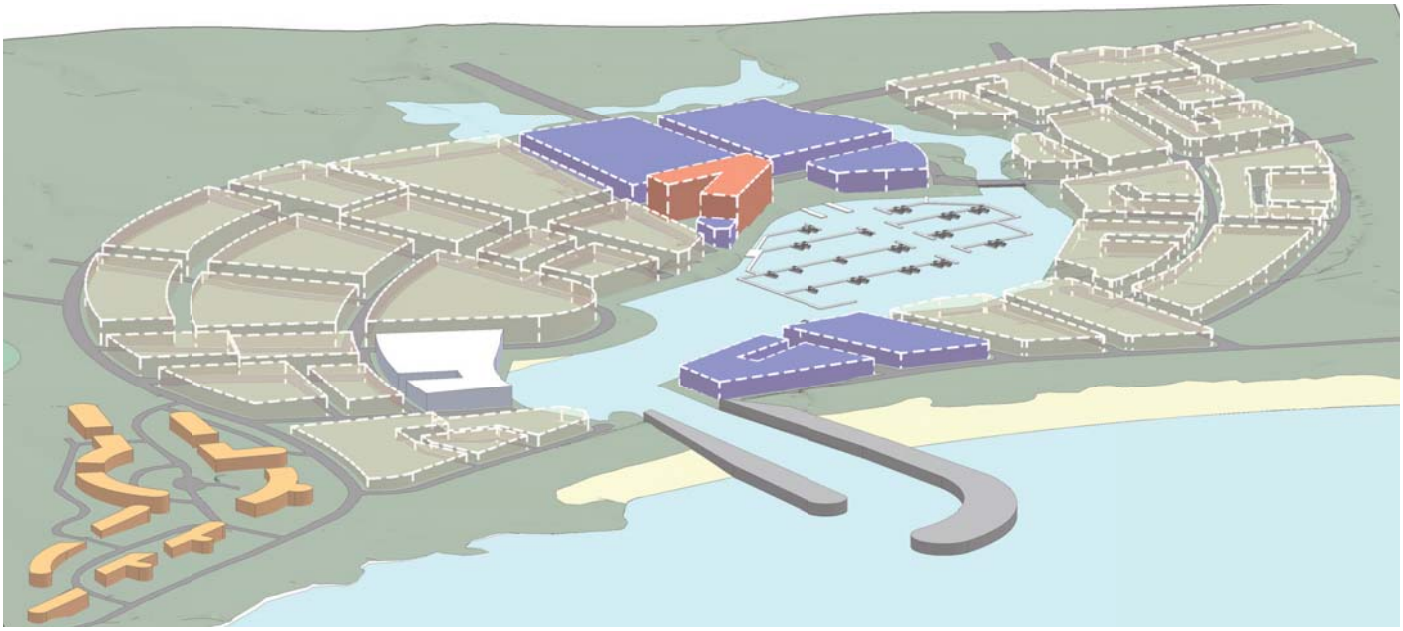

Shell Cove
Boat Harbour Precinct

Concept Plan Application and Environmental Assessment Appendix F - Flood Management Assessment

prepared by LFA (Pacific) Pty Ltd

date February 2010

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AUSTRALAND

SHELL COVE - BOAT HARBOUR PRECINCT

Flood Management Assessment

4717-43 – rp4717-43part3A-cjm-081127

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PROJECT 4717-43 - SHELL COVE - BOAT HARBOUR PRECINCT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Draft for Client Review	CJM	MST	MST	30-Oct-08	N/A	
B	Final Incorporating Client Comment and Internal Review	CJM	MST	MST	10-DEC-08		
C	FINAL	AEW	CJM	MST	28-JUL-09		

AUSTRALAND
SHELL COVE - BOAT HARBOUR PRECINCT
FLOOD MANAGEMENT ASSESSMENT

CONTENTS

1. EXECUTIVE SUMMARY

This report has been prepared for inclusion in a Concept Plan Application for the development of the Shell Cove Boat Harbour Precinct. The report addresses issues relating to flooding including the issues outlined in the Director General's Environmental Assessment Requirements dated 9 November 2007. The findings regarding the key flooding issues are summarised under the DGR issue headings below:

DGR ISSUE 5.7

Provide an assessment of any flood risk on site in consideration of any relevant provisions of the NSW Floodplain Development Manual (2005) and Flood Policy of Shellharbour City Council.

This Flood Management Assessment addresses the relevant provisions outlined in the Floodplain Development Manual (2005) as follows:

Flood Impact

The proposed development would not result in a significant increase in flood levels for the 5 year ARI, 100 year ARI and the PMF event on adjacent properties. The proposal reduces flood levels in some areas of adjacent property for the 100 year ARI and PMF event. The proposed development will be designed such that flooding would not have an adverse impact on the proposed development.

Flood Hazard

The proposed development manages areas of high hazard such that avoidable risk to life is minimised. High flood hazards are restricted to the main flow channels. Safe pedestrian access is available 60 minutes after the peak PMF flood levels occur. The proposed development reduces the extent of existing high hazard areas within Shellharbour Village.

Flood Planning Levels

A Flood Planning Level including the 100 year ARI flood level, 0.55m increase in sea level due to climate change plus an allowance of 0.5m freeboard has been adopted for all development adjacent to major overland flowpaths.

Flood Emergency Response

The Flood Emergency Response is to remain on site during the relatively short duration of all major events up to and including the PMF event. Safe pedestrian access is available 60 minutes after the peak PMF flood level is achieved. Safe vehicular access routes out of the

area would be available to all residents in the 100yr ARI flood. If necessary the site can be traversed by a heavy vehicle during a PMF event.

Impacts of Climate Change

Both the DECC guideline, "Practical Consideration of Climate Change" October 2007 and the Department of Planning "Draft Sea Level Rise Policy Statement" February 2009 have been considered. The DECC guideline, "Practical Consideration of Climate Change" 25/10/2007 recommends sensitivity testing of flood behaviour over a designated range of climate change induced impacts on sea levels and rainfall intensity. Even adopting a combination of the highest sea level rise and highest rainfall intensity rise, the resultant 100yr ARI flood level can be accommodated within the adopted freeboard of 0.5m. As such, the adopted flood planning levels are considered adequate to accommodate possible climate change induced effects on flooding.

This Flood Management Assessment addresses the policy objectives for the relevant provisions as outlined in the Shellharbour City Councils Floodplain Risk Management DCP April 2006 as follows:

a) *To ensure the proponents of development and the community in general are fully aware of the potential flood hazard and consequent risk associated with the use and development of land within the floodplain;*

The Cardno Flood Study and this Flood Management Assessment (FMA) identifies potential flood hazard associated with the proposed development and adjoining existing areas within the floodplain to enable the proponents and community to be fully aware of the associated risks.

b) *Allow development with a lower sensitivity to the flood hazard to be located within the floodplain, subject to appropriate design and siting controls, provided the the potential consequences that could still arise from flooding remain acceptable having regard to the State Government's Flood Policy and the likely expectations of the community in general;*

The FMA identifies appropriate design and sighting controls having regard to the State Governments Flood Policy. These include flood impact, flood hazard, flood planning levels, flood emergency response and impacts of climate change.

A Flood Planning Level including the 100 year ARI flood level, 0.55m sea level rise due to climate change plus an allowance of 0.5m freeboard has been adopted for all development adjacent to major overland flowpaths.

c) *To prevent any intensification of the use of High Flood Risk Precinct or floodways, and wherever appropriate and possible, allow for their conversion to natural waterway corridors.*

The proposal avoids intensification of use of high risk precincts and contains floodways within engineered and natural waterway corridors.

The proposal mitigates high flood risk precincts within the existing adjoining areas of Shellharbour Village.

d) *To ensure that design and siting controls required to address the flood hazard do not result in unreasonable impacts upon the amenity or ecology of an area;*

The design and siting controls do not cause unreasonable impact on the amenity or ecology of the area.

The waterway corridors used as floodways would be designed on Water Sensitive Urban Design principles and would contribute to the improved ecological value of these corridors.

The proposed floodways incorporate wetlands, natural creeklines and open space areas to manage and contain flood hazards. These areas will enhance the ecology and the visual and recreational amenity of the development under regular conditions..

e) *To minimise the risk to life by ensuring the provision of appropriate access from areas affected by flooding up to extreme events;*

The proposed development manages areas of high hazard such that avoidable risk to life is minimised as a result of the proposed development. Furthermore, the extent of high hazard within the existing Shellharbour Village is reduced as a result of the proposed development.

The flood emergency response is to remain on site during the relatively short duration of all major events up to and including the PMF event. Safe pedestrian access is available 60 minutes after peak PMF flood levels occur. If necessary the site can be traversed by a heavy vehicle during a PMF event. Safe vehicular access routes out of the area would be available to all residents in the 100yr ARI event.

DGR ISSUE 5.8

Address the impact of flooding on the proposed development, the impact of the development on flood behaviour and the impact of flooding on the safety of people/users of the development, factors that may affect flooding on the site and flood planning levels. Implications of climate change and sea level on flooding and a range of flood events (up to and including the probable maximum flood) should be considered.

The requirements of DGR Issue 5.8 have been addressed in this Flood Management Assessment by applying the relevant provisions of the Floodplain Development Manual, refer DGR Issue 5.7 above.

DGR ISSUE 5.9

Include an assessment of the sensitivity of flood model parameters (hydrologic and hydraulic).

An assessment of the sensitivity of flood levels to the hydrologic and hydraulic parameters has been undertaken, in part, in the DECC recommended climate change analysis. This sensitivity analysis examined 20% and 30% increases in rainfall intensities and sensitivities of tailwater conditions (different sea level rises). The combined increase on intensities of 30% and tailwater conditions of 0.91m results in an increase in peak 100yr ARI water levels of 0.36m for flood waters in the harbour however this quickly dissipates with distance away from the harbour edge.

Further sensitivity analysis was undertaken to examine the influence of hydraulic roughness and brudge waterway blockage. Sensitivity analysis of the hydraulic roughness for the proposed development has been undertaken with an increase in hydraulic roughness of 20% resulting in an increase in flood levels across the site up to a maximum of 0.15m in the 100 year ARI event.

Sensitivity analysis for blockage of the proposed bridges through the development has been undertaken. The blockage scenario demonstrates within the study area increases in flood level in the range of 0.1-0.5m in the 100 year ARI event.

The proposed freeboard adopted in the flood planning level is able to accommodate all the increases in flood level due to the sensitivity scenario testing. This indicates that the freeboard allowance is robust and appropriate for the site and the proposed development.

DGR ISSUE 5.10

Consider the potential impacts of any filling of the flood regime on the site and adjacent lands.

The proposed development would not result in a significant increase in flood levels on adjacent properties. Some adjacent properties benefit from a reduction in flood levels as a result of the proposed development.

This result is due to the adequate provision of major flowpaths and the beneficial effect of the boat harbour entrance in mitigating wave runup and tailwater conditions.

2. BACKGROUND

The Shell Cove Boat Harbour Precinct site is located 17 km south of Wollongong within the Illawarra region, immediately south of the existing Shellharbour Village. The site comprises approximately 100ha of land that surrounds the Shell Cove Boat Harbour / Marina development and includes the foreshore of Shellharbour South Beach (*refer* ***Figure 1***).

Development of the Shell Cove Boat Harbour Precinct will involve residential, commercial, retail, hotel, marina facilities (on land), public parklands, technology park and subdivision. The development has been declared a project to which Part 3A of the *Environmental Planning and Assessment Act 1979* applies.

Accordingly, the Department of Planning has issued Director General's Environmental Assessment Requirements (DGRS) for preparation of a Concept Plan Application for the project.

WorleyParsons have been commissioned by Australand Holdings Ltd to coordinate the flood study by Cardno (refer Appendix 1) and prepare a Flood Management Assessment (FMA) for the proposed Boat Harbour Precinct at Shell Cove, NSW. This flood analysis and FMA is to be included as part of the environment assessment undertaken in support of a Concept Plan Application under Part 3A (Major Projects) of the NSW Environmental Planning & Assessment Act 1979 (*amended 2005*).

3. OBJECTIVES

This FMA seeks to address the Director General's Environmental Assessment Requirements (DGRs) that relate to flooding as attached to the Department of Planning's letter dated 9th November 2007.

In addition a review of the Shellharbour City Council Floodplain Risk Management DCP has been undertaken to ensure consistency with the DGRs and the proposed development.

3.1 Director Generals Environmental Assessment Requirements

The DGRs were attached to the letter from the Department of Planning dated 9th November 2007. The key issues relating to flooding were contained in Issue 5 Hazard Management and Mitigation. The issues are detailed below and the manner in which the proposed development addresses these issues are described in **Section 6**.

DGR ISSUE 5.7

Provide an assessment of any flood risk on site in consideration of any relevant provisions of the NSW FloodPlain Development Manual (2005) and Flood Policy of Shellharbour City Council.

DGR ISSUE 5.8

Address the impact of flooding on the proposed development, the impact of the development on flood behaviour and the impact of flooding on the safety of people/users of the development, factors that may affect flooding on the site and flood planning levels. Implications of climate change and sea level on flooding and a range of flood events (up to and including the probable maximum flood) should be considered.

DGR ISSUE 5.9

Include an assessment of the sensitivity of flood model parameters (hydrologic and hydraulic).

DGR ISSUE 5.10

Consider the potential impacts of any filling of the flood regime on the site and adjacent lands.

3.2 Shellharbour City Council Floodplain Risk Management DCP

The Shellharbour City Council Flood Risk Management DCP outlines the following relevant policy objectives for developments subject to flood risk:

a) *To ensure the proponents of development and the community in general are fully aware of the potential flood hazard and consequent risk associated with the use and development of land within the floodplain;*

b) *Allow development with a lower sensitivity to the flood hazard to be located within the floodplain, subject to appropriate design and siting controls, provided the potential consequences that could still arise from flooding remain acceptable having regard to the State Government's Flood Policy and the likely expectations of the community in general;*

c) *To prevent any intensification of the use of High Flood Risk Precinct or floodways, and wherever appropriate and possible, allow for their conversion to natural waterway corridors.*

d) *To ensure that design and siting controls required to address the flood hazard do not result in unreasonable impacts upon the amenity or ecology of an area;*

e) *To minimise the risk to life by ensuring the provision of appropriate access from areas affected by flooding up to extreme events;*

4. STUDY METHODOLOGY

The issues listed in the DGR's and Council's Floodplain Risk Management DCP have been addressed in an integrated and co-ordinated fashion in the formulation of this flood management assessment (FMA) for the proposed development. The general approach and methodology employed to develop this FMA involved:

- compilation and review of available information including the flood study, proposed masterplan of the development, details of proposed bridge crossings and other hydraulic structures;
- site inspections and review of aerial photography to establish major flow locations catchment roughness and existing land-use;
- the development of design constraints for input into a flood model to simulate the transfer of rainfall into runoff during the flood and simulate the movement of floodwaters through the proposed development to the proposed harbour (Cardno report, 17 July 2009 – refer **Appendix 1**); and
- preparation of a flood management assessment report based on a review of the Cardno flood study to establish flood impact, flood hazard, flood planning levels and preparation of a flood emergency response plan using definitions provided in the *'Floodplain Development Manual'* (*2005*).

4.1 Design Constraints

As a result of the compilation and review of available information and site inspections, the following design constraints have been developed for incorporation into the design flood study. Each of these constraints have been identified on **Figure 1**.

4.1.1 Flows from Shellharbour Road

Shellharbour Road forms the north western catchment boundary of the Shell Cove site with the exception of a portion of catchment containing the Shellharbour Workers Club. This external catchment is currently directed over Shellharbour Road and conveyed to the Shell Cove site via a channel adjacent to Shellharbour General Cemetery. Upgrades to Shellharbour Road were being undertaken by the RTA at the time of preparation of this report. These upgrades will cut off the overland flow connection for all events above the 10 year ARI pipe flow.

Therefore the flood modelling is to direct all external flood flows exceeding the 10 year ARI pipe capacity at this location to the north along Shellharbour Road.

4.1.2 Existing Shellharbour Township

The proposed Shell Cove site abuts the existing Shellharbour Township along the northern boundary of the site. Runoff from part of this urban area drains to the south towards the Shell Cove site. There is an existing channel aligned in an east west direction which has been constructed to collect and redirect this runoff to the east towards the beach.

It is proposed to formalise the existing channel along the boundary, maintaining existing levels along the northern edge and tying into a proposed road on the southern side of the augmented channel. Flood relief would be provided at two key locations in the form of dedicated overland flow paths directed to the proposed harbour (*refer **Section 4.1.7** below*).

In addition, the augmented channel and two overland flow paths would be designed to perform a water quality function.

Flows from the catchments draining to Ron Costello Oval and the adjacent Keith Hockey Oval are to be directed to the proposed overland flow path connected to the proposed harbour.

The augmented channels have been incorporated into the proposed development for flood analysis as illustrated on **Figure 1**.

4.1.3 Harbour Boulevard North Acoustic Fencing

A potential option has been identified to construct acoustic fencing along Harbour Boulevard North. It will be necessary to provide flood relief through any acoustic fencing to prevent potential trapping of floodwaters at a low point on the eastern side of Harbour Boulevard North. This flood relief will enable floodwaters to be directed to the east, and ultimately the proposed harbour.

The arrangement of the optional acoustic fencing at this location has been incorporated into the hydraulic component of the flood model as illustrated on **Figure 1**.

4.1.4 Harbour Boulevard South Proposed Finished Surface Levels

The proposed finished road surface levels of Harbour Boulevard South required specific consideration with respect to the flood study.

The road is adjacent to a newly constructed landfill cell. It is therefore desirable to minimise cut in this area.

In addition, the proposed levels have been set in order to divert flows away from a proposed road that has limited potential to convey overland flows to the harbour. The proposed levels create a crest to minimise the run-off directed to this road.

The proposed road levels have been incorporated into the proposed development for flood analysis as illustrated on **Figure 1**.

4.1.5 Proposed Bridge Crossings

There are a number of locations within the site that require bridges, refer **Figure 1** for locations. All bridges are proposed to have a minimum span of 10m between 0.5m wide piers. The bridge beam and pavement depth would comprise a total thickness of 0.65m.

The above assumptions are based on general structural advice and need to be confirmed during the detailed design process.

These physical constraints were incorporated into the hydraulic components of the flood model.

4.1.6 Proposed Wetlands / Water Bodies

There are a number of wetlands and water bodies that will improve water quality and be a feature of the proposed development. The still water levels of these wetlands and water bodies have been set with consideration of the amenity to adjacent road levels and the required hydraulic capacity of the bridges.

It is proposed that the still water level of the wetlands and water bodies will be controlled by a series of weirs and drop structures. The conceptual still water levels have been incorporated into the proposed development for flood analysis as illustrated on **Figure 1**.

4.1.7 Proposed Major Overland Flowpaths

There are several flowpaths required to accommodate major overland flows from the development and external urban areas through the development as illustrated on **Figure 1**. The flowpaths will improve water quality. These flow paths are proposed to be dedicated as part of the open space or are contained within a proposed road reserve.

Preliminary design work was undertaken to estimate the width and invert levels of these flow paths to ensure sufficient capacity and no significant impact on adjacent existing urban development. The dedicated flow paths have been incorporated into the proposed development, for flood analysis, with preliminary batter slopes of 1V:3H back to adjoining levels.

The road cross section for the southern loop road includes a central swale to improve water quality and provide additional flow area. This detail has been incorporated into the proposed development for the flood analysis.

4.2 Design Surface Development for Flood Analysis

WorleyParsons developed a design surface of the proposed development area for the flood analysis. This design surface incorporates the requirements outlined in **Section 4.1.2**, **4.1.4**, **4.1.6** and **4.1.7** above and some basic civil design assumptions. These assumptions include the following:

- Minimum road longitudinal grade of 0.5%;
- Road reserve widths have been adopted as follows;
    - General Roads: carriageway 12m and verge 3m (including footway);
    - Harbour Boulevard: carriageway 18m and verge 3m (including footway); and
    - Southern Loop Road: carriageway 2x11m, central swale 8m and no footway.
- No detailed road or intersection design has been undertaken;
- The proposed finished surface levels along the perimeter are designed to match existing surface levels based on existing contours provided by BMD;
- No lot benching has been incorporated. Lots grade evenly between roads;
- The proposed levels for the boat ramp and associated carpark on the southern side of the harbour have been adopted from preliminary designs; and
- A minimum harbour edge land level of RL 2m AHD has been adopted for its entire length other than at flow path or water course outlets.

5. POST DEVELOPED FLOOD ANALYSIS

5.1 Background

Two previous flood studies for the Shell Cove site have been undertaken:

- *Shell Cove Boat Harbour Catchment Flood Study, Cardno Lawson Treloar Pty Ltd, September 2005; and*
- *Shell Cove Boat Harbour Catchment Flood Study PMF Analysis for Preliminary Design, Cardno Lawson Treloar Pty Ltd, April 2006.*

The objective of the September 2005 study was to determine the existing flood behaviour at the proposed development site.

The objective of the April 2006 study was to provide a preliminary analysis of the post-development Probable Maximum Flood (*PMF*) behaviour, based on a preliminary and now superseded Masterplan.

5.2 Shell Cove Boat Harbour – Post Developed Flood Analysis

A post developed flood analysis has been undertaken by Cardno for the proposed development of the Boat Harbour Precinct, 17 July 2009, refer **Appendix 1**. This flood study provides detailed information on flood behaviour for a range of flood events up to and including the PMF. The data provided includes an assessment of flood impact, hazard, peak flood levels and velocities. In addition, the impact of climate change, hydrologic and hydraulic sensitivities have been assessed.

The results of the flood analysis for the proposed development have been used to develop this Flood Management Assessment described in **Section 6**.

6. FLOOD MANAGEMENT ASSESSMENT

This Flood Management Assessment provides an assessment of the flood risk on site and how it can be adequately managed in accordance with the requirements of the *NSW Government Floodplain Development Manual* (*2005*).

The NSW Government's Floodplain Development Manual supports the wise and rational development of flood prone land. This is achieved by the strategic consideration of a number of key risks relating to protecting existing and future occupants from the ramifications of flooding. The issues associated with these risks include:

- Flood Impact;
- Flood Hazard;
- Flood Planning Levels;
- Emergency Response; and
- Impacts of Climate Change.

The following sections describe the consideration of the above issues and the application of strategies to address them.

6.1 Flood Impact

The flood impact considered includes both the impact of flooding on the proposed development as well as the impact of the development on flooding in adjacent areas. This impact has been assessed by considering a range of flood severities including the 5 year ARI, 100 year ARI and PMF events in the flood analysis. The analysis is conservative for the 5 year ARI and 100 year ARI events because no pipe flow was assumed. This assumption results in all flow being as overland flow leading to higher predicted flood flows and levels.

6.1.1 5 Year ARI Event

There are some predicted minor increases in flood levels external to the site in the 5 year ARI event (*refer **Figure 6.19** in Flood Analysis – refer **Appendix 1***). The areas affected external to the site are in the vicinity of Boollwarroo Parade, Ron Costello Oval, and a small portion along the northern boundary. Minor increases also occur in a localised section within the north western corner of the site.

The increases external to the site are 0.07m on Boollwarroo Parade, in the range of 0.01 to 0.02m on the northern part of Ron Costello Oval, near the existing properties and 0.04m along the northern

boundary. Increases of this magnitude are not considered to be significant, noting that the flood study conservatively assumes no flow in the stormwater pipes.

The increase of 0.08m in a localised area within the north west corner of the site can be managed through the design process.

6.1.2 100 Year ARI Event

There are some predicted minor increases as well as decreases in flood levels in the 100 year ARI event (*refer **Figure 6.20** in the Flood Analysis*). The areas affected are along the northen boundary of the site within the existing Shell Harbour Village, Boollwarroo Parade to the north of Ron Costello Oval and a localised section within the north western corner of the site.

The increases external to the site are in the range of 0.01m to 0.02m on Boollwarroo Parade, and 0.02m to 0.03m to the north of Ron Costello Oval near the properties. Increases of this magnitude are not considered to be significant, noting that the flood study conservatively assumes no flow in the stormwater pipes.

The decreases in flood level are in the range of 0.01m to 0.05m along the northern boundary of the site and part of Boollwarroo Parade.

6.1.3 PMF Event

During the PMF event there are predicted minor increases as well as decreases in flood levels in some areas (*refer **Figure 6.21** in the Flood Analysis*). The areas affected are along the northern boundary of the site within the existing Shellharbour Village, Ron Costello Oval, Boollwarroo Parade and the local area within the north western and south eastern corners of the site.

The decreases are significant within the existing Shellharbour Village. Flood levels decrease in the range of 0.15 to 0.5m along the northern boundary of the site, Boollwarroo Parade and to the north of Ron Costello Oval.. The development significantly reduces the flood hazard within Shellharbour Village (*refer **Figures 7.3 and 7.6** in the Flood Analysis*).

The minor increases are within the north western and south eastern corners of the site. The increases are in the range of 0.01m to 0.10m. Increases of this magnitude are not considered to be significant, noting that the flood study conservatively assumes no flow in the stormwater pipes. These impacts are within the area to be developed and can be managed through the design process.

6.1.4 Discussion

The flood modelling conservatively assumes no pit and pipe drainage system.

In the 5 year and 100 year ARI events minor increases and minor decreases in flood levels occur adjacent to the site, within Shellharbour village. The increases are not significant.

During the PMF event a significant reduction in flood level and flood hazard occurs within the Shellharbour Village.

The overall flood impact is satisfactory. In broad terms, this is due to the adequate provision of major flow paths and the beneficial effect of lower tail water conditions created by the boat harbour entrance.

6.2 Flood Hazard

The New South Wales Government Floodplain Development Manual defines flooding in terms of two hazard categories, i.e. Low Hazard and High Hazard, with a zone of transition between the two which is dependent on the particular site conditions. The hazard is referred to as provisional as it only takes into account the velocity depth relationships.

Flood hazard relates to the degree of difficulty that pedestrians, motor cars and other vehicles will have traversing the flooded areas. At Low Hazard, passenger cars and pedestrians *(adults)* are able to traverse the flooded areas. At High Hazard, wading becomes unsafe, cars are immobilised and damage to light timber-framed houses could occur.

The provisional flood hazard as set out in **Figure L2** of the Floodplain Development Manual and velocity depth product for the development has been assessed for the 5 year ARI, 100 year ARI and PMF events in the flood analysis.

6.2.1 5 Year ARI Event

There are areas of provisional High Hazard identified in the assessment of the 5 year ARI event flood conditions (refer **Figure 7.4** in the Flood Analysis). The areas of provisional High Hazard are restricted to the major overland flow paths contained within the proposed open space system. A public road proposed in the southern catchment also contains provisional High Hazard flows which are restricted to a central drainage swale.

The provision of pit and pipe drainage through the design process will reduce the extent and duration of high hazard flows, particularly in the central drainage swale in the southern catchment.

6.2.2 100 Year ARI Event

There are areas of provisional High Hazard identified in the assessment of the 100 year ARI event flood conditions, (refer **Figure 7.5** in the Flood Analysis). The areas of provisional High Hazard are again restricted to the major overland flow paths. The public road proposed in the southern catchment contains provisional High Hazard flows which are restricted to a central drainage swale.

The provision of pit and pipe drainage through the design process will reduce the extent and duration of high hazard flows, particularly in the central drainage swale in the southern catchment.

6.2.3 PMF Event

There are areas of provisional High Hazard identified in the assessment of the PMF event flood conditions, (refer **Figure 7.6** in the Flood Analysis). The areas of provisional High Hazard extend further into additional roads away from the major overland flowpaths in the 100 year ARI event.

The proposed development reduces the area of provisional High Hazard within sections of Shellharbour Village.

6.2.4 Discussion

The flood hazard for a range of events up to and including the PMF event have been considered in the development of strategies to manage areas of hazard. In addition, the velocity depth relationship has been considered (refer **Figures 7.7**, **7.8** and **7.9** in the Flood Analysis).

The provision of pit and pipe drainage through the design process will reduce the extent and duration of high hazard flows.

The proposed development reduces the area of provisional High Hazard within sections of Shellharbour Village.

100 YEAR ARI EVENT FLOOD HAZARD MANAGEMENT STRATEGY

In events up to and including the 100 year ARI event, the areas of provisional High Hazard are restricted to the major overland flow paths including the central wetland corridor, major overland flow paths and the eastern portion of the southern loop road. The risk in each of these areas will be managed as follows:

CENTRAL WETLAND CORRIDOR

The central wetland corridor comprises of the two wetlands to the west of Harbour Boulevard and the series of wetlands that flow east from Harbour Boulevard to the proposed harbour. This corridor contains areas of High Hazard in the 100 year ARI event. The wetlands are permanent areas of High Hazard due to the proposed water depths even in dry weather.

The corridor is an extension of the Shell Cove linear open space system, providing dual-use open space and drainage functions. It is appropriate that High Hazard flood flows occur in these areas. In order to appropriately manage the hazard it is proposed to incorporate the following strategies:

- The side batter slopes are to be a maximum of 1V:6H, unless fenced;

- Safe crossing points over the central wetland are available at Cove Boulevard and Harbour Boulevard during the 100 year ARI event; and
- The corridor will contain permanent water bodies and creek line attributes that raise awareness of the potential for flooding. To ensure consistency with the existing dual-use open space system, signage is not proposed.

Major Overland Flow Paths

Major overland flowpaths comprise of the two northern flow paths allowing external flows to propagate in a controlled manner from Shellharbour Village through to the proposed harbour. The flow paths contain areas of High Hazard in the 100 year ARI event.

It is proposed that these flowpaths are contained within multipurpose drainage reserves and public open space areas. These areas shall provide amenity during dry weather conditions but shall be marked with appropriate signage to reinforce the public's knowledge of their purpose and that these areas may be flood hazardous to the public. These areas will also be utilised to improve water quality. This will be achieved by the frequent discharge of low flows which will reinforce public awareness. In order to appropriately manage the hazard it is proposed to incorporate the following strategies:

- The side batter slopes are to be a maximum of 1V:6H, unless fenced;
- Signage is to be provided warning of the potential for flooding;
- Safe Crossing Points over these overland flow paths are available at four locations through the internal road network during the 100 year ARI event; and
- Multiple egress points be provided along either edge of the flow paths.

Eastern portion of the southern loop road

The eastern portion of the southern loop road contains a central swale. The central swale will contain areas of High Hazard in the 100 year ARI event. It is appropriate that high hazard flood flows occur in this designated area which will be marked with appropriate signage. The swale will also be utilised to improve water quality. This will be achieved by the frequent discharge of low flows which will reinforce public awareness. In order to appropriately manage the flood hazard it is proposed to incorporate the following strategies:

- side batter slopes are to be a maximum of 1V:6H, unless fenced;
- signage is to be provided warning of the potential for flooding;
- the roadways do not contain areas of High Hazard; and
- safe egress is available through the surrounding road network.

PMF EVENT FLOOD HAZARD MANAGEMENT STRATEGY

The strategies employed to manage hazard in the 100 year ARI event described above will have facilitated the public to move out of areas subject to hazard in the PMF event. The Flood Emergency Response Strategy will require that the public move back to their residences or areas of higher ground, refer **Section 6.4**. The flood emergency response is to remain on site during the relatively short duration of all major events up to and including the PMF event.

6.3 Flood Planning Levels

Flood planning levels (FPLs) are an important tool in the management of flood risk. They are derived from a combination of an estimated peak flood level for a flood event and a freeboard.

The NSW Floodplain Development Manual recommends that for new residential development the FPLs are based on the 100 year ARI event.

The Shellharbour Floodplain Risk Management Development Control Plan Schedule 1 specifies that appropriate freeboard to habitable floor levels be 0.5m.

6.3.1 Discussion

The FPL for the precinct will be the 100 year ARI level, including the adopted mid range 0.55m sea rise, plus a freeboard of 0.5m. The FPL would be applied to all development adjacent to a major overland flow path as identified on **Figure 1**, unless final design reduces the extent of High Hazard through underground drainage. Habitable floor levels would have a minimum level at the FPL to provide an appropriate level of protection against flood damages.

All roadways within the development will be designed to convey the 100 year ARI event within the road reserve.

Sensitivity analysis has confirmed that the FPL is satisfactory for all scenarios modelled including high range sea level rise.

6.4 Flood Emergency Response

Both the PMF and the 100 year ARI flood have been considered in order to provide a comprehensive assessment of the flood risk. The PMF event has been considered for assessment of a continuing flood risk beyond the design storm of the 100 year ARI. This is to address concerns for personal safety which need to be managed through the flood emergency response plan for the development.

The *NSW Floodplain Development Manual* states that

> *'Analysing the PMF provides an upper bound of flood behaviour and consequences for emergency response planning.'*

6.4.1 Discussion

Flood emergency response measures will begin when Bureau of Meteorology issues an extreme weather warning prior to inundation. Once rainfall begins it is expected that runoff will quickly accumulate into flooding waters.

Major flooding is expected to occur at the site during a critical storm duration of 90 minutes. During this time flood waters shall travel through the designated overland flowpaths causing a rapid rise in water level within these areas. Residents are to remain indoors and not attempt to traverse flow path crossings.

Bridges overtop during the peak PMF and these areas will be hazardous to both cars and pedestrians at this time. However floodwaters are expected to recede rapidly. Residents must wait 1 hour after waters have overtopped bridges before attempting to cross floodways. This guidance is to mitigate risk of hazard to residents.

It is feasible in an emergency that a heavy vehicle could traverse the site if necessary during a PMF event.

The extent and depth of flooding and Provisional Hazard during a PMF event in the proposed development has been estimated (refer to **Figures 6.12, 6.15 and 7.6** in the Flood Analysis). The maximum depth of flow over any road in the PMF event is 0.75m located over the southern bridge on the western of the two northern flow paths.

6.5 Impact of Climate Change

In order to assess the likely effects of climate change, the following two publications have been considered:

- DECC - Floodplain Risk Management Guidelines, Practical Consideration of Climate Change (October 2007)
- DoP – Draft Sea Level Rise Policy Statement (February 2009)

The DECC in their Floodplain Risk Management Guidelines, Practical Consideration of Climate Change (October 2007) provide advice on the assessment of climate change on flood estimation. The guideline requires sensitivity testing of flood levels resulting from a range of predicted sea level rises and increases in rainfall intensity predicted to occur up to 2100, whilst the DoP policy states the predicted maximum increase at two points in the future, 2050 and 2100.

6.5.1 Elevated Sea Levels

The DECC guidelines provide a range of low, medium and high values for estimated sea level rise resulting from thermal expansion, ice sheet melt and local (NSW) conditions for sensitivity analysis. These values are:

- Low, 0.18m;
- Medium, 0.55m; and
- High, 0.91m.

DoP guidelines state that sea level will rise up to 0.4m by 2050 and up to 0.9m by 2100.

6.5.2 Increases in Rainfall

The DECC guidelines recommend sensitivity analysis of the impact of climate change on rainfall intensities. The range of sensitivities recommended includes increases in peak rainfall and storm volume of:

- Low, 10%;
- Medium, 20%; and
- High, 30%.

DoP does not provide any quantitative recommendation with regards to potential changes to rainfall patterns.

6.5.3 Discussion

Given the proposed development contains a boat harbour directly connected to the ocean the consideration of the impacts of climate change is critical. Therefore the Flood Analysis has assessed the most conservative DECC recommended joint probability scenario including a combination of a 0.91m increase in sea level and a 30% increase in rainfall intensity.

The result of this analysis has estimated a worst case increase of 0.36m in peak flood levels around the boatharbour edge however this increase dissipates quickly with distance into the development from the edge (refer **Figure 8.2** in the Flood Analysis). The maximum increase in flood level could be accommodated within the 0.5m freeboard recommended in the flood planning level (which includes the mid range 0.55m sea level rise), refer **Section 6.3.1**.

As the DECC recommended range of climate change influences on flood level can be readily accommodated within the freeboard adopted for the development, the adopted flood planning level is considered appropriate for existing and future planning horizons.

7. CONCLUSIONS

This Flood Management Assessment provides strategies to manage flood risk to protect existing and future occupants from the ramifications of flooding associated with the proposed development of the Boat Harbour Precinct.

These key risks and strategies include the following:

Flood Impact

The proposed development would not result in a significant increase in flood levels for the 5 year ARI, 100 year ARI and the PMF event on adjacent properties. The proposal reduces flood levels in some areas of adjacent property for the 100 year ARI and PMF event. The proposed development will be designed such that flooding would not have an adverse impact on the proposed development.

Flood Hazard

In the 100 year ARI event the areas of provisional High Hazard are restricted to the central wetland corridor, major overland flow paths and the central swale in the eastern portion of the southern loop road. The risk in each of these areas will be managed as follows:

- The side batter slopes are to be a maximum of 1V:6H, unless fenced;
- Signage is to be provided where it is necessary to raise awareness of the potential for flooding; and
- Multiple egress points along either edge of the flow paths.

In the PMF, the strategies employed to manage hazard in the 100 year ARI event described above will have facilitated the public to move out of areas subject to hazard in the PMF event. The Flood Emergency Response Strategy will require that the public move back to their residences or areas of higher ground.

Flood Planning Levels

The FPL for the precinct will be the 100 year ARI including a 0.55m sea level rise due to climate change plus a freeboard of 0.5m. The FPL would be applied to all development adjacent to a major overland flow path as indentified on **Figure 1**.

Flood Emergency Response

The flood emergency response is to remain on site during the relatively short duration of all major events up to and including the PMF event. Safe pedestrian access would be available 60 minutes

after the peak PMF flood levels. If necessary the site can be traversed by a heavy vehicle during a PMF event. Safe vehicular access routes out of the area would be available to all residents in the 100yr ARI event.

Impacts of Climate Change

The Flood Analysis has adopted a 0.55m increase in sea level to set flood planning levels for the development. A sensitivity analysis assessed the most conservative joint probability climate change scenario including a combination of a 0.91m increase in sea level and a 30% increase in rainfall intensities. The result of this sensitivity analysis has estimated a worst case increase of 0.36m in peak flood levels at the harbour waters edge with the increase dissipating quickly with distance away from the edge. This worst case scenario would be readily accommodated within the 0.5m freeboard recommended in the flood planning level. The adopted FPL is therefore considered to be appropriate for both existing and future planning horizons.

The above key issues relating to flooding have been adequately addressed in accordance with Director General Environmental Assessment Requirements and the Council's Floodplain Risk Management DCP.

8. REFERENCES

1 Floodplain Development Manual, NSW Government, 2005.

2 Floodplain Risk Management Development Control Plan, Shellharbour City Council, April 2006.

3 Floodplain Risk Management Guideline, "Practical Consideration of Climate Change", DECC, 25/10/2007.

4 Shell Cove Boat harbour Post Development Flood Analysis, Cardno Lawson and Treloar, June 2009.

5 Draft Sea Level Rise Policy Statement, Department of Planning, February 2009

FIGURES

FIGURE 1

REFER TO INSET B

DIVERSION OF FLOWS RESULTING FROM SHELLHARBOUR ROAD UPGRADES. 10yr ARI ENTERING SITE

HARBOUR BOULEVARD NORTH ACCOUSTIC FENCING. REFER TO INSET A

INTERFACE WITH EXISTING SHELL HARBOUR VILLIAGE

EXISTING OVERLAND FLOWPATH AND PIPE DRAINAGE NETWORK TO BE DIRECTED TO PROPOSED FLOWPATH

RL 3.15

RL 3.20

RL 2.55

RL 3.63

RL 5.82

RL 8.00

OWL 1.80

OWL 0.00

OWL 3.00

RL 3.44

OVERLAND FLOWPATH OUTLET RL. 0.8mAHD

RL 6.24

OWL 4.00

MINIMUM SEA WALL LEVEL RL. 2.0mAHD

RL 5.48

OVERLAND FLOWPATH OUTLET RL. 1.5mAHD

OWL 5.45

MINIMUM SEA WALL LEVEL RL. 2.0mAHD

RL 8.54

RL 4.16

OWL 7.30

OWL 9.00

RL 17.30

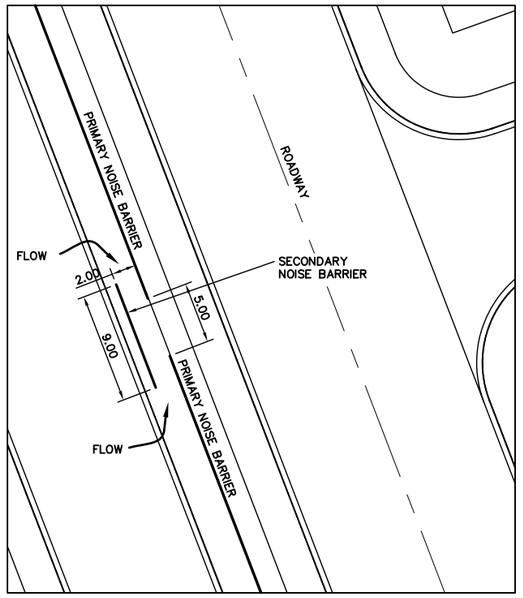
RL 9.20

RL 9.55

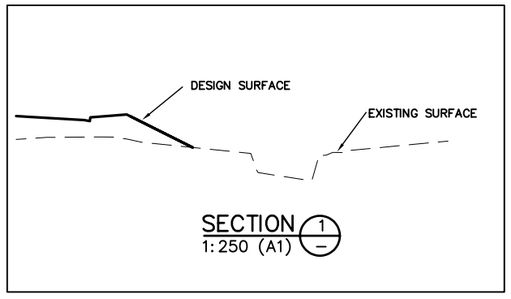
RL 8.70

INTERFACE WITH RELOCATED LANDFILL CELL

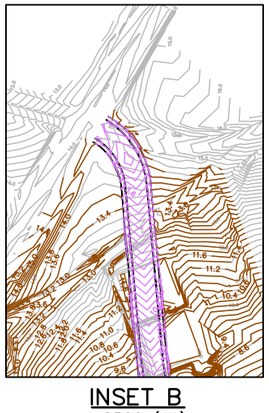
NORTHWEST LINK ROAD DESIGN LEVELS FIXED BY BMD



INSET A – ACCOUSTIC FENCE DETAIL
1:250 (A1)



SECTION 1
1:250 (A1)



INSET B
1:2500 (A1)

LEGEND

- EXISTING SURFACE CONTOUR (0.2m INTERVAL)
- EXISTING SURFACEFOR INCORPARATION INTO 2D FLOOD TIN
- PROPOSED PRELIMINARY SURFACE CONTOUR (0.2m INTERVAL)
- BRIDGE CROSSING LOCATION
- × RL 9.55 — PROPOSED ROAD LEVEL
- × OWL 7.30 — PROPOSED POND OPERATING WATER LEVEL (INCLUDING 0.3m DETENTION DEPTH FOR WATER QUALITY)
- MAJOR OVERLAND FLOWPATH (BASED ON VD > 0.4)

NOTES

1. THE PRELIMINARY SURFACE HAS BEEN CREATED FOR FLOOD INVESTIGATIONS ONLY. NO DETAILED ROAD OR LOT DESIGN HAS BEEN UNDERTAKEN. ROAD LOCATIONS, ROAD WIDTHS, BOUNDARIES AND LEVELS ARE INDICATIVE ONLY AND ARE SUBJECT TO DETAIL DESIGN.
2. THIS FILE IS IN ISG CO-ORDINATES FOR FURTHER INFORMATION REFER TO 12D PROJECT: N:\4717-43 SHELL COVE ROAD SWALES\FLOOD ANALYSIS WORK\12D\090105_NW_ADDITION.PROJECT (TIN SITE GRADING 4).

0 50 100 150 200 250m
1:2500 (A1) 1:5000 (A3)

WorleyParsons
resources & energy

SHELLHARBOUR
DESIGN FLOOD CONSTRAINTS
INCORPORATING NORTH WESTERN AREA
12 JANUARY 2009

Appendix 1 - Shell Cove Boat harbour Post Development Flood Analysis

Cardno LawsonTreloar

Shaping the Future

SHELL COVE BOAT HARBOUR POST DEVELOPMENT FLOOD ANALYSIS

17 July 2009
W4733

Report Prepared for

AUSTRALAND

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Report Copy No. ....

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			Name	Initials	Name	Initials
1	Draft	29 October 2008	Rhys Thomson	RST	Louise Collier	LCC
2	Final	11 November 2008	Rhys Thomson	RST	Louise Collier	LCC
3	Final	12 November 2008	Rhys Thomson	RST	Louise Collier	LCC
4	Working Draft	25 February 2009	Rhys Thomson	RST	Louise Collier	LCC
5	Final	20 June 2009	Rhys Thomson	RST	Louise Collier	LCC
6	Final	30 June 2009	Rhys Thomson	RST	Louise Collier	LCC
7	Final	17 July 2009	Rhys Thomson	RST	Louise Collier	LCC

Front cover: LFA (2006)

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APPENDICES

1. INTRODUCTION

Shell Cove is located approximately 17km south of Wollongong within the Shellharbour City Council Local Government Area. The study area has a catchment of 3.45km^2 and extends from Shellharbour South Beach to Shellharbour Road in the north west. Figure 1.1 shows the study catchment.

Existing development is located in the northern and western portions of the catchment. The northern developed area is part of the existing Shellharbour Village. The western portion of the catchment includes residential areas that have previously been developed in Shell Cove.

In 2005, Cardno Lawson Treloar previously completed a detailed flood study of the area, with its findings presented in the report titled *Shell Cove Boat Harbour Flood Study* (Cardno Lawson Treloar, [1] 2005). The flood study established the catchment flood behaviour in its existing state (based on ground survey undertaken in 2003).

The flood assessment undertaken in this report considers the flood behaviour of the proposed development in the central portion of the catchment. This existing central portion of the catchment includes a disused golf course and Shellharbour Swamp. The proposed development incorporates a harbour together with commercial and residential areas (Figure 1.2).

The purpose of this study is to define the flood behaviour under the proposed development conditions, including:

- Peak water levels, depths and velocities;
- Provisional hazard;
- Hydraulic categories.

In addition, the development condition has been compared with the existing scenario, to ensure that the proposed development does not significantly impact the flood behaviour on adjacent properties.

This analysis has been undertaken utilising the flood models established by Cardno Lawson Treloar [1] (2005). The models have been updated to incorporate the proposed development and approved Boat Harbour design supplied by WorleyParsons.

Figure 1.1 Study Area – Catchment Boundary

Figure 1.2 Proposed Shell Cove Development