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Coal & Allied Industries Limited

Report for Lower Hunter Lands Project

Catherine Hill Bay (Middle Camp): Water Sensitive Urban Design, Flooding and Stormwater Management

October 2010

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

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1. Introduction

1.1 Background

The entire Catherine Hill Bay (Middle Camp) site is owned by Coal & Allied Industries Limited (Coal & Allied) which is proposed to 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 residential subdivision and conservation land transfer will apply to the entire 569 ha Catherine Hill Bay (Middle Camp) site. The key features of the future development of the site are as follows:

- Dedication of 526.6 ha of conservation land to the New South Wales Government (NSWG) as identified in the Lower Hunter Regional Strategy and Lower Hunter Regional Conservation Plan. This comprises approximately 93% of the Middle Camp site.
- Dwelling yield of 222 dwellings (including 57 integrated housing lots) and 3 super lots over 28.2 ha.
- Two developable areas are identified under the Concept Plan located to the north of the Middle Camp heritage township which includes;
  - Developable area A (northeast) = 7.32 ha; and
  - Developable area B (northwest) = 20.88 ha.
- The development will be staged. 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 development includes the provision of associated infrastructure.
- Proposed Torrens title subdivision of the Catherine Hill Bay site. The Torrens title subdivision and boundary realignment of Coal & Allied land will enable the following:
  - transfer of land 526.6 ha in area that is owned by Coal & Allied to be excised and to be dedicated to NSWSG for conservation land.
  - transfer of land 1.6 ha in area that is owned by Coal & Allied, located between the cemetery and the oval and including the adjacent car park to Lake Macquarie City Council.
  - enable land 12.38 ha in area that is owned by Coal & Allied comprising four houses north west of Northwood Road and land 0.17 ha east of Flowers Drive, to be retained by Coal & Allied post transfer of the conservation land.

Approval will not be sought under the Concept Plan for a specific lot or road layout. An indicative lot layout will indicate how the dwelling yield of 222 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.

1.2 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 Lake Macquarie City Council Development Control Plan 1 (LMCC DCP 1). 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. Steeper slopes, such as those encountered across most of the Catherine Hill Bay site, make construction and location of larger treatment measures such as precinct scale detention basins, more difficult particularly when located offline. WSUD measures such as swales, bio-swales along with smaller detention basins are considered more suited to the Catherine Hill Bay topography.

2. Existing Conditions and Derived Constraints

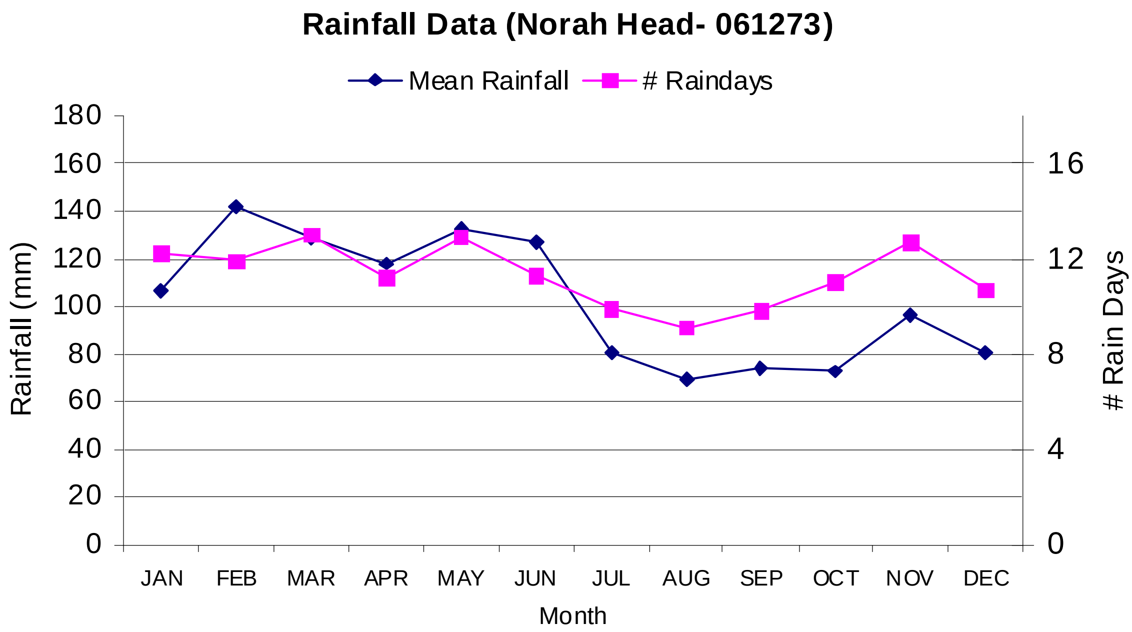
2.1 Climate and Rainfall

Catherine Hill Bay 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 illustrates the 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 may 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 Catherine Hill Bay site generally has gradients varying between 5% and 10% with steeper sections in the order of 16%. To reduce the extent of earthworks, the proposed basins would need to be located in areas of gentler grades closer to existing watercourses.

Steeper slopes (greater than 5%) are generally not suitable for the construction of WSUD facilities such as bioretention swales. 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 (CALM : 1992), the Catherine Hill Bay site is underlain by three major soil landscape groupings:

- *Wyong Landscape.* Underlies the main channel of Middle Camp Gully and the downstream end of its tributaries. The limitations of this soil group include localised waterlogging, poorly drained, potential acid sulfate soils, saline subsoils, localised stream bank erosion and low fertility;
- *Awaba Landscape*. Underlies much of the remainder of the site. The limitations of this soil group include steep slopes, high erosion hazard with localised mass movement, stoniness, shallow, acidic soils with low fertility; and
- *Disturbed Terrain Landscape.* Shown within two pockets adjacent to the Wyong Landscape. At this site, the landscape has been highly modified due to past mining activity. During the preliminary site inspection, coal fines were noted at the ground surface and there is likely to be unconsolidated materials requiring rehabilitation prior to construction commencing.

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

The major watercourse draining the site is Middle Camp Gully. Middle Camp Gully rises to the northwest of Middle Camp, to the east of the Pacific Highway and discharges into the Tasman Sea at Middle Camp Inlet, at the northern end of Middle Camp Beach. Stormwater from the site drains directly into Middle Camp Gully or into one of its unnamed tributaries.

The northern catchment drains in a southerly direction into the main channel of Middle Camp Gully, before passing through two culverts under Flowers Drive, the main arterial road servicing the village of Catherine Hill Bay. A dam, which was most likely constructed when the area was actively mined, is located on this tributary. Drainage from the south-western and south-eastern catchments, passes under Flowers Drive and discharge into Middle Camp Gully, downstream of the road crossing. At its downstream end, Middle Camp Gully becomes a lagoon discharging to the ocean intermittently.

The geomorphic features of many of the tributaries have been modified by past mining activities and construction of the stormwater management system for the existing residential development. However, Middle Camp Gully and its major southwest tributary, both show well-defined bed and banks and typical riparian vegetation along their length.

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 Middle Camp 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 development area of Middle Camp is located generally to the south of the site.

2.6 Key Statutory Requirements

In addition to the statutory requirements under the Part 3A of the *Environmental Planning and Assessment Act 1979 (EP&A Act)*, the key discipline specific guidelines relating to Water Sensitive Urban Design, Flooding and Stormwater Management which should be considered include:

- 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 prioritises investment in natural resource management for this area;
- Lake Macquarie City Council (LMCC) Development Control Plans 1 and 2 – outlines requirements for development within or near water bodies, floodplains, steep lands, acid sulphate 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; and
- NSW Floodplain Development Manual, 2005 - which 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

LMCC DCP 1 nominates target pollutant removal efficiencies aimed at 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)	High - Very High (80 – 100%)
Total Suspended Solids (kg/yr)	Moderate – High (30 – 80%)
Total Phosphorus (kg/yr)	Moderate (30 – 50%)
Total Nitrogen (kg/yr)	Moderate (30 – 50%)

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 site according to the requirements of the LMCC DCP 1, which stipulates:

- Post development 20-year Average Recurrence Internal (ARI) flood peaks should not exceed 5-year existing condition flood peaks; 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 LMCC Floodplain Management Policy 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 the following.

- 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 TUFLOW).
- Appropriate volumes and strategies for detention throughout the site, that responded to the concept plan and which controlled post development flows to the requirements of LMCC DCP 1 (using XP - RAFTS).
- 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 LMCC DCP1 (Volume 2 Engineering Guidelines).

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 detailed phase.

3.2.1 Existing Flooding 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 (IFD) 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 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 XP-RAFTS Modelling Parameters

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

Existing 100-year and PMF Flood Levels

Flood levels, velocities, flood extents and flood hazard were determined with the 2 dimensional TUFLOW hydraulic model. TUFLOW is a hydraulic model for simulating depth-averaged, two and one-dimensional free surface flows. Data is input through the use of text files for controlling simulations and simulation parameters. MapInfo files are used to represent spatially distributed data such as topography, hydraulic structures and boundary conditions. The TUFLOW model compilation was undertaken as follows:

- The available 2 m contour data for the site was imported into the digital terrain model program 12D. The Middle Camp Gully area was extracted and triangulated into a Digital Terrain Model (DTM) to represent the ground surface;

- A TUFLOW grid was generated with a cell size of 2 m. Each point in the grid was given an elevation based on its location in the 12D DTM. The grid size was chosen because this is a compromise between the accuracy of the DTM data, simulation run time, model stability, and the accuracy of the results;
- No road crossings were simulated at this early planning stage, and thus the modelling represents conservative scenario (worst case) of blocked culverts;
- Supplied cadastral information was imported into GIS program and the aerial photography geo-referenced;
- The sub-catchments used in the XP-RAFTS hydrologic modelling were applied as inflows over the 2-D model, with inflows distributed and divided over the model grid points;
- Based on aerial photography and site inspections, hydraulic roughness coefficients for the floodplain were recorded for the model. These coefficients were digitised into MapInfo as polygons to represent the various surfaces; and
- Downstream control was estimated as 2.5 m AHD, allowing for mean high water (approximately 1 m AHD) plus 1 m wave run up plus 0.5 m for combined wind and barometric set-up.

In the absence of corresponding rainfall (hyetograph) and runoff data, calibration of the TUFLOW model was not possible. Furthermore no historic flood markers were available for calibrating of overland flood depths. Calibration of the model was thus limited to checking the “reasonableness” of the overland flow routes and depths, and qualitatively comparing the findings to known flooding occurrences.

3.2.2 Stormwater Quality Management

The water quality assessment for the Catherine Hill Bay 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 model includes swales, bio-retention areas, wetlands gross pollutant traps, sediment basins, ponds and filter strips.

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

- Pollutant generation rates; and
- Pollutant removal rates.

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 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.

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 1023mm/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 1732mm/year.

In pursuing WSUD, LMCC is paying specific attention to the regular low, or base, flows from catchment areas. These flows are of particular importance as they convey the majority of pollutants from catchments to downstream locations, in this case Middle Camp Gully and subsequently the Tasman Sea.

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 Middle Camp site is primarily on account of flooding associated with Middle Camp Gully, overland flow conveyance and potentially sea level rise. Development and land-use in flood prone areas would be in accordance with Lake Macquarie Floodplain Management Policy 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.

Lake Macquarie City Council has adopted these levels for 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.

In summary, Lake Macquarie City Council resolved to adopt a Lake Macquarie Sea Level Rise Preparedness and Adaptation Policy (2008). The key elements of the Policy are:

- Council will use a sea level rise (and lake level rise) figure for the year 2100 of 0.91 metres to assist Council staff to proceed with risk assessment, policy development, planning, development decisions, and community empowerment.
- Council adopt a Schedule of Activities Leading to Preparedness for Sea Level Rise which sets out nearly 40 actions for Council to plan for and adapt to the predicted rise in sea and lake levels over the next 100 years.
- Floor levels for new buildings around the lake foreshore will be adjusted to take into consideration the risk from sea level rise and higher flood levels. Information on new guidelines for floor heights in buildings on low lying land are available upon application for a Development Restrictions Certificate Flooding/Tidal Inundation.

The DECCW Practical Consideration of Climate Change, October 2007 guidelines recommend that the following sensitivity analysis be undertaken in relation to the climate change impacts on rainfall intensities. It recommends assessment of increases of rainfall intensities considering:

- 10% increase in peak rainfall and storm volume;

- 20% increase in peak rainfall and storm volume; and
- 30% increase in peak rainfall and storm volume.

For the Catherine Hill Bay site the high sea level ocean impact scenario was adopted, together with the 30% increase in storm rainfall intensity and storm volume. This was considered an upper envelope of climate change for a 2100 planning horizon. On this basis, the RAFTS and TUFLOW models were resimulated.

As a downstream boundary a level of 4.0m AHD was adopted. This included 1.5 m for wave run up, 0.4 m for barometric setup and 0.2m for wind setup on top of the ocean level rise of 0.91 m applied to the existing climate mean high water level of 1.0 m AHD.

4. Concept Plan and Potential Stormwater Impacts

Development results in increased impermeable surfaces (roofs, driveways, roads, pavements etc.), which affect 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 of 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. Catherine Hill Bay 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.

LMCC is acutely aware of the need to maintain the health of the natural environment and has developed a comprehensive range of criteria for all new developments. The criteria include, but are not limited to, the inclusion of stringent stormwater quantity and quality limits that require the adoption of a range of WSUD treatment measures to form a treatment train.

In general, the principles for stormwater management at Middle Camp 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 Catherine Hill Bay 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 along waterways and provide 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 riparian vegetation;
- Manage the quality and quantity 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 riparian and waterway areas. Furthermore detention basins, lakes and ponds should be located off-line to riparian corridors; 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. Furthermore 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 corresponding to existing drainage corridors. 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 Catherine Hill Bay site is provided in Figure 1, Appendix C and includes the followings strategies:

- Opportunistic vegetated infiltration 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 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 facilities; and
- The 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 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)	19600	78100	3400	95.6
Total Phosphorus (kg/yr)	47.2	161.0	26.1	83.8
Total Nitrogen (kg/yr)	382	1140	306	73.1
Gross Pollutants (kg/yr)	1120.00	10300.00	7.98	99.9

From the above it can be seen that the incorporation of WSUD treatment measures achieves the targets nominated in LMCC DCP 1 (Table 1). The additional net benefit of the inclusion of WSUD measures is a reduction of the existing pollutant load as a direct result of the proposed development.

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 '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 increased peak flows on account of on-lot impervious area increases, with smaller precinct scale detention to manage increased runoff due to primarily 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 Catherine Hill Bay 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 two 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
- The inclusion of 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 tabulated below:

- 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 basins discharge should be limited to 160 l/s/ha; and
- A minimum required precinct scale detention basins 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 LMCC.

Table 4 shows the effectiveness of the detention strategy in reducing the 20-year ARI post development flows to the 5-year ARI predevelopment level and the 100-year post development to a 100-year predevelopment level, for a range of storm durations. The results in general show compliance with the LMCC design criteria.

Table 4 Results of Detention Strategy Modelling at the Outlet

Duration	Existing – 5 Year ARI (m^3/s)	Existing – 100 Year ARI (m^3/s)	Developed with mitigation – 20 year ARI (m^3/s)	Developed with mitigation – 100 year ARI (m^3/s)
25 min	2.7	8.6	3.5	4.4
45 min	3.93	9.09	3.75	5.55
1 hr	4.62	10.5	4.07	6.23
1.5 hr	4.76	10.99	4.13	6.07
2 hr	5.16	11.52	4.23	6.29
3 hr	3.76	8.75	3.70	5.0
4.5 hr	4.49	8.05	3.98	5.59
6 hr	3.95	6.69	3.64	4.72
9 hr	3.47	5.8	3.46	4.35

5.4.2 Flooding and Flood Risk

The extent of existing 100-year ARI and PMF inundation and flood hazard are shown in Appendix C. Referring to:

- Figure 1: The lots are unaffected by the 100-year ARI flood event, although some of the roads in Precinct B would be flood affected. Not withstanding this, floor levels of dwellings would need to be located 0.5m freeboard above the 100-year ARI flood level;
- Figure 1: In the context of the NSW Floodplain Development Manual, a total of approximately 5 lots would be affected by the PMF and would therefore be designated as flood prone, in addition some of the roads would be further affected by flooding;
- Figure 2: With exception to the eastern edge of Precinct B all high hazard flooding in a 100-year ARI is restricted to the creek lines; and
- Figure 2: It is noticeable, that the access road to Precinct B crosses an intermediate hazard flood zone and this road crossing would require careful design to provide effective evacuation.

Development and land-use in flood prone areas should be in accordance with the Lake Macquarie Floodplain Management Policy 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.

Within the Middle Camp site, all dwellings would be located above the 100-year ARI flood level associated with the creeks, local overland flow paths and stormwater management facilities. 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.

As shown in the flood maps, the areas of inundation are located adjacent to the riparian corridors and the extent of impact on the proposed development is limited to the area in the vicinity of the Flowers Drive crossing of Middle Camp Gully. With respect to the flood planning level for the Middle Camp site , this varies dependant upon the location along Middle Camp Gully and each of the tributaries. However, with the cross fall through the site, a flood planning level 500mm above the 100-year water level is considered achievable for each lot within the proposed development area.

For localised flooding associated with discharges within the proposed development area, the capacity of both the overland flow paths and underground stormwater system would 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 variables 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 estate, roadway crossings of creeks will need to be designed such that the impacts on flood level upstream and downstream are limited. 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 impacts of the climate change scenarios are shown in Figure 3 and 4, Appendix B. In general the figures show that:

- Figure 3: The flood extents in the 100-year ARI climate change scenario increase by a small amount adjacent to the precincts. Downstream of the precinct the effect is more dramatic, where backwater effects from elevated ocean levels dominate. In this climate change event, no lots are inundated; and
- Figure 4: In a 100-year ARI event, flood levels adjacent to the site are expected to increase no more than 0.3 m. While this does not cause a significant increase in flood extent, dwelling floor levels would need to consider these impacts.

5.4.4 Evacuation Strategy

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

The most ‘at risk’ properties are adjacent to the creek. Given the timing of flood peaks, evacuation will likely be required at short notice. The strategy and operations must be pre-planned during design stages. It is considered, that the site has sufficient space and locations to assemble and evacuate during flood events.

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.

GHD has proposed lot based and precinct scale bio-retention/detention systems 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, GHD has proposed vegetated swales at selected locations. Vegetated swales are open channel systems, 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 principals.

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 as a minimum benchmark.

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 Catherine Hill Bay (Middle Camp) site.

Stormwater management at the site 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 Catherine Hill Bay site which nominates the following

- 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;
- Precinct scale detention/ bio-retention basins are proposed at key locations to treat the quantity and quality of stormwater flows. These systems 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 need to 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; and
- 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 *Soils and Construction, Managing Urban Stormwater* (Landcom, 2004);
- Habitable floor levels will either be at or above the Flood Planning Level (ie 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 an 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 will be provided and effective evacuation procedures will be provided.
- Under future climate, in a 100-year ARI event, flood levels adjacent to the site are expected to increase no more than 0.3 m. While this does not cause a significant increase in flood extent, dwelling floor levels would need to consider these impacts.

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

- Flood peaks and flood levels for existing and future climate for the creeks within the precinct were determined using RAFTS and TUFLOW;

- 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 LMCC guidelines (DCP 1), the LMCC Floodplain Management Policy and the NSW Floodplain Development Manual for management of stormwater quantity, quality and flooding at the Catherine Hill Bay (Middle Camp) site.

7. References

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- Lake Macquarie City Council, 2003, DCP No. 1 – Volume 2 – Engineering Guidelines – Part 3 – Stormwater Treatment Framework and Stormwater Quality Improvement Device Guidelines.
- Lake Macquarie City Council, 2004, Lake Macquarie City Council *Development Control Plan 1*.
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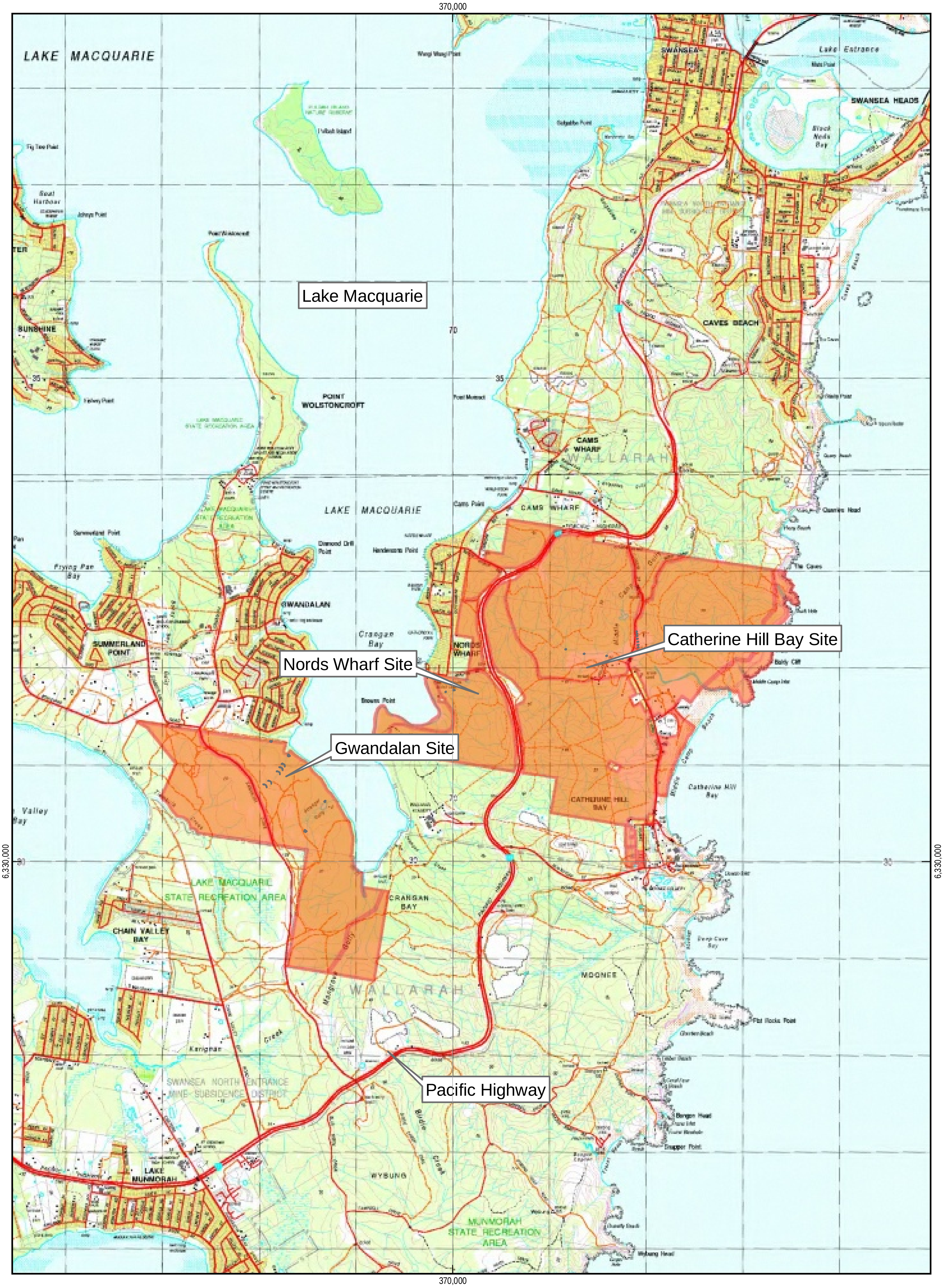
- Mine Subsidence Board. *Graduated Guidelines for Residential Construction (New South Wales)*, Volumes 1 and 2Murphy C.L. 1992.
- *Soil Landscapes of the Gosford-Lake Macquarie 1:100,000 Sheet*, Department of Conservation and Land Management, ISBN No. 0 7305 9166 2.
- NSW Sea Level Rise Policy Statement (2009); and
- DECC Practical Consideration of Climate Change, October 2007.

Appendix A

Site Location and Concept Plan



1:50,000

0 0.2 0.4 0.8 1.2 1.6

Kilometres (at A4)

Map Projection: Transverse Mercator

Horizontal Datum: Geocentric Datum of Australia 1994

Grid: Map Grid of Australia, Zone 56

N

GHD

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

Figure 2
Catherine Hill Bay
Indicative Lot Layout

Appendix B

Flood Maps

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

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100-yr ARI Flood Extents

PMF Flood Extents

100-year ARI Flood Level Contours

Coal & Allied
Lower Hunter Land Project

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

Catherine Hill Bay Existing Flooding

Figure 1

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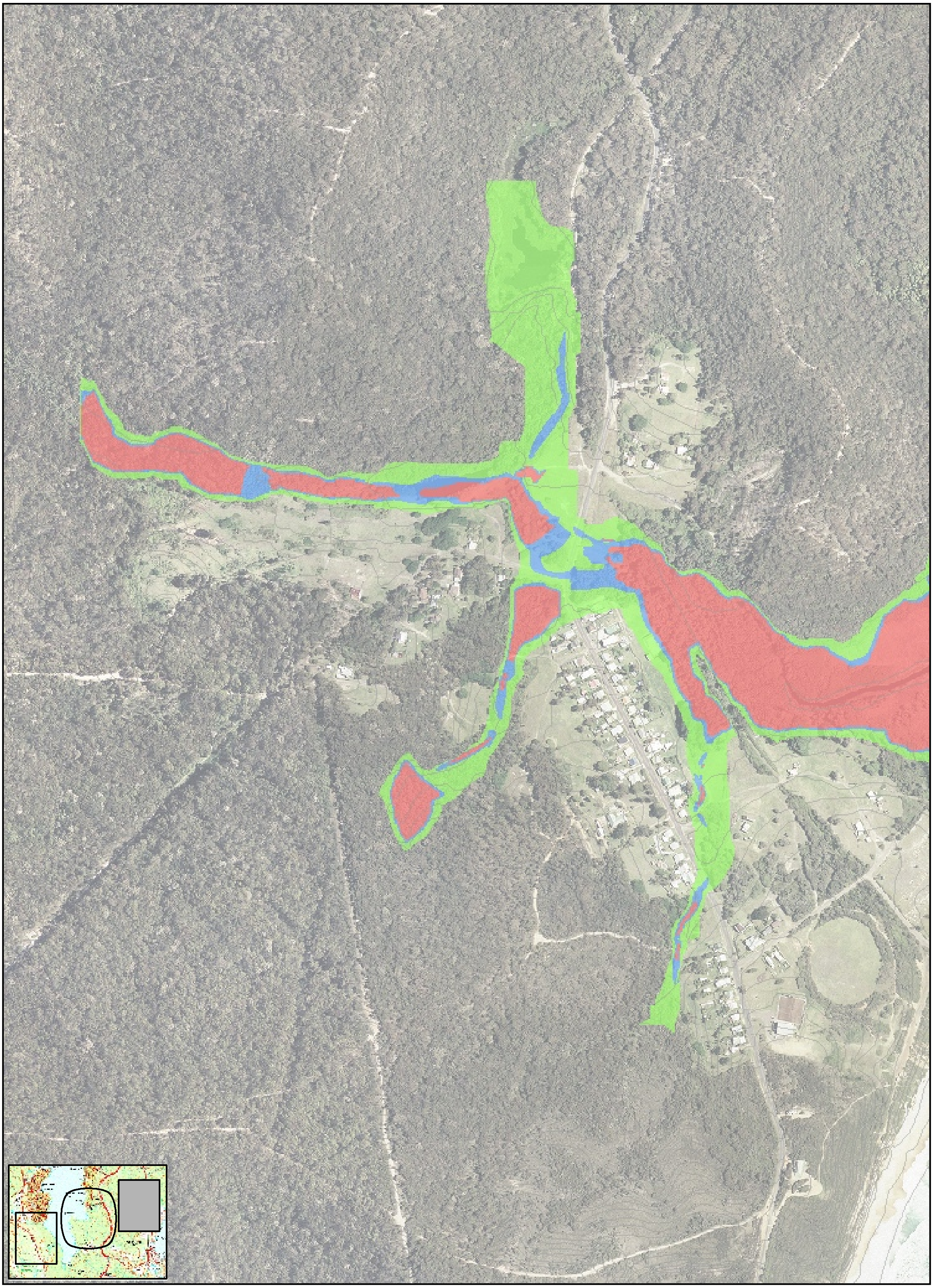

1:7,500

0 50 100 200

Meters

Map Projection: Transverse Mercator

Horizontal Datum: Geocentric Datum of Australia 1994

Grid: Map Grid of Australia, Zone 56

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Flood Hazard

- Low
- Intermediate
- High

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Lower Hunter Land Project

Job Number	21-16058
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Date	21/05/2010

Catherine Hill Bay
Existing Flood Hazard

Figure 2

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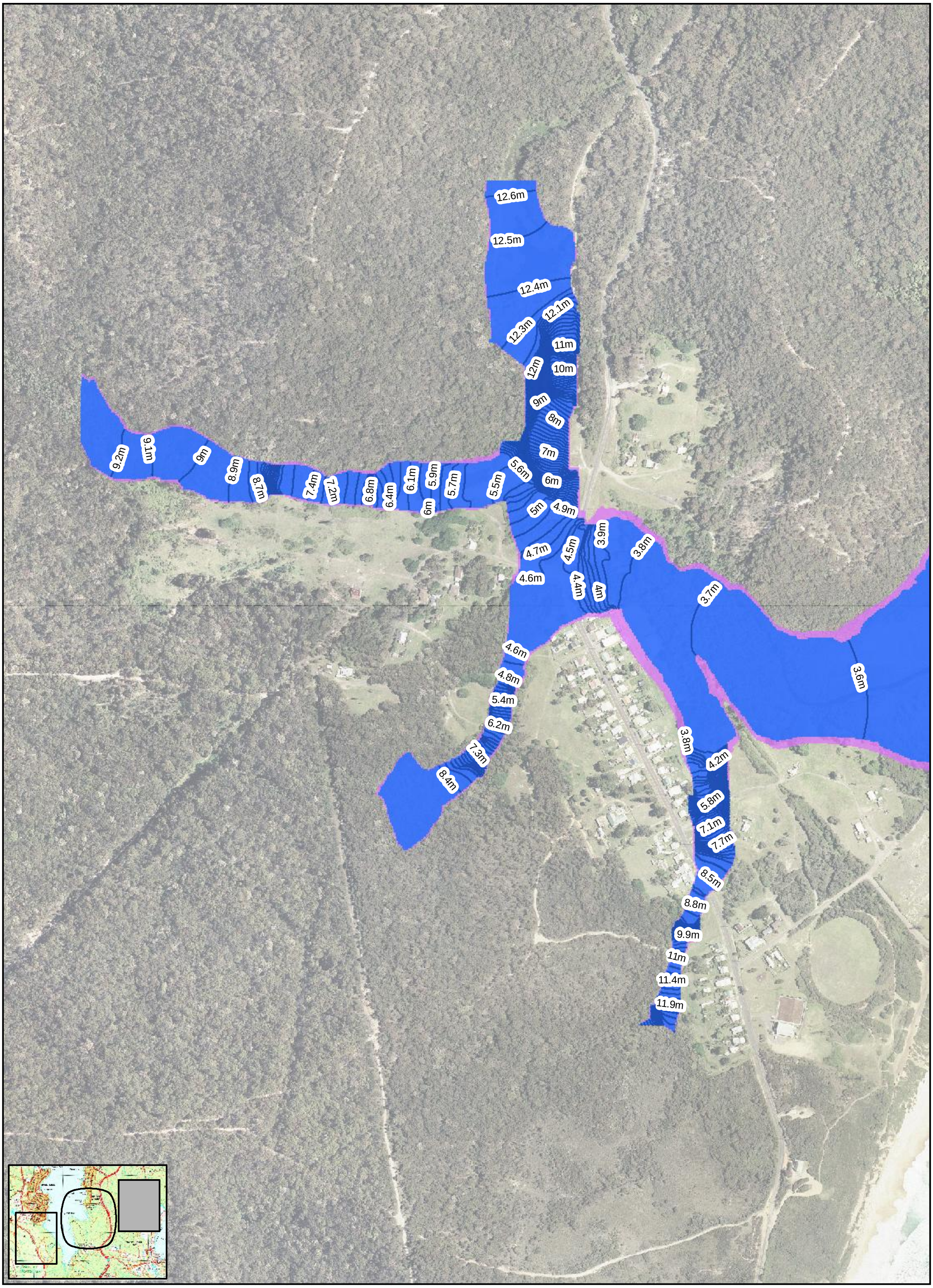

1:7,500

0 50 100 200

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

100-yr ARI Flood Extents

100-yr ARI Flood Extents 2100 climate

100-year ARI Climate Change Flood Contours

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Lower Hunter Land Project

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Revision	0
Date	30/09/2010

Catherine Hill Bay
Climate Change Impacts

Figure 3

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

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

N

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100yr ARI Flood Level Increase (m) due to Climate Change

< 0.1 | 0.1 - 0.3 | 0.3 - 0.5 | 0.5 - 1 | > 1.0

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Job Number 21-16058
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Date 21/05/2010

Catherine Hill Bay Climate Change Impacts

Figure 4

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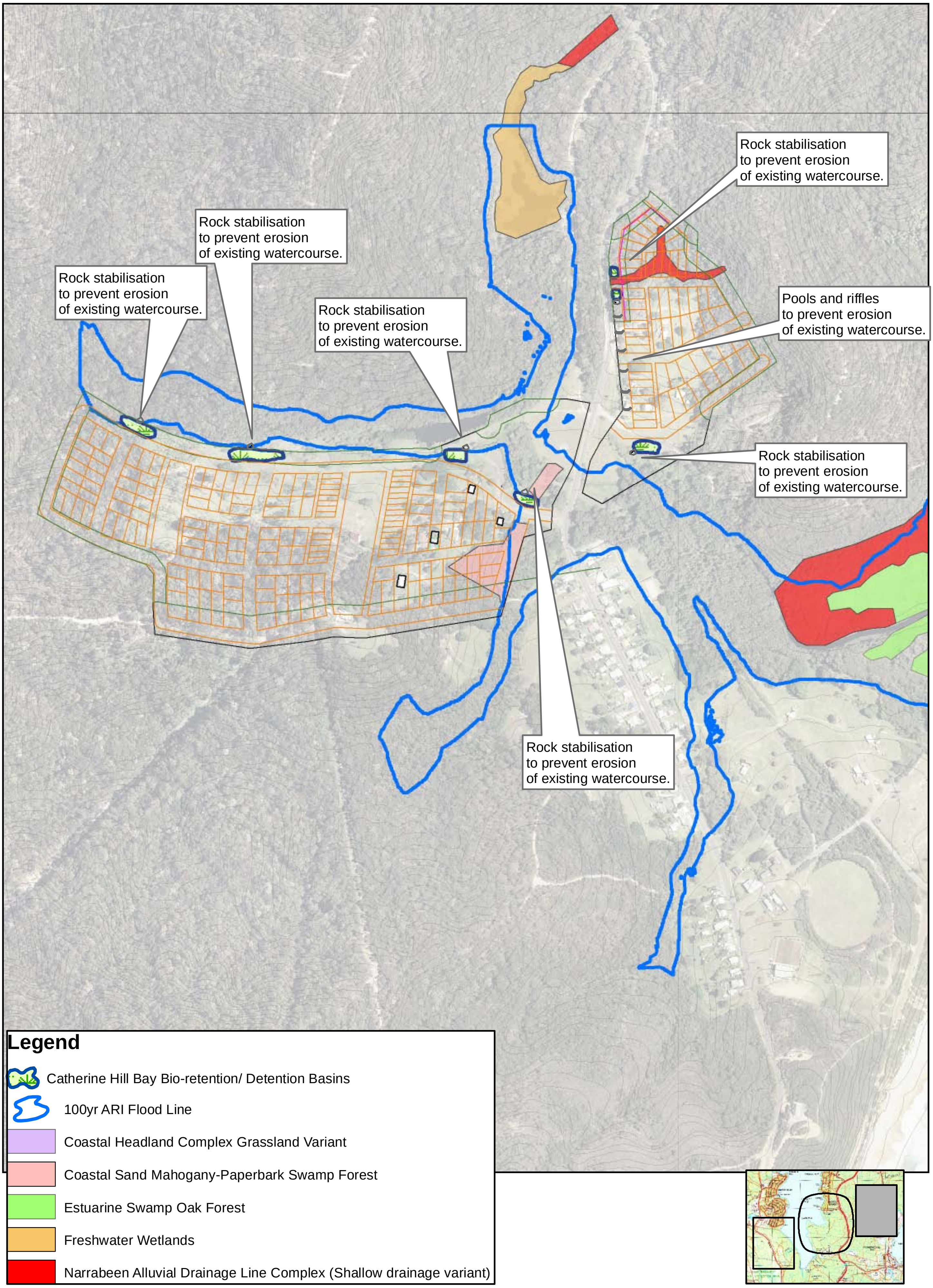
Appendix C

Water Sensitive Urban Design Strategy



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Meters

Map Projection: Transverse Mercator
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Grid: Map Grid of Australia, Zone 56

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Lower Hunter Land Project

Job Number 21-16058
Revision 0
Date 08/11/2010

Catherine Hill Bay
Bioretention/Detention Basin Locations

Figure 1

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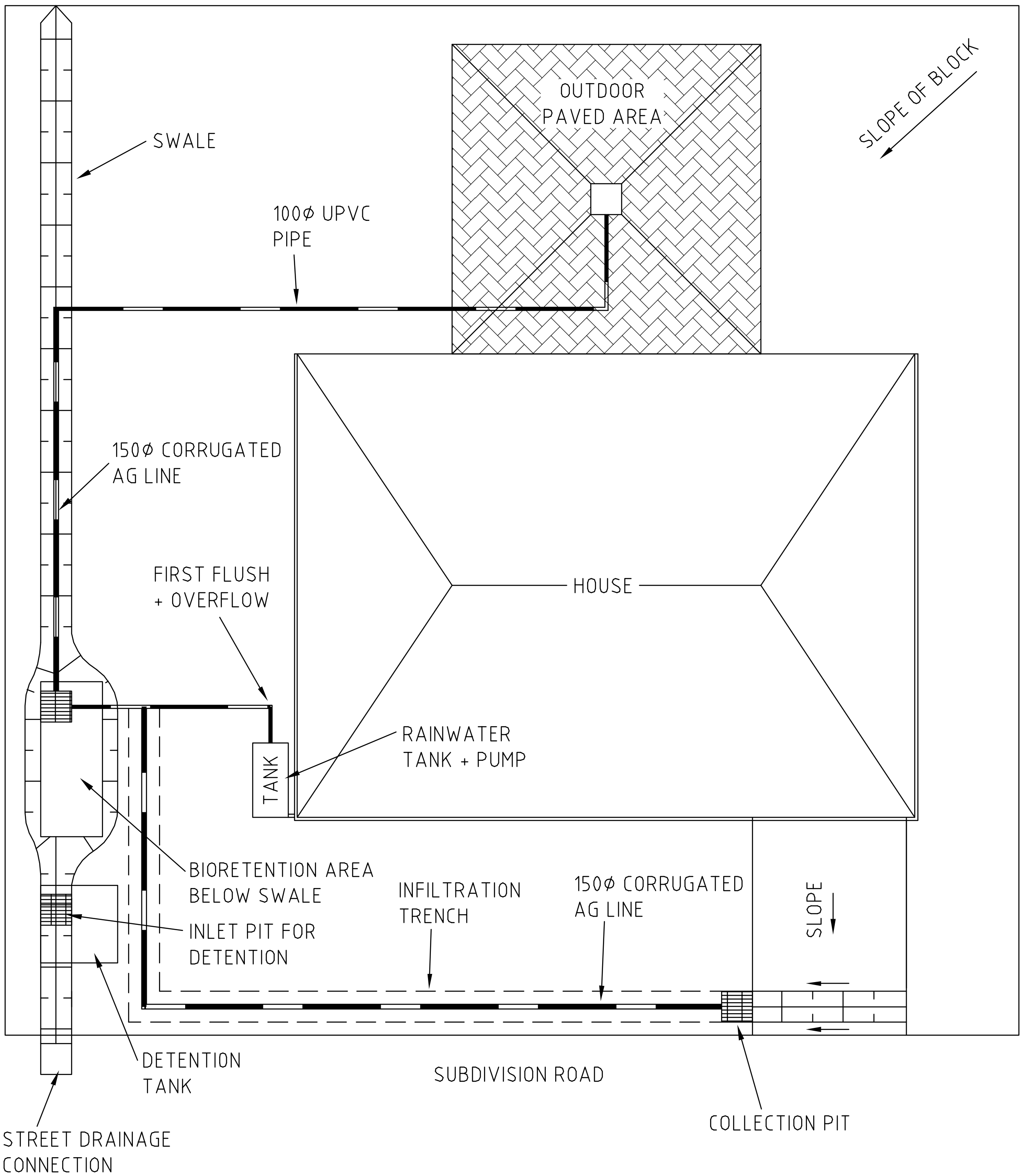
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

Appendix D

Typical on-lot Stormwater Management Configuration



GHD CLIENTS | PEOPLE | PERFORMANCE

COAL & ALLIED
SOUTHERN ESTATES CATHERINE HILL
STORMWATER PLAN
STREET DRAINAGE

scale | NTS   for A4   date | OCTOBER 2007

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

Figure 1

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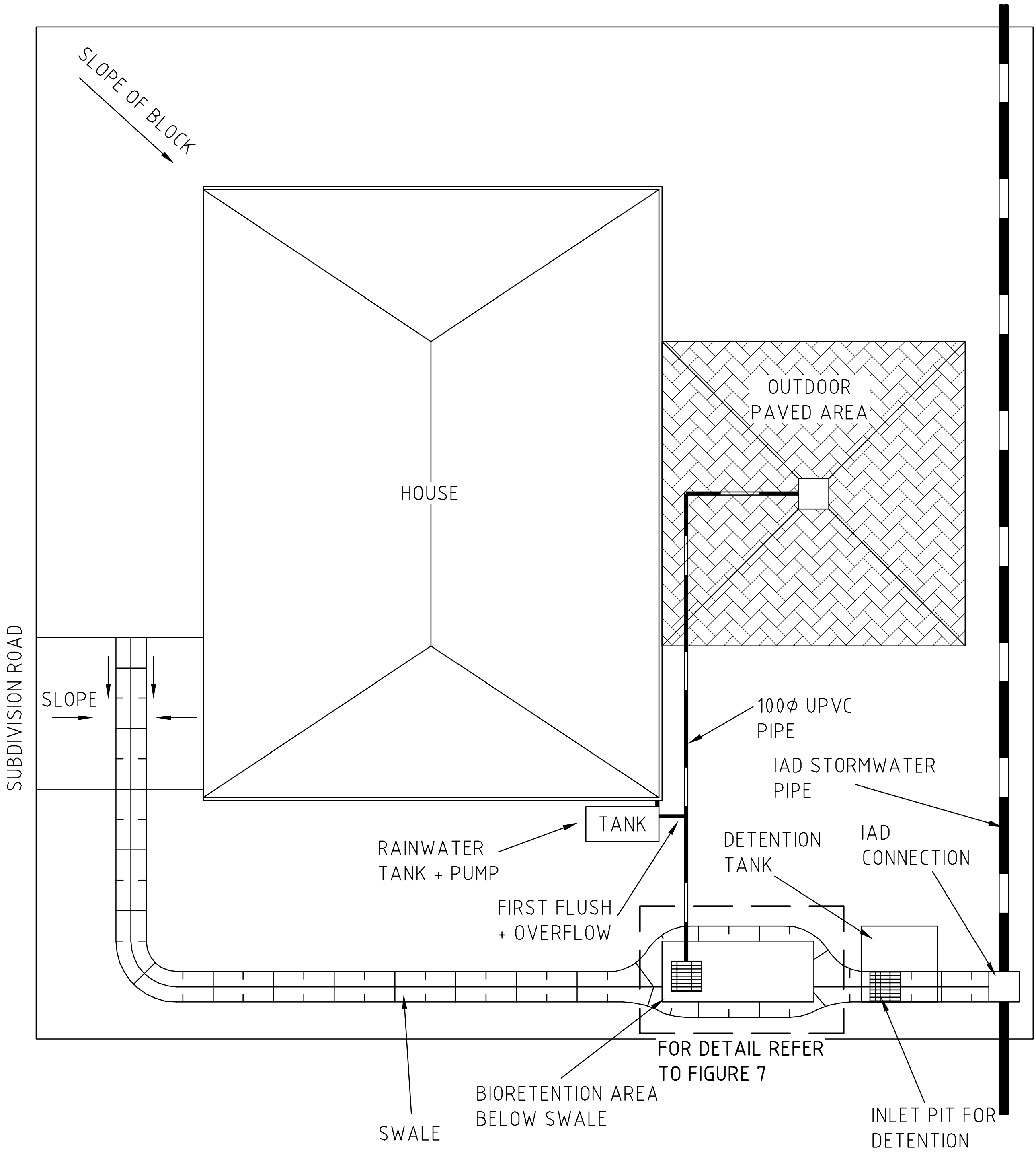
Plot Date: 05 October, 2007 - 11:06 AM   Cad File No: G:\22\13518\CADD\Drawings\ 22-13518-CHBFIG3.dwg



GHD CLIENTS | PEOPLE | PERFORMANCE

COAL & ALLIED
SOUTHERN ESTATES CATHERINE HILL
ON-LOT STORMWATER PLAN
REAR DRAINAGE

scale | NTS for A4 date | month 2005

job no. | 21-16058
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Figure 2

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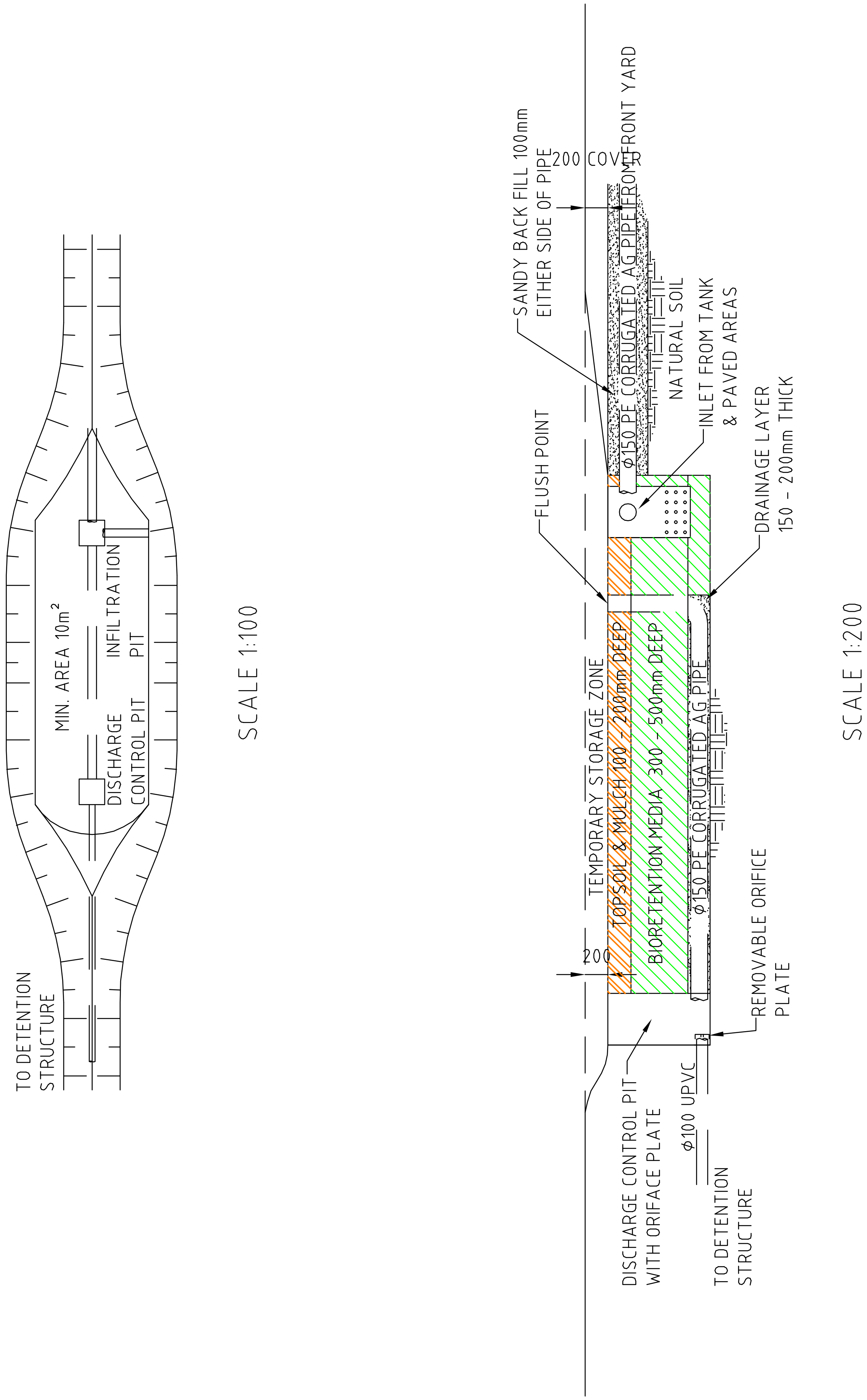

GHD CLIENTS | PEOPLE | PERFORMANCE

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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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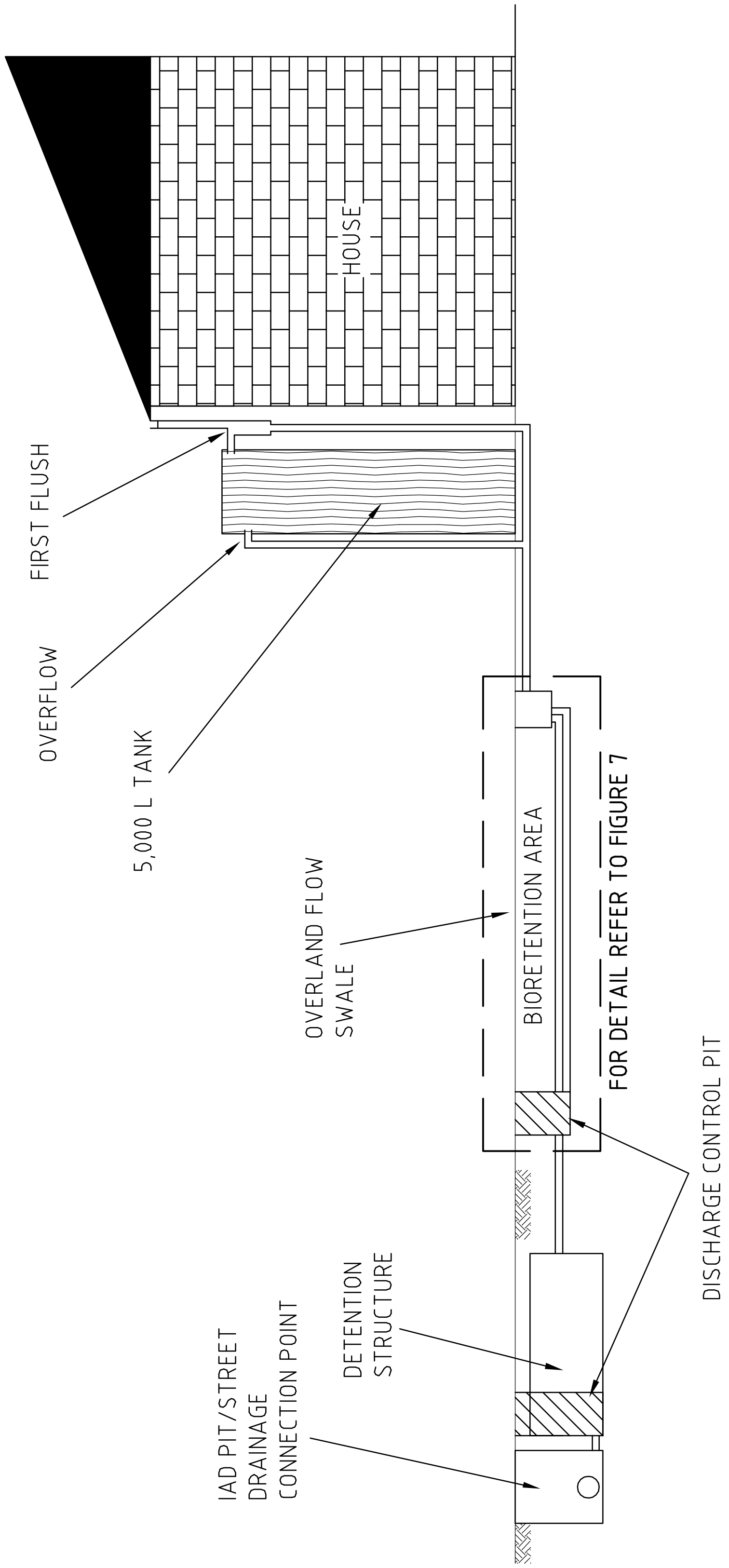

CLIENTS | PEOPLE | PERFORMANCE

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

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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