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Coal & Allied Industries Limited

Report for Lower Hunter Lands Project

Nords Wharf: 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 Nords Wharf 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 Nords Wharf site will apply to the entire 127ha Nords Wharf site. The key parameters for the future development of the site are as follows:

- Dedication of 116.6ha 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 92% of the Nords Wharf site.
- Maximum dwelling yield of 90 dwellings over 10.18ha.
- Indicative development staging. Depending on market forces, it may be decided to release the lots in 3-4 stages of 25-30 lots each.
- The provision of associated infrastructure.
- Torrens title subdivision and boundary realignment of the Nords Wharf site. The Torrens title subdivision and boundary realignment of Coal & Allied land will enable land 116.6ha in area that is owned by Coal & Allied to be excised and dedicated to NSWG for conservation purposes.

Approval will not be sought under the Concept Plan for a specific lot layout. An indicative lot layout will indicate how the maximum dwelling yield of 90 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 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 Lake Macquarie City Council (LMCC) Development Control Plan 1 (LMCC DCP 1). The intent of LMCC'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 the Nords Wharf site, make construction and siting 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 Nords Wharf topography.

2. Existing Conditions and Derived Constraints

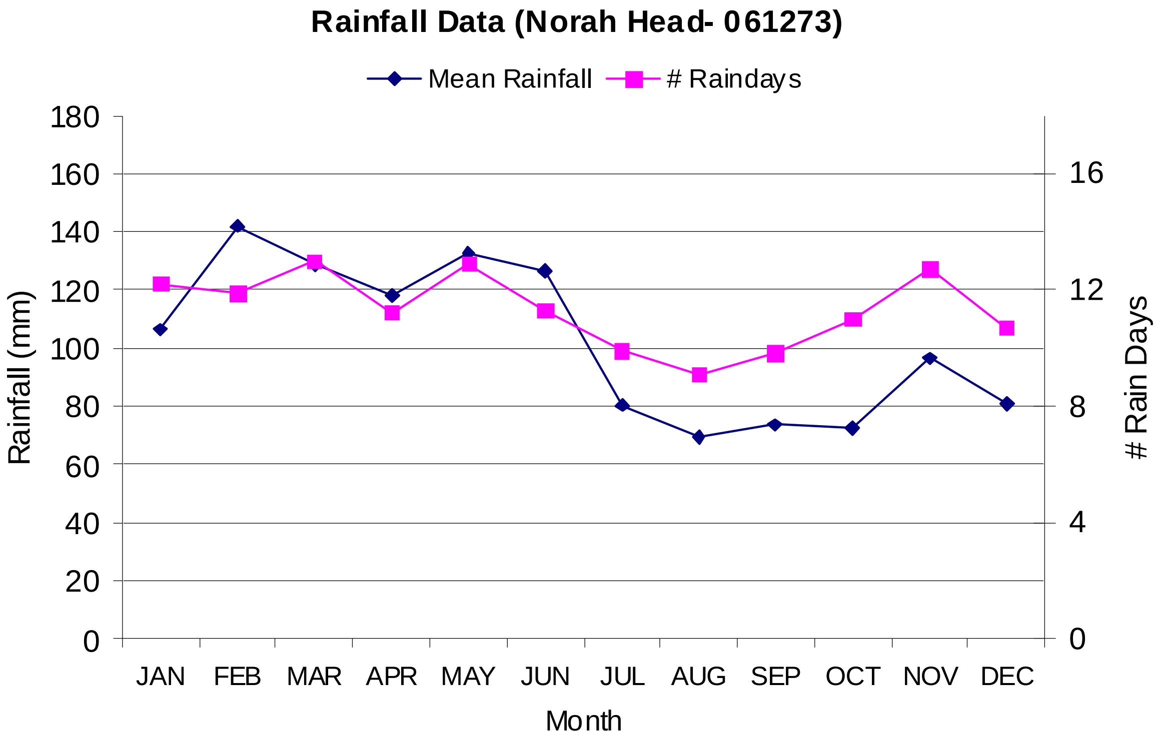
2.1 Climate and Rainfall

Nords Wharf 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 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 Nords Wharf site generally has steep gradients with an average grade in the order of 13%. To reduce the extent of earthworks, the proposed basins would need to be located in areas of gentler grades closer to Lake Macquarie.

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 Landscapes maps of the Gosford-Lake Macquarie 1:100,000 Sheet (CALM : 1992), the Nords Wharf site is underlain by two major soil landscape groupings. They are:

- *Wyong Landscape.* Underlies the low-lying area adjacent to Lake Macquarie. 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 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.

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

There is no major watercourse draining the investigation site. The land generally slopes west towards Lake Macquarie and runoff discharges to Lake Macquarie (Crangan Bay) via dispersed overland flow. No evidence of incised channels was noted in the site inspection.

At present a portion of the site drains to Crangan Bay via a conservation area in the low lying portion of the site. Runoff enters Crangan Bay via overland flow.

2.5 Adjoining Land Uses

The Kanangra Scout Camp currently lies in the northwest corner of the site but will be relocated from site prior to development. The existing residential area of Nords Wharf adjoins the site to the north. Natural bushland lies to the south of the site and the Pacific Highway is situated to the east.

2.6 Key Statutory Requirements

In addition to the statutory requirements under the Part 3A of the *Environmental Planning and Assessment Act 1979 (EPA & Act)* , 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 prioritise investment in natural resource management for this area;
- LMCC Development Control Plans 1 and 2 – 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 - 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 guidelines nominate 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 Interval (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:

- Appropriate volumes and strategies for detention throughout the site that responded, as best possible, to the concept plan and which controlled post development flows to the requirements of LMCC DCP 1 (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 LMCC DCP 1 Volume 2.

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 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. XP-RAFTS is a rainfall-runoff model designed for Australian catchments. Compilation of the model includes:

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

The 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 preliminary structure 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

3.2.2 Stormwater Quality Management

The water quality assessment of the Nords Wharf 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 this estate, 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 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 selected 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 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.

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 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 Nords Wharf is primarily on account of Lake Macquarie and overland flow conveyance through the development.

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. Water levels in Lake Macquarie are expected to rise at the same rate and to the same level as the ocean.

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 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 Nords Wharf 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.), this 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. Nords Wharf 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, 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 Nords Wharf are 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:

- 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 Nords Wharf include:

- Orientate roads to traverse along 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 permits a single site discharge point to Lake Macquarie. 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 Nords Wharf 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 two 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 basins and open areas;
- On-lot detention will be provided in addition to the precinct scale facilities; and
- 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 conditions 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
Flow (ML/yr)	13.2	43.1	20.7	52.0
Total Suspended Solids (kg/yr)	1480	8450	129	98.5
Total Phosphorus (kg/yr)	3.9	17.3	2.4	85.9
Total Nitrogen (kg/yr)	33.2	125.0	39.9	68.0
Gross Pollutants (kg/yr)	119	1,110	0	100

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 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 Nords Wharf 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
- 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 generally 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	0.45	1.39	0.54	0.69
45 min	0.66	1.54	0.58	0.88
1 hr	0.77	1.76	0.63	1.00
1.5 hr	0.79	1.80	0.64	0.97
2 hr	0.86	1.94	0.65	0.98
3 hr	0.63	1.49	0.60	0.83
4.5 hr	0.75	1.34	0.64	0.91

6 hr	0.67	1.12	0.60	0.78
9 hr	0.58	0.97	0.57	0.72

5.4.2 Flooding and Flood Risk

Flooding at Nords Wharf is primarily on account of Lake Macquarie and overland flow conveyance. 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.

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. 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 for Lake Macquarie.

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 LMCC requirement for the floor level of dwellings to be 500 mm above this, the nominated flood planning level for the Nords Wharf 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 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 at approximately 4m AHD and set back approximately 100m from the lake shore.

For localized flooding associated with discharges within the development estate, 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 swale through the riparian corridor.

5.4.3 Climate Change and Flooding

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

At the Nord Wharf site all lots are located above the LMCC adopted 2100 climate change with freeboard and wave run up flood levels, even under a 100-year ARI flood event. Minor affectation of the foreshore road is expected under the extreme climate change conditions, should a PMF prevail. This is an extreme scenario given the long planning period (ie, life span of dwelling is estimated to be 50 years). Should the extreme PMF flood event prevail under future climate conditions with wave runup. 1 lot would experience a minor flood impact, 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 this lot being flood free due to minor localised filling.

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 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' area of the site is located adjacent to Lake Macquarie in the area nominated as conservation. As there are no habitable dwellings in this area an evacuation strategy is not required for the Nords Wharf development site.

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.

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 Nords Wharf 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, which 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 Nords Wharf 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;
- Two 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 well 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. The lowest 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 LMCC requirement for the floor level of dwellings to be 0.5m above this level, the nominated flood planning level for the Nords Wharf estate at the foreshore of Lake Macquarie is 1.88m AHD. ;
- At the Nords Wharf site all lots are located well above the 2100 future climate with 0.5m freeboard, wave run up and 100-year flood level (3.79m AHD. Minor affectation of the foreshore road is expected under the extreme climate change conditions, should a PMF prevail. For the extreme PMF climate change scenario, allowing for wave run up, 1 lot would experience a minor flood impact 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 this lot 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 were determined from 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 LMCC DCP 1, the LMCC Floodplain Management Policy and the NSW Floodplain Development Manual for management of stormwater quantity, quality and flooding at the Nords Wharf site.

7. References

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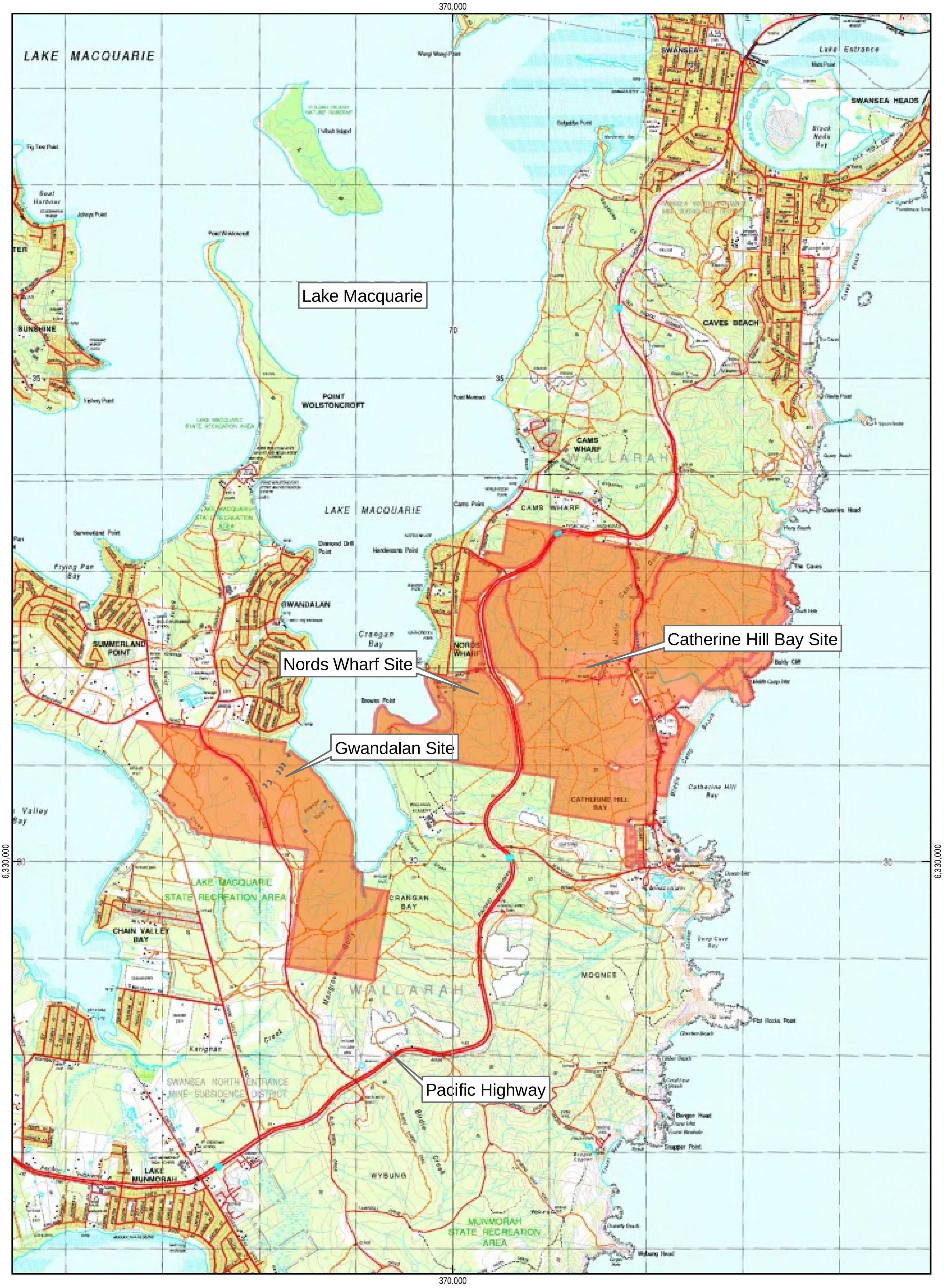
- NSW Sea Level Rise Policy Statement (2009); and
- DECC Practical Consideration of Climate Change, October 2007.

Appendix A

Site Location and Concept Plan



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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