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Coal & Allied Industries Limited

Report for Lower Hunter Lands Project

Gwandalan: Water Sensitive Urban Design, Flooding and Stormwater Management

October 2010

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

It is proposed that the entire Coal & Allied Industries Limited (Coal & Allied) owned Gwandalan site be rezoned/listed as a 'State Significant Site' (SSS) in Schedule 3 of State Environmental Planning Policy (Major Development). A draft Schedule 3 listing will be prepared with the Concept Plan Application.

The Concept Plan for a proposed residential subdivision of the Gwandalan site will apply to the entire 268ha Gwandalan site. The key parameters for the future development of the site are as follows:

- Dedication of 205.75ha of conservation land to the New South Wales Government (NSWG) that is identified in the Lower Hunter Regional Strategy and Lower Hunter Regional Conservation Plan, comprising approximately 77% of the Gwandalan site.
- Maximum dwelling yield of 623 dwellings over 62.24ha.
- Indicative development staging. The number of lots and extent of staging for release areas will be largely dictated by the service infrastructure requirements as well as responding to market forces.
- The provision of associated infrastructure.
- Torrens title subdivision of the Gwandalan site. The Torrens title subdivision and boundary realignment of Coal & Allied land will enable land 205.75ha in area that is owned by Coal & Allied to be excised and dedicated to NSWG for conservation land.

Approval will not be sought under the Concept Plan for a specific lot layout. An indicative lot layout will indicates how the maximum dwelling yield of 623 dwellings could be achieved on the site.

Similarly, approval will not be sought under the Concept Plan for subdivision or construction of individual houses. However, the desired future character of the proposed concept plan will be included in Urban Design Guidelines. Urban Design Guidelines will be prepared to inform the Concept Plan in respect of urban form, built form, open space and landscape, access and movement and visual impact for the site.

It is proposed to dedicate land for conservation purposes as part of the Major Project Application via a Voluntary Planning Agreement (VPA) between Coal & Allied and the NSWG in accordance with s.93F of the Environmental Planning & Assessment Act, 1979 (EP&A Act).

This report supports the Concept Plan application, addressing Water Sensitive Urban Design, Flooding and Stormwater Management for the proposed site, shown in the Concept Plan in Appendix A.

1.1 Water Sensitive Urban Design (WSUD)

WSUD encompasses all aspects of urban water cycle management including water supply, wastewater and stormwater management. WSUD is a multi-disciplinary approach that promotes opportunities for linking water infrastructure, landscape design and the urban built form to minimise the impacts of development upon the water cycle and achieve more sustainable forms of urban development.

The principles of WSUD are incorporated in the Wyong Shire Council (WSC) Draft DCP (WSUD). The intent of Council's requirements in relation to stormwater management is to ensure systems are carefully planned, designed and located to prevent the disturbance, redirection, reshaping or modification of watercourses (and associated vegetation) and to protect the quality of receiving waters. If adequate WSUD measures are not adopted, the proposed development may have the following impacts:

- Increased stormwater runoff and altered/increased pollutant loads, which could impact sensitive downstream habitats in terms of flushing regimes (frequency, volume and rate), and wetting cycles;
- Reduction in rainfall infiltration and decreased groundwater recharge; and
- Disturbance of groundwater flow due to site compaction, fill, landform reshaping and underground structures.

The suitability of WSUD solutions to any proposed development depends upon a number of factors, including climate and rainfall, site topography, geology and available land. Moderate slopes, such as those encountered across parts of the Gwandalan site, make construction and location of larger treatment measures more difficult particularly when located offline. WSUD measures such as swales, bio-swales along with smaller detention basins are considered more suited to the Gwandalan topography. It is however, noted that there is an existing wetland within the site which will be incorporated into the WSUD strategy.

2. Existing Conditions and Derived Constraints

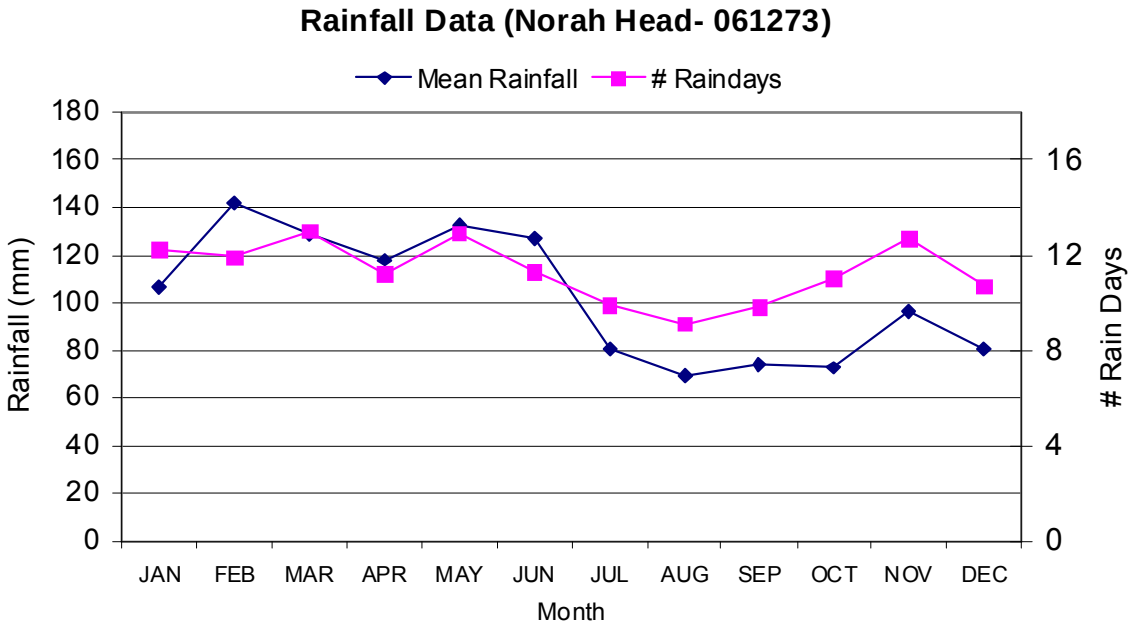
2.1 Climate and Rainfall

Gwandalan experiences a sub-tropical climate with rainfall predominantly occurring in late summer and autumn. The nearest operational daily rainfall station is located at Norah Head lighthouse (BOM Stn 061273), which registered a mean annual rainfall of 1227 mm for the period of 1969 to 2006.

Figure 1 shows the mean monthly rainfall and number of rain days recorded by the Norah Head station. The graph shows elevated monthly rainfalls in the months of January to June, with the least rainfall being recorded in July to December. The mean number of rain days varies between approximately 9 and 13 days per month.

The high likelihood of rainfall occurring in any month throughout the year would support utilisation of vegetated systems such as swales, bioretention and detention basins to manage stormwater. Furthermore, the mild seasonal variability would indicate that rainwater collection via rainwater tanks might be viable.

Figure 1 Monthly Rainfall



2.2 Topography and Slopes

Topography is an important consideration when planning the location of stormwater management facilities such as detention basins. The Gwandalan site has site slopes with an average grade in the order of 6%. To reduce the extent of earthworks, the proposed basins would need to be located in areas of gentler grade closer to Lake Macquarie.

Steeper slopes (greater than 5%) are generally not suitable for the construction of WSUD facilities such as bioretention swales and wetland systems. In such cases, flow attenuation via vegetated swales and bio-retention systems are less desirable due to excessive flow velocities, reduced detention times and potential scouring. In addition, detention basins are difficult to configure, particularly when located off-channel.

2.3 Soils and Erosion Risk

According to the Soil Landscape Maps of the Gosford-Lake Macquarie 1:100 000 Sheet (Murphy,1992), the Gwandalan site is underlain by two major soil landscape groupings. They are:

- *Wyong Landscape.* Underlies the low-lying areas of the Gwandalan site adjacent to the lake foreshore. The limitations of this soil group include localised waterlogging, poorly drained, potential acid sulfate soils, saline subsoils, localised stream bank erosion and low fertility; and
- *Awaba Landscape.* Underlies much of the remainder of the sites. The limitations of this soil group include steep slopes, high erosion hazard with localised mass movement, stoniness, shallow, acidic soils with low fertility.

The limitations of the soil groups and propensity to erosion would need to be considered when planning WSUD facilities. Ground water aspects are dealt with in a separate groundwater report, and WSUD facilities relying on infiltration may need to be lined to prevent contamination of ground water

2.4 Watercourses, Creeks, Riparian Corridors and Receiving Waters

Adjacent to the site there is one creek, Strangers Gully, and several smaller gullies draining through the development site. The land generally slopes east towards Lake Macquarie and runoff discharges to Lake Macquarie via dispersed overland flow.

In terms of riparian corridors, the requirements of the Water Management Act are noted, and while the proposal seeks to encompass the intent of the Water Management Act, under Part 3A of the EP & A Act this piece of legislation is not triggered. Adequate setbacks are proposed for the Gwandalan site , which will cater for the proposed drainage requirements while making due consideration to the existing ecological character of the gullies.

2.5 Adjoining Land Uses

The existing residential area of Gwandalan is located to the north of the site. Vacant land immediately north of the site is approved for industrial development. The Gwandalan Sewer Treatment plant is located immediately to the north west of the development site.

2.6 Key Statutory Requirements

In addition to the statutory requirements under the Part 3A of the *EP& A Act* , key discipline specific guidelines relating to Water Sensitive Urban Design, Flooding and Stormwater Management which should be considered include the following.

- Integrated Catchment Management Plan for the Central Coast 2002 and Draft Hunter Central Rivers Catchment Management Authority (HCRCMA) Catchment Action Plan 2006 – both plans are administered by the HCRCMA and prioritise investment in natural resource management for this area.
- WSC LEP, 1991 – outlines requirements for development within or near water bodies, floodplains, steep lands, acid sulfate soils, mine subsidence districts and heritage conservation areas.
- LMCC Coastline Management Plan – adopted by Council in 1999, identifies works required along the Lake Macquarie Coastline in order to maintain and enhance its natural, visual and recreational amenity.
- The Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.
- NSW Floodplain Development Manual, 2005 - outlines guidelines relating to floodplain management; and
- NSW Sea Level Rise Policy Statement (2009) and associated guidelines – which outline considerations in terms of sea level rise and the NSW sea level rise planning benchmarks

3. Design Criteria and Supporting Simulations

3.1 Design Criteria and Environmental Objectives

3.1.1 Stormwater Quality

WSC's Stormwater Management Plan (1999) nominates target pollutant removal efficiencies for a range of pollutants for residential developments greater than 2 hectares as indicated in Table 1 below.

Table 1 Stormwater Treatment Measure Effectiveness

Pollutant	Target Pollutant Removal Efficiency
Gross Pollutants (kg/yr)	Retain material > 125μm from 25% of the 1-year flow
Total Suspended Solids (kg/yr)	90% reduction in annual load
Total Phosphorus (kg/yr)	50% reduction in annual load
Total Nitrogen (kg/yr)	50% reduction in annual load

3.1.2 Stormwater Quantity and Flood Risk

Development should not increase flood risk over and above existing conditions. It is therefore necessary to control discharges from the sites according to the requirements of the WSC DCP 67, which stipulates:

- Post development 5-year Average Recurrence Interval (ARI) flood peaks should not exceed 5-year existing condition flood peaks (for urban residential – single allotments);
- Post development 20-year ARI flood peaks should not exceed 20-year existing conditions flood peaks (for urban residential – medium to high density); and
- Post development 100-year ARI flood peaks should not exceed 100-year existing condition flood peaks.

Development and land-use in flood prone areas should be in accordance with WSC DCP 67 and the NSW Floodplain Development Manual, 2005.

3.2 Supporting Simulations

Numerical modelling was used in the determination of the existing flood risk and to evaluate the proposed stormwater quantity and quality management system. This modelling allowed an assessment of:

- Existing conditions flood peaks and flood levels for the creeks across the site and future climate change impact, for a range of design storm events (using XP -RAFTS and HECRAS);
- Appropriate volumes and strategies for detention throughout the site, that responded, as best possible, to the concept plan and which controlled post development flows (using XP-RAFTS); and
- The performance of stormwater quality strategies to be incorporated which would mitigate impacts from the development (using MUSIC) and which achieved the pollution load export requirements set by WSC SMP.

All modelling should be considered as preliminary for the purposes of planning and a more detailed investigation will be required as the project progresses to a more detail design phase.

3.2.1 Existing Flood Risk

Flood Peaks and Detention

Flood peaks and detention requirements were simulated using the XP-RAFTS hydrological model designed for Australian catchments. Compilation of the model included:

- Catchment delineation;
- Hydrological parameter determination; and
- Intensity-Duration-Frequency (IDF) determination for generating storm rainfall events.

The XP-RAFTS model was simulated for a range of design storms (2, 5, 10, 20, 100-year ARI and PMF events) and durations ranging from 25 minutes to 9 hours (PMF 15 minutes to 6 hours). For each event the critical duration was determined.

Simulations were undertaken for three scenarios, namely:

- Existing (undeveloped) conditions;
- Developed conditions in response to the concept plan; and
- Developed conditions in response to the concept plan with detention storage. The increases in impervious area on account of the development will, amongst other effects, increase runoff peaks from the development areas. The scenario was used to determine the required volume of detention to mitigate increased flow rates on account of the development.

Percentage impervious areas for the developed conditions hydrology model were stipulated as follows:

- Residential = 70%; and
- Road = 100%.

Key infiltration parameters assumed in the XP-RAFTS modelling are provided in Table 2 below.

Table 2 Key RAFTS Modelling Parameters

	Pervious	Impervious
Initial loss (mm)	15	2.5
Continuing loss (mm/hr)	2.5	0

3.2.2 Stormwater Quality Management

The water quality assessment of the Gwandalan site was undertaken using MUSIC. MUSIC is a computer simulation model developed by the Cooperative Research Centre for Catchment Hydrology (CRC) as a Model for Urban Stormwater Improvement Conceptualisation.

MUSIC simulates both quantity and quality of stormwater generated from a range of stormwater catchment types including urban, rural and forest, using historical rainfall data. The pollution treatment devices available within a MUSIC model include swales, bio-retention areas, wetlands, gross pollutant traps, sediment basins, ponds and filter strips.

In establishing the MUSIC model for the site, the following parameters were considered:

- Pollutant generation rates; and
- Pollutant removal rates.

With respect to the pollutant generation from contributing catchments, the recommended parameters as nominated in MUSIC for both base and storm flows were adopted. For pollutant removal, both the recommended parameters within MUSIC and the Fletcher Technical Report 04/8 (December, 2004) were considered. The most appropriate pollutant removal curve for each individual treatment measure was then adopted.

Historical rainfall for this assessment was obtained from the Bureau of Meteorology (BOM) pluviograph data for Williamtown RAAF base for the period December 1952 to January 2005. Williamtown RAAF base rainfall was chosen for this assessment as it had the longest and most complete period on record of 6 minute rainfall for the Lower Hunter Region.

For this simulation period there were several high rainfall events as well as periods of low rainfall with an average rainfall for the period of 1023 mm/year. The evaporation data used in the model was obtained from the Bureau of Meteorology long-term averages for each month with the average annual evaporation for Williamtown being 1732 mm/year.

Regular low, or base, flows from catchment areas are of particular importance as they convey the majority of pollutants from catchments to a downstream locations, in this case Lake Macquarie.

The model was configured and simulated for the existing and post-development conditions in response to the concept plan.

3.3 Climate Change and Flooding

Flooding at the Gwandalan site is primarily on account of Lake Macquarie, flooding associated with Strangers Gully and overland flow conveyance. Development and land-use in flood prone areas would be in accordance with WSC DCP 67 and the NSW Floodplain Development Manual.

The NSW Sea Level Rise Policy Statement (2009) supersedes DECCW Practical Consideration of Climate Change, October 2007 guidelines on the topic of sea level rise. This 2009 Policy promotes an adaptive, risk-based approach to managing the impacts of sea level rise. The adaptive risk-based approach recognises that there are potentially significant risks from sea level rise and that the accuracy of sea level rise projections will improve over time. The NSW Government has adopted sea level rise planning benchmarks to support this adaptive risk-based approach. The primary purpose of the benchmarks is to provide guidance supporting consistent considerations of sea level rise impacts, within applicable decision-making frameworks. The NSW sea level rise planning benchmarks are an increase above 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100, with the two benchmarks allowing for consideration of sea level rise over different timeframes.

In regards to Lake Macquarie flooding, Wyong Shire Council adopts the findings of the Lake Macquarie Floodplain Management Study 2000. Since Lake Macquarie City Council has adopted the NSW sea level rise planning benchmarks, these would also be applicable to the Gwandalan site in terms of future planning and risk management. Climate change modelling also predicts changes in the frequency and severity of storms, possibly with larger waves and more intense rainfall. However, these predictions are

more uncertain than those for temperature and sea level rise. Water levels in Lake Macquarie are expected to rise at the same rate and to the same level as the ocean.

The existing climate flood levels for Lake Macquarie, as documented in the Lake Macquarie Floodplain Management Study 2000, are:

- 20-year ARI - 0.97m AHD;
- 50-year ARI - 1.24m AHD;
- 100-year ARI - 1.38m AHD; and
- PMF - 2.63m AHD.

It should be noted that the highest observed flood level in Lake Macquarie was 1.2 mAHD and occurred in 1949.

For the Gwandalan site, if 2100 is adopted as a planning horizon, a Flood Planning level of 2.79m AHD (1.38m AHD + 0.5m + 0.91m), could be relevant. Allowing for wind generated waves of approximately 1 m (Design of Small Dam, USBR), would yield a 2100 planning level of 3.79m AHD.

4. Concept Plan and Potential Stormwater Impacts

Development results in increased impermeable surfaces (roofs, driveways, roads, pavements etc.) which affects the hydrological cycle. If not managed effectively, this 'hardening' of the surfaces has the potential to:

- Increase stormwater peak flows, leading to increased flood risk and erosion (on-site and off-site);
- Increase stormwater runoff volumes, which could impact downstream sensitive habitats in terms of flushing regimes (frequency, volume and rate), water quality, and wetting cycles;
- Increase stormwater pollution discharged to receiving environments as a result of pollutant entrainment in the increased runoff. The type of development and associated activities may introduce differing pollutant profiles, for example vehicular traffic could increase hydrocarbon introduction. In general, typical pollutants include litter, sediment, suspended solids, nutrients, hydrocarbons and toxicants;
- Reduce rainfall infiltration to the soil leading to impacts to the water balance, (including groundwater recharge and salinity impacts); and
- Impact groundwater flow due to site compaction, fill, landform reshaping and underground structures. Ground water aspects are dealt with in a separate groundwater report.

During construction there are additional impacts to pollution, erosion and sedimentation. Increased sedimentation on account of landform disturbances and accidental spills within unbunded areas of the site could discharge to the receiving environment. Clearing and earthmoving activities have the potential to impact on surface water quality in the vicinity of the site, especially during high rainfall events. The activities and aspects of the works that have potential to lead to erosion, sediment transport, siltation and contamination of natural waters include:

- Earthworks undertaken immediately prior to rainfall periods;
- Work areas that have not been stabilised and clearing of land in advance of construction works;
- Stripping of topsoil, particularly in advance of construction works;
- Bulk earthworks and construction of pavements;
- Washing of construction machinery;
- Works within drainage paths, including depressions;
- Stockpiling of excavated materials;
- Storage and transfer of oils, fuels, fertilisers and chemicals; and
- Maintenance of plant and equipment.

To reduce the potential pollutant export during construction, a detailed temporary Sediment and Erosion Control Plan would need to be developed during the detail design phase of the project.

5. WSUD Management Strategy

5.1 General

5.1.1 Principles

Water usage and water conservation along with maintaining the health of the surrounding environment are important considerations of any proposed development. The Gwandalan site is located in an area that is sparsely populated with significant aesthetic amenity and as such these considerations have been given a great deal of emphasis.

WSC is aware of the need to maintain the health of the natural environment and as such is actively pursuing the incorporation of WSUD into the treatment train of any proposed development. In general, the principles for stormwater management at the Gwandalan site should aim to retain as much stormwater as possible on site, transport as little stormwater as possible to receiving waters, 'lose' as much stormwater as possible along the treatment train and slow the transmission of stormwater to receiving waters.

5.1.2 Objectives

In applying the above principles the key planning and design objectives are generally:

- Protect and enhance natural water systems in urban developments;
- Integrate stormwater treatment into the landscape by incorporating multiple-use corridors that maximise the visual and recreational amenity of the development;
- Protect water quality draining from the development;
- Reduce runoff and peak flows from developments by employing local detention measures, minimising impervious areas and maximising re-use; and
- Add value while minimising drainage infrastructure development costs.

The development of a management plan to achieve the above will also consider flood management, flow management, water quality management and flow attenuation.

5.1.3 Opportunities

General opportunities for WSUD at the Gwandalan site include:

- Orientate roads to traverse contours, providing slopes with grades of 4% or less to promote the provision of above ground conveyance mechanisms such as vegetated swales into the streetscape;
- Maintain and re-establish vegetation within public open space along drainage lines to develop multi-use corridors linking public and private areas;
- Preserve and restore existing valuable elements of the drainage system such as wetlands, natural channels and vegetation;
- Manage the quantity and quality of stormwater at or near the source, which will involve a significant component of public education and community involvement. Treatment practices such as precinct

scale bioretention basins, to manage water quality, could be provided downstream or close to the point of discharge from development areas before discharge to waterway areas; and

- Provide 'structural' stormwater quantity and quality management practices that provide flood management, flow attenuation and volume reduction, along with water quality management. Typical structures include detention basins, bioretention basins, lakes, ponds, wetlands, rehabilitated waterways and water re-use schemes. In addition, it is proposed to provide primary stormwater treatment measures that target litter, gross pollutants and coarse sediments and secondary treatment measures that target fine sediment, nutrients and bacteria.

5.2 Site Discharge Points

The site topography results in a number of discharge points to Lake Macquarie corresponding to existing drainage lines and topography. Stormwater runoff would be controlled within the precinct in accordance with Council's requirements prior to discharging from the site. This applies to both stormwater quantity and quality.

5.3 Stormwater Quality Management

The proposed WSUD management plan for the Gwandalan site is provided in Figure 1, Appendix C and includes the followings strategies.

- Opportunistic vegetated swales (potentially including bioretention) provided along the identified main overland flow routes and roadside green areas. Vegetated swales are open channel systems, which are used to remove sediment and suspended solids. The proposed configuration could also include bio-retention in the invert of swales with grades <4%. The required width of the vegetated swales are approximately 4 to 6 m.
- Precinct scale detention/ bio-retention basins are proposed at various locations to treat the quantity and quality of stormwater flows. These basins would essentially comprise a dry basin (to provide detention function) combined with bio-retention in the invert of the basin. The bio-retention basins may need to be lined to prevent contamination with groundwater. Structural measures (for example discharge control pits) would be provided to manage discharges conforming to required stream erosion index requirements.
- Gross pollutant traps will be provided upstream of the precinct scale detention basins to remove coarse sediment and gross pollutants prior to discharging into open areas.
- On-lot detention will be provided in addition to the precinct scale facilities.
- Provision of rainwater tanks for individual lots will be maximised.

Typical configuration options for on-lot treatment are provided in Figures 1, 2, 3 and 4, in Appendix D.

To test the effectiveness of the proposed strategies, the existing conditions MUSIC model was amended to represent both the developed conditions without treatment and post-developed with treatment. In the case of the post-development with treatment scenario, the water treatment measures as described previously were incorporated at appropriate locations. The results for the site, listed in Table 3, show a decrease in total suspended solids, phosphorous, nitrogen and gross pollutants as a result of incorporating the appropriate WSUD treatment measures.

Table 3 Stormwater Treatment Measure Effectiveness

	Existing	Post-development (no WSUD)	Post-development (with WSUD)	% Reduction using WSUD
Total Suspended Solids (kg/yr)	20,200	103,000	1,710	98.3
Total Phosphorus (kg/yr)	51.9	212.0	15.8	92.6
Total Nitrogen (kg/yr)	440	1500	235	84.3
Gross Pollutants (kg/yr)	1,560	13,300	3.2	100

From the above it can be seen that there is a reasonable reduction in the average annual pollutant loads due to the incorporation of the proposed WSUD treatment devices. The estimated reduction in exported pollutants exceeds the levels nominated in WSC's (SMP).

5.3.1 Managing Construction Phase Stormwater Quality Impacts

Construction phase water quality impacts will be managed through the implementation of a Soil and Water Management Plan detailing stormwater management strategies in accordance with relevant best practice guidelines eg;'Soils and Construction, Managing Urban Stormwater' (Landcom 2004). Specific strategies may include:

- Material management practices;
- Stockpile practices;
- Topsoil practices; and
- Erosion control practices (earth sediment basins, straw bales, sediment fences, turbidity barriers, stabilised site accesses, diversions and catch drains).

Monitoring, including visual inspections and water quality sampling, will be required as part of any development consent to ensure that management strategies are working effectively.

5.4 Flooding and Stormwater Quantity Management

5.4.1 Detention

Two options were assessed for managing increased stormwater peaks from the development:

- Option 1: Provision of on-lot detention for managing increasing peak flows on account of on-lot impervious area increases, with smaller precinct scale detention to manage increased runoff due primarily to roads; and
- Option 2: Management of all increased peak flows on account of development impervious area increases in larger precinct scale detention facilities (ie. no on-lot detention).

Of the options assessed, Option 1 was adopted as the strategy for the Gwandalan site. This strategy includes:

- Onsite detention for individual lots requiring approximately 4 % of the lot area. These detention areas would be combined with bioretention to provide the dual purpose of stormwater quantity and quality management;
- Precinct scale detention basins are proposed at key locations. The required detention basin land take areas are estimated based on the contributing road sub catchments. In some locations these detention facilities would be combined with bioretention to provide the dual purpose of stormwater quantity and quality management; and
- Rainwater tanks for each dwelling. The size of the tanks will be decided as part of the lot development process. While the purpose of rainwater tanks is for roof water harvesting and reuse, they also detain the stormwater flows to a certain extent. However, this function was not included in assessing the required detention storage volume.

To test the effectiveness of the strategy, detention basins were configured in the XP-RAFTS model and simulated. The results are summarised as follows.

- A maximum permissible site discharge should be limited to 110 l/s/ha;
- A minimum required on-site detention storage of approximately 280 m^3/ha is required.
- A maximum permissible precinct scale detention basin discharge should be limited to 160 l/s/ha is required.
- A minimum required precinct scale detention basin storage of approximately 80 m^3/ha is required.

It is anticipated that as these precinct scale facilities will be allocated to Council ownership at the completion of the construction. As such, these structures will then be operated and maintained by WSC.

Table 4 shows the effectiveness of the detention strategy in reducing the 100-year ARI post-development flows to the 100-year pre-development level, for a range of storm durations. The results general compliance with WSC DCP 67 design criteria can be achieved for the 100-year event.

Table 4 Results of Detention Strategy Modelling at the Outlet

Duration	**Existing – 100 Year ARI (m^3/s)**	**Developed with mitigation – 100 year ARI (m^3/s)**
25 min	14.50	7.65
45 min	17.26	9.73
1 hr	19.49	10.75
1.5 hr	19.48	10.83
2 hr	20.81	11.19
3 hr	16.10	9.88
4.5 hr	16.28	10.19
6 hr	14.02	9.74

9 hr	12.12	9.71

5.4.2 Flooding and Flood Risk

Flooding at Gwandalan Site is primarily on account of Lake Macquarie, flooding in Strangers Gully and overland flow conveyance (see Figure 1 Appendix B). Development and land-use in flood prone areas should be in accordance with WSC DCP 67 and the NSW Floodplain Development Manual. In assessing the flood risk, consideration needs to be given to the full range of risks to people and property, for a full range of flood events up to and including the PMF. Interim development guidelines specify, amongst others:

- Habitable floor levels should either be at or above the Flood Planning Level (500 mm above the 100-year ARI event flood level) or be flood proofed to this level, making additional provision for potential subsidence;
- In flood storage and flood way areas, development must not lead to a significant increase in flood levels, flood damages, flood behaviour or flood hazard at the site or elsewhere. Provision of adequate and acceptable compensating works to offset must be provided; and
- In high flood hazard areas, effective evacuation procedures must be provided.

All dwellings would be located above the 100-year ARI flood level associated with Lake Macquarie, Strangers Gully, local overland flow paths and stormwater management facilities across the site. It is proposed that Flood Planning Levels be adopted that locate floor levels of dwellings with a freeboard of 500 mm above 100-year ARI flood levels.

Figure 1 Appendix B shows the extent of both the existing and future climate 100 year and PMF flood level within the lake.. From the nominated 100-year lake flood level and applying the requirement for the floor level of dwellings to be 500 mm above this, the nominated flood planning level for the Gwandalan estate is therefore 1.88m AHD under existing climate. From Figure 1 Appendix C, it can be seen that the developable area is located outside both the 100 year and mostly outside the PMF lake flood levels and is also well above the nominated flood planning level of 1.88m AHD. In fact, the lowest part of the site is almost entirely above 4m AHD with exception of two lots at 3m AHD. In addition the development is set back approximately 100m or more from the lake shore.

There are minor areas inundated by the PMF that require a flood evacuation strategy. Elevated areas would provide suitable evacuation muster areas. As indicated in the figure, the areas of inundation are located adjacent to both of the riparian corridors and the extent of impact on the site is limited.

For localized flooding associated with discharges within the development site, the capacity of both the overland flow paths and underground stormwater system will be designed to provide a level of service that minimises the flood hazard. Flood hazard is a product of both overland flow depth and velocity. In order to limit the hazard both of these need to be controlled. For the underground system, this would be achieved by providing a sufficient number of surface inlet pits. For the overland system, the flood hazard reduction would be achieved through the incorporation of lower grade swales and rock protection of the steeper swales through the riparian corridors.

As part of minimising the flood hazard within the site, roadway crossings of drainage channels will need to be designed such that the impacts on water level upstream and downstream are limited. The design of these crossings will also need to consider the behaviour of flows over the roadway to ensure that the depth and velocity are at an acceptable limit.

5.4.3 Climate Change and Flooding

The levels of inundation under the future climate scenario have been shown in Figure 1, Appendix B.

Under future climate conditions, considering the long-term predictions to 2100 and allowing for wave run-up and 0.5m freeboard, 8 foreshore lots would be affected in a 100-year ARI event. This is an extreme scenario given the long planning period (ie, life span of dwelling is estimated to be 50 years). However, for these 8 lots, not the entire lot is affected and the rear portion of the lots located at higher levels would still be usable. Should the extreme PMF flood event prevail under future climate conditions with wave run up, 16 lots would be flood affected if the existing topography prevails. However it is reasonable to expect that some changes in level will occur during the subdivision stage and the formation of roads, which could result in some of these, if not all, lots being flood free due to minor localised filling.

5.4.4 Evacuation Strategy

The management of floods and floodplains is the responsibility of State Emergency Service (SES) and Council. SES is mainly responsible for dealing with floods while flood planning and land management rests with Council.

The arrangements for managing flood prone land are detailed in the State Government's Flood Prone Lands Policy and the Floodplain Development Manual. The main considerations for the evacuation strategy are:

- The areas within PMF flood extents to be evacuated;
- Number of people to be evacuated and the time available (at this stage, it is difficult to estimate the number of people);
- Muster areas and evacuation routes; and
- Resources and transport means necessary to meet these needs.

The most 'at risk' area of the site is located adjacent to Lake Macquarie. The strategy and operation of an evacuation plan must be pre-planned during design stages however it is considered that the site has sufficient space and locations to assemble during flood events and the road layout provides a number of routes for evacuation.

5.5 Total Life Cycle Costs

A total life cycle cost analysis considers the cost of owning and operating assets from installation throughout its useful life. It calculates the cost of building a facility plus the net present value of on-going maintenance and operating costs.

Lot based and precinct scale bio-retention/detention systems are proposed throughout the concept plan area to manage stormwater quantity and quality. These systems achieve the following total life cycle cost goals:

- The treatment area is optimised and land take cost is minimised;
- The area could be landscaped without hindering its function; and
- Annual maintenance cost would be less compared to open water bodies such as wetlands. Key maintenance may require periodic landscaping and removal of any debris captured. Filtration media replacement may be required every 20 to 30 years.

In addition, vegetated swales at selected locations have been included in the proposed design. Vegetated swales are open channels system, which could be designed to treat water quality with low capital and maintenance costs.

5.6 Ongoing Monitoring

Monitoring should be undertaken to ensure that stormwater quality management measures are working effectively. Monitoring would rely primarily on visual inspections and potentially sampling. Visual inspections should be undertaken for sediment traps, pits, diversions, GPTs, catch drains and all stormwater conveyance structures.

5.7 Water Demand Management and Reuse

To address Integrated Water Cycle Management, potable water conservation could be achieved by:

- Demand Management; and
- Substitution using fit for purpose principles.

Potable water conservation could lead to wastewater flow reduction, which leads to benefits to the environment in terms of reduced treated discharges. In addition roof and stormwater harvesting would reduce discharge to the environment when used in fit-for-purpose substitution.

Demand management should be maximised and could include water savings fittings, low flow showerheads, water efficient appliances, and low water demand toilets. Demand management would need to be implemented in order to meet the requirements of BASIX.

All dwellings that have sufficient roof areas could be provided with roof rainwater harvesting tanks. The rainwater tanks would overflow to the site sub-surface stormwater system and the road stormwater drainage system.

6. Conclusions

A number of opportunities for management of stormwater quality, quantity and flooding exist at the Gwandalan site. This management would benefit from the implementation of Water Sensitive Urban Design (WSUD) practices. WSUD encompasses all aspects of urban water cycle management including water supply, wastewater and stormwater management, that promotes opportunities for linking water infrastructure, landscape design and the urban built form to minimize the impacts of development upon the water cycle and achieve sustainable outcomes;

A WSUD strategy for management of stormwater quality and quantity has been developed for the Gwandalan site that nominates:

- Opportunistic vegetated infiltration swales provided along the identified main overland flow routes and roadside green areas. Vegetated swales are open channel systems, which are used to remove sediment and suspended solids. The proposed configuration could also include bio-retention in the invert of swales with grades <4%. The required width of the vegetated swales are approximately 4 to 6 m;
- A number of precinct scale detention/ bio-retention basins are proposed at the low point of the site, before discharge to the conservation area draining to Crangan Bay. These basins would essentially comprise a dry basin (to provide detention function) combined with bio-retention in the invert of the basin. The bio-retention system would potentially need to be lined in areas to prevent contamination of groundwater.. Structural measures (for example discharge control pits) would be provided to further manage discharges;
- Gross pollutant traps will be provided upstream of precinct scale basins to remove coarse sediment and gross pollutants prior to discharging into basins and open areas;
- On-lot detention will be provided in addition to the precinct scale basins;
- Provision of rainwater tanks for individual lots will be maximised;
- Construction phase water quality impacts will be managed through the implementation of a Soil and Water Management Plan detailing stormwater management strategies in accordance with relevant best practice guidelines eg:'Soils and Construction, Managing Urban Stormwater' (Landcom 2004);
- All dwellings would be located above the 100-year ARI flood level associated with Lake Macquarie, local overland flow paths and stormwater management facilities across the site, with allowance of 0.5m freeboard. All lots are generally above 4m AHD and set 100m back from the lake shore line, From the nominated 100-year lake water level and applying the requirement for the floor level of dwellings to be 0.5m above this level, the nominated flood planning level for the Gwandalan estate at the foreshore of Lake Macquarie is 1.88m AHD.;
- At the Gwandalan site, under future climate conditions, considering the long-term predictions to 2100 and allowing for wave run-up and 0.5m freeboard, 8 foreshore lots would be affected in a 100-year ARI event. However, for these 8 lots, not the entire lot is affected and the rear portion of the lots located at higher levels would still be usable. Should the extreme PMF flood event prevail under future climate conditions with wave run up, 16 lots would be flood affected if the existing topography prevails. However it is reasonable to expect that some changes in level will occur during the

subdivision stage and the formation of roads, which could result in some of these, if not all, lots being flood free due to minor localised filling..

To test the effectiveness of the WSUD strategy, numerical modelling was used as follows:

- Flood peaks and flood levels for existing and future climate associated with Lake Macquarie and Strangers Gully were determined using RAFTS and available information;
- Volumes of detention that responded as best possible to the Concept Plan and which throttled flood peaks were determined using RAFTS; and
- Appropriate Water Sensitive Urban Design strategies for stormwater quality management throughout the precinct, which responded as best possible to the Concept Plan and which achieved Council's pollution load targets were determined using MUSIC.

The results of the numerical modelling have shown that the proposed WSUD strategy together with the flood plain management would adequately satisfy the requirements of the Wyong Shire Council (WSC) Draft DCP (WSUD), WSC DCP 67 and the NSW Floodplain Development Manual for management of stormwater quantity, quality and flooding at the Gwandalan site.

7. References

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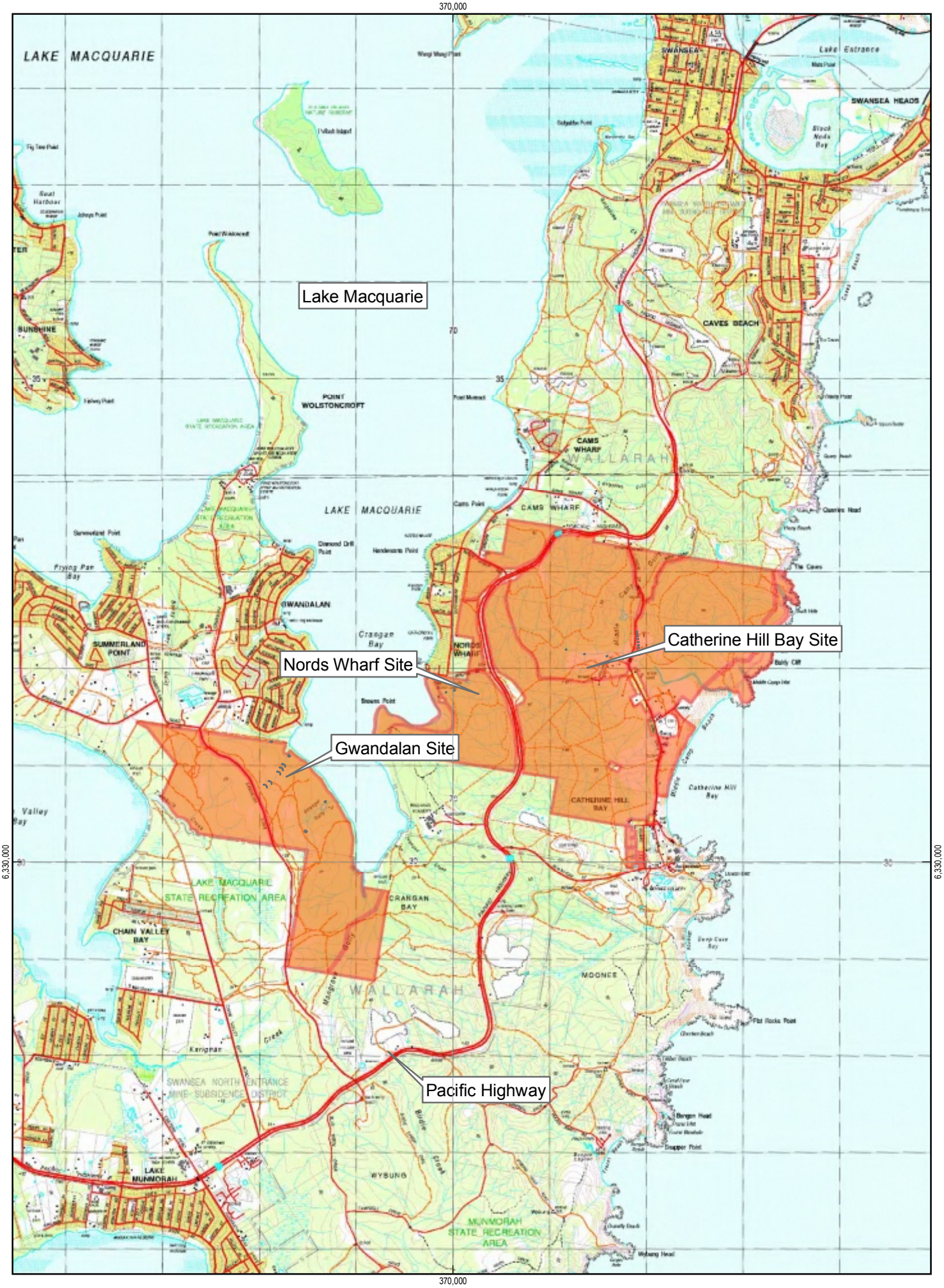
- NSW Sea Level Rise Policy Statement (2009); and
- DECC Practical Consideration of Climate Change, October 2007.

Appendix A

Site Location and Concept Plan



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Grid: Map Grid of Australia, Zone 56

N

Legend

CA Land Holdings

Coal & Allied
Lower Hunter Land Project

Southern Estates
Locality Map

Job Number | 21-16058
Revision | 0
Date | 21/05/2010

Figure 1

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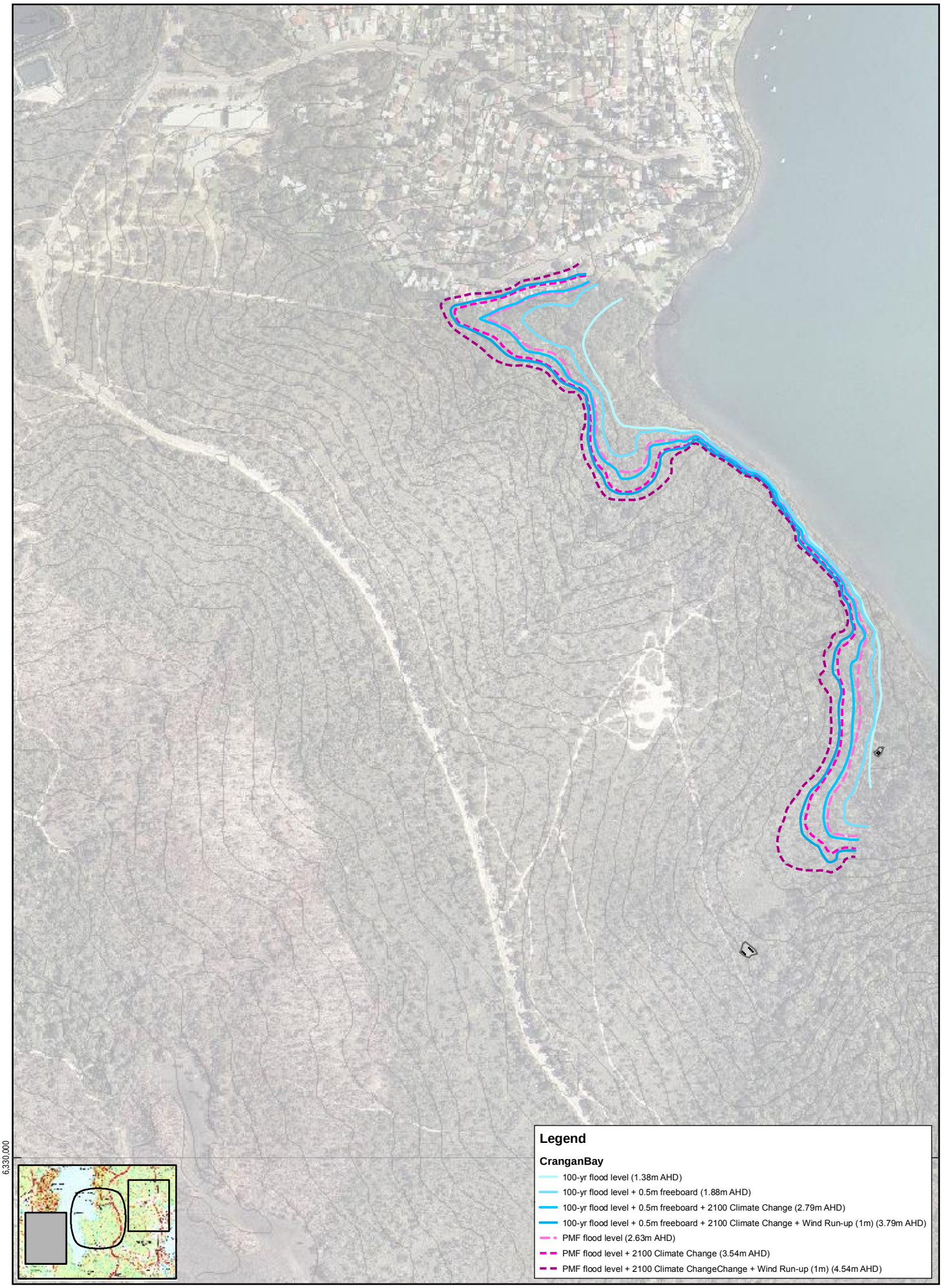
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

10 Bond Street Sydney NSW 2000 Australia T 61 2 9239 7000 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Figure A1.3.1 Gwandalan Indicative Lot Layout

Appendix B

Flood Maps



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Coal & Allied
Lower Hunter Land Project

Job Number 21-16058
Revision 0
Date 16/06/2010

Gwandalan Flooding Assessment

Figure 1

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

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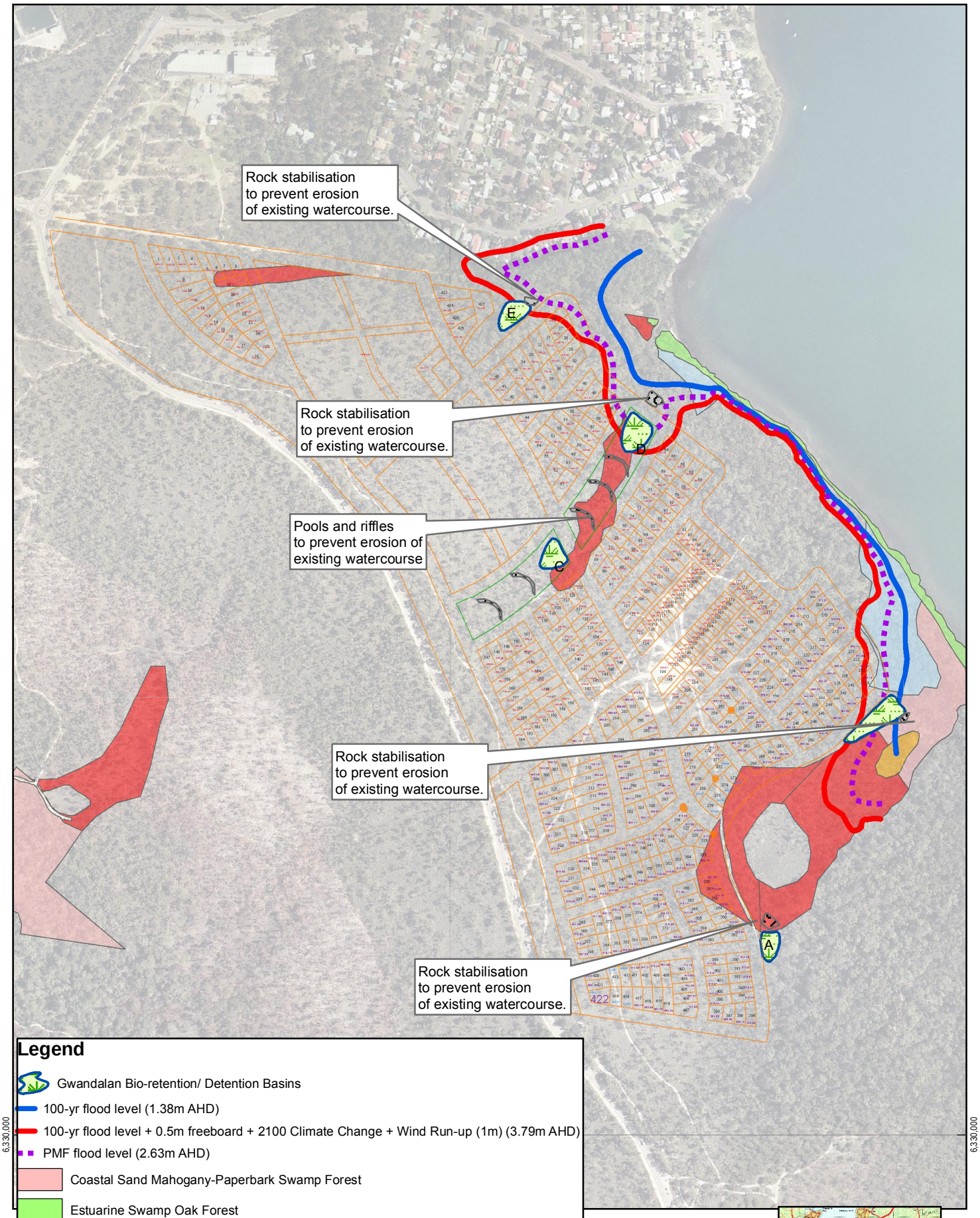
Appendix C

Water Sensitive Urban Design Strategy



Legend

- Gwandalan Bio-retention/ Detention Basins
- 100-yr flood level (1.38m AHD)
- 100-yr flood level + 0.5m freeboard + 2100 Climate Change + Wind Run-up (1m) (3.79m AHD)
- PMF flood level (2.63m AHD)
- Coastal Sand Mahogany-Paperbark Swamp Forest
- Estuarine Swamp Oak Forest
- Freshwater Wetlands
- Narrabeen Alluvial Drainage Line Complex (Shallow drainage variant) [26b]
- Narrabeen Foreshore Redgum-Ironbark Forest (Redgum rough barked variant)

1:7,500
0 50 100 200
Meters
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

O

Coal & Allied
Lower Hunter Land Project

Job Number 21-16058
Revision 0
Date 30/09/2010

Gwandalan Bioretention/Detention Basin Locations

Figure 1

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

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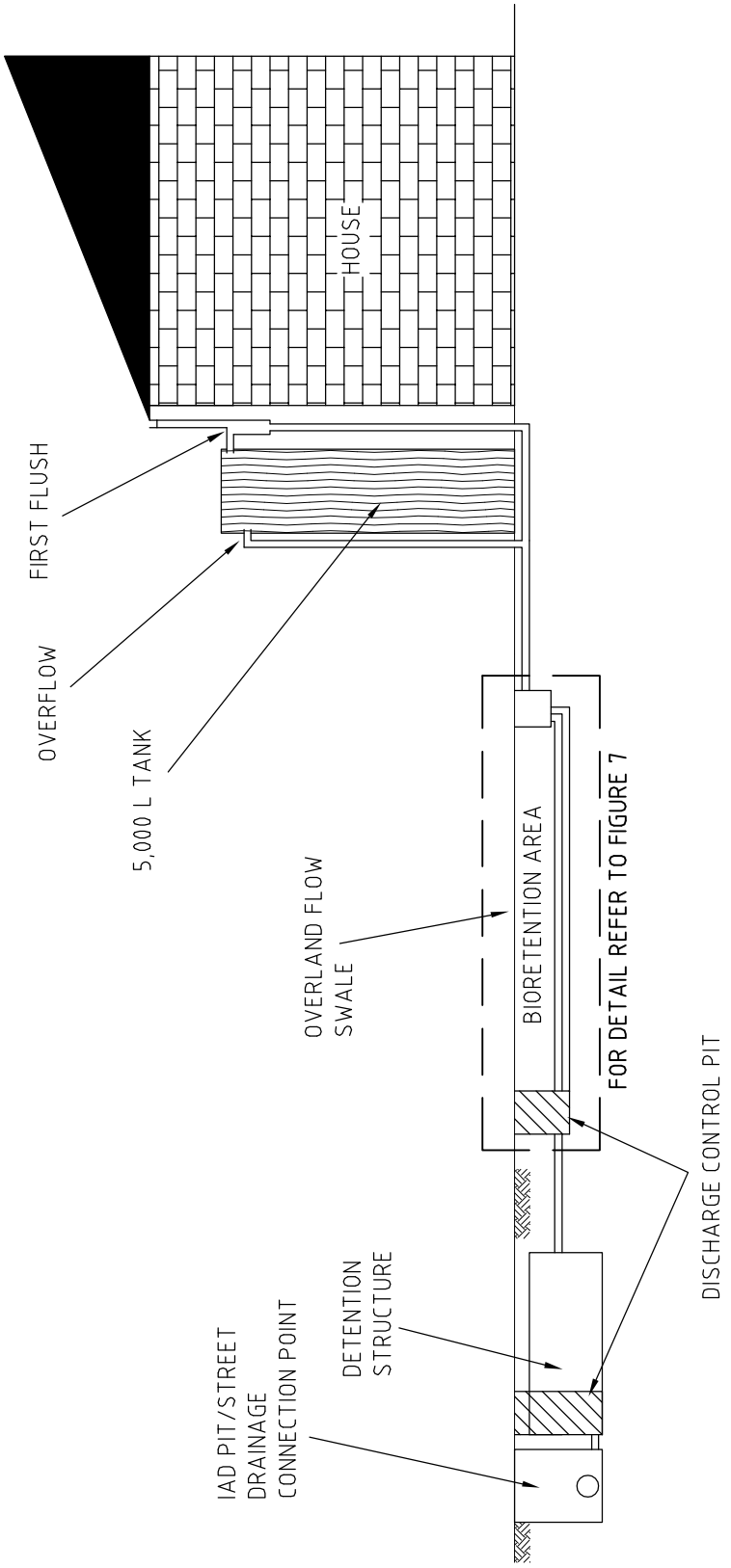
Appendix D

Typical on-lot Stormwater Management Configuration



GHD CLIENTS | PEOPLE | PERFORMANCE

COAL & ALLIED
SOUTHERN ESTATES CATHERINE HILL
ON-LOT STORMWATER TRAETMENT
SECTION VIEW
scale | NTS for A4 date | OCTOBER 2007

job no. | 21-16058
rev no. | A

Figure 4

352 King Street Newcastle NSW 2300 Australia **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

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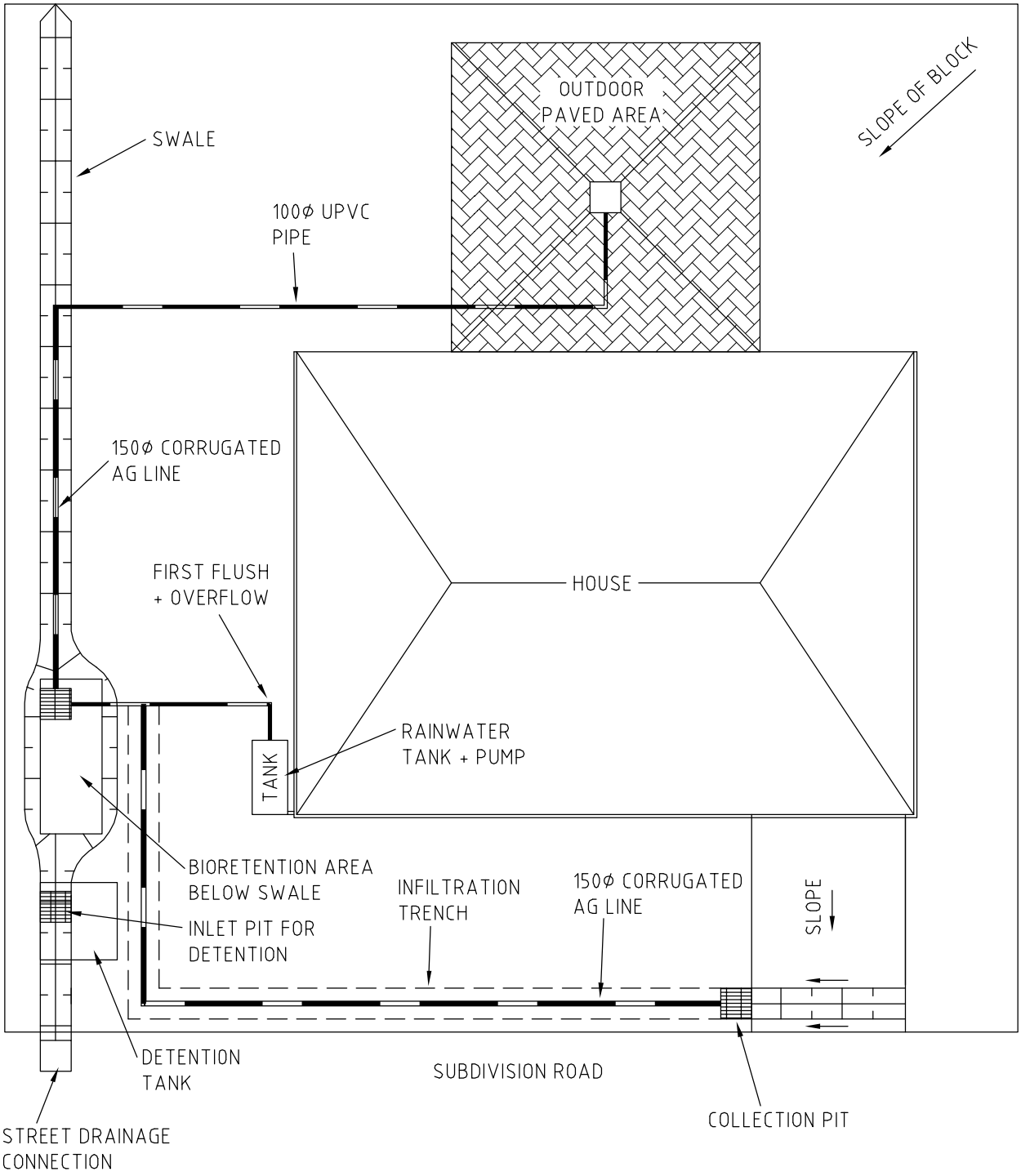

GHD CLIENTS | PEOPLE | PERFORMANCE

COAL & ALLIED
SOUTHERN ESTATES CATHERINE HILL
STORMWATER PLAN
STREET DRAINAGE

job no. | 21-16058
rev no. | A

Figure 1

scale | NTS for A4 date | OCTOBER 2007

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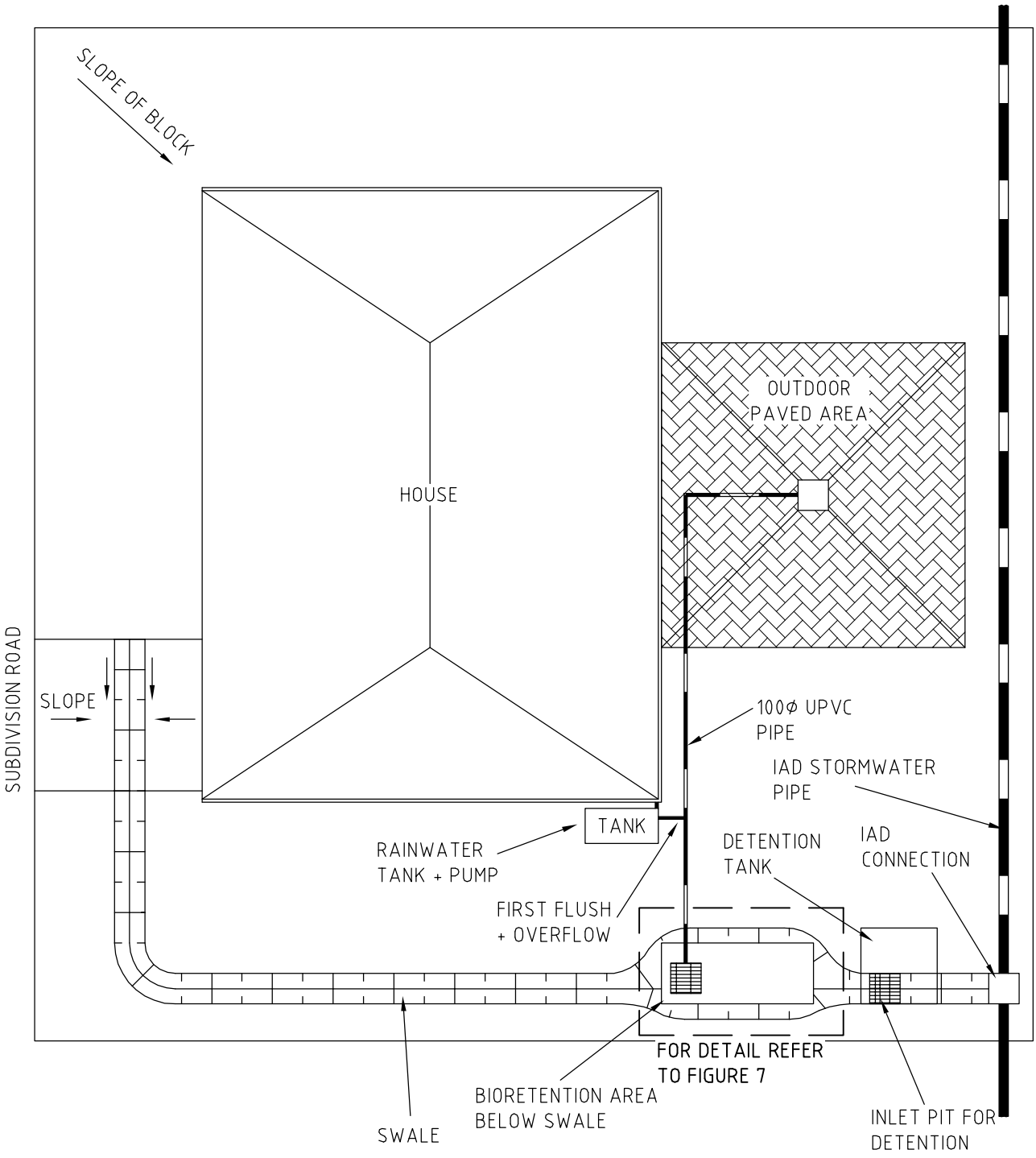

GHD CLIENTS | PEOPLE | PERFORMANCE

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SOUTHERN ESTATES CATHERINE HILL
ON-LOT STORMWATER PLAN
REAR DRAINAGE
scale | NTS for A4 date | month 2005

job no. | 21-16058
rev no. | A

Figure 2

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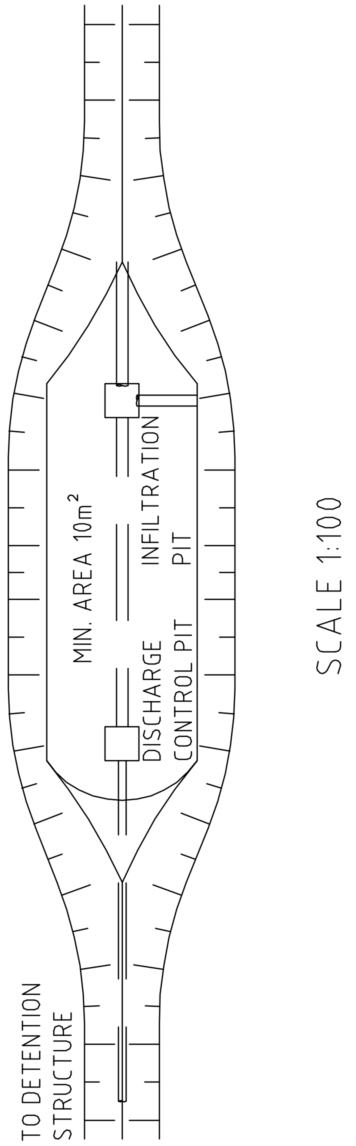

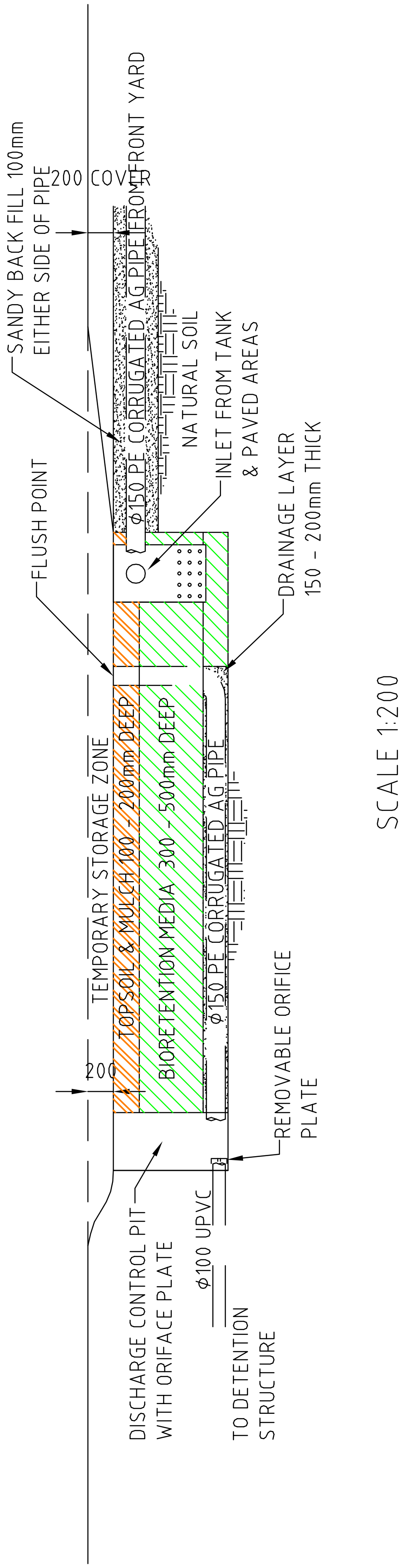

GHD CLIENTS | PEOPLE | PERFORMANCE

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SOUTHERN ESTATES CATHERINE HILL

BIORETENTION AREA DETAIL

job no.	21-16058
rev no.	A

Figure 3

scale | NTS for A4 date | OCTOBER 2007

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Number of DRAFT Versions	R Berg	A number of internal reviews have taken place, on previous versions including a Client's review. Minor changes in all cases		R Berg		Jan, Feb. May Sep 2010
Review of Adequacy	R Berg	Client and Scott Fraser		R Berg		2010.10.11