

Bewsher
Report.



10 January 2013
Ref: J1898L_2

Jane Flanagan
Senior Planner
Metropolitan & Regional Projects South
NSW Department of Planning & Infrastructure
GPO Box 39
SYDNEY NSW 2001

6/28 Langston Place
Epping NSW 2121
PO Box 352
Epping NSW 1710
T : 02 9868 1966
F : 02 9868 5759

www.bewsher.com.au

Bewsher Consulting Pty Ltd
ABN: 24 312 540 210

By Email: jane.flanagan@planning.nsw.gov.au

Dear Ms Flanagan

TALLAWARRA LANDS PROJECT SUPPLEMENTARY FLOOD RISK ASSESSMENT REPORT

We write to provide a response to the matters raised by Evans & Peck (E&P) in their review of flood risk management issues associated with the Concept Plan submission for the above project.

E&P's comments were initially provided in their "Issues Paper" dated 6 November 2012. Following receipt of their paper, there have been two meetings between ourselves and Dr Steve Perrens and Mr Dan Hickey of E&P, and various emails have been exchanged. These meetings and emails have enabled us to fully identify E&P's concerns and to jointly explore the best means to respond to these concerns. This letter has been prepared following our final meeting with Dr Perrens this morning at which the general contents of this letter were agreed. We also agreed that Dr Perrens will be separately writing to you about other flood related issues including the interpretation of the existing flood risk information, that are more appropriately expounded by him rather than us.

Given the above, this letter provides a consolidated response to various matters raised by E&P in their paper of 6 November 2012, in their emails of 12 December 2012 and 8 January 2013 and in our meetings with them on 27 November 2012 and 10 January 2013.

Flood risk issues in the catchment and those associated with the project have been documented in various reports since Cardno Forbes Rigby's initial report in 2007. There have also been matters raised by agencies to which the Proponent has responded as the Concept Plan has been developed. Some of these have occurred after our 2010 Flood Risk Assessment (FRA) for the project. Bringing all these matters into focus is important in order to be confident that the flood risk issues associated with the project are being properly managed in accordance with current best practice.

In this regard E&P's review and their subsequent comments provide a valuable milestone as it has overviewed all the documentation available and identified inconsistencies requiring extra explanation or suggested areas where the provision of additional information has been useful.



1. FLOOD REPORTS - TIME LINE

There have been a number of reports and statements which deal with the issues of flooding and floodplain development associated with the Tallawarra Lands project.

Time wise they range from 2007 to the present and are chronologically listed below:

- (a) Cardno Forbes Rigby (CFR) 2007 *Duck Creek Flood Study*. This report was the first to model and examine flood issues throughout the Tallawarra Lands project area. A summary of the work which was done can be found in the Bewsher 2010 *Tallawarra Lands Flood Risk Assessment (FRA)* report;
- (b) 2010 *Tallawarra Lands Concept Plan*. This plan identified the then proposed extents of development. Its road network was incorporated into the 100 year flood inundation plan (i.e. Figure 2) of the Bewsher 2010 *Tallawarra Lands Flood Risk Assessment* report in order to schematically show that the vast majority of the proposed development lay outside the 100 year floodplain;
- (c) Bewsher December 2010 *Tallawarra Lands Flood Risk Assessment (FRA)* report. This report used a similar hydrologic modelling approach to that used by CFR (2007) to derive flood flows throughout the Duck Creek floodplain and also extended that approach to look at flood flows in the smaller catchments that lie north of Duck Creek. The report documents the development of a more sophisticated (i.e. 2-dimensional) hydraulic model to that which was developed by CFR (2007). The report formed part of the project's Environmental Assessment (EA) Report dated August 2011;
- (d) Bewsher 2011 *Supplementary Flood Risk Assessment Advice*. This short report which was prepared as a response to DP&I feedback on the project's draft EA report, dealt with issues such as upper catchment development impacts, modelling of floodtime blockage of Duck Creek floodplain structures and riparian corridor re-vegetation issues;
- (e) Bewsher April 2012 *Tallawarra Lands Response to Flood Issues raised by OEH*. This short report was prepared in response to flood issues raised by OEH in November 2011 including matters such as upper catchment development impacts and the modelling of Duck Creek floodplain structures;
- (f) Cardno January 2012 *Lake Illawarra Floodplain Risk Management Study* (prepared for Wollongong Council). This report is focused on the lake's flood regime (as opposed to the flood regime along the various creeks draining to it). It identified the Lake Illawarra 'current conditions' 100 year ARI flood level as RL 2.24 m AHD, which is the same value adopted in the Bewsher 2010 *FRA* report;
- (g) BMT WBM February 2012 *Duck Creek Flood Study* report (prepared for Wollongong Council). It is noted that whilst this report used the same software packages as the Bewsher 2010 *FRA* report its floodplain modelling extended over the whole catchment and included model calibration against catchment-wide flood events;
- (h) *Preferred Project Report and Updated Statement of Commitments* prepared by Don Fox Planning in June 2012. Appendix J of the report includes the project's current Concept Plan which is dated 7 May 2012 and it is noted that there are minor changes to the development road layout compared with the 2010 layout

(which is presented in Figure 2 of the Bewsher 2010 FRA report). With regard to floodplain issues, the *Updated Statement of Commitments* provides for "All access roads to the development precincts to be at or above the 100 year flood level after allowing for year 2100 climate change impacts";

- (i) Evans & Peck 6 November 2012 *Tallawarra Lands Issues Paper*. This letter report was prepared for DP&I and represented a review of the Tallawarra Lands project's flood risk management strategy. Consequently its focus was on the Bewsher 2010 FRA report.

2. SUGGESTED ADDITIONS TO THE STATEMENT OF COMMITMENTS

It can be seen from the above history that there have been various documents relating to the project's floodplain development issues since the completion of the Bewsher 2010 FRA report. Of particular importance are the commitments made regarding floodplain fill levels, design floor levels and flood evacuation routes within the 2012 *Updated Statement of Commitments* which were made subsequent to the FRA report.

E&P have suggested that further commitments may be useful in order to clarify aspects of the future development of the project which they consider are not adequately addressed currently. Accordingly we have prepared a list of 'proposed additional commitments' for the Proponent and the Department to consider and have presented these in **Attachment A**. These are matters which in our view would be undertaken as a matter of course but nonetheless we agree that their inclusion will provide additional clarity.

For the sake of completeness the existing commitments which related to flood risks as well as the proposed additional commitments are listed in **Attachment A**.

3. RESPONSE TO ISSUES RAISED BY EVANS & PECK

We now provide our itemised response to the *Issues Paper* (and subsequent comments) prepared by E&P. Having listed a number of floodplain issues as "considered to be resolved" in Section 4 of their *Issues Paper*, E&P list ten issues "requiring clarification prior to Concept Approval" in Section 5 and three issues for "conditioning within the Concept Approval" in Section 6.

Sections 3.1 below provides our response to the ten issues raised by E&P in their Section 5, and our **Section 3.2** below responds to E&P's Section 6.

3.1 Response to E&P Section 5 Issues

The ten dot points listed in Section 5 have been numbered one to ten as presented below.

1. Provision of a detailed contour map of the existing site topography with the proposed development footprint overlaid. This has been prepared and is presented in **Figure 1**. The corresponding extent of fill within and adjacent to the Duck Creek 100 year ARI floodplain is shown against the 2010 FRA's floodplain map in **Figure 2**. It can be seen that there is only the one minor incursion into the 100 floodplain (on the western boundary of the Southern Precinct – see western 'red pocket' on **Figure 2**).

2. Inclusion of reference 100 year flood levels and matters associated with modelling of the old railway bridge. **Table 1** Lists the 100 year flood levels, which were generated as part of the 2010 *FRA* modelling of the Duck Creek floodplain, and their locations, are shown in **Figure 2**. The table also lists values which have been extracted from the 2012 *Duck Creek Flood Study* (DCFS). It is important to appreciate that the two sets of 100 year flood levels are not directly comparable since, as correctly identified by E&P, the 2010 *FRA* did not adopt the same blockage factors at the various floodplain structures. (This is due to the *FRA*'s focus on the Tallawarra development scenario.) Given that some of the major floodplain structures have relatively limited waterway areas, it follows that differences in 'design' blockage factors (which further restrict the waterway areas) will produce different flood levels when modelled. It should be of no surprise therefore that the flood results are not directly comparable for a variety of reasons including:

- the DCFS examines 'existing' conditions and allows for blockage of culverts/bridges as per Council guidelines;
- the *FRA*'s 'existing' conditions assumes 'worst case' conditions for the site would occur if there were no blockage of upstream culverts/bridges (which as agreed with E&P, is appropriate for the site) and the railway bridge is removed;
- the topographic data used in the DCFS (including channel geometry) is largely based on LIDAR data, whereas in the *FRA* the cross sections at critical locations (culverts/bridges) were based on ground based survey (which would generally be more accurate than LIDAR).

As discussed further below, and as appreciated by E&P, when future applications are lodged for components of the project which are dependent on flood behaviour (e.g. floor levels, levels of evacuation routes, etc), the most up-to-date flood models will need to be used to determine flood behaviour (see proposed additional commitments 'a' and 'f').

Table 1: Reference 100 Year Flood and PMF Levels (m AHD)

Figure 2 Location	Tallawarra Lands Location	100 Year ARI Flood Level		PMF Level
		2010 FRA ^a	2012 DCFS	2012 DCFS
1	Duck Creek, at Wollingurry Creek confluence	2.2m	2.6m ^b	4.0m ^b
2	Duck Creek, downstream of old railway bridge	3.3m	3.3m ^b	4.5m ^b
3	Duck Creek, upstream of old railway bridge	3.5m	4.5m ^c	6.3m ^c
4	Duck Creek, adjacent to western limit of fill for Southern Precinct	4.9m	5.2m ^b	6.8m ^b
5	Duck Creek, downstream of the Princes Highway bridge	6.0m	6.0m ^b	7.6m ^b

NOTES:

^a as extracted from the 2010 *FRA* report's hydraulic model

^b as estimated from the 2012 *Duck Creek Flood Study* report's Figure 7-2

^c as extracted from the 2012 *Duck Creek Flood Study* report's Table 7-4

Such models will include for:

- any revisions, at that time, to the Council's adopted flood model (which occur routinely as new technology or additional calibration data becomes available);
- revisions to design rainfall data, which E&P have noted are currently under review nation-wide by the Bureau of Meteorology;
- the latest estimates of the impacts of climate change on Lake levels and rainfall intensities; and
- blockage factors consistent with the design of the project's infrastructure at that time, and the Council's blockage policy.

Approach to Blockage

As detailed in Section 4.5.1 of the FRA report, the FRA modelling looked at two different blockage scenarios (over a range of design flood durations) in order to arrive at the potentially worst flow scenarios through the Tallawarra Lands area; firstly, nil blockage of all upstream Duck Creek structures and upstream tributary structures and secondly, 100% blockage of all upstream tributary structures (where this latter provision happens to be in accordance with WCC's blockage policy) together with nil blockage of upstream Duck Creek structures (i.e. as per Table 1 of the FRA report). In both scenarios, all of the structures within the Tallawarra Lands area were modelled as unblocked.

Since the DCFS was reporting design flood levels in accordance with Council's catchment-wide (& LGA-wide) blockage policy, it formally reports the results of design flood modelling based on incorporation of Council's 'standard' 25% and 100% blockage factors. As also stated in the FRA report, the Tallawarra Lands Duck Creek flood levels were found to be only marginally higher along Duck Creek in the second scenario.

Flood Level Differences Downstream of the Old Railway Bridge

Table 1 shows that the FRA and DCFS reports have close agreement in terms of flood levels downstream of the old railway bridge (and also downstream of the Princes Highway away from the influences of the old railway bridge).

Flood Level Differences Upstream of the Old Railway Bridge

The considerable differences between the FRA and DCFS flood levels at the old railway bridge (i.e. Location '3') are apparent in **Table 1** and were raised by E&P in their email after an initial copy of **Table 1** was provided to them for review. (Unfortunately the initial table provided by us contained some typing errors which has hindered E&P's review and for which we apologise).

To assist with understanding the flood behaviour at the structure, a survey and photograph are reproduced in **Illustrations A** and **B** below.

The FRA has assumed the bridge (and its abutments) are in place but with no blockage. The 19m width between the abutments in the FRA model agrees closely with that in the DCFS model (see **Illustration A**).

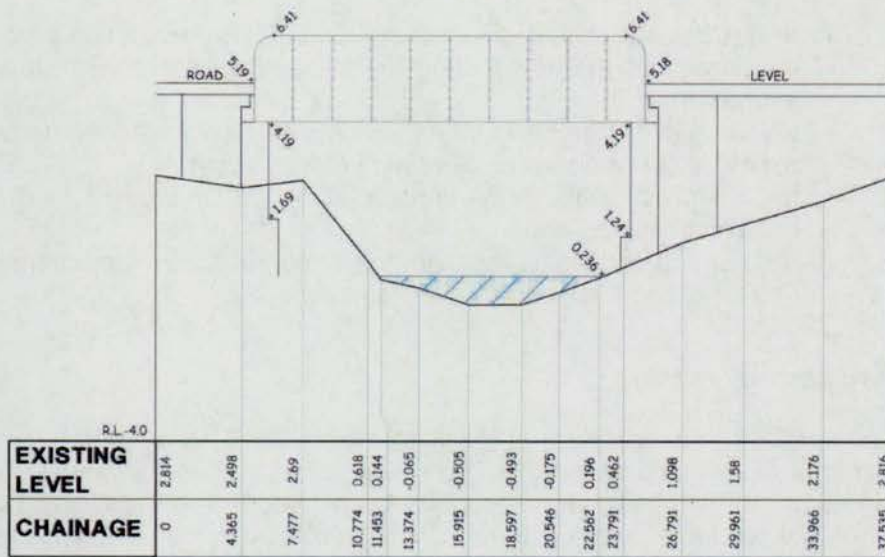


Illustration A: Old Railway Bridge Survey (provided by BMT WBM from DCFS)



Illustration B: Old Railway Bridge Photograph (reproduced from App A of FRA)

The approach to the modelling of the old railway bridge in the DCFS is not clearly documented and has been clarified by telephone discussions with BMT WBM following our separate discussions with E&P. The allowance for blockage and possibly differences in the surveyed bed levels, have produced higher levels in the DCFS model. Further as can be seen from **Illustration A**, once water levels rise high enough to touch the underside of the bridge superstructure (i.e. 4.19mAHD) the passage of flood flows becomes significantly constricted and upstream water levels are likely to rise even further. This appears to be the principal reason for the significant differences between the DCFS and the FRA flood levels immediately upstream of the bridge.

The FRA has not made any separate allowance for increased flood levels resulting from construction of a future bridge. Whilst the design concept of the new bridge has not yet been determined, the removal of the current abutments will likely result in a significantly larger waterway area, which even after allowance for blockage (25%) would be unlikely to see the flood levels rise above the FRA estimates. In any event modelling will be required to determine the upstream flood levels so that other future components of the project, whose design will be dependent on these flood levels, can be designed. (Refer proposed additional commitment 'f' in **Attachment A**).

In our view the existing documentation, together with the additional information presented here including the proposed additional commitments in **Attachment A**, provides the necessary assurances that the project can be designed consistent with best practice flood risk management at each stage into the future.

3. Comment on 100 year ARI plus climate change scenario. It is noted that E&P have already determined that the 2010 FRA's adoption of an increase of 0.5 m over the 100 year existing conditions is reasonable since very similar increases were reported in the Council-commissioned BMT WBM 2012 *Duck Creek Flood Study*.
4. Revision of PMF flood level assumption. 'Existing conditions' PMF levels have been formally modelled as part of the BMT WBM 2012 *Duck Creek Flood Study* and the levels were presented in Table 7-4 and Figure 7-2 of that report. The PMF levels at key locations within the project area have been extracted from those sources and included in **Table 1**. While they are considered to represent appropriate estimates of 'existing conditions' it is important to note that they will not be applicable for 'post-development conditions' at and upstream of the old railway bridge since that structure will be demolished and replaced by the new bridge servicing the Southern Precinct. (When this happens flood levels will be lowered upstream of the bridge – refer proposed additional commitment 'f').

Figure 7-2 of the DCFS shows that there is a significant difference in the relationship between PMF and 100 year levels upstream and downstream of the old railway bridge. Typically the difference is of the order of one metre downstream of the bridge and 1.6-1.8 metres upstream of the bridge. Hence, the modelling of the old railway bridge is having a significant impact on the modelled PMF flood levels (as for the 100 year levels, as addressed in Point 2 above).

Also as per Point 2 above, the DCFS PMF levels will not be relevant to the Tallawarra Lands project since the removal of the old railway bridge and its abutments and the construction of a new crossing upstream of the current bridge will result in reduced PMF levels between the old bridge and the highway.

The FRA proceeded on the basis that the PMF would be approximately 1.0m higher than the 100 year flood level. Based on the DCFS results it could well be that the PMF year level is approximately 1.0m–1.5m higher, not the 1.0m that was assumed. Immediately upstream of the new railway bridge, the actual difference will be dependent on the future design of the bridge but given that a difference of 1.8m between PMF and 100 year levels was determined in the DCFS for the existing bridge, it is unlikely that the PMF level would be more than 1.5m higher than the 100 year level at the new structure.

Noting the commitments in **Attachment A**, the implications of the PMF being up to 0.5m higher than assumed in the FRA, have no major significance in relation to the Concept Plan Approval including addressing the DG's requirements. The principal implications of the higher PMF levels will be marginally higher water levels on evacuation routes (which are to be at a minimum level of the 100 year flood plus climate change). Nevertheless the evacuation strategy already recognises that egress from the site in these extreme events will not be possible and resident safety is to be assured by early evacuation, or if residents have not evacuated for some reason, by sheltering on site.

With the additional flood level information that has now come available through the DCFS, it remains our view that the flood risks associated with events bigger than the 100 year can be safely managed within the project, and that the measures envisaged within the Concept Plan can be designed and implemented within future stages of the project, consistent with current best practice for flood risk management (and the most up-to-date flood model results) at the time that the DAs for these future stages are submitted to Council.

5. Mapping of Proposed Evacuation Routes. As requested, descriptions of each of the main evacuation routes and their access status have been included in **Figure 2**. It is important to note that all roads from each proposed house/property could be used as an evacuation route. All evacuation routes (with the single exception of Gilba Road which will provide daily access for the North Shore Precinct) will have levels which are no less than "the 100 year flood after allowing for year 2100 climate change impacts" (as listed in the 2012 *Updated Statement of Commitments* and further clarified in **Attachment A**). It is important to note that the low point in Gilba Road is located beyond the site's northern boundary and hence the road will remain at current levels. However in flood events which temporarily restrict access via Gilba Road, alternative access will be able to be achieved via Yallah Bay Road.

It is noted that in relation to the Southern Precinct, evacuation has been assumed to occur via the new Duck Creek bridge and a direct route to the Highway has not been considered. Whilst this route may be an option that could potentially be considered in future stages of the project, our flood modelling of the Duck Creek tributaries indicated that the Highway would be inundated and hence while the project road could be built at the 100 year plus climate change level, the same level of performance cannot be achieved in the receiving road system. Accordingly, for the purposes of the Concept Plan and in order to fulfil the commitment to have every new dwelling serviced by an evacuation route at a minimum level of the 100 year flood (plus 2100 climate change), evacuation via the new Duck Creek bridge is provided.

6. Comments on the relationships between flood levels and flow rates. E&P have quoted the WBNM (or hydrologic) model flow rates from the 2010 *FRA* and compared these with the 2012 *Duck Creek Flood Study* TUFLOW (or hydraulic) model results and noted that the former values are higher despite the corresponding flood levels being lower. Since floodplain routing associated with major floodplain crossings has the potential to reduce downstream flood peaks it is important that the comparison of peak flows be either consistently based on either the hydrologic model outputs or the hydraulic model outputs (where the latter explicitly accounts for such routing). Together with the different approaches to design blockage factors at the floodplain crossings (reference this report's Point's 2 & 7), it would be expected that there would be a better correlation of flood flows and levels if both the models themselves and their results were based on the same model approaches and data sets.

Unlike WBNM, it is not possible to extract flows from TUFLOW results without the introduction of a 'flow line' into the model and re-running the model. This is not a trivial task given the size of both TUFLOW models and we have made a call not to undertake this additional work at this time. Nevertheless if E&P wish this to be pursued further, and subject to approval to re-run the models, additional in-depth comparisons could be provided. However as the currently modelled 100 year flood levels within the project area are very similar downstream of the old railway bridge (and downstream of the highway away from the influence of the old railway bridge), it follows that the design flood flows are similar.

7. Clarification regarding the modelling of bridge structures (especially the old railway bridge within the project site). As detailed in the 2010 *FRA* report, the focus of the upstream flood regime modelling has been on assessing the 'worst' potential flow and flood level conditions at the various Duck Creek and tributary entry points into the project site. Hence the 100 year ARI flood mapping presented in that report's Figure 2 is an envelope of hydraulic model run outputs assuming different combinations of bridge and culvert blockage upstream of the site in order to arrive at those 'worst' conditions. This focus on the 'worst' flow regime conditions entering the project site means that the chosen design blockage factors are consciously not consistent with the design factors specified by Council.

As discussed in Point 2 above, there is also a difference in the *FRA*'s and the *DCFS*'s approaches to the blockage factor applied to the old railway bridge. It is anticipated that the new crossing will have substantially less impact on Duck Creek flood levels than the current bridge. Further the future bridge will likely not increase upstream flood levels beyond those assumed in the *FRA* because of the increased conveyance that will occur through removal of the existing abutments and earthen approaches, despite the introduction of a blockage assumption.

8. Clarification of the extent of filling into the 100 year ARI floodplain. The extent of encroachment of fill into or adjacent to the 100 year ARI floodplain is shown in **Figure 2**. The 'red pockets' show where fill is proposed in floodplain areas whereas as the 'green pockets' show where fill is proposed in areas that are already bunded. (These green areas, whilst technically in the floodplain, are already isolated by bunding and consequently their filling has no impact beyond the bunded area).

Of the three 'red pockets' shown in **Figure 2**, it can be seen that the only pocket of any significance is located on the western side of the Southern Precinct (i.e. the lower left red pocket). The volume of flood storage displaced is slightly less than 1000m³ and this occurs immediately upstream of an existing dam on the Yallah Gully Tributary (which already blocks tributary flows). Because this encroachment is located on a tributary, there will be no impacts on Duck Creek flows and in any case, the upstream impacts on the tributary itself will be contained within the project area.

Moving further north, the middle red pocket is not in an area currently inundated by the 100 year flood but may possibly be so if climate change impacts are considered. The upper red pocket is also located on a tributary of Duck Creek rather than the Creek itself. The volume of displaced storage is less than 100m³ and its impacts will not extend off-site. Nevertheless both the middle and upper red pockets have been shown as they may be within the Duck Creek floodplain in larger events (including for the effects of climate change). Given that the encroachment volume represents less than 0.005% of 100 year flood volume on Creek, the potential impact even in larger events, will be of no consequence.

It is noted that all filling (or other project works within the floodplain) will be designed consistent with proposed additional commitment 'd' which commits the Proponent to ensuring there will be no off-site flood impacts. In some cases this may necessitate provision of compensatory works or amendment of fill proposals (or other project works) to achieve this outcome.

9. Clarification of fill and free-draining conditions (especially in the Southern Precinct). At the time of the *FRA* the current outlet conditions in the bunded and filled areas of both the Southern Precinct and the Future Development Area were unclear and hence those areas were modelled – as a 'worst case' flood scenario – on the basis of having no outlets to the adjacent waterways. It has since been clarified that both areas are currently free-draining to the adjacent waterways and hence the "highest pond level" notes included in **Figure 2** of the *FRA* report are no longer relevant. It also follows that the retention of the lake within the Southern Precinct (refer **Figure 2**) will see the lake level essentially reflecting the concurrent flood level in its adjacent waterway (i.e. Wollingurry Creek). The filling adjacent to the retained lake will be such that the developed areas will be flood free in the 100 year plus climate change event.

An additional commitment (see 'c' in **Attachment A**) has been proposed to further clarify the manner in which drainage of these fill areas will be implemented.

10. Clarification of overflow arrangements in fill areas. The discussion in Point 9 above concerning the *FRA*'s treatment of filled and bunded areas in both the Southern Precinct and the Future Development Area is also relevant to this response. Note also the proposed additional commitment 'c' in **Attachment A**.

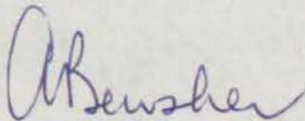
Due to the 'free draining' status in both areas, issues of potential elevated ponding levels and associated overland flow provisions for adjacent developed areas are no longer potentially problematic. The potential for hydraulic hazard in areas of proposed fill within bunded areas – such as filling adjacent to the retained lake in the Southern Precinct - will be analysed at such time as the stormwater concept designs are developed.

3.2 Response to E&P Section 6 Issues

It is recognised that flood models need revision over time as new data becomes available or Government policies alter. Best practice requires that the most up-to-date flood model that is available at the time should be used when relevant future Development Applications are made.

The commitments in **Attachment A** also provide for "*development floor levels for each land use to be at the flood planning levels set by Wollongong City Council's DCP (Chapter E13)*". The commitments will ensure that the most appropriate flood model is used when flood planning levels need to be set, and that the resultant levels are fully compliant with Council's requirements at the time.

Yours sincerely



Drew Bewsher
Director

cc. Dr Steve Perrens, Evans & Peck

STATEMENT OF COMMITMENTS RELEVANT TO FLOOD RISKS
 (For review by Proponent and the Department)

Existing Commitments

No	Subject	Commitment	Timing	Responsible Monitoring Body/Authority
28	Flood Risk Management	Future DAs will adopt the following flood risk management principles. It is noted that these principles exceed, or are equal to, those currently applied by Wollongong City Council in respect of the West Dapto Release Area: <ul style="list-style-type: none"> • All access roads to development precincts to be at or above 100 year flood level after allowing for year 2100 climate change impacts. • Filling for development areas to be at a minimum level of the 100 year flood level allowing for year 2100 climate change impacts. • Development floor levels for each land use to be at the flood planning levels set by Wollongong City Council's DCP (Chapter E13). 	Design to be incorporated into future development applications and on a stage by stage basis.	Relevant development application consent authority

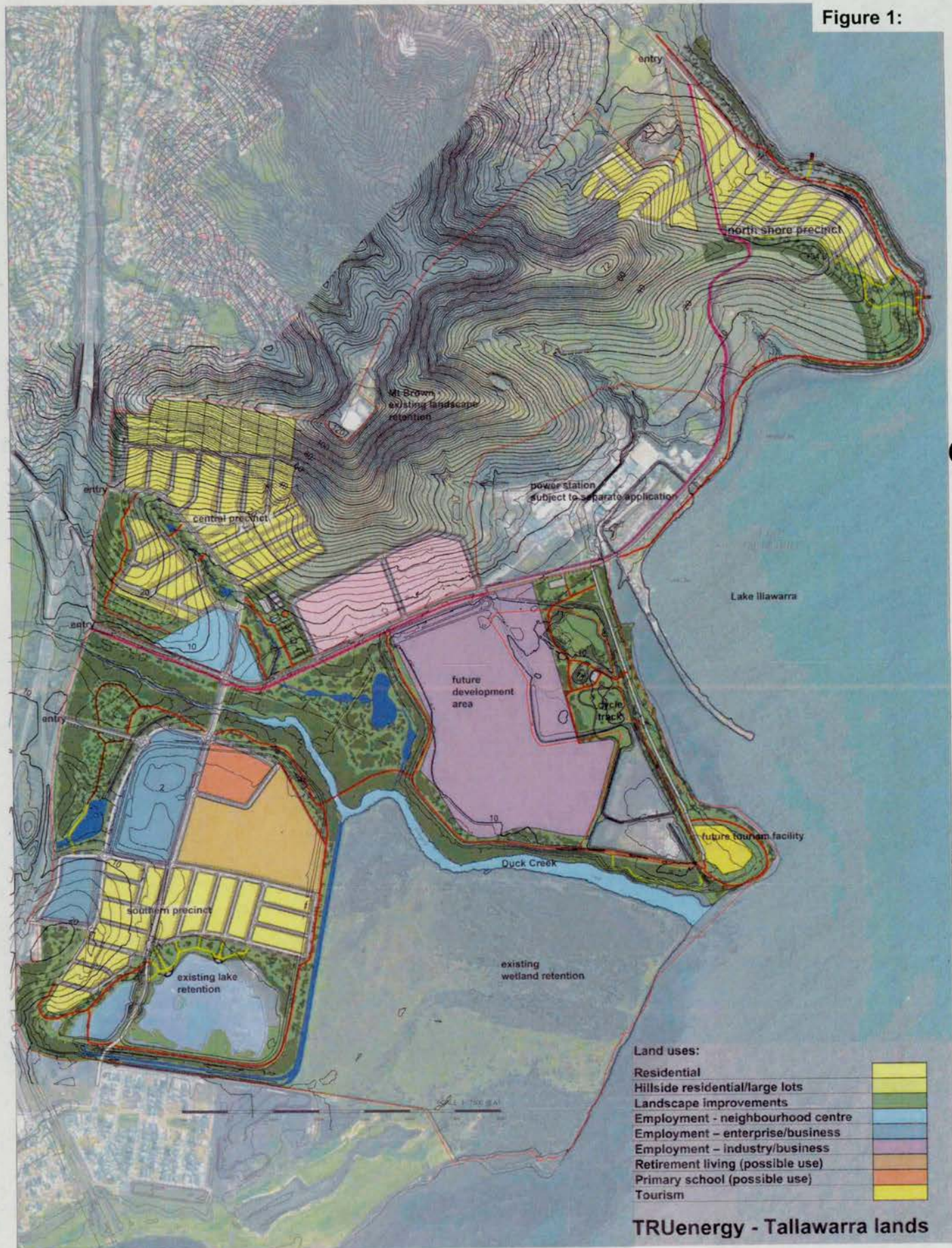
Proposed Additional Commitments

(Note that for reference purposes within this letter, each new commitment has been labelled (a), (b), etc. For consistency with the format of the existing commitments, it is anticipated that this labelling will subsequently be removed).

No	Subject	Commitment	Timing	Responsible Monitoring Body/Authority
??	Flood Risk Management	<p>Future DAs will adopt the following flood risk management principles:</p> <ul style="list-style-type: none"> (a) All future development decisions will be based on the most up-to-date flood model available at the time of the future DA and include all components of the project which may influence flood behaviour (e.g. changes to riparian vegetation, filling adjacent to the floodplain, new bridges, etc). It is recognised that flood models need revision over time as new data becomes available or Government policies alter. This includes the imminent revisions to the rainfall intensity-frequency-duration data published by the Bureau of Meteorology, and changes in Government policy and/or accepted practice concerning the impacts of climate change on sea levels and rainfall intensities. Further, flood levels within development areas remote from the main waterways will be modelled having regard to the capacity of the drainage system of the development area and its overland flow routes. (b) Land to be filled will be at sufficient height and grade to allow free-drainage of the filled area into the surrounding waterway. (c) When stormwater concept designs are developed for proposed fill areas, potential flood hazard areas will be analysed and managed in accordance with best practice and the requirements of the Floodplain Development Manual and Council's DCP (Chapters E13 and E14). (d) No filling of floodplain land will occur which produces off-site impacts in accordance with the "flood affectation" requirements of Chapter E13 of Council's DCP. (e) All future housing will be serviced by at least one road route providing egress off-site and at a height for the entire route which is no lower than the 100 year ARI flood level after allowing for year 2100 climate change impacts. Where future housing areas are isolated in a PMF, facilities (e.g. high ground or elevated building floors) will be provided for safe refuge above the PMF level, within the isolated area. (f) The existing old railway bridge across Duck Creek provides significant constriction to flood flows, raising flood levels upstream in major flood events. The Proponent commits to the following measures to mitigate flooding impacts: <ul style="list-style-type: none"> • designing the new bridge to provide less constriction to achieve lower upstream flood levels for the 100 year ARI and larger events; and • setting the levels of new roads, landfill and habitable floors levels of proposed buildings based on flood modelling consistent with Council's Blockage Policy. 	Design to be incorporated into relevant future development applications and on a stage by stage basis.	Relevant development application consent authority

*see 29
Soc 28 sheet 4
App E Concept Approval*

Figure 1:



Land uses:

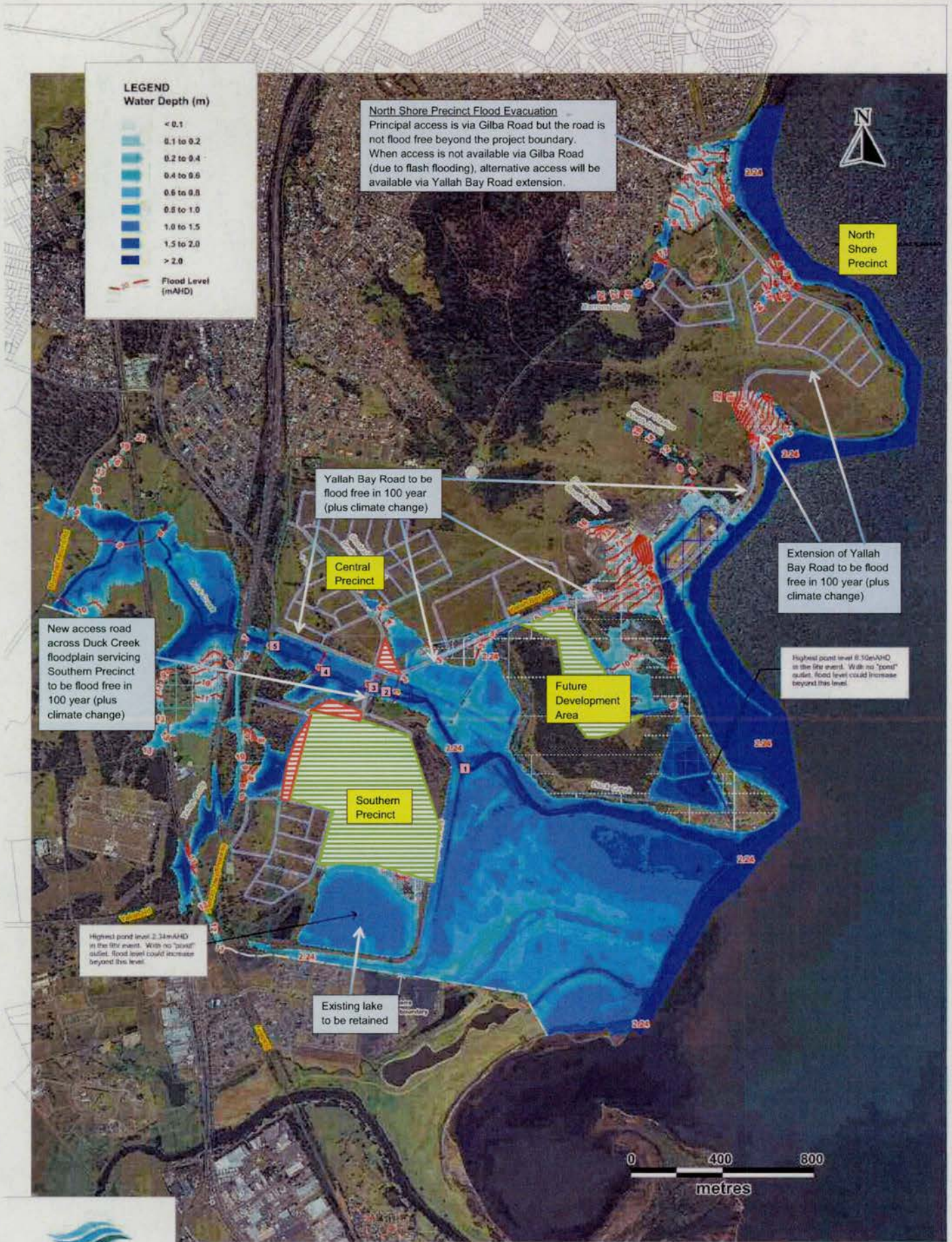
Residential	
Hillside residential/large lots	
Landscape improvements	
Employment - neighbourhood centre	
Employment - enterprise/business	
Employment - industry/business	
Retirement living (possible use)	
Primary school (possible use)	
Tourism	

TRUenergy - Tallawarra lands

0 1500m



concept plan
7 May 2012



LEGEND
Water Depth (m)

- < 0.1
- 0.1 to 0.2
- 0.2 to 0.4
- 0.4 to 0.6
- 0.6 to 0.8
- 0.8 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- > 2.0

Flood Level (m-AHD)

North Shore Precinct Flood Evacuation
Principal access is via Gilba Road but the road is not flood free beyond the project boundary. When access is not available via Gilba Road (due to flash flooding), alternative access will be available via Yallah Bay Road extension.

Yallah Bay Road to be flood free in 100 year (plus climate change)

Extension of Yallah Bay Road to be flood free in 100 year (plus climate change)

New access road across Duck Creek floodplain servicing Southern Precinct to be flood free in 100 year (plus climate change)

Highest point level 8.30el-AHD is the life event. With no "pond" outlet, flood level could increase beyond this level.

Highest pond level 2.34m-AHD in the life event. With no "pond" outlet, flood level could increase beyond this level.

Existing lake to be retained



Job No: J1260
File: Tel_EngBU100y_02
Date: 15 Dec 2010

- Development fill areas beyond current filled /bunded areas
- Development fill areas within current filled /bunded areas
- Locations of Flood Level Comparisons (refer Table 1)

Figure 2:
Existing Conditions 100 Year ARI Flood Envelope
Floodplain Fill Areas and Evacuation Routes