areas located on the valley flanks. These facilities will be located in the APZ's adjoining the riparian corridor.

(iii) Proprietary GPTs (eg, Baramy traps or CDS units) located on stormwater discharge lines at the point of discharge into the pond/wetland system within the APZ.

The proposed stormwater quality control measures for the Village Area are presented in **Figure 7**.

The intermittent ponds located within the APZ adjoining the riparian corridor will be formed with an earthen bund with a spillway at the downstream end of each pond, with a low flow pipe underneath. Conceptual designs for a typical arrangement are shown on **Figure 8**.

When medium to high flows are carried through the chain of ponds (deriving from the urban drainage system from the adjoining residential area), flows will discharge over the spillways. In extreme flow events, most of the riparian corridor (and APZ) will be inundated by floodwaters.

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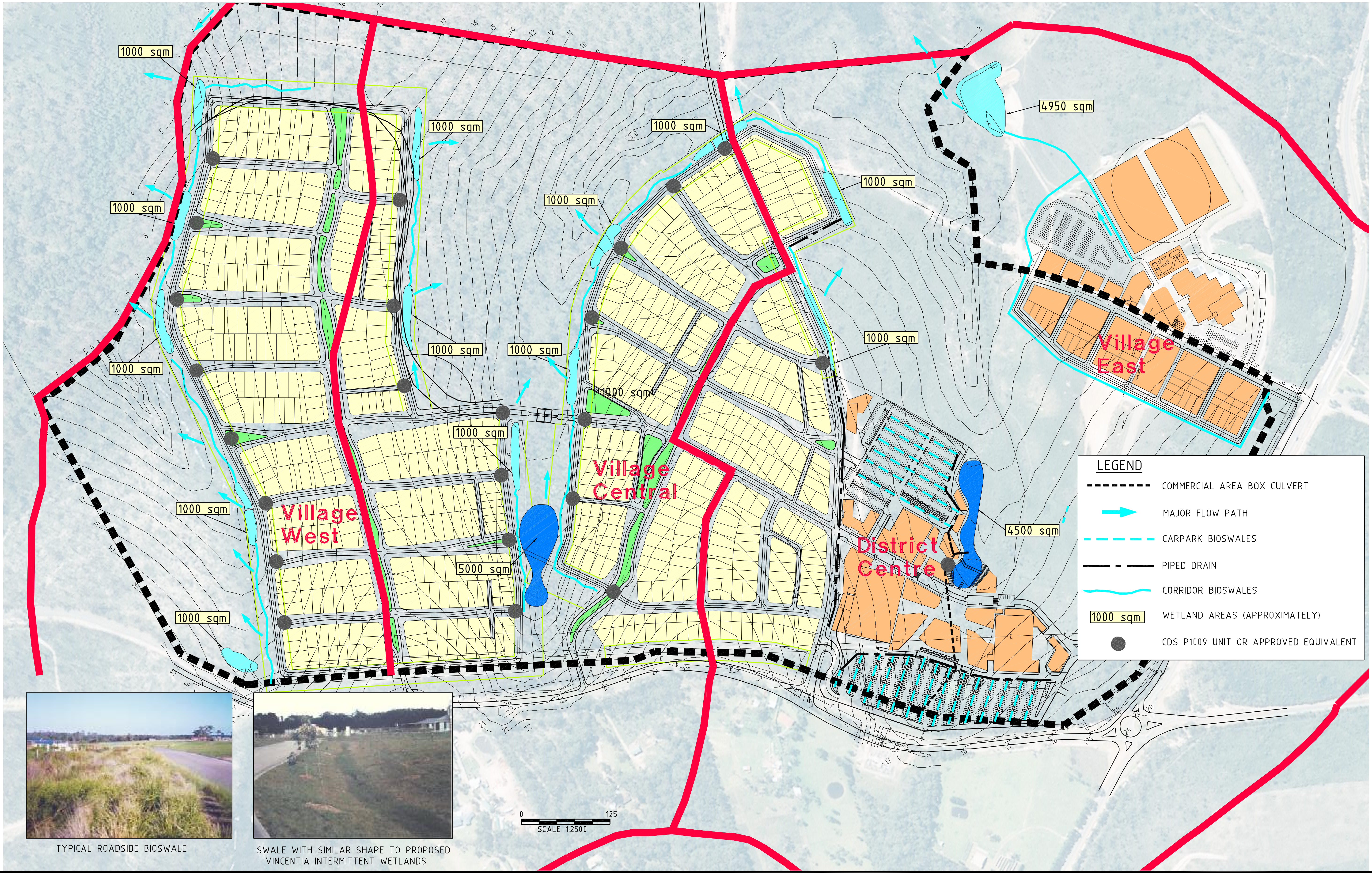

TYPICAL ROADSIDE BIOSWALE

SWALE WITH SIMILAR SHAPE TO PROPOSED VINCENTIA INTERMITTENT WETLANDS

REV	DATE	BY	APP.	DETAILS
P2	13/01/06	AP	AW	UPDATED FOR DEC 2005 DEVELOPMENT FOOTPRINT

DRAWING STATUS		
DESIGN BY	AW/SR	10/12/03
DRAWN BY	AP	06/05/04
DRAFTING CHECK	PJS	10/02/05
DESIGN CHECK	AW	14/12/04
FINAL APPROVAL	PSN	10/02/05

PRELIMINARY

SCALE: (on A1 Original) 2500

HEIGHT DATUM AHD

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PROJECT TITLE
VINCENTIA COASTAL VILLAGE and DISTRICT CENTRE for STOCKLAND DEVELOPMENTS PTY LT

DRAWING TITLE
PROPOSED STORMWATER QUALITY CONTROL MEASURES

Project No.	Com No.	Drawing No.	REV
104016	3	FIG 7	P2

A1

File Plotted: U:\2004\104-016-03 - VINCENTIA DISTRICT CENTRE - WSUD STUDY\MONITORING\DRAWING\BUILD\13-01-06\FIG7-WSUD_MGA.DWG
January 16, 2006 2:04:37 p.m.
Xrefs: x104016-03_base_3.DWG

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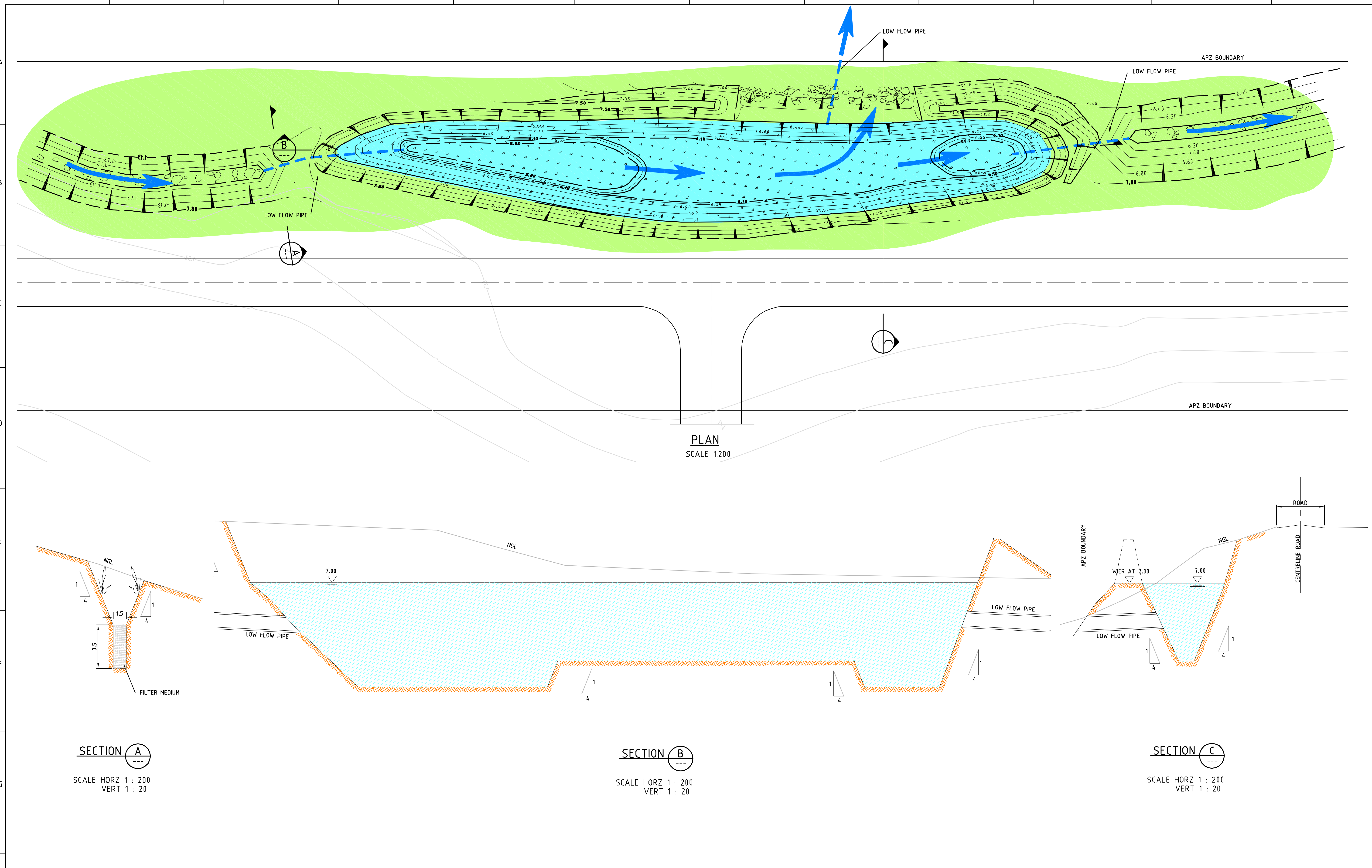

REV	DATE	BY	APP.	DETAILS
P2	13/01/06	AP	AW	UPDATED FOR DEC 2005 DEVELOPMENT FOOTPRINT

DRAWING STATUS

DESIGN BY	A.W.	02/06/04
DRAWN BY	A.P.	02/06/04
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DESIGN CHECK	A.W.	14/12/04
FINAL APPROVAL	P.S.N.	10/02/05

PRELIMINARY

SCALE: (on A1 Original) 1:200

HEIGHT DATUM AHD

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PROJECT TITLE
VINCENTIA VILLAGE & DISTRICT CENTRE for STOCKLAND DEVELOPMENTS PTY LTD

DRAWING TITLE
TYPICAL POND/BIOSWALE DETAILS AND CROSS SECTIONS

Project No.	Com No.	Drawing No.	REV
104016	3	FIG 8	P2

A1

File Plotted: U:\2004\104-016-03 - VINCENTIA DISTRICT CENTRE - WSUD STUDY\MONITORING\DRAWING\BUILD\13-01-06\FIG8-POND DETAILS.DWG
January 13, 2006 5:41:03 p.m.

Sediment transport from these ponds during large flow events will be minimised by:

- Inherent positioning of the ponds on the fringe of the riparian corridor, which places them offline to the main flood flows and subjects them to lower velocities (therefore lower chace of scour)
- Use of high-flow bypass weirs to divert large flows around the ponds
- Design of ponds to lower velocities within the ponds themselves to below scour thresholds (this can be achieved through establishment of appropriate vegetation and avoiding steep grades/transitions).

After rainfall has ceased, low flows will steadily decrease in the absence of further rain, and will become trickle flows and then cease altogether. For those ponds designed to be intermittent (which will have bed invert levels above the groundwater table) the pond water level will progressively drop as a result of seepage and evapo-transpiration losses and will completely dry out over a period ranging from days to weeks (depending on the amount of seepage that is occurring and the seasonal effects on evapo-transpiration rates). Nevertheless, even though the ponds may soon dry out, they will still be regularly wetted even during light rainfall events and thus macrophytes will grow in them. In this regard we note that there are wetland plant species naturally adapted to frequent wetting and drying cycles and that use of such species would result in a healthy stand of macrophytes.

Ponds designed to be permanent will not be affected by seepage as they will be deeper, lined if necessary and kept topped up with ‘make-up’ water re-circulated from other ponds. Where sub-surface conditions permit, bed invert levels of permanent ponds will be set close to or below the groundwater table. They thus represent a window into the groundwater table and will not dry up like the intermittent ponds.

Wetland vegetation is also an important design element as it provides for enhanced water treatment by:

- Direct filtration of water
- Enhanced settlement of sediment
- Development of biofilms on plant stems which harvest nutrients
- Providing quiescent conditions reducing wind induced re-suspension
- Providing nutrient conversion into less bio-available organic forms
- Aeration of wetland subsoils to enhance breakdown of organic matter.

Appropriate vegetation species will be specified for particular depth ranges and to enhance treatment processes, as well as representing species native to the area. Examples of appropriate species for the different depth zones are provided in **Table 7.1** (DLWC, 1998; Wong *et al*, 1998).

Table 7.1 - Sample Vegetation Selection

Zone	Depth range	Species
Deep zones	1-2 m	*Eloecharis sphacelata*
Macrophyte zones	0.5-1 m	*Baumea articulata, Schoenoplectus validus*
Littoral zones	0-0.5 m	*Juncus spp., Cyperus spp.*

Appropriate site preparation is also required prior to planting for successful macrophyte establishment. In this regard a topsoil covering of approximately 0.2 m will be specified, and manual control of water levels will likely be required during the establishment phase. Effective control of water levels will result in optimum conditions for the establishment of each species and allow for sequential planting. Nursery grown seedlings will likely be used to vegetate the macrophyte beds, with a planting density of about 80% of the vegetated zones (Wong *et al*, 1998).

Planting proposals are also to be consistent with how people access or interact with the riparian corridor buffers within which the system of ponds and bioswales are located, including creation of a variety of spaces, views and vista. These issues are identified in the Clouston Associates Landscape Study and will be a key input in the preparation of detailed designs of the proposed stormwater quality management measures.

7.2. DISTRICT CENTRE

The District Centre is located in the upper part of the eastern sub-catchment.

A number of creek management options were considered for the District Centre:

- Option 1 - 'Natural Creek' (with the natural creek in its current location running through middle of District Centre)
- Option 2 -'Reconstructed Creek' (with the natural creek filled and a new reconstructed creek channel located around the perimeter of the District Centre)
- Option 3 - '10-year [10% AEP] Culvert ' (with the natural creek filled and a 10% AEP capacity culvert constructed in its place, with an overflow path through the District Centre that carries the balance of flow in the 1% AEP event)
- Option 4 - '100-year [1%AEP] Culvert' (with the natural creek filled and a 1% AEP capacity culvert constructed in its place with its inlet oversized to accommodate blockage, and with an overflow path that carries no flow in 1% AEP event, only in more extreme events).

Option 4 was found to be the preferred arrangement because of:

- Benefit of a single water quality control pond allowing for creation of a significant ornamental feature around the District Centre (rather than one on each side of the creek)
- Elimination of the need for 500-mm freeboard over the calculated depth of overflow in the overflow path running through the District Centre during the 1% AEP storm event by using an oversized culvert, thus enabling shop floor levels to be set closer to general ground levels facilitating more ready access for disabled and connectivity of shops in Main Street
- Improved architectural and operational outcome
- Maximum development flexibility
- Maintenance aspects
- Security and public safety.

Further detail on the relative advantages and disadvantages associated with each option is presented in **Table 7.2**.

Table 7.2 - Creek Management Options For District Centre In New Location Adjacent To Naval College Rd

Option	Description	Advantages	Disadvantages
Option 1 **'Natural Creek'**	Natural creek in its current location running through middle of District Centre	• Creek retained in natural state	• Bisects District Centre, and make a less workable space from architectural perspective • Makes control of services transition across the site difficult (likely resulting in potential conflicts at a later stage). • Loss of connectivity and design flexibility would adversely impact on the District Centre design to the extent that its viability is questionable
Option 2 **'Reconstructed Creek'**	Natural creek filled and new reconstructed creek channel located around perimeter of District Centre	(i) Affords a more workable uninterrupted space resulting in maximum development flexibility and an improved architectural and operational outcome (ii) A single water quality control pond can be provided (rather than one on each side of the creek) (iii) The single water body also allows creation of a significant ornamental feature around the Town Centre	• Topography does not suit new reconstructed creek channel located around perimeter of District Centre • Would result in a channel up to 4-m deep that would potentially encroach into the habitat corridor
Option 3 **'10-yr Culvert '**	Natural creek filled and 10-yr capacity culvert constructed in its place, with overflow path that carries balance of flow in 1% AEP event	(i), (i) and (iii) as above (iv) Culvert option preferable for maintenance, security and public safety reasons.	• Minimum floor levels must be set to provide 500-mm freeboard over the calculated depth of overflow in the overflow path running through the District Centre during the 1% AEP storm event • Such elevated floor levels adversely impact on shop access for disabled and connectivity of shops within Main Street
Option 4 **'100-yr Culvert'** with inlet oversized to accommodate blockage [a]	Natural creek filled and 100-year capacity culvert constructed in its place, with overflow path that carries no flow in 1% AEP event	(i), (ii), (iii) and (iv) as above (v) Oversized culvert eliminates need to provide freeboard within overflow path and thus shop floor levels do not require significant elevation to achieve 500-mm freeboard	

Notes:
[a] Council DCP100 cl.D5.04/4 calls for culvert inlets to be analysed assuming waterway 50% blocked

The then-named DIPNR (now DNR) advised by letter dated 28 April 2004 (refer **Appendix E)** that Option 4 was on balance an outcome that could be agreed to in principle. This however was subject to finer detail on footprints of the District Centre and proposed treatment pond, bearing in mind that the pond's principal function was water quality and quantity control with respect to the Moona Moona Creek wetlands downstream. The (then-named) DIPNR also commented that the stormwater quality treatment system should identify the likely pollutant sources so each could be targeted to a high degree (eg, sediment and oil from carparks and litter from the District Centre).

DEC suggested in their 15 November 2004 letter that 'run-on water' from the upstream catchment be diverted around (or under) the Centre to separate clean and dirty water, to better mimic the natural flow regime and minimise the impact of development on hydrology and water quality.

We note that the eastern creek has limited catchment upstream of the District Centre (approx 0.19 km^2). It does not flow unless there has been significant rain (eg, >10mm in 24 hours). It is therefore an ephemeral stream, with low flows only occurring for very limited periods after heavy rain. Diversion of run-on water around or under the Centre will therefore have only minimal effect on the low flow regime.

The catchment upstream of the District Centre is predominantly cleared pasture (including an electricity substation). Runoff from this catchment cannot be described as pristine. This is confirmed by additional water quality monitoring that has been undertaken since the date of our initial report. The recent water quality monitoring campaigns shows elevated TN, TP, RP and O&G significantly in excess of ANZECC trigger values. This subcatchment exhibited the poorest water quality out the 5 sub-catchments sampled in the last wet weather campaign (see **Section 3.4**).

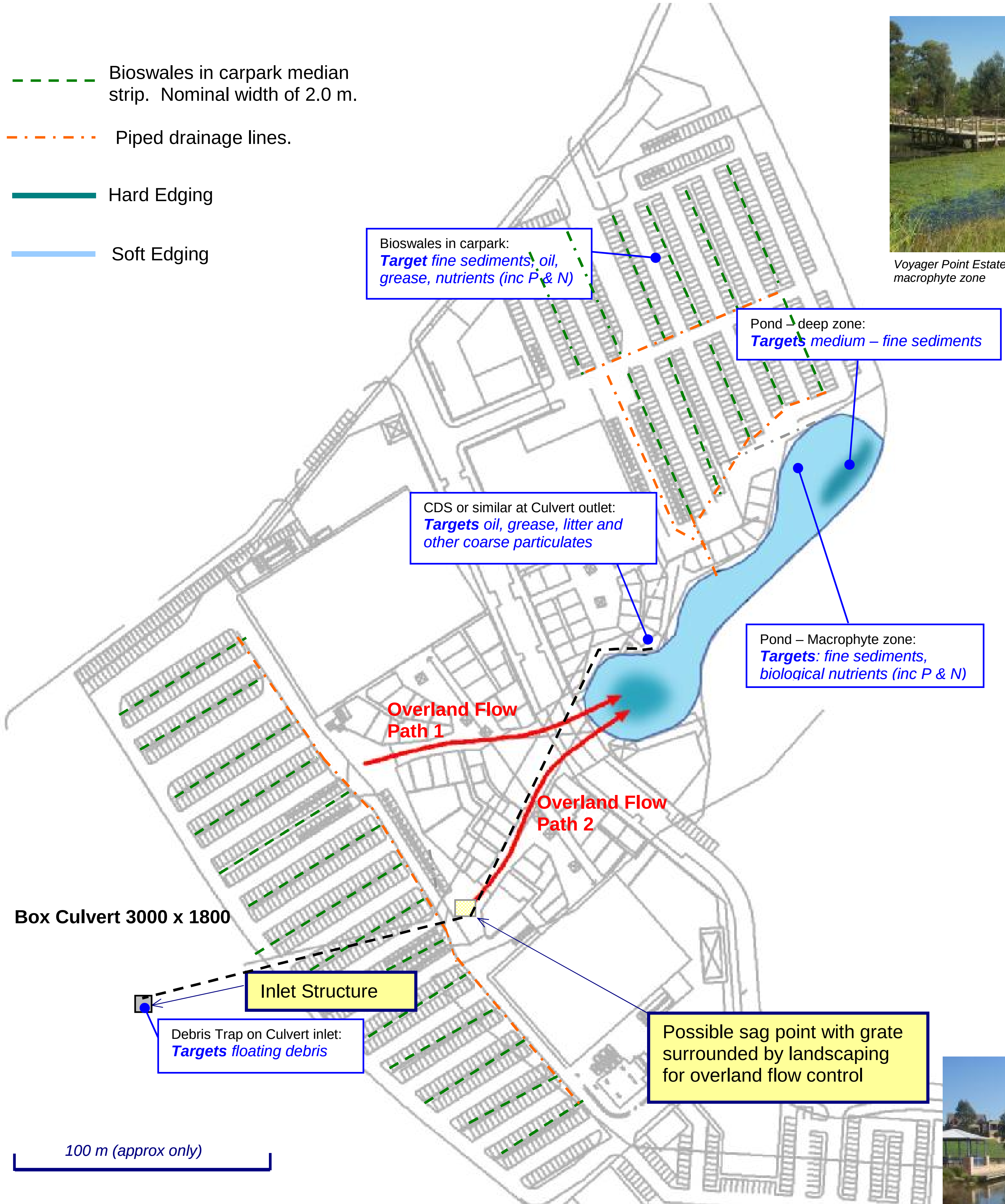
We agree with DEC that separating clean and dirty water is a good design principle, but in this instance there is no benefit (from a water quality perspective) to divert run-on water from the upstream catchment around the commercial area given its poor quality. It is preferable to direct it into the treatment chain rather than bypassing the District Centre treatment ponds.

The WSUD measures for the District Centre, based on creek management Option 4 and the then-named DIPNR's letter of 28 April 2004, are presented in **Figures 9 and 10**.

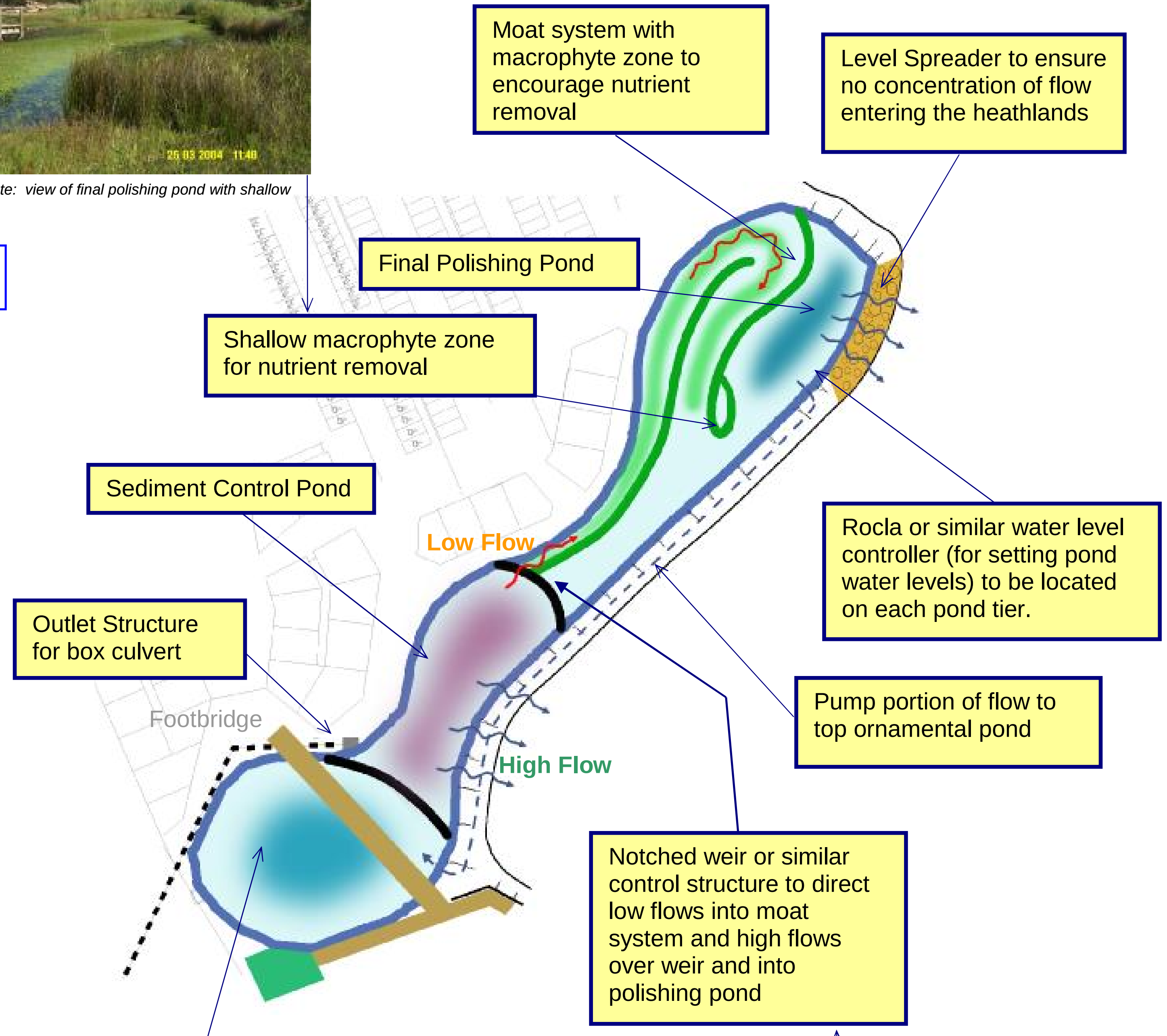
A system of bioswales is located throughout the carparks to target fine sediment and oil & grease, with the main drainage lines draining the extensive paved surfaces feeding into the large culvert passing through the District Centre.

The outlet of the main culvert under the District Centre is located adjacent to a sediment control pond immediately downstream of the ornamental pond. After sedimentation in this zone, flows are directed into a 'moat' system with densely planted macrophytes and then into a final polishing pond.

Water from the final polishing pond is recirculated into the ornamental pond and/or discharged to the heathland downstream via a 25-m wide level spreader. The 1 in 5 year peak flow across the level spreader is 11.3 m^3/sec and the exit velocity at the base of the level spreader at the start of the heathland is 1.1 m/s, with a flow depth of 400 mm. The 1% AEP peak flow across the level spreader is 20.4 m^3/sec and the exit velocity at the base of the level spreader at the start of the heathland is 1.3 m/s, with a flow depth of 600 mm. These flow depths and velocities are similar to the natural flood depths velocities experienced by the heathland.



Voyager Point Estate: view of final polishing pond with shallow macrophyte zone



The Cascades (Mt Annan): dual-use ornamental / deep water pond

Bridgewater Estate (Camden) – construction phase: view of moat system (yet to be planted with macrophytes)

Vincentia Coastal Village

Figure 9 Proposed Pond and Culvert Layout for Shopping Centre

FR Ref: 104016-3

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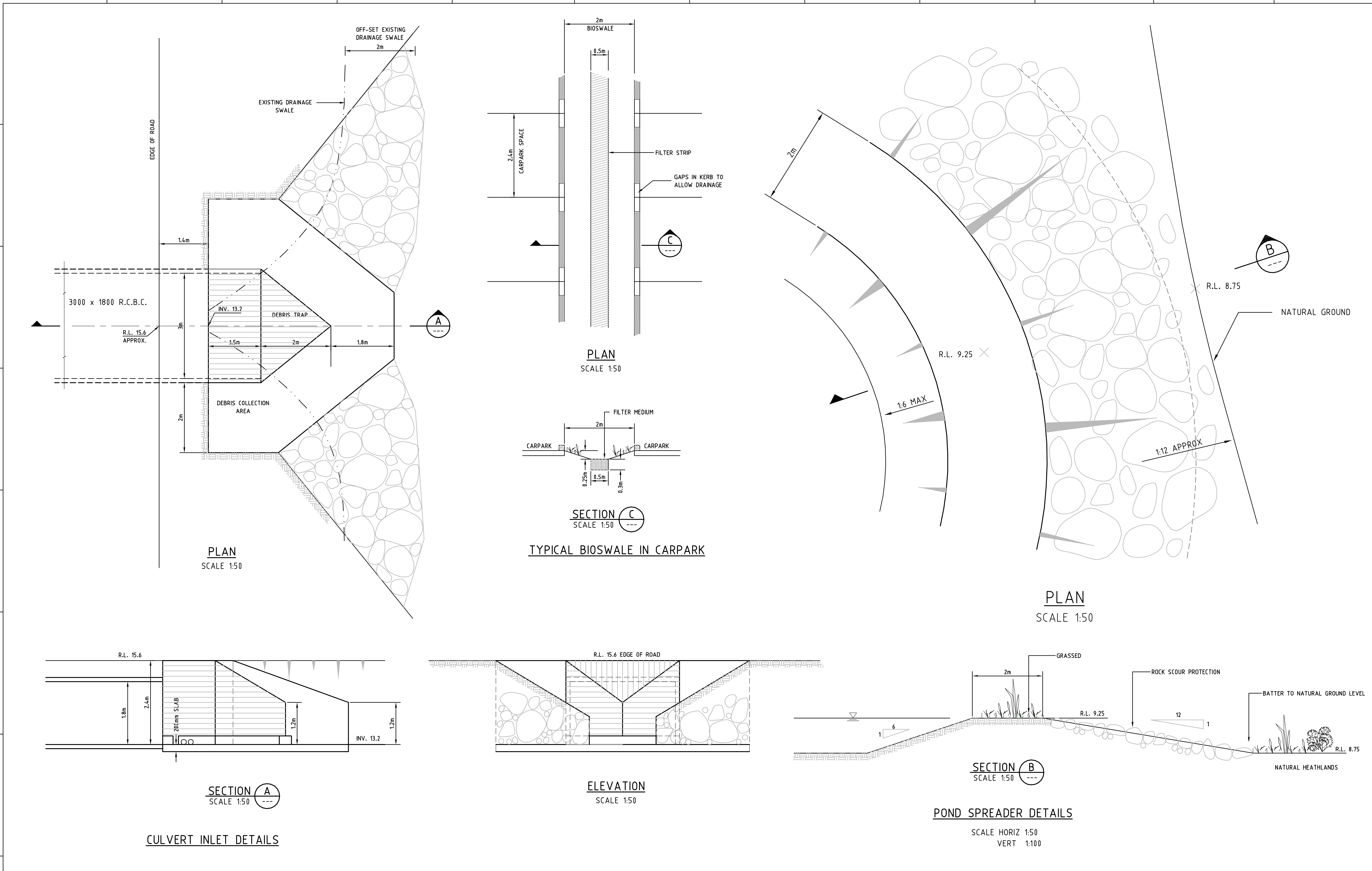

REV	DATE	BY	APP.	DETAILS

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PROJECT TITLE
VINCENTIA COASTAL VILLAGE and DISTRICT CENTRE VINCENTIA
for
STOCKLAND DEVELOPMENTS PTY LTD

DRAWING TITLE
DISTRICT CENTRE WSUD DETAILS

Project No.	Com No.	Drawing No.	REV
104016	3	FIG 10	P1

A1

The first tier 'ornamental' component of the District Centre Pond primarily serves an aesthetic function. It does however also perform a secondary water quality role in that it provides the opportunity to recirculate water through the treatment system.

The ornamental pond itself does not generally receive any untreated stormwater (the main box culvert and surface runoff from the surrounding area will be directed into the second tier sedimentation section). With the exception of rare events where the drainage system overflows, the ornamental pond only receives 'clean' roofwater runoff and treated water from the final polishing pond (delivered by a pumping system). Treated water pumped from the third tier will thus supply the ornamental pond with water that has minimal suspended solids and is low in pollutants. This will maximise the clarity of water and discourage algal growth within the first tier. Any overflows from the (first tier) ornamental pond pass into the second and third tier treatment system.

In very heavy rainfall events where the capacity of the piped drainage system serving the District Centre is exceeded, surface flows will be diverted direct to the ornamental component of the proposed District Centre pond system. This however will be a relatively rare occurrence (typically once in 5 or 10 years) and will thus have minimal impact on the usual day to day appearance of the ornamental pond.

Given the primary aesthetic nature of the first (ornamental) tier, only the second (sedimentation) and third (macrophyte and polishing) tiers were explicitly modelled in the MUSIC modelling undertaken for this study. Nonetheless, the ornamental pond is integral in the re-circulation of water through the pond system, an important process that minimises pond stagnation and therefore mosquito breeding and algal growth.

While the water quality entering the heathlands is not highly dependent on the surface area of the ornamental section, it is still a vital component of the pond system and it is recommended that a minimum surface area of 750 m^2 be adopted. The precise size and geometry of the first tier may therefore be determined at the detailed design stage, where other constraints on its configuration can be more closely appraised (such as architectural interface with the surrounds).

Rainwater collection tanks will be provided to take advantage of the large roof area of the District Centre. Rainwater captured in these tanks will be used for irrigation and ornamental pond top-up water.

Some care may be needed in the establishment phase with respect to the water quality in the pond system given the dispersive nature of the local soils. Dosing of the pond system may be required as a contingency item if the water is excessively turbid as a result of dispersive soils (refer further discussion in **Section 8.1**).

7.3. VILLAGE EAST

Village East is located in the lower part of the eastern sub-catchment. The ultimate development of this area is a mix of low-density residential and commercial areas with provision for sporting facilities (including tennis courts and a pool) and other civic amenities. The centre covers approximately 15 ha and incorporates the existing Bay and Basin Leisure Centre and sports field.

An existing water quality control pond is located to the north of the Bay & Basin Leisure Centre. It serves as a dual-use pond for irrigation of the sports field, as well as performing a water quality control function. The pond was designed with spare capacity in order to serve future development, with the design surface area of 5000 m^2 based on an ultimate development area of 13 ha (refer Lyall & Macoun, June 1998).

Our assessment of site topography confirms that the Village East (adaptable housing) can be readily drained to the Bay & Basin Leisure Centre pond. As discussed in **Section 7.2** above, the District Centre will have its own water quality pond and treatment facilities as the site topography does not lend itself to directing stormwater flows across the valley to the existing pond.

Lyall and Macoun indicate that the development of the Bay & Basin Leisure Centre was to be completed in three stages:

(i) Development of Leisure Centre, associated roads and carpark facilities;

(ii) Development of 2 sports fields;

(iii) Development of additional 2 sports fields and additional carpark facilities.

At the present time the first two stages have been completed.

The effectiveness of the existing Bay & Basin Leisure Centre pond in reducing pollutant loads is indicated in **Table 7.3** below (based on water quality modelling undertaken by Lyall & Macoun for the ultimate development scenario, which includes completion of Stage 3).

Table 7.3 - Existing Bay & Basin Leisure Centre Pond – % Reduction in Pollutant Loads

Year	TSS [a]	TN [a]	TP [a]
10% (Dry) Year	89%	95%	91%
Median Year	65%	47%	69%
90% (Wet) Year	11%	11%	23%

[a] from Table 3.3 Lyall & Macoun 1998 for Stages 1 to 3 development

While the existing pond has spare capacity (even under the ultimate development scenario which has not yet been constructed), there is opportunity to significantly improve its function as a water treatment measure. The pond was designed primarily for irrigation purposes and was conceived prior to the advances in wetland design that have occurred in the last 5 years. As such the pond has several deficiencies from a water quality control perspective, including:

- Several dead zones that provide water for irrigation but are ineffective in low-flow treatment;
- Short circuits, whereby water is directed to the outlet before passing through the maximum possible treatment length;
- Lack of macrophyte establishment due to poor soil and/or inappropriate species selection.

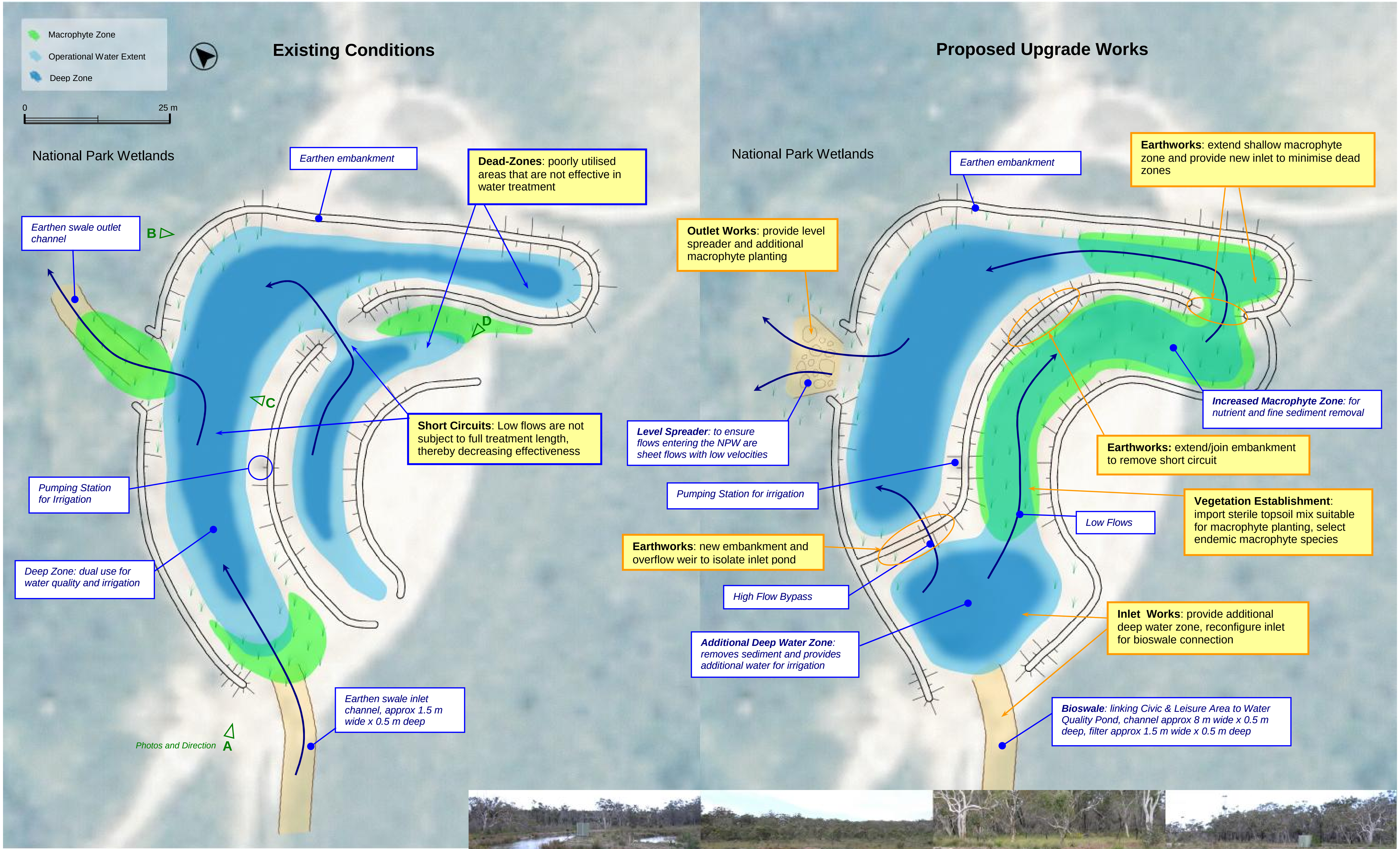
It is proposed therefore to carry out upgrade works to increase the pond effectiveness and thus enable runoff from a greater catchment area to be treated. The proposed upgrade works will remove the water quality deficiencies described above with minimal changes to existing pond geometry whilst still maintaining sufficient volumes of water for irrigation requirements. The proposed works are detailed in **Figure 11** and include:

- Minor re-shaping to maximise flow lengths and increase water quality treatment benefits
- Inlet modification to allow for bioswale connection
- Outlet modification to increase flow control
- Additional macrophyte and riparian planting around the pond perimeter and within the increased moat length connecting the inlet and outlet ponds. Given that irrigation demand will increase water level fluctuation, the macrophyte species selected will need to tolerate both wet and dry conditions.

Although the upgraded pond will be able to service a larger catchment area, it will still be necessary to provide supplementary treatment measures to fully control the quality of stormwater runoff from Village East. Bioswales are therefore proposed to provide additional benefits higher up the treatment chain. Approximately 650 m of bioswale will be located within the road reserve along the perimeter adjacent to the heathlands and a further 300 m of bioswale will link the existing pond with Village East.

Bioswales are thus provided on each side of the heathlands (ie, within the reserve of the Village East perimeter road on the south-eastern side of the heathlands; and within the reserve of Moona Creek Road on the north-western side). These bioswales will afford protection to the heathlands (and the leek orchids located in them) by:

- Helping to maintain increase soil moisture levels (offsetting the changes to the pervious nature of the existing ground following the introduction of impervious surface in the forms of roofs, roads etc post-development)
- Promoting groundwater recharge
- Filtering out pollutants in urban stormwater.



Vincentia Coastal Village

Figure 11 - Proposed Upgrade Works to Existing Bay & Basin Leisure Centre Water Quality Pond

FR Ref: 104016-03

7.4. STATUTORY APPROVAL ASPECTS

7.4.1. Artificial Water Bodies

Under the EP&A regulation, development applications for artificial water bodies with an aggregate maximum surface area greater than 5,000 m^2 situated in an area of high groundwater table (or within 40 m of a natural watercourse or in area of acid sulfate soils) are designated development. However, dry detention basins and other stormwater management construction designed to only hold water intermittently are exempted from the definition of artificial water bodies. Groundwater levels measured in piezometers constructed on the site to date indicate that the groundwater table is within 3 m of the surface, which would be deemed under the EP&A regulation as constituting an area of high seasonal groundwater.

Nevertheless, it has been clarified as a result on the Tullimbar Village court case earlier this year (Miltonbrook Management Pty Ltd v Shellharbour City Council, 2003) that the aggregate maximum surface area of 5,000-m^2 is deemed to apply to each creek system covered in any particular development application.

In the case of the Vincentia Coastal Village and District Centre, there are 3 separate creeks, so the aggregate maximum surface area threshold of 5,000-m^2 would apply to each creek. Thus a total of 15,000 m^2 of permanent pondage would be permissible without triggering the designated development threshold (provided that it was uniformly distributed and that not more than 5,000-m^2 of permanent pondage was located in any one of the 3 creeks).

As the intermittent ponds shown on **Figure 7** fall into the category of *stormwater management construction designed to only hold water intermittently* and the aggregate area of permanent ponds in any of the 3 subcatchments does not exceed 5,000-m^2, what is being proposed for the Vincentia Village and District Centre is not designated development.

7.4.2. Justification for Change to 9 (a) Zoning

The current 9(a) Natural Hazards Zone (Urban Flooding) prohibits the location of the District Centre as proposed under the Stockland proposal. In discussions with the (then-named) DIPNR (now Department of Planning, DoP), a draft Local Environmental Plan (LEP) was required for the intended uses within the 9(a) zone and to address other zone anomalies affecting the District Centre site. The draft LEP to rezone certain areas within the District Centre site would need to have regard to applicable state, regional and local environmental planning instruments (EPIs). A summary of some relevant EPIs is provided below:

State

- *S.117 directions G25 flood liable land*
- *NSW Floodplain Development Manual*
- *Water Act*
- *Native Vegetation Act*
- *Fisheries Management Act*
- *Rivers and Foreshores Improvement Act*
- *TSC Act*
- *SEPP 71*
- *Jervis Bay Leek Orchid Recovery Plan*

Regional

- *Jervis Bay Regional Environmental Planning (JREP)*

- *Flood liable land provisions*
- *Settlement strategy*

LEP
- *Objectives of the 9(a) zone together with Council's Floodplain Management requirements.*
- *Cl.29 – flood liable land*

The requirement for rezone application has been superceded by the decision by the Minister for Planning to assess the application under Part 3A of the EPAA (1979). The proposal to develop the District Centre over land currently zoned 9(a) is justifiable, given the limited intrusion of development into flood liable land and the improved outcomes with respect to threatened species in the immediate vicinity. In this regard we note the proposed development satisfies Section 117 Directions under the EPAA (1979) for rezoning of Flood Liable Land (G25), in particular:

- There is no significant increase in development of the area, with the majority of the existing 9(a) zone reserved as heathlands for environmental protection (addresses G25.2.ii.a)
- There is no increased requirement for Government spending on flood mitigation measures or infrastructure or services as the developer will be responsible for the associated costs (addresses G25.2.ii.b)
- The land to be rezoned is not substantially high hazard flood liable land, with flood flows generally constricted to the narrow stream channel (addresses G25.3).

The eastern creek (which flows through the 9(a) zone) is a lower order creek of an ephemeral nature, and as such the then-named DIPNR (now DNR) has advised that some sections may be given less 'natural' riparian treatment. The proposed development footprint of the District Centre Area is approximately 10 ha and extends into areas currently consisting of heathland and woodland (refer *Species Impact Statement, Figure 4.2*). The area of proposed vegetation removal does not significantly encroach into threatened critical habitat or adversely impact on threatened species (specifically the Leek or Leafless Tongue Orchid – refer *Species Impact Statement, Figure 4.6*).

Water Quality modelling indicates the proposed mitigation measures will ensure the total nutrient loads for post-development conditions are at or below pre-development levels. The proposed development within the 9(a) zone will therefore not adversely affect the water quality entering the heathlands and downstream Moona Moona Creek wetlands.

In discussions with the then-named DIPNR (now DoP), the concept of rezoning land to better accommodate the proposed District Centre was supported and encouraged. The (then-named) DIPNR highlighted this in the recently released Jervis Bay Settlement Strategy. The development area 9(a) land and other zones is being pursued to maximise the retention of critical habitat and preserve threatened species.

8. OPERATIONAL ISSUES

8.1. SOIL & WATER MANAGEMENT DURING CONSTRUCTION

There was a construction-phase pollution incident at a large construction site in Old Erowal Bay in May 2003, which resulted in the export of significant quantities of suspended clay sediment through forested areas downstream of the site, and into a SEPP 14 mangrove salt marsh fringing the Bay.

It appears that the reasons behind the incident were:

- Commencing work before the temporary sediment basins called for in the Erosion and Sediment Control Plan for the site had been implemented
- The nature of the underlying Permian marine deposits of siltstone, mudstone and shale, known as Wandrawandian Siltstone. Such marine shales very often weather to produce saline dispersible clay soils of high smectite content containing a high percentage of sodium in their exchange complex.

The Department of Housing “Blue Book” (the relevant guideline in NSW for all construction sites) describes such soils as Type F soils for which there is a recognised high risk of erosion, requiring special control measures. The measures required include dosing of turbid waters captured in temporary sediment basins with alum or polyaluminium chloride.

To mitigate against the potential environmental impact of sediment laden water from the construction zone being discharged into nearby watercourses, a comprehensive soil and water management plan (SWMP) would be prepared during the detailed design stage.

The SWMP would outline the method through which stormwater run-off is controlled throughout the construction phase. This would include the use of the proposed wetlands in the APZ as temporary sediment basins and the provision of catch drains and filter fabric fencing (above and below the works area respectively). Sound environmental practices dictate that these control structures are constructed and established prior to works commencing, and immediately following construction exposed soil will be grassed.

The proposed ponds and wetlands will need to be constructed in advance of each development stage for use as temporary sediment basins. Planting with macrophytes will be delayed until subdivision development construction (roads, drainage and services) is effectively complete for each stage. The developer would be responsible for establishment and maintenance of the macrophytes, with handover to Council proposed once 80% of the houses have been constructed.

For the District Centre, the bulk earthworks for the whole site and the construction of the main culvert and pond will be carried out as part of the first construction stage. This will facilitate good control of sediment runoff and protection of the adjoining heathlands.

Village East is likely to follow on after the District Centre, but as it drains to the existing pond system serving the Bay & Basin Leisure Centre, it is an independent stage. The existing Bay & Basin Leisure Centre pond system however will require temporary modification to function as a sediment basin. Depending on detailed designs for Village East there may also be a need for further temporary sediment basins within the precinct itself. This should be addressed at the Construction Certificate stage.

The proposed staging of the Western and Central Villages is compatible with the orderly provision of temporary sediment basins (refer staging plan in **Appendix F**). Areas adjacent to the riparian corridors are to be developed first, typically in an upstream to downstream sequence, thus enabling the ready use of proposed ponds and wetlands as temporary sediment basins for these stages.

Stages 7 & 8 (adjacent to District Center) are, however, some distance from the riparian corridor and it may therefore be necessary to set aside some residential land within the

Stages to act as temporary sediment basins if these Stages cannot be drained to the wetlands constructed for Stages 5 & 6.

As well as careful wetland staging the SWMP would also incorporate the following general provisions:

- Defining the works area (ie, marking out) to limit the extent of soil disturbance, and by limiting the time the soil is exposed to weathering
- Diverting clean runoff around the works area
- Limiting the vehicular activity around the works area, and vehicles should not stray from defined roadways or be driven onto saturated ground during or soon after rain events
- Implementing soil erosion control measures during the works. Measures should include silt barriers (geotextile silt stop fencing, staked haybales wrapped in geotextile fabric) and sediment traps where the soil area has been disturbed
- Rehabilitating damaged areas to at least their pre-worked condition
- Regular inspection of culverts and sedimentation structures for blockage and erosion damage.

The SWMP would also detail:

- Locations of catch drains, diversion drains, temporary sediment basins, sediment fences
- Locations and sizes (storage capacities) of temporary sediment basins
- Procedures relating to the capture and treatment of sediment laden runoff including dosing requirements
- A detailed work programs and schedules
- Re-vegetation and grassing requirements.

Soil and water management during the construction phase of Vincentia Coastal Village and District Centre will be implemented in accord with current best industry practice. Documentation of construction phase sediment control measures can be dealt with at the detail design stage as there is no strategic planning level constraints inhibiting their successful implementation.

The above approach is consistent with the Jervis Bay Settlement Strategy which calls for best practice soil and water management to be implemented when constructing urban infrastructure so as not to have a detrimental impact on the water quality of receiving waters in the region.

8.2. MAINTENANCE

General maintenance for the Vincentia Coastal Village and District Centre wetland will require regular inspections and cleaning of inlet structures and gross pollutant traps. This should occur at least every six months, and after heavy rainfall. Inspection of banks and structures after large storm events is also recommended, with any required repairs being completed. Inspection and maintenance of outlet structures is also essential to the functioning of the wetlands. It should be ensured that outlet structures remain unblocked. Regular cleanout of sediments from ponds or cleaning of macrophyte beds within wetlands is generally not required, apart from the initial phase prior to handover to Council. This is one of the advantages of adopting a wetland system for stormwater treatment.

The ponds and wetlands will however still need management intervention from time to time in the event of invasive species starting to colonise them, or some other ecological disturbance that upsets the desired species balance. For instance heavy populations of water birds have been observed to build up at a recently constructed wetland system in south-western Sydney, with excess bird numbers leading to damage to vegetation and a decline in water quality because of heavy bird manure loads. Reducing the amount of permanent water during the breeding season, which encourages the birds to migrate elsewhere to breed, can control instances such as this.

Council would be responsible for the maintenance of the proposed stormwater quality control measures to ensure they meet their performance objectives in the long term. Given that the proposed stormwater quality control measures occupy the entire APZ (Asset Protection Zone) alongside the riparian corridor boundaries, Council would also in effect be responsible for maintenance of the bushfire APZ's, as the maintenance regime for WSDUD is compatible with APZ maintenance.

Monitoring and management of the macrophyte beds is important in the first twelve months of operation to ensure plant establishment, and should be the responsibility of contractors responsible for the land development and building phase. Handover to Council would occur on a staged basis, once 80% of the houses in each stage are constructed and would also only occur after macrophytes are fully established. Establishment may involve manual manipulation of the water levels to allow different species to establish at the appropriate water depth. Water level control will also be appropriate for controlling any weed species which may establish. Manual weeding of non desirable species during the establishment phase may also be required. These aspects should be addressed in the Vegetation Management Plan for the project.

DEC advised in their 15 November 2004 letter that maintenance of WSUD measures should be addressed in the approval application submission including ownership, responsibility, goals for on-going management and operation, and contingency plans if goals not met.

We have prepared a preliminary maintenance schedule detailing typical maintenance tasks and the frequency of inspection for each WSUD measure (refer **Table 8.1**). It is noted that this table relates specifically to maintenance of the WSUD measures (GPT's, bioswales, ponds and wetlands) and does not include allowance for maintenance of riparian vegetation within the riparian corridor proper.

TABLE 8.1. SCHEDULE OF WSUD-RELATED MAINTENANCE ACTIVITIES AND ESTIMATED COSTS

Item	Component	Description	Frequency [a]	Comparison of maintenance regime against other stormwater systems		
				Required for traditional piped drainage stormwater system?	Required for Modern Drainage System with GPT's and ponds?	Required for WSUD drainage system with bioswales and intermittent ponds? [b]
1. Inspections & Public education						
1.1	Inspection of GPTs, Bioswales, Intermittent Wetlands and Ornamental Ponds	Check inlet, outlets and overflow areas are all clear of debris. Check for any evidence of erosion or scour. Inspect condition of concrete structures, pits and grates. Check bioswales filter media infiltration rates.	Allow 6 inspections per year (comprising 2 semi-annual dry-weather inspection and 4 wet weather inspections, after significant flow events)	No	Yes (50%)	Yes
1.2	Resident Education	Prepare and distribute quarterly newsletter and/or educational pamphlets (with site-specific content) to each resident household - based on documentation prepared by developer at hand-over stage	Twice per year	No	Yes	Yes
2. Minor and Routine maintenance						
2.1	Cleaning and maintenance of GPTs and trash racks	Regular clean-out of each of the 24 CDS units using the 'Basket' clean-out method (avoiding use of suction truck)	3 times per year	No	Yes	Yes
2.2	Trimming / general care of vegetation in bioswales and wetlands	Trimming, mowing and general care of grass and vegetation. Excludes landscape areas within the residential development and vegetation along southern boundary of site.	Regularly throughout the year	No	No	Yes
2.3	Removal of Debris	Remove dead trees, household waste, garden clippings, shopping trolleys. Also remove floating and dead vegetation from ponds.	Twice annually	Yes	Yes	Yes
2.4	Maintenance of batters and banks	Excavator used to reshape areas affected by scour or erosion	Once annually	Yes	Yes	Yes
2.5	Replanting and rehabilitation	Replant, fertilise, consolidate areas of poor growth and damaged areas as required.	Once annually	Yes	Yes	Yes
2.6	Pump maintenance for ornamental pond in Central Ck	Inspection, service & preventative maintenance	Once annually	No	Yes	Yes
2.7	Mosquito control measures	Control areas of temporary ponding, spray pesticide (Bti) as necessary, remove any floating mats of thick vegetation.	Six times per year (monthly for 6 months between October and April)	No	Yes	Yes
2.8	Adjustment of water levels in ponds and intermittent wetlands to optimise environmental outcomes	Reduce amount of permanent water during water bird breeding season to encourage migration elsewhere, thereby reducing vegetation damage and heavy manure loading of wetland	2 times per year	No	Yes	Yes
3. Major maintenance						
3.1	Rehabilitation of clogged bioswales	Dewater, excavate and dispose clogged filter media, supply and replace new material to design profile, replant, grass/vegetate and irrigate to establish	Once every 5 years	No	No	Yes
3.2	Removal of invasive species entering ponds and wetlands	Remove invasive species using hand removal and/or herbicide	Once every 10 years	No	Yes (50%)	Yes

TABLE 8.1. SCHEDULE OF WSUD-RELATED MAINTENANCE ACTIVITIES AND ESTIMATED COSTS

Item	Component	Description	Frequency [a]	Comparison of maintenance regime against other stormwater systems		
				Required for traditional piped drainage stormwater system?	Required for Modern Drainage System with GPT's and ponds?	Required for WSUD drainage system with bioswales and intermittent ponds? [b]
3.3	Removal of sediment build-up	Dewater ponds by pumping where required and use long reach excavators to remove sediment build-up	Once every 5 years	No	Yes	Yes
3.4	Major rehabilitation of vegetation, batters, etc after major storm event	Rebuild affected area, including clearing, re-profiling and replanting	Once every 10 years	Yes	Yes	Yes
3.5	Response to possible undesirable environmental events brought about by unforeseen factors (eg, possible algal blooms, oil/fuel spills)	Investigate reasons for undesirable event then take remedial action within affected area and rehabilitate to original condition	Once every 10 years	Yes	Yes	Yes

Foot notes:

[a] Based on Part 6 of "The Constructed Wetlands Manual Volume 2" DLWC 1998.

[b] As proposed for Vincentia Coastal Village

8.3. POST-CONSTRUCTION WATER QUALITY MONITORING

It is recommended that post-construction water quality monitoring be undertaken of the proposed ponds and wetlands, particularly during the establishment phase to confirm the water quality performance. This will be particularly important for initial development stages to ensure the WSUD measures are functioning as intended. If necessary, design modifications can be undertaken in subsequent stages to optimise water quality performance.

A typical monitoring methodology may include sampling for a range of typical urban pollutants at selected pond/ wetland inlets and outlets and within the downstream Moona Moona Creek Wetlands during both dry and wet weather periods.

The typical range of pollutants considered necessary would include:

- Total Phosphorus
- Forms of Nitrogen (TKN, NH_3-N, NO_x)
- Total Suspended Solids
- Oil and Grease.

These pollutants should be measured for say 2 to 3 wet weather events per year and during dry weather on a quarterly basis. Monitoring could cease once it had been demonstrated for a sufficiently long enough period that the ponds were functioning as designed.

To assist in assessing the impacts of pollutants, the new ANZECC guidelines (2000) should be used. These are risk-based guidelines based on site-specific trigger values and replace the single threshold values in the 1992 guidelines. The new guidelines promote a decision tree approach, whereby:

- The primary management aim is initially defined (eg aesthetic/drinking water/aquaculture)
- Environmental concerns are established
- Appropriate indicators are identified and 'default' trigger values determined
- Trigger values are then compared with measured concentrations. If measured concentrations are above the default triggers, then further assessment is undertaken (eg, modelling of Zn and Al migration to ascertain extent of dilution and attenuation). If still found to be high risk, then some form of remedial action is required.

'Default' trigger values should be those pertaining to south east Australia for protection of slightly disturbed ecosystems (estuaries) as per Table 3.3.2 of the ANZECC 2000 guidelines.

In addition to the monitoring of surface water runoff quality (pre- and post-construction) within the Coastal Village and District Centre, more extensive biophysical monitoring should also be conducted in the receiving water bodies downstream (ie, Moona Moona Creek wetlands). An appropriate program needs to be developed in conjunction with ecological consultants and the relevant authorities, together with a management response framework.

It is anticipated that the additional monitoring of downstream watercourses and the Moona Moona Creek wetlands would include:

- Monitoring changes to riparian vegetation along banks of creek downstream of site
- Monitoring of biological indicators within the Moona Moona Creek wetlands (including the balance of saltmarsh and mangroves)

- Monitoring sediment accumulation within the Moona Moona Creek wetlands at several locations
- Supporting long term research projects in the local area to improve knowledge of sedimentation rates, water quality changes and sustainability issues. This would include promoting exchange of monitoring data with other local researchers and managers and carrying out inter-site comparisons to improve understanding of management issues.
- Preparing a weed inventory and monitor change in weed coverage and extent both within site and downstream, particularly on the closest fringes of the Moona Moona Creek wetlands
- Monitoring of resident behaviour and education of residents as appropriate in regarded to composting and environmentally responsible use of fertilisers and chemicals.

Monitoring for any illegal dumping on fringes of Coast Village (abandoned shopping trolleys, discarded white goods, waster oil, excess domestic garbage, etc) and arranging for clean-up as needed.

8.4. MOSQUITO CONTROL

Mosquito control can be achieved through use of good design and management practice to minimise conditions conducive to mosquito breeding (Greenway, 2003).

Design features minimising mosquito breeding opportunities include:

- Minimising submerged and floating dead vegetation
- Ensuring topography does not result in small pools of water that are isolated from source of predators
- Appropriate maintenance, including removal of trash and weed species
- Maximising macro-invertebrate predators by providing suitable habitat, noting that maximum biodiversity can be achieved through combination of shallow marsh vegetation (200 to 400 mm deep) with no more than 70% plant cover and deeper (1 to 1.5m) open water ponds.
- Avoiding aggressive plant species such as *Typha* and *Phragmites* unless managed to prevent spreading and build-up of dead leaves and stems
- Avoiding plant species that produce thick floating mats such as *Paspalum distichum* and *Persicara sp*, which cause anaerobic conditions in underlying water columns, provide pockets of stagnant water and prevent predator access

9. OTHER POST-DEVELOPMENT WATER-RELATED ISSUES

9.1. HYDROLOGIC REGIME APPLYING TO MOONA MOONA CREEK WETLANDS

Development of the study area could potentially lead to:

(i) Increased runoff volume (potentially impacting downstream flooding and stream geomorphology). This arises from the considerable reduction in infiltration created by the introduction of impervious roof and road surfaces.

(ii) Increased runoff peak flow (also potentially impacting downstream flooding and stream geomorphology). This arises in the main from the increase in speed with which flows travel over the much smoother impervious surfaces.

(iii) Increased frequency/ magnitude of low (environmental) flows (potentially impacting stream ecology). This also arises from the introduction of significant impervious cover. Small events that would normally be fully absorbed by the pervious pre development surface create, post development, significant runoff from the impervious surfaces.

With respect to effect (i), from **Table 6.4** the average annual runoff volume is increased from 280 ML to 328 ML for the western Moona Moona Creek wetland (fed by the Western Creek) post development. Similarly, the annual runoff volume is increased from 787 ML to 993 ML for the Moona Moona Creek wetland adjacent to Collingwood Beach (fed by the Eastern and Central Creeks).

The overall annual inflow to the western Moona Moona Creek wetland (fed by the western creek) is of the order of 112 ML for the driest year in 10 and 533 ML for the wettest year in 10, compared to 253 ML for the average year. For the eastern Moona Moona Creek wetland (fed by the eastern and central creeks) the overall annual inflow is of the order of 321 ML for the driest year in 10 and 1488 ML for the wettest year in 10, compared to 714 ML for the average year. Whilst an increase in volume occurs post-development, it is noted from the above that the change attributable to effect (i) is within the range of natural year to year variability of inflows.

With respect to effect (ii), comparison of peak flows pre- and post-development in **Tables 4.2** and **4.3** show a 5% increase for the Western Creek and an increase of 9% at the confluence of the Central and Eastern Creeks for the 1% AEP event. For the PMF event, there is no increase in peak flow for the Western Creek and an increase of 4% at the confluence of the Central and Eastern Creeks.

As discussed previously such increases in peak discharges would result in a negligible increase in flood levels in the relatively large Moona Moona Creek wetland downstream.

In regard to effect (iii), MUSIC was used to analyse the change in the number of flow days from pre to post-development, arbitrarily defining a flow day as one where there was more than the equivalent of 3-mm of runoff. The results are presented in **Table 9.1**. Again, the effect is within the range of natural year to year variability and is not considered to have an adverse impact.

Table 9.1 - Number of Flow Days per Year (based on a notional 3mm Runoff Threshold

Description	Year	Number of Flow Days per Year					
		West		Central		East	
		PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*
Average Year	1911	17	30	14	44	58	61
Median Year	1964	13	27	10	30	61	55
10% (Dry) Year	1907	13	20	8	29	33	47
90% (Wet) Year	1914	38	32	31	65	111	103

Concern was expressed by the Jervis Bay Marine National Park Authority at Planning Focus Meeting No 2 that although annual flows would be within the range of currently experienced,

the effect of the proposed development is to shift the overall flow regime to that of a wetter system. The Authority noted that a shift to a wetter system would require closer ecological assessment at a local level. As an example it was suggested that freshening of saltmarsh favours encroachment of mangroves.
Our response to this concern has been two-fold:

- The developer has requested GHD, in conjunction with Dr Neil Saintilan, to undertake baseline biological monitoring of the Moona Moona Creek wetlands (ie, vegetation communities and sedimentation). Assuming such monitoring is continued both during construction and after completion of the development, this will facilitate long term management of the wetlands to ensure there are no detrimental impacts on the marine park over time. Baseline biological monitoring undertaken by GHD to date within the Moona Moona Creek wetlands (subsequent to Planning Focus meeting No.2) has shown the ecosystem is relatively intact with generally weed-free wetlands (despite encroaching development) and no obvious changes to saltmarsh/mangrove distributions over the past 50 years.
- We have reviewed our modelling and have taken into account WSUD aspects that were not specifically modelled by MUSIC. Based on this assessment we have determined that the trend to a wetter system is less than previously predicted.

The proposed development incorporates a number of WSUD that serve to reduce the volume of runoff that would otherwise occur post-development. These include:

a) The use of rainwater tanks on residential lots to provide water for toilet flushing/garden use

b) Re-use of water from large roof areas in the commercial area to provide top-up water from ornamental ponds and for toilet flushing

c) Use of buffer swales and small wetlands with pervious substrates to enable maintenance of groundwater levels

d) Provision of large ornamental ponds that will result in evaporative losses.

In order to quantify the potential reduction in annual runoff offered by rainwater tanks and associated water re-use, typical water usage rates were obtained from Sydney Water for Albion Park and the Shellharbour LGA. It is anticipated that the Vincentia Coastal Village would have comparable water usage rates to this area, given the similarity in rainfall and housing density (both are low-medium density residential areas). These figures indicate that the average household water usage is approximately 440 L/day. Of this, 23% (101L) is used for toilet flushing and 25% (110L) is used for outdoor purposes such as garden watering (assumed to be lost to the system through evaporation and deep percolation). These values were used to assess the likely reduction in post-development flows due to water re-use for toilet flushing and garden watering.

The reduction in annual runoff volumes attributable to factors a) through d) above are summarised in **Table 9.2**.

Table 9.2 - Reductions to Average Annual Runoff Volume (ML) attributable to WSUD Measures

WSUD Measure Reducing Runoff	Average Annual Runoff Volume to Western Moona Moona Ck Wetland (ML)	Average Annual Runoff Volume to Eastern Moona Moona Ck Wetland (ML)
Pre-Development Flows (ML/yr)	280	787
Post-Development Flows (ML/yr) – without specific allowance for WSUD measures	328	993
Effects of WSUD measures:		
a) Reductions through rainwater tanks & re-use on residential lots [1]	-13.6	-43.4
b) Reductions through rainwater tanks and re-use in District Centre [2]	0	-4.6
c) Reductions through seepage losses from wetlands [3]	-21.4	-69.7
d) Reductions through evaporative losses from ornamental ponds	0	-7.9
Post-Development Flows incl. allowance for WSUD measures (ML/yr)	293	875

Notes:
[1] based on 176 lots draining to western wetland and 564 lots to the eastern wetland
[2] based on 3.1 ha of net shopping area, water usage rate of 41kL/ha/day with 10% used for toilet flushing
[3] based on seepage rate of 1.7x10-7 m/s

It can be seen from the above that the effects on the hydrologic regime are far less than originally modelled once the WSUD measures are taken into account.

DEC questioned in their 15 November 2004 letter whether the predicted increase in annual flow volume to the Moona Moona Creek wetlands might be environmentally significant and said that the Study should justify whether the change in flow pattern is significant.

We have undertaken further modelling of the impacts of existing and proposed development on the eastern Moona Moona Creek wetland (the wetland most affected). Results are reproduced in **Table 9.3**.

Table 9.3 - Impacts of Existing and Proposed Development on Eastern Wetland

Subcatchment	Average Annual Flow before European settlement	Average Annual Flow for existing development extent (% increase over pre-European settlement [a])	Average Annual Flow following development of District Centre & Coastal Village (% increase over pre-European settlement [a])
North-Eastern subcatchment (Collingwood Beach)	748 ML	886 (18%)	886 (18%)
South-Western subcatchment (containing District Centre & Coastal Village)	1612 ML	1664 (3%)	1752 (8.7%)
Total catchment draining to eastern Moona Moona Creek wetland	2360 ML	2550 (8.1%)	2638 (11.8%)

[a] as calculated at sewage treatment plant access road.

As can be seen from the above table, the increase in annual runoff to the eastern Moona Moona Creek wetland associated with the existing Collingwood Beach development is double the increase predicted for the proposed District Centre & Coastal Village. We understand from biological monitoring conducted by GHD that the present health of the eastern Moona Moona Creek wetland is good (despite adjoining development with no quality controls), and therefore conclude that it is a robust system that has been resilient in the face of increased flow and other impacts over time resulting from the existing Collingwood Beach development. On this basis we would contend that the increased flows from the proposed District Centre & Coastal Village, at one-half of the impact of the increase in flows already experienced as a result of the Collingwood Beach development, are unlikely to have an adverse environmental outcome.

9.2. FLOOD EVACUATION

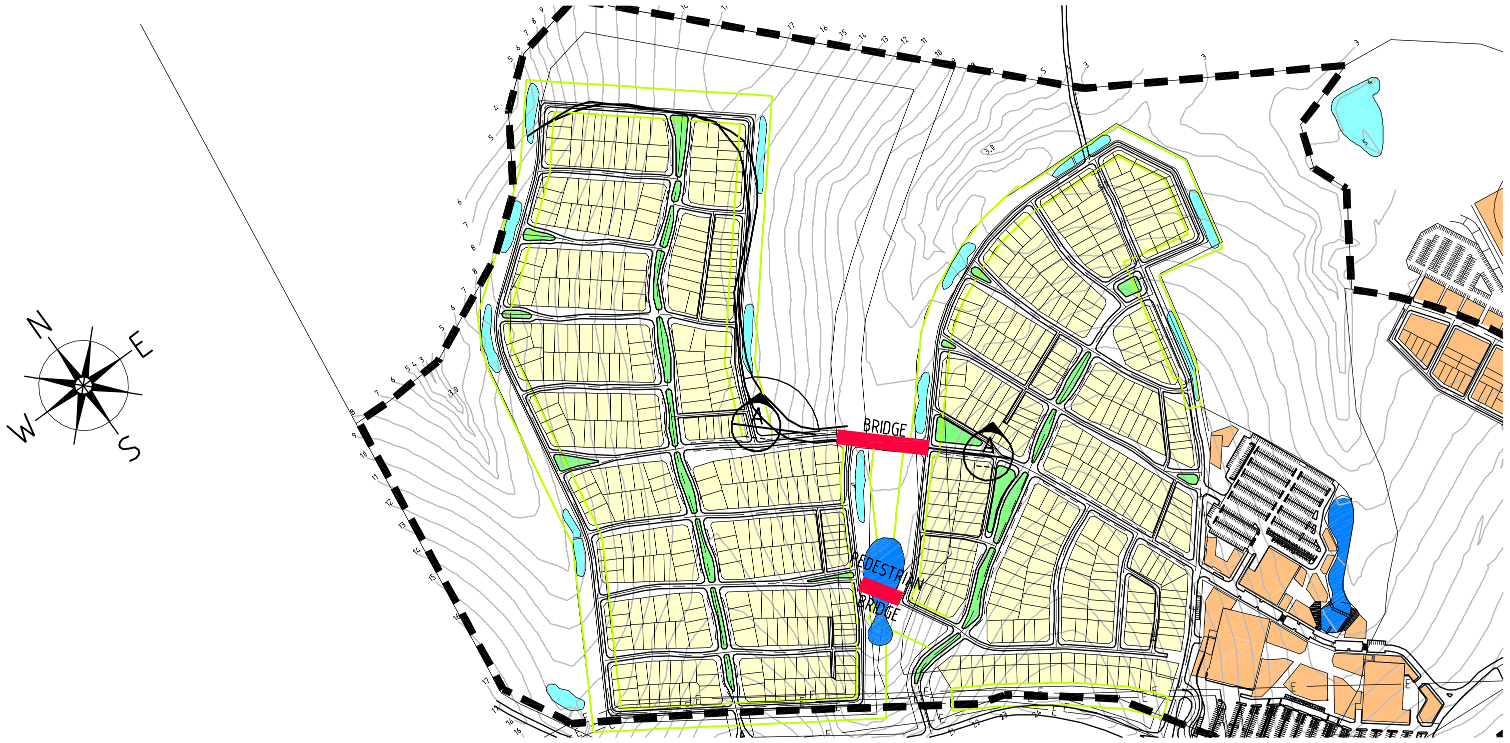
Large-scale flood events (including 1% AEP and PMF) are primarily confined to the corridors set aside for ecological requirements. This renders it unlikely that any complex evacuation procedures will be required, even in the PMF. Nonetheless, the development plan as proposed is ideal for evacuation, with roads rising from the edge of riparian corridors to the main thoroughfares which traverse the ridgelines. This is entirely consistent with preferred design arrangements described in the Floodplain Management Manual.

9.3. CREEK CROSSINGS

The development has been planned to minimise creek crossings. Refer to **Figures 12** and **13** for locations and conceptual crossing arrangements.

The bridges will be designed to have 500 mm minimum clearance between the 1% AEP flood level and the underside of the bridge girder in accord with Council standards.

DO NOT SCALE IF IN DOUBT ASK



PLAN
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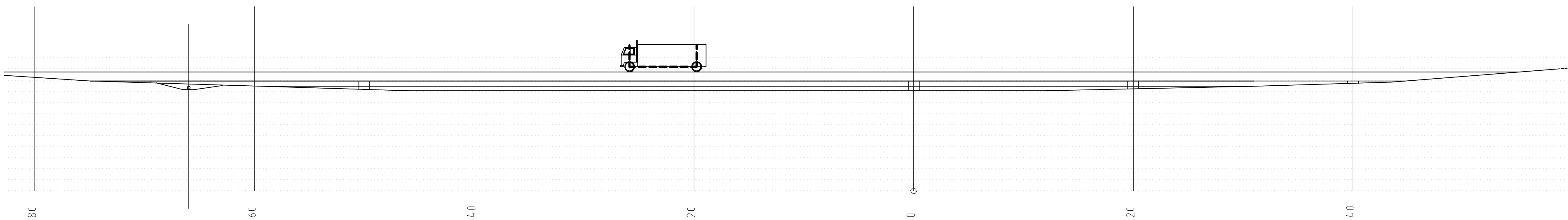
CROSSINGS AT NATURAL SCALE



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P2	13/06/01	AP	AW	UPDATED FOR DEC 2005 DEVELOPMENT FOOTPRINT

DRAWING STATUS		
DESIGN BY	AW	28/5/04
DRAWN BY	AP	28/5/04
DRAFTING CHECK	PJS	10/02/05
DESIGN CHECK	AW	14/12/04
FINAL APPROVAL	PSN	10/02/05

PRELIMINARY

SCALE: (on A1 Original) AS SHOWN

HEIGHT DATUM AHD

FORBES RIGBY PTY LTD
Engineers Planners & Scientists
Quality Endorsed Company, ISO 9001 LIC QEC 10508, Standards Australia
278 KEIRA STREET, WOLLONGONG, NSW 2500
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PROJECT TITLE
VINCENTIA COASTAL VILLAGE & DISTRICT CENTRE
for
STOCKLAND DEVELOPMENTS PTY LTD

DRAWING TITLE
BRIDGE AND CAUSEWAY CONCEPT DESIGN FOR ROAD CROSSINGS

Project No.	Com No.	Drawing No.	REV
104016	3	FIG 12	P2

A1

File Plotted: U:\2004\104-016-03 - VINCENTIA DISTRICT CENTRE - WSUD STUDY\MONITORING\DRAWING\BUILD\13-01-06\FIG12-ROAD CROSSING.DWG
January 13, 2006 5:48:37 p.m.
Xrefs: x104016-03_base_1.DWG

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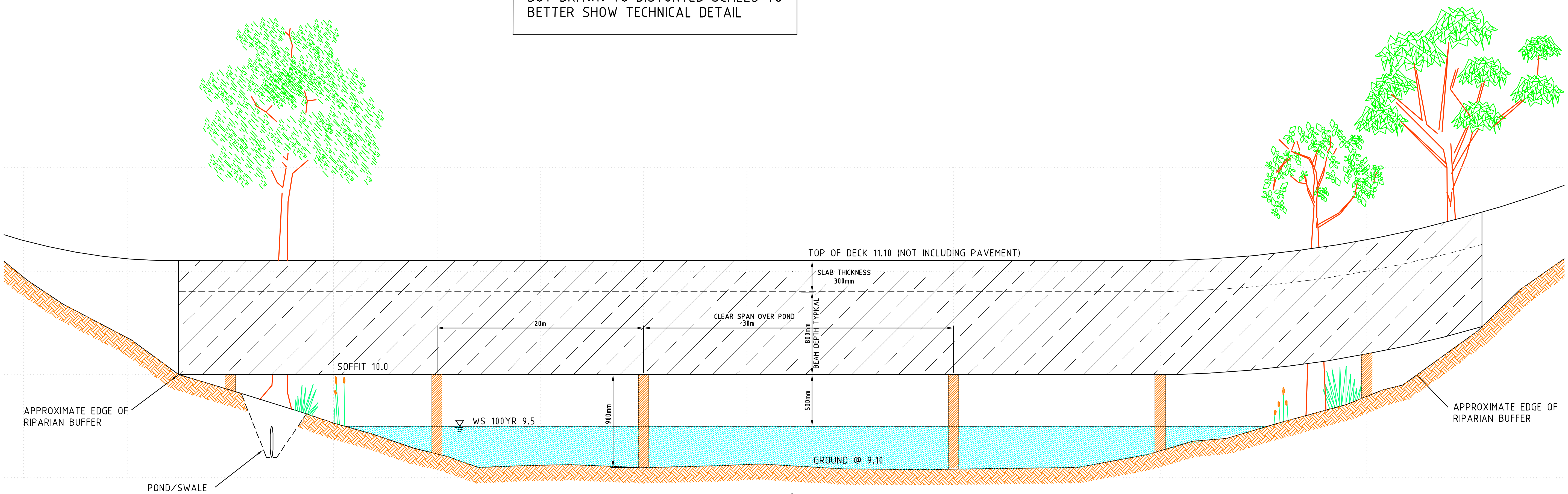

SECTION A

SCALE HORZ 1 : 200
VERT 1 : 20

REV	DATE	BY	APP.	DETAILS
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DRAWING STATUS		
DESIGN BY	AW	28/5/04
DRAWN BY	AP	28/5/04
DRAFTING CHECK	PJS	10/02/05
DESIGN CHECK	AW	14/12/04
FINAL APPROVAL	PSN	10/02/05

PRELIMINARY

SCALE: (on A1 Original) AS SHOWN

HEIGHT DATUM AHD

FORBES RIGBY PTY LTD
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PROJECT TITLE
VINCENTIA COASTAL VILLAGE & DISTRICT CENTRE for STOCKLAND DEVELOPMENTS PTY LTD

DRAWING TITLE
BRIDGE AND CAUSEWAY ROAD CROSSING DETAILS

Project No.	Com No.	Drawing No.	REV
104016	3	FIG 13	P2

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January 13, 2006 5:51:31 p.m.

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9.4. WATER BODY LONGEVITY

It was a requirement of Stockland, for aesthetic reasons, that frequent drying out of the large ponds on the Central Creek and the ornamental component of Eastern Creek (ie, District Centre pond) does not occur. Stockland advised that these ponds should remain substantially full for the average year, but may dry out for a month or two in the driest year in ten.

A spreadsheet based water balance model was used to predict the water levels in the ponds over a 102-year simulation period.

The data used for modelling comprises:

- Recorded daily rainfall data from the Bureau of Meteorology for the Jervis Bay (Point Perpendicular Lighthouse) rainfall gauge from July 1899 to November 2003
- Daily mean evapo-transpiration data for each month. The adopted values were identical to those used in the MUSIC model and were determined from maps of the region provided by the Bureau of Meteorology
- Seepage data based on commonly adopted values for sandy-clays. The estimated permeability was taken as $k=1.7\times10^{-7}$ m/s (0.6 mm/hr).

The water balance model consists of three calculation modules:

(a) Runoff Module which calculates the amount of water entering the ponds each day due to runoff from the local catchment (calculated by applying a runoff factor to the daily rainfall). This reflects the fact that only a proportion of the rainfall depth will be converted to runoff, with the remainder lost through a variety of mechanisms including ground infiltration, interception by trees and filling of depression storages. The adopted runoff factor (C) was 0.56, which is typical for an urban environment. A minimum rainfall event of 2mm was adopted (ie, daily rainfall less than 2 mm is assumed to cause zero runoff).

(b) Loss Module which calculates the amount of water removed from the pond as a result of evapo-transpiration, seepage and flows over the outlet weir.

(c) Final Volume Module which calculates the volume of water remaining in the pond at the end of each day. There is a net input on any given day if the runoff volume is greater than the losses due to seepage, evapo-transpiration and weir overflow. Conversely, there is a net output if the runoff volume is less than the losses due to seepage, evapo-transpiration and weir overflow. The amount of water in the pond at the end of each day is calculated by adding (or subtracting) the net input or output volume for that day from the amount of water present at the start of the day.

The model results are presented graphically in **Figure 14** and **15** below.

Figure 14 shows the proportion of time that the Central Ck pond is dry for each year of simulation. Over the 102 year simulation period there are only 6 years where the pond is dry for more than 10% of the time.

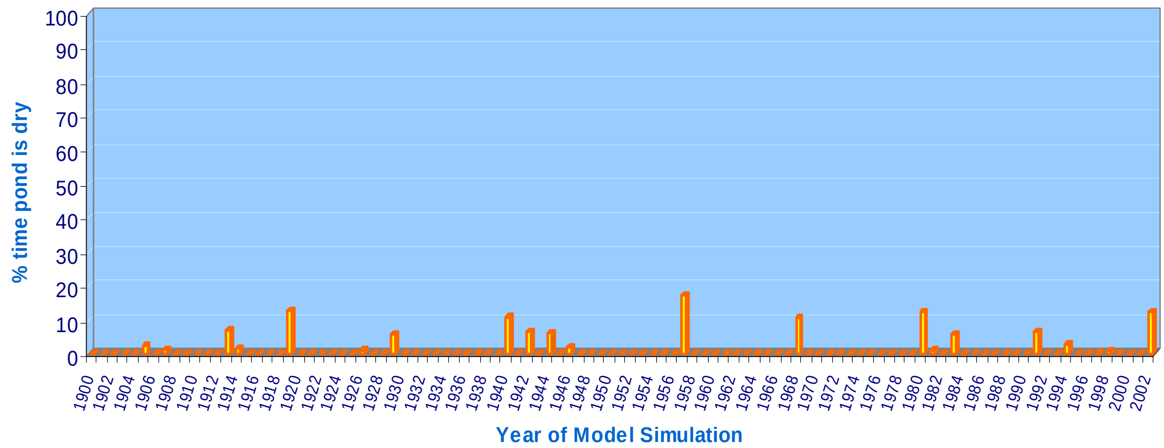

Figure 14 - Proportion of Time Central Creek Pond is Dry

Figure 15 shows the long-term persistence of the water body in the Central Ck Pond. It indicates that there is at least 1000 m^3 of water in the pond for 96% of the time. With appropriate design and treatment of pond edges and batters, a 1000 m^3 body of water would still achieve the desired aesthetic purpose.

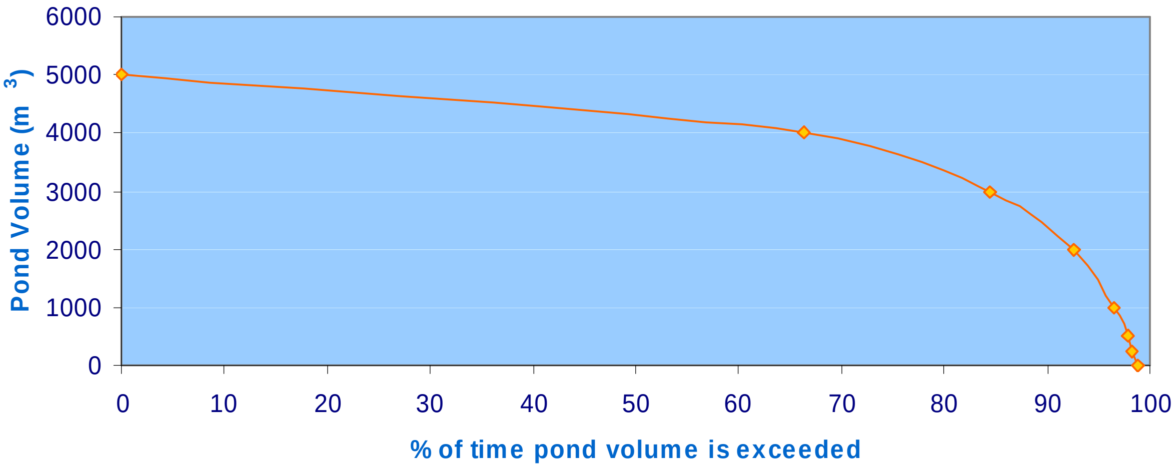

Figure 15 - Water Body Persistence in Central Creek Pond

Figure 16 shows the proportion of time that the ornamental component Eastern Ck (Commercial) pond is dry for each year of simulation. Over the 102-year simulation period there are no years where the pond is dry for more than 10% of the time.

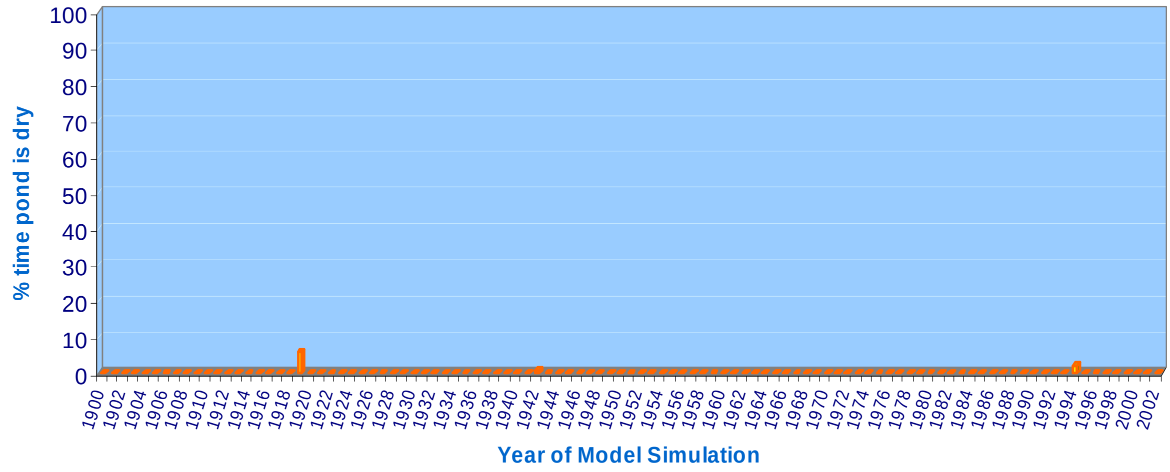

Figure 16 - Proportion of time District Centre Pond is Dry

Figure 17 shows the long-term persistence of the water body in District Centre Pond. It indicates that there is at least 500 m^3 of water in the pond for 99% of the time. Again, with appropriate design and treatment of pond edges, a 500 m^3 body of water would achieve the desired aesthetic outcome.

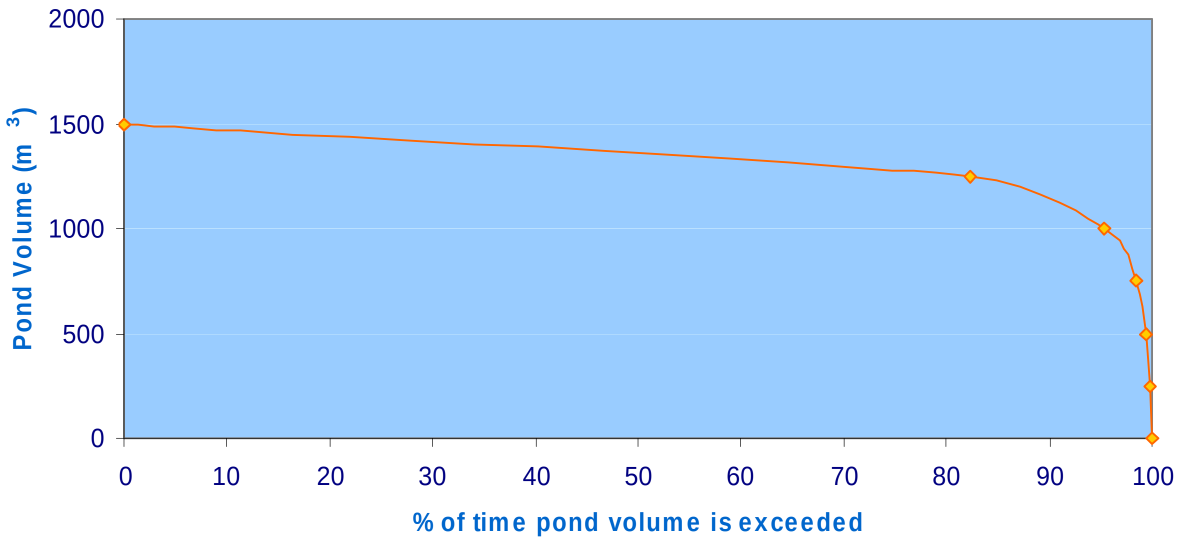

Figure 17 - Water Body Persistence in District Centre Pond

Given the possibility of refinements to parameter estimates based on further testing of site soils, additional modelling was conducted in order to determine the sensitivity of pond water levels to variations in runoff quantity and seepage losses. Two runoff coefficients were considered:

- C=0.56 – typical for urban environments with paved surfaces
- C=0.30 – representing natural/rural catchments with predominantly pervious surfaces.

Three seepage loss parameters were modelled for each runoff coefficient, with seepage (k) varying from 0.6 mm/hr (sandy-clay) to 3.6 mm/hr (very fine sands with clay content) – compared to 0.6 mm/hr adopted in the original analysis as typical for sandy-clays.

The sensitivity results are reproduced in **Table 9.4** and presented graphically for the Central Ck Pond in **Figure 18** and for the District Centre Pond in **Figure 19.** Comparison of the results for the two different C-values shows that the ponds are not particularly sensitive to runoff quantities, with water body longevity remaining similar for both cases. However, comparison of the results for different seepage rates indicates the pond water levels are sensitive to infiltration losses, with water body longevity dropping sharply with each increase in k-value.

Table 9.4 - Sensitivity Results for Water Balance Modelling

Scenario	Central Ck Pond % time pond volume is at least 1000 m^3	Eastern Ck Pond % time pond volume is at least 500 m^3
Runoff Coefficient C = 0.56		
k = 0.6 mm/hr [a]	96 %	99.4 %
k = 1.2 mm/hr	76 %	95 %
k = 3.6 mm/hr	26 %	65 %
Runoff Coefficient C = 0.30		
k = 0.6 mm/hr	85 %	99.0 %
k = 1.2 mm/hr	45 %	92 %
k = 3.6 mm/hr	11 %	53 %

[a] scenario presented graphically in figures 15-18

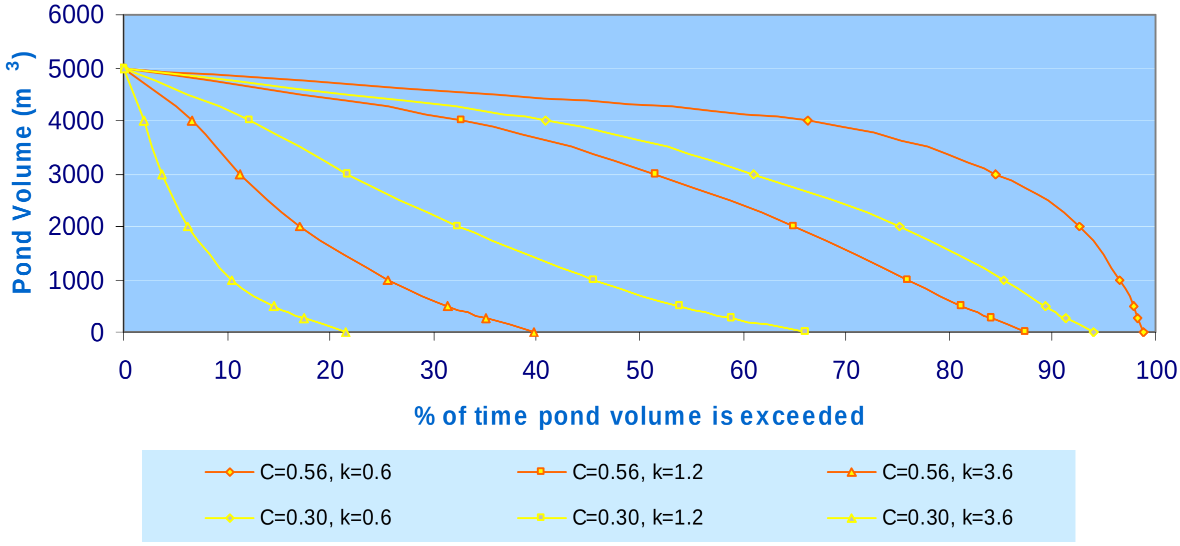

Figure 18 - Sensitivity Analysis for Central Ck Pond

Site specific testing of the permeability of on-site soils has already been initiated for each of the large permanent pond sites to appraise what further measures may be required to alimit seepage losses from the base of the ponds. Depending on the outcome of this testing , it may be necessary at the detailed design stage to consider lining the ponds with a clay or other impervious material to ensure water levels in the ponds do not drop rapidly due to excessive seepage losses. It is noted that use of rainwater tanks and/or recirculating water from ponds lower in the system can also be used for top-up water for the ornamental ponds.

It should therefore be possible to keep the main ornamental ponds filled with water in all times except for severe drought periods. Nevertheless, further assessment is recommended at the detailed design stage to confirm the nature of pond water top-up arrangements once better seepage loss estimates are obtained following additional geotechnical testing.

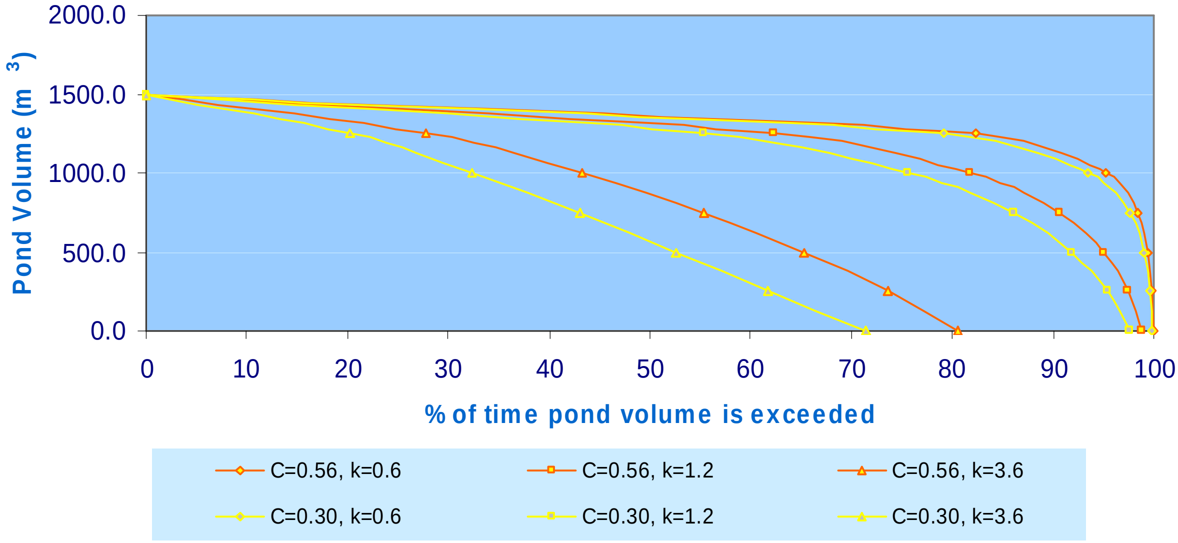

Figure 19 - Sensitivity Analysis for District Centre Pond

10. CONCLUSIONS & RECOMMENDATIONS

10.1. CONCLUSIONS

The conclusions of this study are as follows:

Flooding

- 1% AEP flood inundation extents are generally contained within the proposed riparian corridors which have been defined on the basis of more spatially significant ecological constraints.
- Backwater modelling indicates that an increase in Manning's n from 0.1 (for existing forested conditions) to 0.2 (representing an upper limit of possible vegetation density) has minimal impact on the inundation limits.
- The site is not constrained by flood evacuation issues, having well elevated ridges linked to the floodplains by roads at numerous locations.

Water Quality Objectives

- The principal water quality objective often applied to new urban release areas is *"the maintenance of water quality within receiving water bodies at pre-development levels".* This is in accord with the JBSS (DIPNR, 2003) objectives and is therefore considered an appropriate water quality objective for the Vincentia Coastal Village and District Centre.
- Given that almost the whole site is forested or heathland and only small portions of the headwaters of each of the 3 subcatchments covering the site subject to a rural land use, this objective represents a demanding requirement.

Proposed WSUD Measures

WSUD measures considered most appropriate to the Vincentia Coastal Village & District Centre are in the areas of water supply management, stormwater quality control and groundwater management.

For <u>water supply management,</u> the following measures are proposed (with further detail provided in the Cundall Johnston & Partners ESD Opportunities report):

- demand management (including use of AAA-rated fittings and native landscaping/gardens to reduce garden watering usage); and
- 5-kL rainwater tanks for each house to collect roof runoff (used for toilet flushing and garden watering).

For <u>stormwater quality management</u> a combination of proprietary litter/sediment traps, bio-retention swales and water quality control ponds/ artificial wetlands is proposed, located in ways sympathetic to the other environmental constraints of the site.

Preliminary concept designs have been developed for the stormwater quality treatment system. The proposed stormwater quality control measures for the Village Area are presented in **Figure 7**. The WSUD measures for the District Centre are presented in **Figure 9** and **10**.

For <u>groundwater management</u>, the following measures are proposed:

- General use of bioswales and unlined intermittent wetlands.

- Provision of a bioswale within the reserve of the (slightly relocated) Moona Creek Road, to help increase soil moisture levels and groundwater recharge on the north-western side of the leek orchid area.
- Leaving the lower part of the proposed District Centre pond system unlined, again to assist maintenance of soil moisture levels and groundwater recharge upstream of the leek orchid area.
- Ensuring that flows from the piped creek underneath the District Centre are not concentrated, but are spread out as sheet flow as they would have more likely occurred under natural conditions.

Other Issues

- Statutory approval aspects in relation to artificial water bodies and justification for development over 9(a) Zoning are discussed in **Section 7.4**.
- Operational issues including staging, soil and water management during construction, maintenance and post-construction monitoring are discussed in **Section 8** of the report. It is concluded that the site readily lends itself to highly effective soil and water management controls.
- Other water-related issues are discussed in **Section 9**. These include:

⇒ Changes to the hydrologic regime applying to the Moona Moona Creek wetlands downstream – where it was found that increases in peak discharges would result in negligible increases in flood levels and increased runoff volume post-development is small compared to the natural year to year variability of inflows. Furthermore, the proposed development incorporates a number of WSUD measures that serve to reduce the volume of runoff post-development. These include:

  - The use of rainwater tanks on residential lots to provide water for toilet flushing/garden watering use
  - Re-use of water from large roof areas in the commercial area to provide top-up water from ornamental ponds and for toilet flushing
  - Use of buffer swales and small wetlands with pervious substrates
  - Provision of large ornamental ponds that will result in significant evaporative losses.

Such runoff reduction measures serve to reduce the post-development runoff volumes entering the Moona Moona Creek Wetlands to close to pre-development levels.

Biological monitoring indicated that the eastern Moona Moona Creek wetland is a robust system that has been resilient in the face of increased flow and other impacts over time resulting from the existing Collingwood Beach development. Given this resilience to flow variations we would contend that the increased flows from the proposed District Centre & Coastal Village, shown by modelling to be one-half of the increase in flows already experienced as a result of the Collingwood Beach development, are unlikely to have an adverse environmental outcome.

⇒ Creek crossings - bridges are located in areas subject to additional traffic and/or in environmentally more sensitive areas, with causeways/pedestrian bridges at other locations. Refer to **Figures 11** and **12** for locations and conceptual crossing arrangements.

⇒ Long term persistence of open water in the larger ponds (which also serve an ornamental function) - water balance modelling indicated that the large ponds on the Central Creek and the ornamental component of the District Centre pond remain substantially full for the average year, but may dry out for a month or two in the driest year in ten.

⇒ Biological monitoring by GHD and Dr Neil Saintilan of the Moona Moona Creek wetlands (ie, vegetation communities and sedimentation) which will be continued both during construction and after completion of the development, to facilitate long term management of the wetlands to ensure there are no detrimental impacts on the marine park over time.

10.2. RECOMMENDATIONS

It is recommended that:

- This report is included as a supporting document in the submission to the state government under the Major Projects SEPP (Part 3A of the Environmental Planning & Assessment Act).
- Further water quality modelling is undertaken at the Construction Certificate stage to confirm performance of the proposed stormwater quality treatment measures (ie. once engineering details are better defined).
- Further modelling is undertaken at the detailed design stage to confirm the scope of pond water top-up arrangements on the basis of better seepage loss estimates obtained from further testing of site soils.

Prepared by
for and on behalf of
FORBES RIGBY PTY LTD

…………………………………….
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Reviewed by

…………………………………….
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GLOSSARY

Technical Term	Meaning
Average Recurrence Interval	The expected or average interval of time between exceedances of a rainfall or flood event of given magnitude
Biological Oxygen Demand	Measure of the organic pollution of water, expressed as the amount of oxygen that is taken up when bacteria break down a sample of organic matter. Removal of large quantities of oxygen from the receiving waters can lead to fish kills.
Bio-retention Swales	Water quality treatment devices used to remove nutrients from stormwater. Consist of a grassed swale with gravel or sand filter beneath.
Catchment	Area draining into a particular creek system or its tributaries, typically bounded by higher ground around its perimeter
Discharge	The flow rate of water
Ephemeral	A body of water which only contains water on an irregular basis. Generally only immediately following wet weather.
Eutrophication	increase in the rate of supply of organic matter to a river or stream
Evapo-transpiration	measurement of the amount of water vapor returned to the air in a given area
Event Mean Concentration	The flow weighted average concentration of a water based pollutant estimated from discrete measurements taken at regular intervals during a storm event.
Faecal Coliforms	Measure of water quality
Gradient	Slope or rate of fall of land/pipe/stream
Heathland	Area covered predominantly in grass with light tree cover
Hydraulic	A term given to the study of water flow, as it relates to the evaluation of flow depths, levels and velocities
Macrophyte	Aquatic plant
Manning's n	A measure of channel (or pipe) roughness. The higher the value of 'n', the rougher the channel and the smaller the calculated discharge for a given waterway cross-section
Morphology	The form or shape of something (eg. Creek bed)
MUSIC	Model for Urban Stormwater Improvement Conceptualisation-Computer Model used to predict stormwater quality outcomes associated with development and associated improvement measures
Topography	Terrain or formation of land

SHORTENED FORMS

Acronym	Meaning
AEP	Annual Exceedance Probability
APZ	Asset Protection Zones
ARI	Average Recurrence Interval
DEC	Department of Environment & Conservation
DNR	Department of Natural Resources
DoP	Department of Planning
DTM	Digital Terrain Model
DIPNR	(the former) Department of Infrastructure, Planning and Natural Resources
DLWC	(the former) Department of Land and Water Conservation
EMC	Event Means Concentration
EPA	New South Wales Environment Protection Authority
EPI	Environmental Planning Instrument
ERM	Environmental Resources Management Pty Ltd
ESD	Ecologically Sustainable Development
FR	Forbes Rigby Pty Ltd
GIS	Geographical Information System
GPT	Gross Pollutant Trap
HECRAS	Hydrologic Engineering Centers River Analysis System
LEP	Local Environmental Plan
LES	Local Environmental Study
LGA	Local Government Act 1993
LPI	Land Property Information Pty Ltd
NURP	Nationwide Urban Runoff Program
OSD	On Site Detention
PCB	Polychlorinated Biphenyl
PMF	Probable Maximum Flood
SS	Suspended Solids
SCA	Sydney Catchment Authority
SCC	Shoalhaven City Council
SEPP	State Environmental Planning Policy
SWMP	Soil and Water Management Plan
TN	Total Nitrogen
TP	Total Phosphorus
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
USTM	Universal Stormwater Treatment Model
WCMWG	Water Cycle Working Management Working Group
WSUD	Water Sensitive Urban Design

APPENDIX A

BASELINE SURFACE WATER QUALITY MONITORING

TABLE OF CONTENTS

A1. INTRODUCTION

A1.1. PURPOSE OF BASELINE WATER QUALITY MONITORING

This baseline water quality monitoring aims to determine the typical water quality of local watercourses within the catchments of the proposed Vincentia Coastal Village & District Centre, prior to development. This will enable comparison for future water quality sampling in this area and assist in the design of appropriate water quality control measures.

This working paper presents the results for four sampling campaigns carried out between October 2004 and January 2005. It also describes the results of the fifth and most recent campaign conducted in late November 2005.

A1.2. SCOPE OF STUDY

A program of baseline monitoring was requested by agencies in response to a paucity of pre-development baseline water quality data.

It was agreed that within the limited time period available, a program of two 'wet' (>25 mm rainfall in day) and two 'dry' campaigns be undertaken for five locations in the three subject watercourses. The monitoring concentrates on nutrient parameters (which were highlighted as potential stressors to downstream wetlands), suspended solids and Grease & Oils.

More recently (in September 2005), Stockland instructed Forbes Rigby to conduct further surface water quality monitoring, as a continuation of the baseline monitoring program discussed above. This includes sampling at the 5 previous locations within or near Stockland's site (SW1 to SW5), providing for 2 wet and 2 dry weather sampling campaigns, and additionally involves testing for faecal coliforms as well as nutrient parameters, suspended solids and grease & oils. The scope of monitoring work has also been expanded to include additional water quality monitoring points within the Moona Moona Creek wetlands (MCW1 to MCW5).

As stated in the February 2005 WSUD Report, the principal water quality objective often applied to recent urban release areas has been *"the maintenance of water quality within receiving water bodies at pre-development levels".* It is also the approach advocated by Appendix H1 of the EPA's *Managing Urban Stormwater – Council Handbook (Draft, 1997*), and is in accord with the Jervis Bay Settlement Strategy (DIPNR, 2003) objectives. It is thus considered an appropriate water quality objective for the Vincentia Coastal Village and District Centre.

Given that almost the whole site is forested or heath land and only small portions of the headwaters of each of the 3 sub catchments covering the site are subject to a rural land use, it may be assumed current water quality is high, and therefore meeting an objective of *no net increase in pollutant loadings* may be a demanding requirement. This paper then, seeks to quantitatively determine if this is actually the case, and compares the results with runoff quality from published studies in order to assist the reader establish a relative perception of the existing water quality.

This paper outlines the limited background data available and the sampling methodology employed. It then outlines the water quality results and discusses them in the context of standard national trigger values. A discussion then follows which examines trends in the results.

A2. EXISTING DATA

A2.1. BACKGROUND DATA

Whilst there is no comprehensive long term water quality data available for the Moona Moona Creek wetlands (approximately 0.5 km downstream of the site boundary), there is reference in Lyall & Macoun's 1998 report to a limited sampling program undertaken by Council in the Moona Moona Creek estuary over the period 1992-97.

Parameters measured were turbidity, dissolved oxygen and faecal coliforms. The data indicates good water quality, but there is no information on the estuary's nutrient status. The Lyall & Macoun report also refers to a study by Broadbent in 1988 which indicates no sign of degradation to the wetlands by human activity other than sediment associated with the Collingwood Beach development and the sewerage line behind Collingwood Beach.

We have made further enquiries of Shoalhaven City Council in regard to any more recent data that may be available. Mr Andrew Gibbs of SCC advised water quality testing is undertaken regularly in Moona Moona Ck and at other locations along the Vincentia beachfront. However, the samples are primarily tested for bacterial pathogens associated with sewage contamination (such as faecal coliforms) and not for analytes that are indicators of stormwater quality (such as total suspended solids, phosphorous and nitrogen). Following a request made at a meeting in the DIPNR offices in Lee St Sydney on 19 October 2004, Council undertook to collate the available water quality data and provide it to the Stockland consultant team. The data however is not yet to hand.

A2.2. NETWORK GEOTECHNICS DATA

An initial campaign of baseline water quality monitoring was undertaken by Network Geotechnics as part of the current studies commissioned by Stockland. This involved grab samples at 3 locations immediately after a moderate rainfall event and testing them for a wide range of analytes including total dissolved solids, turbidity, heavy metals, pesticides and some nutrients. Results for all tested analytes are reproduced in **Table 2.1** below.

The test results indicate that some trace metals (aluminium, chromium, lead and zinc) and also ammonia are at elevated levels, when compared with the default trigger values for 99% protection of species criteria for category 1 high conservation/ecological value (refer ANZECC/ ARMCANZZ 2000 Table 3.4.1 for metals; and Table 3.3.2 "South-East Australia, slightly disturbed low land rivers" for nutrients and biodegradable inorganic matter). The trace metals are typical of the urban suite of pollutants associated with runoff from road surfaces, and the ammonia may be indicative of the rural land use to the south of Naval College Road.

Table 1 Baseline Surface Water Quality Monitoring Results – Nov 2003 [a]

Analyte	Units	SW-A (Upstream)	SW-B (Upstream)	SW-C Downstream)	Threshold Levels
pH		6.07	5.62	4.47	6.5-8.0[1]
Total Dissolved Solids (TDS)	mg/L	358	630	478	<650[3] (very low to low salinity
Colour (True)	PCU	150	70	5	30-40[3]

Analyte	Units	SW-A (Upstream)	SW-B (Upstream)	SW-C Downstream)	Threshold Levels
Turbity	NTU	70.0	24000	65.0	6-50[1]
Total hardness as $CaCO_3$	mg/L	71	39	116	20-100[3]
Calcium – Filtered	mg/L	11	5	11	<1000[3] (Stock)
Magnesium – Filtered	mg/L	11	7	21	<15[3]
Sodium – Filtered	mg/L	54	45	102	
Potassium – Filtered	mg/L	3	1	2	
Bicarbonate as CaCO3	mg/L	10	12	<1	
Sulphate – Filtered	mg/L	24	5	53	250[2]
Chloride	mg/L	125	99	241	250[2]
Iron – Total	mg/L	4.42	29.2	7.08	-
Silver – Total	mg/L	<0.001	<0.001	<0.001	0.00005[1]
Aluminium – Total	mg/L	**0.75**	**29.2**	**1.69**	0.055[1]
Arsenic – Total	mg/L	<0.001	0.008	<0.001	0.013[2]
Boron – Total	mg/L	0.01	0.03	0.01	0.370[1]
Barium – Total	mg/L	0.020	0.161	0.059	1.0[2]
Cadmium – Total	mg/L	<0.001	0.001	<0.001	0.0002[1]
Chromium - Total	mg/L	**0.004**	**0.024**	**0.003**	0.001[1]
Copper – Total	mg/L	**0.002**	**0.030**	**0.003**	0.0014[1]
Manganese – Total	mg/L	0.004	0.162	0.020	1.9[1]
Molybdenum – Total	mg/L	<0.001	<0.001	<0.001	0.05[2]
Nickel – Total	mg/L	0.001	0.011	0.001	0.011[1]
Lead – Total	mg/L	<0.001	**0.072**	**0.006**	0.0034[1]
Antimony - Total	mg/L	<0.001	<0.001	<0.001	
Selenium – Total	mg/L	<0.01	<0.01	<0.01	0.011[1]
Zinc – Total	mg/L	0.007	**0.051**	**0.042**	0.008[1]
Mercury – Total	mg/L	<0.0001	<0.0001	<0.0001	0.0006[1]
Total Cyanide	mg/L	<0.005	<0.005	<0.005	0.007[1]
Fluoride	mg/L	<0.1	<0.1	<0.1	1.5[2]
Ammonia as N	mg/L	0.02	**0.18**	<0.01	0.9[1]
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01[3]

Notes:
1. Denotes ANZECC Guidelines and Marine (Freshwater) 2000 for 95% species protection
2. Denotes Clean Water Regulation 1972 schedule 2 – restricted substances in streams
3. Denotes Network Geotechnics original values (from ANZECC 1999)
4. Bolded Values in the above table nominated threshold levels

[a] From Table 3 in Network Geotechnics report G23085/1-D November 2003
*[b] Upper end of Central Ck (Close to SW2, see **Figure 2B**)*
*[c] Upper end of East Ck (Close to SW3, see **Figure 2B**)*
*[d] Confluence of Central and East Cks (close to SW5 see **Figure 2B**)*

A2.3. BOODEREE NATIONAL PARK DATA

Previous discussions with National Parks staff indicated the existence of a water quality results for the Moona Moona Creek Wetland systems. Despite several requests in December 2004 and January 2005, the data has not been provided and therefore cannot be presented in this report.

A3. SAMPLING METHODOLOGY & RATIONALE

A program of further baseline monitoring was initiated in response to agency requests for more extensive predevelopment baseline data.

The program included more detailed testing of nutrients (ie, various forms of nitrogen and phosphorus) coupled with flow measurements. Sampling parameters include: total suspended solids; oil & grease; ammonia-nitrogen; total oxidised nitrogen; Total Kjeldahl Nitrogen; total phosphorus; and reactive phosphorus.

Two 'wet' (>25 mm rainfall in day) and two 'dry' campaigns were scheduled over 4 months, (from June 2004) dependent on weather. Due to the intermittent nature of the watercourses, regular sampling can only be carried out after a wet weather event sufficient to generate enough flow for a sample to be taken, therefore even the 'dry' campaigns need some antecedent rainfall to generate trickle flow in the creeks. Consequently “wet weather” sampling campaigns can only be undertaken when there is a significant rainfall event.

To date, one further (wet weather) campaign has been carried out, in late November 2005. This included sampling at the 5 previous locations within or near Stockland's site (SW1 to SW5), and additionally involved testing for faecal coliforms as well as nutrient parameters, suspended solids and grease & oils. The scope of monitoring work was also been expanded to include additional water quality monitoring points within the Moona Moona Creek wetlands (MCW1 to MCW5).

A3.1. SAMPLING LOCATIONS

Almost the whole site is forested or heath land with small portions of the headwaters of each of the 3 sub-catchments covering the site subject to a rural land use. Each of the three sub-catchments feed national park wetlands immediately down stream of the development site.

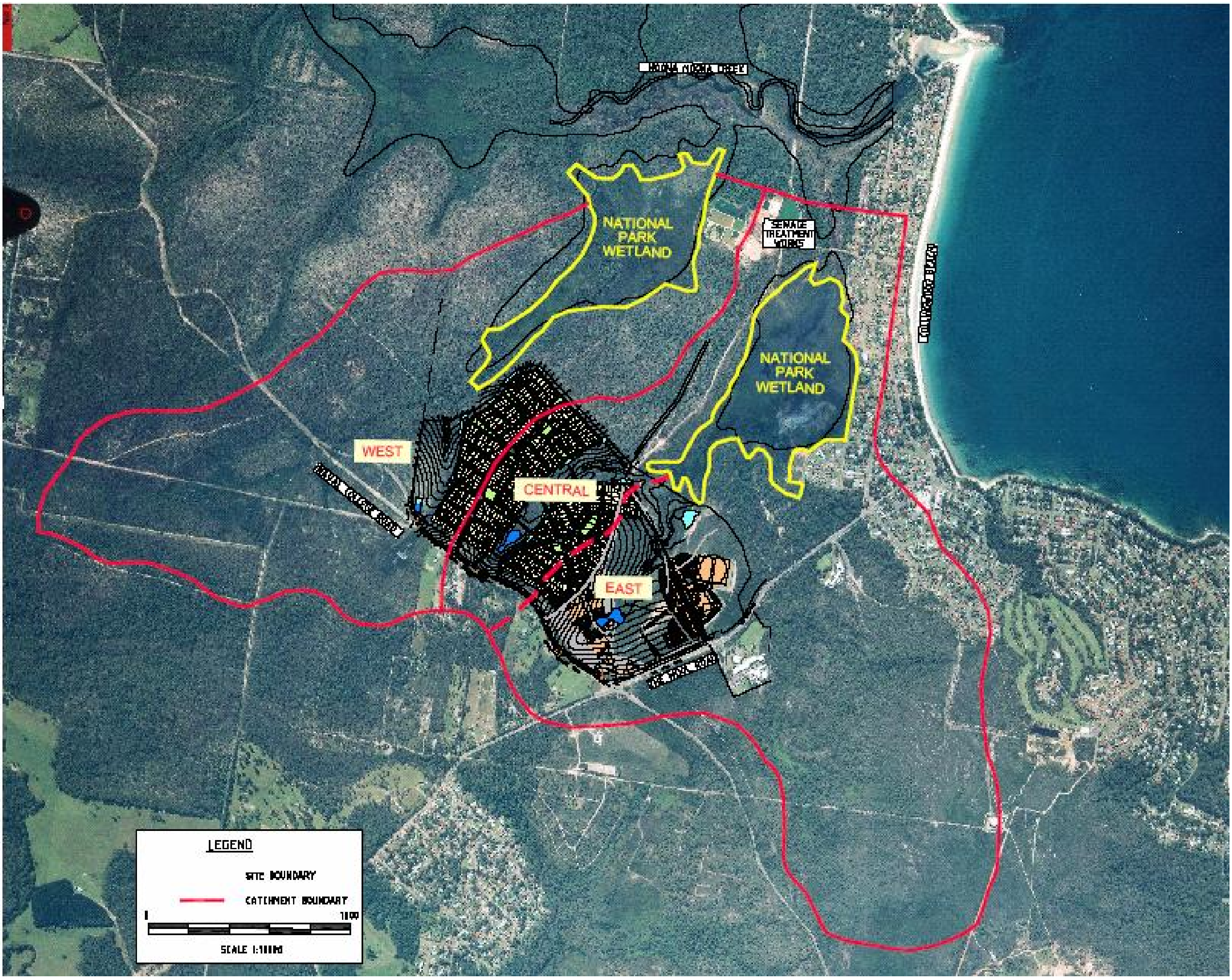
Five sampling locations were selected to:

- examine the water quality as it enters and leaves the site.
- monitor the water quality as it is received from the rural land uses upstream (across Jervis Bay Rd).
- monitor the runoff from Jervis Bay Naval college road.

The sampling locations comprise 3 upstream locations, on each of the Western, Central and Eastern creeks, at culvert locations on Naval College Road (SW1, SW2, SW3), and at 2 downstream locations on the Central and Eastern Creeks, at existing track crossings of these creeks (SW4 and SW5). An electricity substation is located on the Western side of Naval College Rd in the East catchment. The 5 sampling locations are shown in **Figure A1** below. **Figure A2** shows the relevant Catchment boundaries.

Figure A1. Sampling Locations

Figure A2 - Catchment Plan



A3.2. SAMPLING PROCEDURES

Water samples were collected in decontaminated plastic bottles supplied by Australian Laboratory Services, Smithfield, who are a NATA-accredited testing laboratory.

Water samples for NH3-N, NOx-N, TKN and TP were collected in decontaminated bottles with sulfuric acid preservative and were immediately chilled to 4 ^{0}C with chill packs in an Esky, the samples were then frozen to aid with preservation.

Samples were taken by hand (dip samples) and away from the edges of the watercourse where possible. Given the intermittent nature of watercourse however, samples were taken wherever physically possible.

A3.3. CAMPAIGN FREQUENCY

Four water quality sampling campaigns were carried commencing in October 2004 Monitoring was not possible earlier than this time because of the dry winter experienced in the south coast region. Sampling dates are outlined in **Table 2** below.

Table 2 Campaign Summary

Campaign No.	Date	Wet or Dry campaign	Flow	Antecedent Rainfall (mm)* (24hrs)	Antecedent Rainfall (mm)* (7 Days)
1	18 October 2004	Dry	No	10	18
2	21 October 2004	Wet	Yes	60	98
3	14 December 2004	Dry	SW 4 & 5 only	3.8	66
4	21 January 2005	Wet	No	24.8	30
5	28 November 2005	Wet	Yes	25	52

*Jervis Bay Weather Station (Pt Perpendicular Lighthouse)

A4. MONITORING RESULTS

Monitoring results for the four campaigns conducted over the period October 2004 to January 2005 are presented in **Table 3** below.

Table 3. Monitoring Results

Analysis	Units	SW1	SW2	SW3	SW4	SW5	ANZECC Default Trigger Values [1]
Campaign 1: 18 October 2004 - Dry							
TSS	mg/L	55	108	15	16	13	-
Ammonia as N	mg/L	**0.51**	**0.09**	**0.13**	**0.1**	**0.41**	**0.02**
Nitrate & Nitrite as N	mg/L	**0.26**	**0.09**	**0.32**	**0.06**	0.03	**0.04**
TKN as N	mg/L	1.5	0.8	0.9	1.7	1.7	**-**
Total Nitrogen (TN)	mg/L	**1.76**	**0.89**	**1.22**	**1.76**	**1.73**	**0.5**
TP as P	mg/L	**0.1**	**0.11**	**0.09**	**0.32**	**0.06**	**0.05**
RP as P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	**0.02**
Oil & Grease	mg/L	<5	<5	<5	<5	<5	-
Campaign 2: 21 October 2004 - Wet							
TSS	mg/L	12	52	14	16	18	-
Ammonia as N	mg/L	**0.03**	**0.05**	**0.07**	**0.08**	**0.04**	**0.02**
Nitrate & Nitrite as N	mg/L	<0.01	<0.01	<0.01	0.03	0.04	**0.04**
TKN as N	mg/L	0.7	1.2	1.1	0.7	0.8	**-**
Total Nitrogen	mg/L	**0.71**	**1.21**	**1.11**	**0.73**	**0.84**	**0.5**
TP as P	mg/L	0.05	**0.08**	**0.38**	0.02	0.02	**0.05**
RP as P	mg/L	0.02	<0.01	**0.25**	<0.01	<0.01	**0.02**
Oil & Grease	mg/L	22	<5	58	9	<5	
Campaign 3: 14 December 2004 - Dry							
TSS	mg/L	7	6	19	2	8	-
Ammonia as N	mg/L	**0.1**	**0.1**	**0.1**	0	**0.1**	**0.02**
Nitrate & Nitrite as N	mg/L	0.01	0.01	**0.06**	0.01	0.01	**0.04**
TKN as N	mg/L	0.9	0.7	1.1	0.5	1.3	**-**
Total Nitrogen	mg/L	**0.91**	**0.71**	**1.16**	**0.51**	**1.31**	**0.5**
TP as P	mg/L	0.03	0.01	0.04	0.02	0.02	**0.05**

Analysis	Units	SW1	SW2	SW3	SW4	SW5	ANZECC Default Trigger Values [1]
RP as P	mg/L	0.02	0.01	0.02	0.01	0.01	**0.02**
Oil & Grease	mg/L	6	10	2.5	12	2.5	-
Campaign 4: 21 January 2004 - Wet							
TSS	mg/L	6	22	16	31	250	-
Ammonia as N	mg/L	-	-	-	-	-	**0.02**
Nitrate & Nitrite as N	mg/L	0.014	<0.01	0.011	0.020	0.010	**0.04**
TKN as N	mg/L	1.3	1.6	1.4	1.2	0.7	**-**
Total Nitrogen	mg/L	**1.314**	**1.61**	**1.411**	**1.22**	**0.71**	**0.5**
TP as P	mg/L	**0.06**	0.04	**0.10**	0.03	0.04	**0.05**
RP as P	mg/L	<0.01	<0.01	**0.039**	<0.01	<0.01	**0.02**
Oil & Grease	mg/L	10	14	14	13	15	-
Total Averages							
TSS	mg/L	20	47	16	16	72	-
Average TN	mg/L	**1.17**	**1.105**	**1.22**	**1.06**	**1.15**	**0.5**
Average TP	mg/L	**0.06**	**0.06**	**0.15**	**0.1**	0.035	**0.05**

[1]Trigger Values for physical and chemical stressors SE Australia in lowland rivers.
[2]Lab Results for Ammonia were not provided for Campaign 4.
Bold values exceed Trigger Values for physical and chemical stressors SE Australia in lowland rivers.

A5. DISCUSSION

A5.1. NOTABLE RESULTS

Campaign 1 was essentially a dry weather campaign, with approximately 10mm of rain having fallen in the 24 hrs prior to sampling. There were generally no measurable flows observed in the watercourses, and as such samples were taken from pools fed by trickle flows.

With respect to the Campaign 1 results we note the following:

- Some elevated TSS in SW2
- Ammonia exceeds the trigger value at all sites, but is significantly elevated in SW1 and SW5
- Elevated levels of Nitrate & Nitrite at all sites other than SW5 with SW1 & SW3 being significantly above ANZECC trigger values.
- Total Nitrogen exceeds the trigger value at all sites.
- Elevated levels of Total Phosphorus above ANZECC trigger values) at all sites, but particularly for SW4 (near the Bay and Basin Leisure Centre).
- Reactive Phosphorus: all below lab limits of reading
- Oil & Grease: all below laboratory limits of reading

The generally high Nitrogen and TP readings obtained for Campaign 1 may be due to samples being taken from pools rather than flowing water. The wet weather campaign undertaken on 21 October 2004 with flowing water is considered to give a more representative indication of water quality within the catchment.

Campaign 2 was a wet weather campaign, with 60mm of rain having fallen in the 12 hours prior to sampling. Flow was observed at the sampling sites and samples taken from flowing water during rainfall.

With respect to the Campaign 2 results we note the following:

- Total suspended solids (TSS) levels being quite low despite heavy rain.
- Ammonia levels slightly exceed trigger values for all sites
- Nitrate and Nitrite levels were below the level or reading for SW1,2 & 3 with SW 4 & SW5 showing levels near the trigger value.
- Total Nitrogen exceeds the trigger value at all sites.
- Slightly elevated levels of Total Phosphorus in SW2 and significantly elevated levels in SW5 compared to ANZECC trigger values)
- Reactive Phosphorus was close to or below lab limits of reading except for SW3 (east catchment near electrical substation).
- Oil & grease readings in two upper catchment sites SW1 and SW3 were elevated, particularly for SW3 (east catchment near electrical substation).

The Campaign 2 results are generally indicative of clean water typical of predominantly forested/native environments, with some elevated TN and TP levels, possibly due to rural uses in the upper catchments.

Campaign 3 was a dry weather campaign, with 3.8mm of rain having fallen in the 24 hours prior to sampling. Flow was only observed at SW4 and SW5.

Notable results include elevated Ammonia at all sites except SW4 and a slightly elevated Nitrate & Nitrite level in SW3. Total Nitrogen once again exceeded the trigger value at all sites. Other parameters were under trigger values and there were no other remarkable results.

Campaign 4 was a wet weather campaign, with 25mm of rain having fallen in the 24 hours prior to sampling. Site observations however, indicate that the rain was localised to the weather station and the indicated rain depth may not have been experienced locally. Despite the rain, flow was only observed at SW4 and SW5. Notable results include:

- An abnormally high suspended solids reading of 250 was obtained from SW5.
- Nitrate and Nitrite levels were well below the trigger value.
- Total Nitrogen exceeds the trigger value at all sites.
- Slightly elevated levels of Total Phosphorus in SW1 and SW3 compared to ANZECC trigger values).
- Reactive Phosphorus slightly exceeded the trigger value in SW3 (east catchment near electrical substation).
- Oil & grease readings in two upper catchment sites SW1 and SW3 were elevated, particularly for SW3 (east catchment near electrical substation).

A5.2. OBSERVED TRENDS

The four campaigns show significant variability across the parameters measured, as would be expected with the varying flow regimes. Nevertheless, some trends can be observed.

A5.2.1.Suspended Solids

Firstly, total suspended solids appear to be well within acceptable levels for all sites for the majority of campaigns. The notable exception to this is a high reading at SW5 in the 4th campaign. This high reading can be attributed to runoff from the unsealed road immediately upstream of the sampling point. The sampling point was upstream of the road for all prior campaigns however the sample in the 4th campaign was taken downstream of the road as a different staff member undertook the sampling on this occasion

A5.2.2. Forms of Nitrogen

Ammonia levels exceed trigger values for physical and chemical stressors SE Australia in lowland rivers, in almost all cases. In many samples, the concentrations are either under, or only slightly exceed the ANZECC trigger values for 95% protection of freshwater species (0.9 mg/l), which is a less rigorous trigger value than the trigger Value for physical and chemical stressors SE Australia in lowland rivers. It is notable that concentrations in the dry campaigns, are higher for many sites than the wet weather samples taken in Campaign 2. This may reflect the higher flow observed during that campaign. In dry periods of very low flow we may be observing increased mineralisation of Organic nitrogen (both aerobically and anaerobically) to produce NH_3-N.

Conversely, Nitrate and Nitrite levels generally do not exceed trigger values other than in Campaign 1. Nitrite Nitrogen (NO_2-N) is usually produced from ammonia when specific bacteria and dissolved oxygen are present. Nitrite can be further oxidised to Nitrate Nitrogen (NO_3-N). It is readily bio-available. We note that only in campaign one does this parameter exceed trigger values at almost all sites. This may be possibly be attributed to dry conditions and very low flow encouraging the nitrification of NH_3-N (aerobically) to NO_x-N.

Total Nitrogen is equivalent to the sum of (Total Nitrite and Nitrate) plus (Total Keldjahl Nitrogen). Total Keldjahl Nitrogen (TKN) is the sum of Ammonia plus Organic Nitrogen. Therefore the contribution of organic nitrogen can be calculated by subtracting the concentration of ammonia from that of TKN.

The results show that of the three Nitrogen species analysed, TKN is by far the major contributor to elevated TN, and that the organic nitrogen component of TKN, is by far the major contributor to TN. Organic Nitrogen (Org-N) includes simple and complex proteins that derive from animal or plant material. They are typically not soluble but generally break down to smaller, more reactive compounds. Ammonia Nitrogen (NH_3-N) is produced by such means. Ammonia is readily bio-available, and can be used as a nutrient by algae, aquatic plants or other bacteria. It can be toxic to some species at low concentrations.

Total Nitrogen concentrations exceed the trigger value for all sampling locations in all campaigns. The mean values for TN over the four campaigns are remarkably similar (around 1.1mg/l) for all sampling locations. The means exceed the trigger value by a factor of approximately 2. These are not perceived to be excessive levels and could be interpreted to reflect the land uses in the upstream catchment, and nutrient inputs that would be expected from rural land use and roads. For example, published event mean concentrations of TN for mixed rural and urban catchments range from 2.6 to 5.0mg/l, and concentrations range from 1 to 17mg/l as indicated in **Table 4** below.

The results for Total Nitrogen then, could be interpreted as analogous to very mildly polluted stormwater runoff.

Table 4 - Published event mean concentrations for mixed rural and urban catchments

REFERENCE	O'Loughlin et al. (1992)	Sharpin (1995)	Mudgeway et al. (1997)
Pollutant	mean *(range)*	mean *(range)*	mean *(range of s.d)*
Suspended solids	250 *(50 - 800)*	296 *(27 - 1430)*	140 *(42 - 480)*
Total phosphorus	0.6 *(0.1 - 3.0)*	0.4 *(0.04 - 1.3)*	0.24 *(0.08 - 0.72)*
Total nitrogen	3.5 *(2.6 - 6.0)*	5.0 *(1.0 - 17.4)*	2.6 *(1.3 - 5.4)*
BOD	15 *(17 - 40)*	—	15.1 *(7.9 - 29)*
Lead	0.25 *(0.05 - 0.45)*	0.31	0.10 *(0.01 - 0.74)*
Zinc	0.04 *(0.01 - 1.0)*	0.59	0.63 *(0.23 - 1.7)*
Copper	0.4 *(0.01 - 0.15)*	0.05 *(0.03 - 0.09)*	0.06 *(0.02 - 0.18)*
Cadmium	0.006 *(0.001 - 0.1)*	0.09 *(0.008 - 0.01)*	0.01 *(0.003 - 0.02)*
Chromium	0.02 *(0.004 - 0.06)*	0.02 *(0.01 - 0.03)*	0.03 *(0.01 - 0.11)*
Nickel	—	0.02 *(0.01 - 0.03)*	0.02 *(0.01 - 0.04)*

From NSW Department of Land and Water Conservation (DLWC), “The Constructed Wetlands Manual”, Volumes 1 & 2, 1998

A5.2.3.Forms of Phosphorus

All sites slightly exceeded the trigger value in Campaign 1, with other slight exceedances in subsequent campaigns at various sites. The only two exceedances for reactive phosphorus was at SW3, which recorded the greatest mean concentration of TP.

The mean concentration of TP for other sites only slightly exceed the trigger value or in the case of SW5, are under the trigger value. Comparisons with **Table 3** show the sample sites mean concentrations compare favourably with event mean concentrations for mixed rural and urban catchments. The results for Total Phosphorus then, could be interpreted as analogous to very mildly polluted stormwater runoff.

A5.2.4. Attenuation of Pollutants along the Flow path

The results from this small number of samples present no identifiable trend in attenuation of nutrients as they migrate downstream.

A5.2.5. Oils and Grease

Concentrations of oils and grease were generally higher in wet sampling campaigns as would be expected given the pollution potential of runoff from Naval College Rd.

A5.2.6. Influence of Antecedent Rainfall

Comparisons between the driest campaign (campaign 1) and the wettest campaign (campaign 2) for TN, TP, reveal that in all except one sample, the concentrations in the driest campaign exceed those obtained in the wettest campaign.

Ammonia concentrations for the two dry campaigns (1 and 3) are all higher than those obtained in the wet campaign (campaign 2). No ammonia results were obtained for the 4th campaign due to a laboratory error. For the driest campaign concentrations are noticeably higher up to a factor of seventeen, when compared to the wet weather campaign.

Although the sample size is too small to draw any firm conclusions, these trends could perhaps reflect the influence of dilution during higher flows, or evaporative concentration during low flows noting that samples were taken from stagnant pools. Increased ammonia in the driest campaign (where very low flow was observed) may possibly indicate increased mineralisation of Organic nitrogen (both aerobically and anaerobically) to produce NH_3-N.

Reactive Phosphorus is typically very low or below detection limits for all sites except site SW3, where the two wet weather samples slightly exceeded the trigger value.

In interpreting the results it is worth considering that only campaign 2 could be described as a wet campaign in the true sense. Although campaign 4 has nominally been referred to as a wet campaign, anecdotal evidence suggest not a great deal of rain was experienced near the actual sites, and in fact the rain depth experienced in the week previous to sampling was less than that for the preceding dry campaign (campaign 3).

A6. RECENT (5TH) CAMPAIGN MONITORING RESULTS

Previous versions of this working paper recommended that further monitoring be undertaken to determine the typical water quality in the subject watercourses prior to development. This will enable a more complete determination of typical water quality and determination of event mean concentrations of suspected ecosystem stressors, and therefore a more credible comparison with future (particularly post development) water quality monitoring in this area.

The monitoring regime was recommended be extended to include both downstream wetlands as proposed by ERM in their proposal for aquatic works. This will assist in determining baseline water quality in the wetland receiving waters and also in determining what the key physical and chemical stressors may be, and if any of the nutrients are acting as limiting nutrients within the wetlands (and therefore controlling algae growth/ eutrophication processes).

Recently (in September 2005), Stockland instructed Forbes Rigby to conduct further surface water quality monitoring, as a continuation of the baseline monitoring program discussed above. This includes sampling at the 5 previous locations within or near Stockland's site (SW1 to SW5), providing for 2 wet and 2 dry weather sampling campaigns, and additionally involves testing for faecal coliforms as well as nutrient parameters, suspended solids and grease & oils. The scope of monitoring work has also been expanded to include additional water quality monitoring points within the Moona Moona Creek wetlands (MCW1 to MCW5).

To date, one further (wet weather) campaign has been carried out, on 28 November 2005. This recent campaign was preceded by and undertaken in quite wet conditions with 52mm experienced in the week of sampling which includes approximately 25mm on the actual day of sampling. The results are described below.

Results for faecal coliforms (not analysed in previous campaigns) for the 8 surface water sites sampled (including 3 sites in Moona Moona Ck wetlands) were all well below the National Water Quality Guidelines (Recreational Waters) for Secondary contact (median of 1000cfu/100mL). Only one site (SW3) exceeded the guideline value for primary contact (median of 150/100mL).

Levels of nitrate were below National Water Quality Guideline trigger values for physical and chemical stressors (in a lowland river ecosystem) except for two sites in the Moona Moona Ck wetlands adjacent to development.

Ammonia Nitrogen levels at all sites were very low, with all sites except one showing concentrations below the limit of detection (<0.01mg/L).

Total Kjeldahl Nitrogen (TKN) levels were much higher than the other nitrogen based analytes with most sites recording concentrations around 1.0 mg/l. As Ammonia Nitrogen and nitrates were generally very low, this indicates the vast majority of dissolved Nitrogen is represented as organic Nitrogen (which is less bio-available and less toxic than the ammonia and nitrate forms).

Total Nitrogen concentrations exceed the National Water Quality Guideline trigger values for physical and chemical stressors (in a lowland river ecosystem) except for one site in the Moona Moona Ck wetlands (which was located the furthest of any site from existing development at Vincentia).

Total Phosphorus concentrations were varied but generally close to or just exceeding the National Water Quality Guideline trigger value for physical and chemical stressors (in a lowland river ecosystem) of 0.05mg/L.

Reactive Phosphorus concentrations were all very low, being below the level of detection (<0.01mg/L) for all but one site.

Oil and Grease concentrations were generally low (<5mg/L) with only one site having a concentration of 10mg/L.

Suspended solids concentrations were variable between sites and below the National Water Quality Guideline trigger value for physical and chemical stressors (in a lowland river ecosystem) except for one site which slightly exceeded the trigger value.

As a whole, the results from the recent December campaign indicate similar water quality compared to previous campaigns. One trend observed in the most recent data however, is that natural treatment of Nitrogen and Phosphorus appears to be occurring, with higher concentrations recorded in the sites near development in the South East of the Eastern

Moon Moona Ck wetland (MCW1, MCW2), and significantly lower concentrations in the downstream northern site of this wetland which is located at the road crossing leading to the sewage treatment plant (MCW3).

A7. CONCLUSIONS

From our consideration of the results presented we conclude that:

- Total suspended solids appear to be well within acceptable levels for all sites for the majority of campaigns.
- Ammonia levels exceed trigger values for physical and chemical stressors SE Australia in lowland rivers, in almost all cases, except for the most recent (5^{th}) campaign where levels were very low.
- Total Nitrogen concentrations exceed the trigger value for almost all sampling locations in all campaigns. The mean values over the four campaigns are remarkably similar (around 1.1mg/l) for all sampling locations. These are not perceived to be excessive levels and could be interpreted to reflect the land uses in the upstream catchment, and nutrient inputs that would be expected from rural land use and roads. For example, published event mean concentrations of TN for mixed rural and urban catchments range from 2.6 to 5.0 mg/l.
- Total phosphorus levels slightly exceeded the trigger value on various (but not all) occasions. The mean concentration of TP for most sites only slightly exceed the trigger value or in the case of SW5, are under the trigger value.
- Concentrations of oils and grease were at acceptable levels in most samples but generally higher in wet sampling campaigns as would be expected given the pollution potential of runoff from Naval College Rd.
- Results from the fifth and most recent campaign which included three sites in the Eastern Moona Moona Ck wetland indicate natural treatment of Nitrogen and Phosphorus appears to be occurring, with higher concentrations recorded in the sites near development in the South East of the Eastern Moon Moona Ck wetland (MCW1, MCW2), and significantly lower concentrations in the downstream northern site of this wetland which is located at the road crossing leading to the sewage treatment plant (MCW3).
- Faecal coliforms results from the fifth and most recent campaign (not analysed in previous campaigns) for the 8 surface water sites sampled (including 3 sites in Moona Moona Ck wetlands) were all well below the National Water Quality Guidelines (Recreational Waters) for Secondary contact (median of 1000cfu/100mL). Only one site (SW3) exceeded the guideline value for primary contact (median of 150/100mL).

The water quality results presented could be interpreted as analogous to very mildly polluted stormwater runoff when compared to published event mean concentrations for mixed rural and urban catchments. Although the sample size is too small to draw any firm conclusions, trends observed indicate the intermittent nature of the watercourses could perhaps result in evaporative concentration of nutrients during low flows.

This working paper will be updated when data for upcoming campaigns is received.

SAMPLING CAMPAIGN LABORATORY REPORTS

ALS Environmental

RECEIVED
04 NOV 2004
FORBES RIGBY PTY LTD

CERTIFICATE OF ANALYSIS

CONTACT:	MR MURRAY WARD	**BATCH:**	ES51206
CLIENT:	FORBES RIGBY PTY LTD	**SUB BATCH:**	0
ADDRESS:	278 KEIRA STREET WOLLONGONG NSW 2500	**LABORATORY:**	SYDNEY
		DATE RECEIVED:	19/10/2004
		DATE COMPLETED:	27/10/2004
ORDER No.:	104016-3	**SAMPLE TYPE:**	WATER
PROJECT:		**No. of SAMPLES:**	5

COMMENTS

Oil and Grease determined as per APHA 20th edition method 5520 A and B. This report supersedes any previous preliminary reports of the same batch number.

NOTES

This is the Final Report and supersedes any preliminary reports with this batch number.
All pages of this report have been checked and approved for release.

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Reports signed by signatories as required

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NATA Accredited Laboratory Number 825
Site: SYDNEY

Batch: ES51206
Sub Batch: 0
Date of Issue: 29/10/2004
Client: FORBES RIGBY PTY LTD
Client Reference:

CERTIFICATE OF ANALYSIS

				SAMPLE IDENTIFICATION									
		Laboratory I.D.		1	2	3	4	5					
		Date Sampled		18/10/2004	18/10/2004	18/10/2004	18/10/2004	18/10/2004					
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	WEST-UPP	EAST-UPP	CENTRAL-UPP	EAST-LOW	EAST-CENT-LOW					
EA-025	Suspended Solids (SS)	mg/L	1	55	15	108	16	13					
EK-055A	Ammonia as N	mg/L	0.01	0.51	0.13	0.09	0.10	0.41					
EK-059A	Nitrite and Nitrate as N	mg/L	0.01	0.26	0.32	0.09	0.06	0.03					
EK-061A	Total Kjeldahl Nitrogen as N	mg/L	0.1	1.5	0.9	0.8	1.7	1.7					
EK-067A	Total Phosphorus as P	mg/L	0.01	0.10	0.09	0.11	0.32	0.06					
EK-071A	Reactive Phosphorus as P - Total	mg/L	0.01	<0.01	0.01	<0.01	<0.01	<0.01					
EP-020	Oil & Grease	mg/L	5	<5	<5	<5	<5	<5					

Batch: ES51206
Sub Batch: 0
Date of Issue: 29/10/2004
Client: FORBES RIGBY PTY LTD
Client Reference:

QUALITY CONTROL REPORT

				SAMPLE IDENTIFICATION									
		Laboratory I.D.		200	201	202							
		Date Sampled		19/10/2004	19/10/2004	19/10/2004							
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	METHOD BLANK	LCS	MS							
				CHECKS AND SPIKES									
EA-025	Suspended Solids (SS)	mg/L	1	<1	99.0%	----							
EK-055A	Ammonia as N	mg/L	0.01	<0.01	104%	90.0%							
EK-059A	Nitrite and Nitrate as N	mg/L	0.01	<0.01	98.0%	91.0%							
EK-061A	Total Kjeldahl Nitrogen as N	mg/L	0.1	<0.1	99.0%	115%							
EK-067A	Total Phosphorus as P	mg/L	0.01	<0.01	97.0%	99.0%							
EK-071A	Reactive Phosphorus as P - Total	mg/L	0.01	<0.01	93.0%	79.0%							
EP-020	Oil & Grease	mg/L	5	<5	87.0%	----							

CERTIFICATE OF ANALYSIS

ALS Environmental

CONTACT:	MR MITCHELL WATTS	**Batch:**	ES52743
CLIENT:	FORBES RIGBY PTY LTD	**Sub Batch:**	0
ADDRESS:	278 KEIRA STREET WOLLONGONG NSW 2500	**LABORATORY:**	SYDNEY
		DATE RECEIVED:	15/12/2004
		DATE COMPLETED:	24/12/2004
		SAMPLE TYPE:	SURFACE WATER
ORDER No.:	104016-3	**No. of SAMPLES:**	5
PROJECT:			

COMMENTS

Oil and Grease determined as per APHA 20th edition method 5520 A and B.

NOTES

This is the Final Report and supersedes any preliminary reports with this batch number.
All pages of this report have been checked and approved for release.

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Lima

Australian Laboratory Services Pty Ltd (ABN 84 009 936 029)

NATA Accredited Laboratory Number 825

Site: SYDNEY

Batch: ES52743
Sub Batch: 0
Date of Issue: 04/03/2005
Client: FORBES RIGBY PTY LTD
Client Reference:

CERTIFICATE OF ANALYSIS

				SAMPLE IDENTIFICATION									
		Laboratory I.D.		1	2	3	4	5					
		Date Sampled		14/12/2004	14/12/2004	14/12/2004	14/12/2004	14/12/2004					
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	SW1	SW2	SW3	SW4	SW5					
EA-025	Suspended Solids (SS)	mg/L	1	7	6	19	2	8					
EK-055A	Ammonia as N	mg/L	0.01	0.06	0.05	0.05	0.04	0.05					
EK-059A	Nitrite and Nitrate as N	mg/L	0.01	<0.01	<0.01	0.06	<0.01	0.02					
EK-061A	Total Kjeldahl Nitrogen as N	mg/L	0.1	0.9	0.7	1.1	0.5	1.3					
EK-067A	Total Phosphorus as P	mg/L	0.01	0.03	0.01	0.04	0.02	0.02					
EK-071A	Reactive Phosphorus as P - Total	mg/L	0.01	0.02	0.01	0.02	<0.01	<0.01					
EP-020	Oil & Grease	mg/L	5	6	10	<5	12	<5					