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Queensland Floods Commission of Inquiry
GPO Box 1738
BRISBANE QLD 4001

By Email

Attention: Ms Jaclyn Rolfe

Dear Madam

DRAFT QUEENSLAND DEVELOPMENT CODE

I refer to your email communication of 13 December in relation to the proposed Draft Queensland Development Code (QDC), and our subsequent discussions at your offices on 14 December. I confirm that I am able to address the scopes of work on the QDC for both hydrology and structural engineering. I provide the following relevant information in those regards. I note that I am required to assume the following in providing this advice:

- A building is to be built on a single lot within an area designated by the local government as a natural hazard management area (flood)
- The local government has not
    - declared an expected flood level
    - adopted a highest recorded flood level for the lot
    - designated an inactive flow or backwater area
    - specified a maximum flood velocity
- There are no existing relevant hydrologic or hydraulic models available to the applicant

I also note that my advice is sought in respect of questions relating to a previous report that I prepared on backflow stormwater flooding. I have also addressed this requirement on the next page.

Hydrology Scope of Work

The scope of work required is defined by the following questions.

What is involved in determining:

1. the defined flood level for an individual lot?
2. the defined flood level for the part of the lot on which the building work is proposed, rather than the entire lot?
3. whether or not there needs to be an allowance for the possible effects of wave actions in determining the defined flood level?
4. the expected maximum velocity for an individual lot?
5. whether an area is an inactive flow or backwater area?

Structural Engineering Scope of Work

The scope of work is defined by the following questions.

1. What would be involved in demonstrating compliance with Performance Requirement 1 of the draft QDC including an explanation as to

    a. what type of information would be required to prepare a design that complies with Acceptable Solution 1?
    b. whether a design can be prepared to demonstrate compliance without complying with Acceptable Solution 1?
    c. the cost implications of demonstrating compliance.

2. What would be involved in demonstrating that it is reasonable to expect a lot to be subjected to a maximum flow velocity of less than 1.5 m/s?

3. Whether I agree with the recommendation of the Queensland Floods Commission of Inquiry in respect of the draft QDC?

Before addressing these questions, it is necessary to consider the specific requirements of the draft QDC.

Stormwater Backflow

In my report to the Commission on stormwater backflow (Exhibit 868, known as 'Trevor Johnson Cardno report, Queensland Floods 2011 Stormwater Backflow, Prepared for QFCI September 2011'), the following statement was made in paragraph 13.

> ***Backflow flooding will continue to be a problem for most near-coastal local authorities in Queensland, and will be significantly exacerbated if climate change predictions for sea level rise become reality.***

I have been asked to consider this comment in light of the following questions for the Queensland Floods Commission of Inquiry:

1. Notwithstanding the issue of climate change, is backflow flooding something that also affects in-land councils (as opposed to near-coastal councils)?

2. If so, would it be appropriate for those councils to also consider whether a backflow flooding risk assessment is required?

I advise that backflow flooding certainly may arise in respect of inland rivers and waterways. All local authorities in Queensland, and not simply those in coastal areas, should therefore determine whether a backflow flooding risk assessment is required for their communities. The comment in my previous report related primarily to the potential impacts of climate change, and could have been better worded to state that all areas of the state may suffer from potential backflow flooding problems.

Draft Queensland Development Code

The principal intent of the draft QDC appears to be to set appropriate construction and electrical service standards for residential and other building development in flood affected areas. In particular, compliance with the QDC involves the nomination or determination of flood levels and flow velocities in such areas. This information will then be used so that appropriate structural design of the building can occur, and relevant measures are adopted for the safe provision of various infrastructure services (defined in the QDC as utilities). A third part of the QDC requires connections for sewer to be protected against backflow by the installation of a suitable reflux (non-return) valve in the sanitary drain.

It is obviously sensible for the Queensland Government to seek to impose requirements to improve flood protection and building resistance. However, it is also sensible to expect that these requirements can be reasonably and cost-effectively complied with. The Queensland Floods Commission of Inquiry is currently reviewing the possible operation and effect of the draft QDC. In that regard, I have considered the potential requirement for an individual home-owner to determine design flood levels and peak flow velocities in the situation where the local authority cannot supply this information.

Once the level and velocity information is determined, the draft QDC requires the applicant to assess the performance of the building during the design flood event. The Acceptable Solution adopted by the draft QDC for criteria P1 (see below) is compliance with the requirements of the draft national standard.

MP 3.5 – CONSTRUCTION OF BUILDINGS IN FLOOD HAZARD AREAS

	PERFORMANCE REQUIREMENT		*ACCEPTABLE SOLUTION*
	Buildings in flood hazard areas		
P1	A *building* must be designed, constructed, connected and anchored so that, in the event of a flood up to a *DFE*, it: (a) resists flotation, collapse or significant permanent movement, resulting from: (i) *hydrostatic action*; and (ii) *hydrodynamic action*; and (iii) erosion and scouring; and (iv) wind; and (v) any other action; and (b) safeguards occupants and other people against illness and injury caused by flood water affecting the *building*.	A1	The *building* complies with sections 2.6 – 2.11 and section 2.13 of the *draft national standard*. Note: 1 The definitions for this Part apply for the purpose of interpreting sections 2.6 – 2.11 and section 2.13 of the *draft national standard*. 2 Where A1 does not apply to a *building*, or part of a *building*, (refer to limitations in this Part), an *alternative solution* will be required to comply with P1. To formulate an *alternative solution*, the services of an engineer may be required.
P2	*Utilities* associated with a *building*, other than an electrical meter for a *class 1 building*, must be designed or located to reduce the effects of flood water on the *utilities* in the event of a flood up to a *DFE*.	A2	*Utilities*, other than an electrical meter for a *class 1 building*, are located above the *flood hazard level*. Note: Electrical installations must be installed by a licensed electrician. Electrical meters must also be installed in accordance with electrical entity requirements.
P3	A sanitary drain for a *building* must be protected so that in the event of a flood up to a *DFE* the effects of flood water on the *building* are reduced.	A3	(1) A sanitary drain for a *building* is protected from backflow by a reflux valve fitted between the building and the connection point. (2) A reflux valve fitted under (1) is accessible for maintenance.

Note: Some planning schemes may not permit development be to be carried out on land prone to flooding. Check with the Local Government in the area to determine what land use restrictions apply to the lot.

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MP 3.5
Construction of buildings in flood hazard areas

The draft national standard referred to here is the Draft Standard for Construction of Buildings in Flood Hazard Areas (Version 7, October 2011). This Draft Standard specifies flood loading criteria for Class 1, 2, 3, 9a health care and 9c buildings, and Class 4 parts of buildings, as per the draft QDC. In effect, the Draft Standard provides a blueprint for calculating the forces of flood waters on residential buildings based on relevant engineering formulae and methods. In that respect, it is not so much an Acceptable Solution as a design note. While there might be other formulae and methods available for structural analytic purposes, the concept remains unchanged, ie sufficient analysis must be completed to quantify the forces applied to the structure by flood waters up to the Defined Flood Level.

This quantification relies upon the value of the peak flood level (ie the height of water against the building) and the peak velocity of flow acting against the building.

I also note that the underlying designation of a Natural Hazard Management Area (Flood) may also be considered problematic in the situation where there is either no flood model, or no determination of a peak historical flood level. Under these circumstances, it is likely that the designated area will be conservative (ie larger than actually required) and more people will be affected than if accurate flood level information was available. It is of course possible that a landowner could then be put to the expense of a detailed study which showed that his or her land was unaffected by flooding. This would seem to be a very undesirable outcome for an individual home owner.

Hydrology Requirements

The questions to be answered are as follows.

What is involved in determining:

1. the defined flood level for an individual lot?

Determination of relevant flood level and flow velocity information will rely on some form of flood modelling. In the absence of appropriate information from the local authority, a home-owner will be required to commission a flooding investigation to be carried out by a suitably competent and experienced person. In most cases, this will be a university-qualified engineer. The extent (and cost) of the required flooding investigation will depend upon the specifics of the situation, ie what is the size and complexity of the watercourse or flow path affecting the property.

Two different models will be required. Firstly, design flow rates (eg the 100 year Average Recurrence Interval hydrograph) need to be calculated using a hydrologic model such as the Rational Method, RORB or WBNM. Based on this information, a hydraulic model would be developed. This could be as simple as a set of hand calculations, but would normally require a computer model ranging from a backwater model such as HEC-RAS up to full linked 2-dimensional model such as MIKE-FLOOD or TUFLOW. The hydraulic model will also require relevant survey information which would normally require input from a licensed surveyor.

2. the defined flood level for the part of the lot on which the building work is proposed, rather the entire lot?

Flood modelling will normally provide information at a set of user-defined locations which are independent of allotment boundaries. However, the hydraulic model clearly needs to be accurate enough to differentiate adequately between different locations. The level of accuracy achieved relies heavily on the quality of the survey information available, and the type of model selected.

3. whether or not there needs to be an allowance for the possible effects of wave actions in determining the defined flood level?

This is a site-specific requirement dependent again upon the particular characteristics of the area being modelled. In a terrestrial situation (rather than a coastal one), the type of waves considered would normally be those generated by vehicles or boats passing by. In that context, the normal freeboard allowance of 300 mm would usually be considered sufficient to safeguard a habitable floor against overtopping.

For a coastal location, wind-generated wave impacts will often be critical to the protection of a building, and detailed wave climate analyses would usually be required. This requirement is specifically excluded from the draft Australian standard.

4. the expected maximum velocity for an individual lot?

The flood study referred to above in the answer to Question 1 would provide flow velocity information as well as flood level. Again, however, the requirement would rely upon the accuracy necessary. For example, a backwater model relies on cross-sections of flow, and assumes a constant horizontal velocity across a particular cross-section at any specific time. This is obviously a significant simplification of the actual situation where velocity varies in three dimensions. The assumptions implicit in the choice of hydraulic model need to be well understood by the engineer so that a suitably accurate model is adopted. In many cases, this may require utilisation of a 2-dimensional model with attendant complexities and costs.

5. whether an area is an inactive flow or backwater area?

Again, the flood study referred to in the answer to Question 1 will provide the relevant information. However, interpretation by the engineer will usually be required to assess the situation accurately. The determination of an inactive flow area would usually require the use of a 2-dimensional hydraulic model, since 1-dimensional models assume a constant velocity at any time across a flow section which may be several hundred metres wide.

Also, it must be recognised that a hydraulic model will not display a consistent zero velocity result except in very isolated situations. In most real world scenarios, the occurrence of inactive flow or backwater areas will be determined by areas of velocity less than say 0.2 m/s. The designation of an inactive flow area may therefore require skilful assessment by the engineer.

Hydrology Conclusions

In my experience, the reasonable minimum cost of a flood study would be about $20,000, and this cost could increase to several hundreds of thousands of dollars for a major stream, or one where there was significant two-dimensionality of the flow. Survey alone would be a major component in the latter case. Timing to undertake such investigations would range from perhaps 2 months to 12 months or longer. Further, if the study is not based on available flooding information (which could be used to calibrate the model and affirm its accuracy against historical floods), its accuracy may be questionable, and the findings may be significantly disputed by the local authority. In that situation, further significant time delays are likely to occur in the planning approval process.

In the context where flooding information is not available from the local authority because of the cost of investigations, it is difficult to see how an individual land owner would be in a position to fund such work. This also raises the questions of equitable treatment between landowners in a particular area. Presumably, the first landowner in an area would be required to bear the full cost of the flooding investigation. Others following in this path might be able to utilise at least some of the available information and therefore reduce costs significantly.

Currently, if an existing hydraulic computer model has been developed by a local authority, it will normally be made available to consulting engineers acting for landowners so that potential disagreements on modelling processes are largely avoided. This is a process which has consistently worked well in my experience. The alternative, of having a number of competing model analyses for the same area, is both inefficient and potentially confusing in my opinion.

Secondly, if the local authority does not have the expertise to undertake the study, it almost certainly will not have the expertise to adequately review a study undertaken by others. This may have a significant impact on the quality of work accepted, and the subsequent potential risk profile for an individual residence.

It could be argued that approximate information could be used by a land owner at a much reduced cost. However, it would still be a requirement for a suitably qualified person to undertake this work, and to make the assessment that the quality of the investigation was appropriate. The efficacy of landowners funding a range of flooding studies within the same catchment, with attendant differences in results and interpretations seems questionable to me. In addition, a reduction in the accepted accuracy of the flooding analysis leads directly to an increased risk. Depending upon the type of modelling undertaken, and the level of expertise applied, results may vary widely.

In my experience, the review of detailed flooding studies currently provided to local authorities is often a contentious issue involving time delays and eventual litigation in the Planning and Environment Court. The QDC process has the potential to significantly increase the level of dispute by potentially requiring every home builder in a designated area to independently commission flood studies.

I believe that having either the local government or state government fund the work to carry it out properly is probably the only practical solution available. If desirable, these organisations could then seek to recover the cost from landowners in the future as development occurs.

I also note that criterion P3 of the draft QDC requires the fitting of a non-return valve in the sanitary drain which connects the building to the municipal sewerage reticulation system. This installation will prevent backflow in the sanitary drain during a significant flood event, and this concept is sound. However, significant sewage contamination during flood events comes from surcharging in the reticulation system and consequent surface discharge of sewage. This occurrence will not be affected by the placement of a valve in the sanitary drain. In addition, non-return valves in sewerage pipes are prone to blockage and may cause increased head losses which in turn will lead to increased pipe sizes. The installation of such valves should therefore only be considered in situations where it is likely that sewage surcharging could occur.

Structural Requirements

1. **What would be involved in demonstrating compliance with Performance Requirement 1 of the draft QDC including an explanation as to**

    a. **what type of information would be required to prepare a design that complies with Acceptable Solution 1?**

Firstly, a structural analysis of the proposed building frame would be required, taking into account the forces imposed on the structure by flood waters. There are two types of force involved. Hydrostatic forces are those caused by stationary flood waters, and would involve potential uplift forces on ground slabs, as well as lateral forces acting on walls. Hydrodynamic forces are those caused by moving water, and are analogous to wind loading on a building, such that the faster the water, the higher the loading.

Finally, the finished floor level of habitable rooms must be located above the designated flood level plus freeboard, and the finished floor level of enclosed non-habitable rooms must be no more than 1.0 m below the designated flood level.

b. whether a design can be prepared to demonstrate compliance without complying with Acceptable Solution 1?

In general, no. Compliance with the major sections of the Draft National Standard requires determination and assessment of loading, based on the depth of water and velocity of flow. In that regard, calculation of forces is an engineering requirement based on proven formulae and methods. While different methods might be available, the outcome will be the same, namely that a detailed structural assessment is necessary. Perhaps the only area where compliance could be achieved without relying on Acceptable Solution 1 is in respect of floor levels. In some cases, it may be argued that lower habitable and non-habitable floor levels might be acceptable. However, given that the engineering criteria specified in the Draft National Standard are in accordance with standard best engineering practice, it is doubtful that much variation would be approved.

c. the cost implications of demonstrating compliance.

The cost implications of compliance with the QDC are two-fold. Firstly, there is a cost of engineering assessment for both hydraulic and structural purposes. Secondly, the increased loading on the building may increase the cost of construction, particularly if a velocity of 1.5 m/s occurs. However, it should be carefully noted that there is no reasonable alternative to the strengthening of the building, at least from an engineering point of view. Engineers comply with design standards which have been developed over time to be conservative and to achieve safe buildings where risk to property and life is very low. If it is known that a flood could impose loading on a building, the engineer has a professional responsibility to take that loading into account.

2. What would be involved in demonstrating that it is reasonable to expect a lot to be subjected to a maximum flow velocity of less than 1.5 m/s?

There would need to be sufficient hydraulic analysis by way of the flood study nominated above to allow accurate determination of flow velocities. Secondly, and more importantly, it would be necessary to determine that a house could reasonably be able to withstand the associated lateral loading with relative minor changes to the structural elements. For example, Section 2.6.3 of the Draft National Standard provides a formula which allows velocities to be converted into an equivalent depth of hydrostatic loading. For a velocity of 1.5 m/s, the increase in hydrostatic depth will be about 143 mm. Given that hydrostatic force is proportional to the square of the height of water, an increase in depth from 1.0 m to 1.143 m will increase the hydraulic force on the wall about 31%. Design wind loading pressure on the walls and roof of a house is of the order of 1 kPa. In comparison, the average water loading pressure from a 1.0 m height of water will be approximately 4.9 kPA over the 1.0 m depth. Depending upon the height of the water, water loading may therefore impose a significant force on a building, and an increase in that loading of 30% or more is relevant if a velocity of 1.5 m/s is applied.

The adoption of 1.5 m/s as the reasonable limit for a house is probably also connected to the question of public safety. Velocities in excess of 1.5 m/s (depending on the height of the water) would be considered dangerous to pedestrians for depths in excess of about 0.4 m. In addition, flow velocities in excess of 1.5 m/s are likely to cause erosion, particularly around unprotected foundations.

3. Whether I agree with the recommendation of the Queensland Floods Commission of Inquiry in respect of the draft QDC?

I agree that imposition of a requirement to determine flood levels and flow velocities is impractical (and maybe unreasonable) in the situation where the local government is unable to provide any relevant information or flood models. The reasons for this are explored in detail above, but include:

- Cost of studies, particularly if the local government has determined that it is too expensive for it to undertake such investigations.
- Variability of outcome, particularly if many landowners are affected.
- Non-acceptance of the information by the local government.
- Applicability of the designation of the area for natural hazard (flood).

Structural Conclusions

There is no doubt that buildings constructed in flood-affected areas should be assessed for both level of habitable floor as well as structural stability. The underlying requirements implicit in the QDC are therefore sensible, and comply with standard engineering practice. The requirement to assess building performance under flooding conditions is therefore eminently supportable. The adoption of 1.5 m/s as the maximum allowable velocity is also consistent with risk management and best engineering practice.

There are several reasons, therefore, why suitable structural analysis should be undertaken based on nominated flood levels and peak flow velocities. The difficulty, of course, is how to accurately obtain this flooding information.

Final Conclusions

In my opinion, the requirement of the draft QDC for individual landowners in flood-affected areas to commission and fund suitable flooding studies to determine peak flood levels and flow velocities is unlikely to yield successful outcomes for either those individuals or the community as whole. While the requirement for structural flood loading on residential buildings to be assessed is fully supportable, the accurate determination of the underlying flooding data would best occur if the relevant studies were undertaken by either the relevant local government or the state government.

I also confirm that the concept of putting a non-return valve into an affected building's sanitary drain is supportable, but that there are practical limitations which mean that such valves should be installed only where they are deemed necessary.

Yours faithfully

[redacted]

Dr Trevor Johnson
Director
for **Cardno**