BORE NO**	
GIS LNG	146.0231108	**COUNTY**	NARES			**BORE LINE**	-
CHECKED	Y	**PROPERTY NAME**					
		FIELD LOCATION				**POLYGON**	
						RN OF BORE REPLACE	
FACILITY TYPE	SF	**DATE DRILLED**	10/03/2006			**DATA OWNER**	
STATUS	EX	**DRILLERS NAME**	BLIESNER, NORMAN			**CONFIDENTIAL**	N
ROLES	WS	**DRILL COMPANY**	INGHAM DRILLING				
		METHOD OF CONST.	ROTARY AIR				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	10/03/2006	1	Polyvinyl Chloride	12.300	WT	223	-0.40	24.60
A	10/03/2006	2	Perforated or Slotted Casing	2.500	AP	223	12.50	24.50
A	10/03/2006	3	Gravel Pack	4.000	GR			
A	10/03/2006	4	Grout				0.00	6.00

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	6.00	CLAY SILTY
2	6.00	8.00	MUD
3	8.00	9.00	SILT & SAND VERY FINE *
4	9.00	18.00	SAND FINE TO MEDIUM ****
5	18.00	21.00	SAND VERY FINE TO FINE **

GROUNDWATER DATABASE

DATE 23/05/2007

BORE CARD REPORT - PUBLISHABLE

REG NUMBER 126941

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
6	21.00	24.50	SAND GRAVEL & COBBLES *
7	24.50	29.00	BASALT WEATHERED

AQUIFER DETAILS

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK	PIPE	DATE	MEASURE (m)	N/R	RMK
A	10/03/2006	-6.20	N											

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**** End of Report ****

APPENDIX D

“Important Information About Your Geo-Environmental Site Assessment”

Important Information About Your

Geo-environmental Report

These notes have been prepared by Golder Associates Pty Ltd using guidelines prepared by ASFE; The Association of Engineering Firms Practising in the Geosciences, of which Golder Associates Pty Ltd is a member. They are offered to help you in the interpretation of your Geo-environmental Report.

Geo-environmental studies are commissioned to gain information about environmental conditions on and beneath the surface of a site. The more comprehensive the study, the more reliable the assessment is likely to be. But remember, any such assessment is to a greater or lesser extent based on professional opinions about conditions that cannot be seen or tested. Accordingly, no matter how much data is accumulated, risks created by unanticipated conditions will always remain. *Have realistic expectations.* Work with your Geo-environmental consultant to manage known and unknown risks. Part of that process should already have been accomplished, through the risk allocation provisions you and your Geo-environmental professional discussed and included in your contract's general terms and conditions. This document is intended to explain some of the concepts that may be included in your agreement, and to pass along information and suggestions to help you manage your risk.

Beware of Change; Keep Your Geo-environmental Professional Advised

The design of a Geo-environmental study considers a variety of factors that are subject to change. Changes can undermine the applicability of a report's findings, conclusions, and recommendations. *Advise your Geo-environmental professional about any changes you become aware of them.* Geo-environmental professionals cannot accept responsibility or liability for problems that occur because a report fails to consider conditions that did not exist when the study was designed. Ask your Geo-environmental professional about the types of changes you should be particularly alert to. Some of the most common include:

- modification of the proposed development or ownership group,
- sale or other property transfer,
- replacement of or additions to the financing entity,
- amendment of existing regulations or introduction of new ones, or
- changes in the use or condition of adjacent property

Should you become aware of any change, *do not rely on an existing Geo-environmental report.* Advise your Geo-environmental professional immediately; follow the professional's advice.

Recognize the Impact of Time

A Geo-environmental professional's findings, recommendations, and conclusions cannot remain valid indefinitely. The more time that passes, the more likely it is that important latent changes may occur. *Do not rely on a Geo-environmental report if too much time has elapsed since it was completed.* Ask your environmental professional to define "too much time." In the case of Phase I Environmental Site Assessments (ESAs), for example, more than 180 days after submission is generally considered "too much."

Prepare To Deal with Unanticipated Conditions

The findings. recommendations, and conclusions of a Phase I ESA report typically are based on a review of historical information, interviews, a site "walkover," and other forms of noninvasive research. When site subsurface conditions are not sampled in any way, the risk of unanticipated conditions is higher than it would otherwise be.

While borings, installation of monitoring wells, and similar invasive test methods can help reduce the risk of unanticipated conditions, *do not overvalue the effectiveness of testing.* Testing provides information about actual conditions only at the precise locations where samples are taken, and only when they are taken. Your Geo-environmental professional has applied that specific information to develop a general opinion about environmental conditions. *Actual conditions in areas not sampled may differ (sometimes sharply) from those predicted in a report.* For example, a site may contain an unregistered underground storage tank that shows no surface trace of its existence. *Even conditions in areas that were tested can change,* sometimes suddenly, due to any number of events, not the least of which include occurrences at adjacent sites. Recognize, too, that *even some conditions in tested areas may go undiscovered,* because the tests or analytical methods used were designed to detect only those conditions assumed to exist.

Manage your risks by retaining your Geo-environmental professional to work with you as the project proceeds. Establish a contingency fund or other means to enable your Geo-environmental professional to respond rapidly, in order to limit the impact of unforeseen conditions. To

help prevent any misunderstanding, identify those empowered to authorize changes and the administrative procedures that should be followed.

Do Not Permit Any Other Party To Rely on the Report

Geo-environmental professionals design their studies and prepare their reports to meet the specific needs of the clients who retain them, in light of the risk management methods that the client and Geo-environmental professional agree to, and the statutory, regulatory, or other requirements that apply. The study designed for a developer may differ sharply from one designed for a lender, insurer, public agency ... or even another developer. *Unless the report specifically states otherwise, it was developed for you and only you.* Do not unilaterally permit any other party to rely on it. The report and the study underlying it may not be adequate for another party's needs, and you could be held liable for shortcomings your Geo-environmental professional was powerless to prevent or anticipate. Inform your Geo-environmental professional when you know or expect that someone else - a third-party will want to use or rely on the report. *Do not permit third-party use or reliance until you first confer with the Geo-environmental professional who prepared the report.* Additional testing, analysis, or study may be required and, in any event, appropriate terms and conditions should be agreed to so both you and your Geo-environmental professional are protected from third-party risks. *Any party who relies on a Geo-environmental report without the express written permission of the professional who prepared it and the client for whom it was prepared may be solely liable for any problems that arise.*

Avoid Misinterpretation of the Report

Design professionals and other parties may want to rely on the report in developing plans and specifications. They need to be advised, in writing, that their needs may not have been considered when the study's scope was developed, and, even if their needs were considered, they might misinterpret Geo-environmental findings, conclusions, and recommendations. *Commission your Geo-environmental professional to explain pertinent elements of the report to others who are permitted to rely on it, and to review any plans, specifications or other instruments of professional service that incorporate any of the report's findings, conclusions, or recommendations.* Your Geo-environmental professional has the best understanding of the issues involved, including the fundamental assumptions that determined the study's scope.

Give Contractors Access to the Report

Reduce the risk of delays, claims, and disputes by giving contractors access to the full report, *providing that it is accompanied by a letter of transmittal that can protect you* by making it unquestionably clear that: 1) the study was not conducted and the report was not prepared for purposes of bid development, and 2) the findings, conclusions, and recommendations included in the report are based on a variety of opinions, inferences, and assumptions and are subject to interpretation. Use the letter to also advise contractors to consult with your Geo-environmental professional to obtain clarifications, interpretations, and guidance (a fee may be required for this service), and that-in any event-they should conduct additional studies to obtain the specific type and extent of information each prefers for preparing a bid or cost estimate. Providing access to the full report, with the appropriate caveats, helps prevent formation of adversarial attitudes and claims of concealed or differing conditions. If a contractor elects to ignore the warnings and advice in the letter of transmittal, it would do so at its own risk. Your Geo-environmental professional should be able to help you prepare an effective letter.

Do Not Separate Documentation from the Report

Geo-environmental reports often include supplementary documentation, such as maps and copies of regulatory files, permits, registrations, citations, and correspondence with regulatory agencies. If subsurface explorations were performed, the report may contain final boring logs and copies of laboratory data. If remediation activities occurred on site, the report may include: copies of daily field reports, waste manifests, and information about the disturbance of subsurface materials, the type and thickness of any fill placed on site, and fill placement practices, among other types of documentation. *Do not separate supplementary documentation from the report. Do not, and do not permit any other party to redraw or modify any of the supplementary documentation for incorporation into other professionals' instruments of service.*

Understand the Role of Standards

Unless they are incorporated into statutes or regulations, standard practices and standard guides developed by the American Society for Testing and Materials (ASTM) and other recognized standards-developing organizations (SDOs) are little more than aspirational methods agreed to by a consensus of a committee. The committees that develop standards may not comprise those best qualified to establish methods and, no matter what, no standard method can possibly consider the infinite client and project-specific variables that fly in the face of the theoretical "standard conditions" to which standard practices and standard guides apply. In fact, these variables can be so pronounced that Geo-environmental professionals who comply with every directive of an ASTM or other standard procedure could run foul of local custom and practice, thus violating the standard of care.

Accordingly, when Geo-environmental professionals indicate in their reports that they have performed a service "in general compliance" with one standard or another, it means they have applied professional judgement in creating and implementing a scope of service designed for the specific client and project involved, and which follows some of the general precepts

laid out in the referenced standard. To the extent that a report indicates "general compliance" with a standard, you may wish to speak with your Geo-environmental professional to learn more about what was and was not done. *Do not assume a given standard was followed to the letter.* Research indicates that that seldom is the case.

Realize That Recommendations May Not Be Final

The technical recommendations included in a Geo-environmental report are based on assumptions about actual conditions, and so are preliminary or tentative. Final recommendations can be prepared only by observing actual conditions as they are exposed. For that reason, you should retain your Geo-environmental professional to observe construction and/or remediation activities on site, to permit rapid response to unanticipated conditions. *The Geo-environmental professional who prepared the report cannot assume responsibility or liability for the report's recommendations if that professional is not retained to observe relevant site operations.*

Understand That Geotechnical Issues Have Not Been Addressed

Unless geotechnical engineering was specifically included in the scope of professional service, a report is not likely to relate any findings, conclusions, or recommendations about the suitability of subsurface materials for construction purposes, especially when site remediation has been accomplished through the removal, replacement, encapsulation, or chemical treatment of on-site soils. The equipment, techniques, and testing used by geotechnical engineers differ markedly from those used by Geo-environmental professionals; their education, training, and experience are also significantly different. If you plan to build on the subject site, but have not yet had a geotechnical engineering study conducted, your Geo-environmental professional should be able to provide guidance about the next steps you should take. The same firm may provide the services you need.

Read Responsibility Provisions Closely

Geo-environmental studies cannot be exact; they are based on professional judgement and opinion. Nonetheless, some clients, contractors, and others assume Geo-environmental reports are or certainly should be unerringly precise. Such assumptions have created unrealistic expectations that have led to wholly unwarranted claims and disputes. To help prevent such problems, Geo-environmental professionals have developed a number of report provisions and contract terms that explain who is responsible for what, and how risks are to be allocated. Some people mistake these for "exculpatory clauses," that is, provisions whose purpose is to transfer one party's rightful responsibilities and liabilities to someone else. Read the responsibility provisions included in a report and in the contract you and your Geo-environmental professional agreed to. They are important.

Rely on Your Geo-environmental Professional for Additional Assistance

Membership in ASFE exposes Geo-environmental professionals to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a Geo-environmental project. Confer with your ASFE-member Geo-environmental professional for more information.