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Dear Christopher

Discovery Point Flood Assessment

1. Introduction

The Discovery Point development site, located on the southern banks of the Cooks River at Wolli Creek, is proposed to consist of approximately fourteen buildings both north and south of the Wolli Creek Railway Station. This document provides design flood information for the proposed development site, to address the relevant Director General Requirements (DGR's) that form part of the Part 3A Environmental Assessment currently being prepared by Australand.

It is understood that Rockdale City Council (RCC) determined the adopted flood design standard for the site to be 0.5% Annual Exceedance Probability (AEP) (RCC, November 1999). An AEP of 0.5% means there is a 0.5% or a one in two hundred chance of a flood event occurring in any one year. This can also be expressed as an Average Recurrence Interval (ARI) of 200 years, which means on average, there will be approximately 200 years between floods of this size or larger. As such the 200 year ARI has been included in the assessment.

This flood assessment draws on the *Cooks River Flood Study* (PB + MWH, 2009), which estimated design flood levels for a range of flood events for the entire Cooks River catchment. A climate change sensitivity analysis was also completed as part of the flood study (PB + MWH, 2009). This sensitivity analysis was based on the NSW Government advice at the time and considered 10%, 20% and 30% increase in intensity rainfall and a 55 cm increase in sea levels.

Since completion of the *Cooks River Flood Study,* DECCW have updated their advice and released a *NSW Sea Level Rise Policy Statement.* This notes that "the best national and international projections of sea level rise along the NSW coast are for a rise relative to 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100" (DECCW, Oct 2009). However, the Intergovernmental Panel on Climate Change (IPCC) in 2007 also acknowledged that higher rates of sea level rise are possible. As such in *Climate Change Risks to Australia's Coast: a First Pass National Assessment,* published by the Australian Department of Climate Change in 2009, a sea level rise of 1.1 m by 2100 was adopted. From a NSW perspective the DECCW advice is followed with respect to floodplain management.

This report addresses the DGR's and documents the findings from the climate change sensitivity analysis based on DECCW advice of considering the potential impacts of climate change on flood behaviour. This report also documents the results of the 100 year average recurrence interval (ARI) and Probable Maximum Flood (PMF).

It is intended that Smart Civil and Australand will utilise this information in the overall flood and drainage management for the development.

2. Scope of works

To complete the flood assessment for the proposed Discovery Point development site, the following tasks were carried out:

- Task 1: Update hydrology to produce 200 year ARI design flows

  The existing *Cooks River Flood Study* did not model the 200 year ARI design rainfall event and was therefore simulated for this project. A review of the existing hydrologic model was undertaken and appropriate 200 year ARI design rainfall depths calculated and input into the model. The design rainfall depths were calculated in accordance with procedure outlined in *Australian Rainfall and Runoff, Volume 1 and 2* (Engineers Australia 1987, 2001). The hydrological model was then run and design flood hydrographs extracted at selected locations for incorporation into the hydraulic model.

- Task 2: Design flood levels including climate change assessment

  In line with the latest climate change advice, flows representing a 10%, 20% and 30% increase in 100 year ARI rainfall intensity were simulated through the hydraulic model (TUFLOW). The downstream boundary condition in the model was amended to represent a 40 cm and a 90 cm rise in sea levels to enable assessment of the impact that each of these scenarios have on flood levels in the Cooks River. In addition to the 100 year ARI climate change model runs, the TUFLOW hydraulic model was also run with the present day 200 year ARI design flows produced as part of Task 1, as well as the PMF and present day100 year ARI design flows.

- Task 3: Reporting

  Results of the hydraulic modelling for the final design have been documented. Flooding information (peak flood level, depth and velocity) at strategic locations within the site has been provided, along with maps of flooding extents, depths and velocities. These results have been assessed against the DGR's with respect to site flooding, drainage and groundwater processes.

3. Terms of reference

DGR's have been developed for the Part 3A Concept Plan for the Discovery Point development at Wolli Creek. This flood assessment has been carried out to address the DGR's pertaining to stormwater and flooding for the development site. The requirements relevant to drainage and flooding, addressed in this report, are taken from the *Discovery Point Masterplan Modification Flood Investigation Brief* (Smart Civil, 7 April 2010) and entail:

- "*The EA shall address drainage/flooding issues associated with the development/site, including: stormwater, drainage infrastructure and incorporation of Water Sensitive Urban Design measures."*
- *"The EA shall provide an assessment of any flood risk on site in consideration of any relevant provisions of the NSW Floodplain Development Manual (2005) including the potential effects of climate change, sea level rise and an increase in rainfall intensity."*
- *"The EA must address planning provisions applying to the site, including permissibility and the provisions of all plans and policies contained in "Development near Rail Corridors and Busy Roads- Interim Guideline".*

4. Limitations and assumptions

This study has been completed within the limitations of the *Cooks River Flood Study*, as detailed in the flood study report (PB+MWH, February 2009). Key limitations to note include:

- Modelling conducted for the *Cooks River Flood Study* was developed as a catchment wide flood study, primarily to provide a baseline assessment for impacts of proposed bank naturalisation works within designated areas along the Cooks River. Detailed modelling of flow paths within urban and industrial areas (i.e. flow paths between properties etc) and of small tributaries was not included in the modelling.
- Blockage of structures by debris during flood events was not incorporated in the modelling.
- Ground levels used for the modelling, and used in this review, are based on airborne laser scanning (ALS) flown in 2007 and obtained from AAM Hatch. This survey is accurate to within +/-0.15m.
- The two dimensional component of the model was developed based on a 7m grid. Representation of features within the floodplain is limited in accuracy due to the scale of this grid.
- Channel bathymetric survey was available for the modelling from the mouth of the Cooks River upstream to Burwood Road and for Alexandra Canal.
- TUFLOW hydraulic modelling results are reported to the nearest 0.1m only, to account for modelling limitations, including those listed above.

These limitations are typical of large-scale hydraulic modelling.

5. Results

Results of each of the modelled events are presented as flood maps in Attachment A. The following sections document the results of the Cooks River TUFLOW hydraulic model, in the area of the development site. The results include peak flood levels, depths and velocities and can be used to inform the Environmental Assessment and future detailed design of the Discovery Point development.

5.1 Modelled scenarios

The results of the following scenarios are presented in this section:

- 100 year ARI
- 200 year ARI
- PMF
- Climate change: 100 year ARI plus 10% increase in rainfall intensity and 0.4m sea level rise
- Climate change: 100 year ARI plus 20% increase in rainfall intensity and 0.4m sea level rise
- Climate change: 100 year ARI plus 30% increase in rainfall intensity and 0.4m sea level rise
- Climate change: 100 year ARI plus 10% increase in rainfall intensity and 0.9m sea level rise
- Climate change: 100 year ARI plus 20% increase in rainfall intensity and 0.9m sea level rise
- Climate change: 100 year ARI plus 30% increase in rainfall intensity and 0.9m sea level rise

It should be noted that the above scenarios did not include the proposed development, that is, they represent a 'pre-development' situation. However, the development was considered in this report alongside the results of the *Cooks River Flood Study* (PB + MWH, 2009). These results indicated that the Discovery Point development encroached only slightly into the floodplain in the 100 year ARI scenario. Accordingly, the effect on flood levels is expected to be minimal, and detailed modelling is therefore not warranted for this level of assessment (C. Vink, pers. comms., 8/4/10, 2:20pm).

From a review of the additional model results produced as part of this assessment (specifically the 200 year ARI), versus the building footprint, it is expected that there will be no significant change in flood levels or distribution of flood waters as a result of the development. Modelled flood levels, inundation, depths and velocities are discussed in the following sections.

5.2 Peak flood levels

Modelled flood extents for the scenarios listed above are presented in Attachment A. Peak flood levels at points adjacent to the Discovery Point development site are listed in Table 5.1. The location of each point is shown on Figure 1.

Table 5.1 Peak flood levels (mAHD)

Location	100yARI	200yARI	100 yr ARI +10% rainfall, 0.4mSLR	100 yr ARI +20% rainfall, 0.4mSLR	100 yr ARI +30% rainfall, 0.4mSLR	100 yr ARI +10% rainfall, 0.9mSLR	100 yr ARI +20% rainfall, 0.9mSLR	100 yr ARI +30% rainfall, 0.9mSLR	PMF
1	2.2	2.4	2.5	2.6	2.6	2.7	2.8	2.8	3.6
2	2.2	2.4	2.5	2.6	2.6	2.7	2.7	2.8	3.5
3	Not flooded	2.4	2.5	2.5	2.6	2.7	2.7	2.8	3.5
4	2.2	2.4	2.4	2.5	2.5	2.7	2.7	2.8	3.5

Note: SLR= sea level rise

Table 5.1 shows flood levels along the Cooks River adjacent to the development site to be fairly even, resulting in a relatively flat flood water surface. The PMF results in the highest peak flood levels along the Cooks River adjacent to the site. Section 5.4 provides further longitudinal flood surface information along the Cooks River.

In general, the increase in rainfall intensity (of 10%, 20% or 30%) does have an impact on design flood levels. However, the change in flood levels is greater between the 0.4 m and 0.9 m sea level rise scenarios than between the different rainfall intensity scenarios (10%, 20% or 30%).

The flood extent mapping of the peak flood levels indicates that part of the site is currently inundated for events greater than the 100 year ARI design event. The area inundated increases slightly with the increase in flows and also by the increase in flood levels, as presented in Table 5.1. Further development beyond that proposed should consider the impact of the loss of this inundated area. Loss of this area can cause the redistribution of floodwaters.

A review of current design information (provided as part of the Smart Civil brief in Attachment B) indicates that proposed floor levels are above the 200 year ARI design flood levels presented in Table 5.1, and therefore are acceptable in terms of Rockdale City Council's design flood standard.

5.3 Flood depths and velocities

The speed and depth of floodwaters has an impact to the level of threat to personal and structural safety (NSW Govt, 2005) and their consideration is a requirement of the *NSW Government Flood Development Manual* (NSW Govt 2005). In light of this flood depths and velocities from the Cooks River hydraulic model are provided in the following tables. Overall the results show that the proposed floor levels are above the predicted PMF design flood levels, and therefore the risk to personal safety and property damage is minimal. In light of this, and considering the guidelines of the *NSW Government Flood Development Manual* (NSW Govt 2005), the risk is managed through elimination of flooding within the development.

Flood depths and velocities are provided for the 100 year ARI, 200 year ARI and climate change scenarios, and are presented in Attachment A. Peak depths and velocities at points strategic to the Discovery Point development site are listed in Table 5.2 and Table 5.3. The location of each point is shown on Figure 1.

Table 5.2 Peak depths (m) (relative to 2007 ALS)

Location	100yARI	200yARI	100 yr ARI +10% rainfall, 0.4mSLR	100 yr ARI +20% rainfall, 0.4mSLR	100 yr ARI +30% rainfall, 0.4mSLR	100 yr ARI +10% rainfall, 0.9mSLR	100 yr ARI +20% rainfall, 0.9mSLR	100 yr ARI +30% rainfall, 0.9mSLR
1	0.7	0.8	1.1	1.0	1.0	1.4	1.4	1.5
2	1.2	1.4	1.7	1.6	1.6	2.0	2.0	2.1
3	Not flooded	0.8	1.2	1.0	1.0	1.4	1.5	1.5
4	0.9	1.1	1.1	1.2	1.2	1.4	1.4	1.5

Table 5.2 shows depths to vary along the boundary of the site at locations 1 to 4. Comparing depths between each flood event shows that depth increases as the design flow increases. The depths estimated for the 100 year ARI event and above are significant. A review of the current design information indicates that these depths will be beyond the development area. However, public access to the river edge will need to consider flood safety and therefore consider depths of flooding in the area.

As indicated in the figures presented in Attachment A, the proposed site is currently partially inundated. The loss of the inundated area may impact flood depths and velocities, as floodwaters may redistribute. It is expected the impacts will be localised at the river bank, which can be managed though bank stabilisation works during subsequent project application stages.

Table 5.3 Peak velocities (m/s)

Location	100yARI	200yARI	100 yr ARI +10% rainfall, 0.4mSLR	100 yr ARI +20% rainfall, 0.4mSLR	100 yr ARI +30% rainfall, 0.4mSLR	100 yr ARI +10% rainfall, 0.9mSLR	100 yr ARI +20% rainfall, 0.9mSLR	100 yr ARI +30% rainfall, 0.9mSLR
1	0.03	0.04	0.03	0.03	0.03	0.04	0.05	0.05
2	0.06	0.08	0.06	0.06	0.07	0.06	0.07	0.07
3	Not flooded	0.06	0.24	0.27	0.28	0.26	0.29	0.32
4	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03

Table 5.3 shows velocities varying between locations along the site boundary at locations 1 to 4. Velocities are highest in the vicinity of point 3, due to localised overbank flooding. Velocities increase slightly between the 100 year and 200 year ARI's and with the climate change scenarios. Apart from at point 3, velocities pose no threat to structures or people. For point 3 the velocities greater than 0.2m/s may cause localised erosion, which will need to be managed through the design, such as bank stabilisation works during subsequent project application stages. Given the proposed development is above the PMF design flood level, flood velocities within the development will not occur.

5.4 Cooks River longitudinal profile

A longitudinal flood profile along the length of the Cooks River has been provided to show the slope of the water surface in each of the modelled flood events, presented in Figure 27. The flood profile indicates that the PMF event results in the highest flood levels along the length of Cooks River. Apart from the PMF, the design events resulting in the highest flood levels in the vicinity of the Discovery Point development,

between the Illawarra Railway Line and the Princes Highway, are those of the climate change events; specifically, climate change with an increase in rainfall intensity by 30% (the maximum climate change scenarios modelled).

The flood profile indicates that the Illawarra Railway Line is a constriction with flood levels dropping immediately downstream of the railway. The flood surface falls from the Illawarra Railway Line to Botany Bay which would indicate more of a fluvial influence on flooding a the Discovery Point site. This is also shown in the results of the *Cooks River Flood Study* (PB+MWH, 2009) where catchment areas upstream of Marsh St (of where the current site resides) are dominated by fluvial processes rather than tidal processes. This means that for the Discovery Point site, flood events modelled with increased rainfall intensity will produce greater flood levels than for flood events modelled with sea level rise only.

5.5 Stage hydrographs

Stage hydrographs, showing flood levels with time for each modelled scenario, have also been provided to indicate the rate of rise and the recession of flood waters, and to show the timing of the flood peak, with respect to the start of the rainfall event.

The hydrographs provided refer to a section of the Cooks River in the vicinity of the Discovery Point development, and include results from the 100 year ARI, 200 year ARI and climate change modelled flood events, and are presented in Figure 28.

It should be noted that in the 100 year and 200 year ARI scenarios, only the fluvial ARI results have been shown. As mentioned in the section above, in the part of the catchment where the Discovery Point site resides, fluvial processes dominate and hence produce stage hydrographs with higher flood levels.

6. Discussion

The information provided in this assessment furthers the understanding of flood behaviour in the development area and addresses the requirements in the Environmental Assessment with respect to flooding.

6.1 Flooding

The purpose of this assessment is to document and expand on flood information from the *Cooks River Flood Study* (PB + MWH, 2009) in the area of the proposed Discovery Point development.

The flood modelling carried out in this assessment should be used to add to the current understanding of site conditions, outlined in the *Internal Memorandum on Stormwater Drainage, Flooding and Groundwater Levels* (from C. Vink to C. Pope, 25/3/10, provided in Attachment B). The memorandum includes a current understanding of flood levels, as provided by the RCC for the Discovery Point site. Section 5.2 of this report documents flood levels along the site boundary adjacent to the Cooks River (see Figure 1) as simulated by the current TUFLOW hydraulic model. The modelled flood heights (see Table 5.1) in this area are lower than the levels reported in the memorandum by approximately 0.35 m for the 100 year and 200 year ARIs (reported as 2.55 and 2.75 mAHD respectively), and approximately 1.8-1.9 m lower for the PMF (reported as 5.4 mAHD). The 500 year and 10,000 year ARIs reported in the memorandum were not

modelled as part of this assessment. Flood levels reported in this assessment may be lower than those provided by the RCC due to levels potentially being taken in different locations, or perhaps due to the more recent and more accurate topographic information available for the *Cooks River Flood Study* (PB + MWH, 2009).

The results indicate the proposed development encroaches onto the existing floodplain for the flood events considered in this assessment, and will result in some loss of floodplain storage. This loss of storage is considered minimal for the 200 year ARI event and will not cause any significant impact on existing 200 year ARI flood levels, provided the development footprint (shown in Figures 1 to 26) does not change and encroach further into the floodplain. Proposed levels between buildings are at RL +6.1 mAHD, and the ground floor car park nearest the Cooks River is at RL +7.6 mAHD, which are above the modelled flood levels for the PMF. Considering the RL of +6.1 mAHD between buildings, approximately 2.5 m of freeboard is predicted above the PMF flood level (see Table 5.1). Therefore there will be no impacts on the development.

The removal of the flood storage may impact localised flood levels but can be managed by maintaining the current set back from the river bank, and through the maintenance of overland flow paths from the upstream catchment. The DGR flooding issues are addressed through setting the development above the design flood standard. The development will also be above the PMF and predicted climate change flood levels, which provides the development with protection from any future changes to the Cooks River flooding regime.

6.2 Site drainage

Changes to drainage infrastructure afforded by the development may also alter flood behaviour locally, as drainage will be re-directed to gutters and pipes and discharged into the Cooks River, as outlined in the internal memorandum (Attachment B). The *Development Near Rail Corridors and Busy Roads- Interim Guideline* (Dept Planning, Dec 2008) outlines that drainage infrastructure should be designed to manage stormwater to minimise impacts on water courses and existing drainage infrastructure. In addition, discharge locations for stormwater drainage should consider bank stability and velocities within the Cooks River.

Any change to local drainage patterns around the Wolli Creek Railway Station are likely to be minimal given that the developed levels immediately surrounding the railway station are above the PMF and modelled climate change events. The drainage infrastructure should be designed to manage stormwater to minimise impacts on water courses and existing drainage infrastructure.

6.3 Groundwater

The hydraulic modelling indicates inundation of part of the site in the 100 year ARI flood, increasing with the 200 year ARI event and again with climate change. Subsequently, groundwater levels in the site area may change with the proposed development. Seepage from flood waters may decrease as the site develops and impervious surfaces are added which may subsequently affect groundwater levels and processes. Management of the complete water cycle therefore needs to be part of the design.

6.4 Climate change

The Director General requires the assessment of climate change as part of the Environmental Assessment (see section 3). Climate change sensitivity and its impacts with respect to floodplain management has been assessed in line with the *NSW Floodplain Development Manual* (DIPNR, 2005), the *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC, 2007) and the *NSW Sea Level Rise Policy Statement* (DECCW, Oct 2009).

The climate change scenarios simulated in this study do not show any new floodways in the vicinity of the Discovery Point development site. Flood hazard is unlikely to change as the development is designed to be above the simulated climate change flood levels. In light of this change to flood damages is likely to be minimal.

As discussed in the *Floodplain Risk Management Guideline: Practical Consideration of Climate Change (*DECC, 2007), the increase in rainfall intensity will change the recurrence interval of rainfall from the current predicted recurrence. This means that more severe rainfall events would become more recurrent and therefore increase the frequency of inundation at the site. There is also the potential that the frequency of inundation at the site may change as a result of an increase in sea level, but this will be dependent on conditions in the Cooks River at the time of the peak tide level; that is, if it is in flood or not. The increase in rainfall intensity and sea level rise is likely to have an impact on the frequency of high water levels within the Cooks River. The increase in rainfall intensity is also likely to have implications on the local stormwater management system. Design of the local stormwater system should therefore consider the climate change predictions as part of its design. This is discussed in greater detail in the Soil and Water Management Report for the Part 3A environmental assessment.

With reference to the DGR's the potential effects of climate change have been considered for the development. These will be managed through building the development such that it is above the predicted climate change and PMF flood levels.

7. Conclusion

In summary, this flood assessment provides the latest results of the TUFLOW hydraulic model, in the vicinity of the Discovery Point development site. The flood assessment addresses climate change considerations, drainage and flooding, flood risk and flooding near rail corridors, as required by the Director General. The results provided are based on pre-development conditions at Discovery Point, as modelled in the previous *Cooks River Flood Study* (PB + MWH, 2009). The previous model has been extended to include the 200 year ARI flood scenario (nominated by Rockdale City Council as the design flood standard for the Discovery Point site) and includes updated climate change predictions based on more recent advice from DECCW in the *NSW Sea Level Rise Policy Statement* (DECCW, Oct 2009), as well as advice provided in the *NSW Floodplain Development Manual* (DIPNR, 2005) and the *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC, 2007).

The results indicate that proposed habitable floor levels are above the largest flood event modelled (PMF), including a predicted freeboard of approximately 2.5 m. In this way the flood risk for the site is managed, as advised in the *NSW Floodplain Development Manual* (DIPNR, 2005). The results also

indicate that the development will not adversely affect the Wolli Creek Railway Station, due to development immediately surrounding the station being higher than predicted flood levels for all modelled flood events, including the PMF. As such impacts are minimised as required in *Development Near Rail Corridors and Busy Roads- Interim Guideline* (Dept Planning, Dec 2008).

The results show the proposed development encroaches onto the existing floodplain for the flood events considered in this assessment, and will result in some loss of floodplain storage. This loss of storage is considered minimal for the 200 year ARI event and will not cause any significant impact on existing 200 year ARI flood levels, provided the development footprint does not change and encroach further into the floodplain. The loss of flood storage will increase for higher order flood events, such as the PMF and predicted climate change scenarios. However, the impact on existing PMF and predicted climate change flood levels is also expected to be small and localised, and will have no impact on the development as it will be built above predicted PMF flood levels. Nonetheless there should be no further encroachment of the building footprint into the floodplain and no filling between the development and the Cooks River.

If future development proposals for the site encroach further into the floodplain and or the existing Cooks River bank is changed or significant redevelopment of the catchment on the adjacent land occurs, then further modelling and design will be required to ensure there is no significant impact to flood levels both on the Discovery Point site and adjacent Cooks River land.

Yours sincerely

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References

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Rockdale City Council, Letter to Jack Hughes at Hard and Forester from Gary Williams, 23 November 1999*

Parsons Brinckerhoff MWH Joint Venture, Cooks River Flood Study 2009

Paul Davis Rajalingam, Internal Memorandum- Stormwater Drainage, Flooding and Groundwater Levels (PDR-INTM-000002), 25 March 2010*

Smart Civil, Discovery Point Masterplan Modification Flood Investigation Brief (REF: C0100170-FB1, Issue No 2- Final), 7 April 2010*

*included in Attachment B

Attachments

Attachment A – Figures

Attachment B

-Rockdale City Council letter to Hard and Forester, 23 November 1999