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All over Brisbane**

Queensland Floods Commission of Enquiry
PO Box 1738
Brisbane   4001

26 April, 2011

Dear Sir/Madam,

Having been directly impacted by the flooding, both personally (flooding of our home) and professionally (flooding of a major development site of ours), and having fully read SEQWater's report ("**the Report**") on Somerset and Wivenhoe dam management during the 2011 flood as well as the statements of, and transcripts of cross examination of, the four engineers ("**the Engineers**") controlling operations of the Wivenhoe dam, we submit the following points, further to our earlier submission of 9th March 2011, for the Commission to consider on behalf of our development company Eastbank Developments Pty Ltd and real estate agency Phil Hassid Flats Sales (please note that whilst we are not engineers or hydrologists, Phil has degrees in mathematics and is absolutely qualified to make observations of a general quantitative / probabilistic / mathematical modelling nature):-

1.   FLAWED, CLOSED-LOOP MANUAL DESIGN PROCESS ENTRENCHED FLAWED RISK
         ANALYSIS, FLAWED CONSEQUENT SYSTEMS DESIGN & SELF REFERENTIAL DEFENCE

         When a small group of (similarly focussed) people design the rules they will operate under without significant independent external crosschecking and without input by stakeholders affected by those rules, the resultant system is one that entrenches blind spots or analytical weaknesses. In this case the designers of the process by which the dam operation manual ("**the Manual**") was itself to be designed failed to understand and thus allow for the fact that the Engineers are not experts in deciding on the relative cost of the impacts of alternative dam management actions (the province of financial experts), nor in designing the conceptual (systems) approach required to best produce procedures that result in an inverse relationship between cost and likelihood of occurrence across all scenarios (the province of systems engineers /analysts), but they are only experts in translating the prescribed systems approach into actual dam management actions (and even that needs to be independently checked).

         The obviously poor judgment in respect of areas outside their expertise that the Engineers demonstrated by their actions and their testimony (see below) is therefore no surprise. Furthermore it has resulted in the totally unacceptable situation of the Engineers attempting to deflect many criticisms of their actions and disprove the benefits of alternatives simply or principally by recursive reference to their own Manual! Then if the manual itself is questioned, the crossexaminers appeared to repeat the Manual design process error by simply deferring to the Engineers' engineering experience without any reference to the issue of expertise in assessing relative cost of impacts or of systems design. (It must be stressed that systems design is most definitely a vital separate major area of specialisation which has nothing whatsoever to do with hydrology, dam engineering or water management. Leaving it to non-specialists gives the results we see).

2.   CURRENT RULES UNNECESSARILY GUARANTEE MAJOR FLOODING IN MAJOR EVENTS AND
         THIS MUST BE REDRESSED BY A TRANSPARENT RISK ANALYSIS, A CHANGE TO CURRENT
         PRIORITY IMPLEMENTATION, REPHRASING THE SECOND PRIORITY & INCLUDING IPSWICH

         The Engineers have explained their approach. That approach contains a heavy bias (see below) towards protecting areas vulnerable to low level flooding, meaning that the ability to avoid major flooding in major events (especially multi-peaked ones as per 2011) is greatly reduced if not eliminated. (One suspects that arises because the relevant risk factors have not been properly identified by the Engineers insofar as they frequently refer to flood mitigation generally but rarely if ever mention major flood avoidance per se. As further evidence, the Engineers use the fear of worsening things downstream - most often meaning in regard to low level flooding - to justify many actions and decry obvious alternatives, whilst having clearly taken no account of the possibility of, and having declared as inevitable and presumably to be expected again under similar circumstances, the worst possible outcome of perfect alignment of their biggest - and only - release spike's arrival downstream with maximum flows downstream!).

In reality, despite the greater frequency of potential low level flooding, the cost impact alone of major flooding so drastically outweighs that of low level flooding that proper risk analysis would surely conclude that the emphasis of dam management rules must change drastically. Before any attempt is made to permanently change the rules, thorough risk analysis must be carried out (and made open to public input and viewing) by suitably qualified experts (accountants, economists etc). Public and private costs must be professionally estimated for every level of flooding and a clear and fair principle must be enunciated as the basis upon which avoidance and mitigation priorities should be deduced.

Then systems analysts must devise a systems approach to ensuring those priorities will be reflected in the appropriate inverse relationship across all scenario types and that approach should be open to public comment. Then engineers can translate that approach into actual instructions and that also should be open to public comment. (Systems approach and actual interpreted instructions should appear publicly together because there will unavoidably be some overlap - simple concepts such as "release water" don't need much interpretation - so there should first be a couple of loops between systems analysts and engineers so that, for example, physical impossibilities or known very undesirable actions aren't necessitated by the system).

In particular, the Manual's system of graduated strategies as it currently stands is inherently flawed insofar as it tends to undermine if not actually alter the identified primary list of priorities. Specifically, that system obligates engineers at times to take actions which are overwhelmingly, if not fully, defined in relation to low level priorities, whereas adherence to the primary priority list would have engineers obligated under all circumstances to first, and immediately, take actions that take prudent account of the possible (as opposed to almost certain) occurrence later in the flood event of higher priority incidents before even thinking about lower level incidents. Because the Engineers will undoubtedly assert that this somehow, magically, was happening, (and that, to the extent it was happening, and contrary to their testimony, they weren't requiring virtual certainty) effort should be made to specify as far as possible, a minimum threshold probability of occurrence demanding certain high priority derived actions (this probability necessarily would be derived from the various models and from rainfall forecasts with their attendant probabilities). See specifics in 4.

The argument that the inaccuracy of the best available particular rainfall predictions should preclude them (or any such predictive component) from contributing to actions at the time is entirely fatuous and typical of the lack of capability of the Engineers in assessing risk. By definition prudence means taking proper account of the full probability / cost spectrum ("expected outcome" in probability jargon), not the best case scenario (as Mr Rangieh rightly pointed out in his cross examination). And surely nobody in their right mind would suggest the dam should not be operated prudently during flood events! (With respect to all priorities, not just dam security, but again reflecting the order of priorities at all times).

Finally, avoiding *major* flooding is not even enunciated as a priority in itself. Simply saying "avoiding urban flooding" does not properly convey the point that there is a great distinction between flood levels. So the 2nd priority should be rephrased (and Manual rules must refer to river levels at Brisbane and Ipswich).

3.   THE ONLY OPERATIONAL DEFENCES AGAINST MAJOR FLOODING ARE ANTICIPATORY RELEASES & FAST REACTIVE RELEASES. THE ENGINEERS MAY HAVE INTENTIONALLY UNDERSTATED THE BENEFITS, POTENTIALLY DENYING US THOSE DEFENCES

Increasing the dam height would help avoid major floods, but it comes at great cost and long realisation delays. By comparison two elements of dam operation come with little cost and little implementation time. *Anticipatory releases* lower the starting point and thus logically provide more buffer to work with. But there is an assumption, raising questions as to motive (see below), in Engineer Terry Malone's modelling thereof in his second statement, whereby he disallows the obvious benefit sought by this approach by insisting that no releases be permitted until full storage level of 67m is attained (in keeping with *his* rules).

Fast, significant, proportionate, *reactive releases* when levels exceed 67m and inflows occur, would set aside the inbuilt overconfidence and poor reflection of priorities of the Engineers' approach and ensure that, whilst incurring some low level flooding, major flood avoidance is kept as the highest avoidance / mitigation priority. Mr Malone's attempt to show in his statement that such an approach offers no significant benefit once again contains several unnecessary and counteractive assumptions again raising questions as to motive (see below). Firstly Mr Malone conveniently redistributes the releases such a strategy properly enacted would involve, reducing early releases and introducing a bigger than necessary (see below) later spike. This has the effect of directly countering the benefit of such a strategy.

Secondly, he justifies the size of that later spike by recourse to his own rules (when you get to 74m you rapidly up the release till it exceeds inflow). At the same time he conveniently avoids charting his hobbled version of this strategy on 9.1.2 of the Report because doing so would make it obvious that the situation prevailing at the time of arrival at 74m under that hobbled version (3pm 11th January he says, which is earlier than such arrival would be in a genuine version - late evening) is totally different to that prevailing when 74m was actually arrived at (mid to late morning on 11th January). In the former, inflows had greatly reduced from the peak and were still rapidly reducing, whereas in the latter inflows were very high and still increasing. It is doubtful that even he would have reacted in the same way in the two situations.

Thirdly, and more subtly, Mr Malone offers an explanation for the lack of benefit of the early (reactive) release strategy, namely the attenuation effect of the structure of the Brisbane River and its surrounds as a series of flood plains each followed by a constriction point in the river. The implication is that flow rates through each constriction point will derive from a "passage" formula mostly dependent on volume of water backed up awaiting passage, or to put it another way, the delay in a certain volume of water passing through the constriction point compared to its rate of progress at unconstricted points is mostly dependent on the size of that volume. Hence, Mr Malone argues, roughly speaking, that there is no point sending some of that volume a bit earlier as it will still all back up and the outcome will be the same.

Mr Malone's contention is reasonably easy to test. Looking at figure 9.1.2 of the Report one can see that the release spike on the 11th of January lasted about 24 hours. Now looking at figure 8.10.3 of the Report one can see in case 3 (Wivenhoe releases only) that the consequent river level spike (above the surrounding noise) is approximately 36 hours in duration (with the peak 33 hours after the release peak). This represents a maximum overall flow delay of 12 hours (the average would be less). Even if total flows are looked at, the delay is not much more. From 9.1.2 we see that the entire double spike rain event lasts 3 days. If we assume that that reasonably approximates the duration of the rain events causing downstream inflows, we see from 8.10.3 that the overall main river level spike (above surrounding noise) lasts about 3.5 to 4 days.

The point is that an early release spike on the 9th / 10th would begin to materialise in the river levels as in 8.10.3 on very early am on the 11th (and would be smaller than the existing case 3 spike). Clearly there would be enough time for the bulk of the flow from that release to avoid coincidence with the bulk of the case 2 (No Wivenhoe releases) flows as there is enough time separation. This would then materialise far more dramatically on the overall river levels than Mr Malone has shown (total flow is just case 2 and case 3 added together, but case 1 [total actual flow] in 8.10.3 also spreads out precisely because cases 2 and 3 are entirely coincident, whereas the suggested early release would avoid that, although later releases wouldn't).

As to motive, it seems unlikely that Mr Malone would not be aware of the way in which the assumptions that he injects into those strategies for his model inputs, are obviously contrary to the objectives of the proposed strategies, and also impact the outcomes in the modelling (in respect of which he has undoubted expertise) in ways favourable to his contentions. The other Engineers have endorsed Mr Malone's modelling and thus should share the consequent doubt as to motive. A finding casting doubt on motive in this matter might then possibly put other aspects of the testimony of the Engineers in question. This then might lead to the question as to possible forces driving such motives which is discussed later (see below).

4.   FLAWED APPROACH TO REFLECTING PRIORITIES IN RULES BY MEANS OF MUTUALLY EXCLUSIVE STAGES MUST BE REPLACED WITH UNIVERSAL CONCURRENT RULES SO ALL PRIORITIES ADDRESSED AT ALL TIMES IN SAME ORDER (MATCHING PRIORITY ORDER)

In Appendix 1 we suggest an approach to system design referred to above given Phil's qualifications (in the distant past) & aptitude in this field. The current approach where there are seemingly different priorities at different dam levels (W1, W2, W3 and W4) is inherently flawed because there is no way to properly or simply take account of more important priorities (which surely must be considered at all levels) within lower strategies. This is precisely where the systems design thinking of the Engineers (and hence the structure of their Manual) fails. Instead, what should maintain is a universal, concurrent set of rules, comprising of some general (definitional) rules independent of priorities (to help clarity) plus one or two rules per priority, with the relative importance of the priority-based rules always reflecting that of the priorities. (Two rules are needed for each flood avoidance priority - one requiring release and one limiting it). The rules are numbered in descending order of priority so that there is never any confusion as to what should be done. In other words, at all times the check list starts at the first rule then works down the list to the last one. The first encountered trigger must be responded to in the designated way, and any subsequent triggers can only be responded to to the extent that that doesn't detract from higher priorities. (Suggested rules below take it a step further embodying all inputs in adaptable formulas, so you only need first trigger).

The biggest factors directly influencing events, and thus sensible responses, are dam inflows, dam lake level and river levels (other factors such as rainfall contribute to those so are indirect influences). Previous rate of outflow also contributes. As pointed out earlier there is no reference to river levels in the Manual at all, and it similarly defies all common sense that the Manual only has reference to inflows in W4. The only major factor appearing throughout the current rules is dam lake level. The results of this omission are plain to see (ie an avoidable major flood). To have responses that are not directly related to all the primary influencing factors constitutes arbitrariness. (And the reduction to 75% after the flood was another arbitrary act which should instead have been replaced by the Anticipatory release rule below). In the suggested rules below, the common structure is therefore proportionality to inflow rates and reference to dam lake, river levels and previous outflow rates. (Sustained proportionality to inflow rates constitutes proportionality to inflows). This consistent rule structure produces a desirable relative clarity. Finally, rules should be in a form that can easily adapt to dam structure changes with minor parameter changes (the rules below do that as well).

It is anticipated that the Engineers might claim that the current strategies operate in the above suggested way because one is always assessing if all the rule preconditions are being met. But it is in having (or, as we have seen, messily attempting to have) those preconditions be mutually exclusive (hence giving the staged response structure) where that claim would fall down and the problem arises. The objection that the Engineers have with using predictions as active components in triggers is also an ideological barrier to the better approach put here, but the suggested approach provides the inbuilt ability to temper its impact.

The final important point to be made about these rules is that the format (ie the system) has nothing to do with hydrology, dam engineering or water management. Where these areas of expertise (and requisite modelling and research) do come in is in evaluating the optimum details such as functions used in formulas (simple as shown here or more complex), number of "situations" (see below) in any given rule, scaling factors (see below), constants and priority (and hence rule) order. The functions, scaling factors and constants volunteered in the suggested rules below are a good sensible starting point. They must be researched and subjected to public scrutiny, and the system should be scrutinised by systems analysts. "Situations" can be added to rules over time reflecting new experiences. Over time they should morph into a mathematical model. The suggestions in Appendix 1 assume current dam structure.

5. FUSE PLUG DESIGN IMPROVEMENT NEEDS ANALYSIS, TO MAKE OPTIMUM BENEFIT OF DAM AVAILABLE & REMOVE CONSTRAINT ON MAJOR FLOOD AVOIDANCE CAPABILITY

The fuse plugs act for dam structural security by causing unavoidable releases under trigger conditions (the attainment of the triggering dam levels). The fuse plug trigger levels (fuse plugs 1 to 3) are 75.7m, 76.2m and 76.7m respectively, and the released flows upon plug erosion (time it takes to erode is unknown) are 1,700 m³/s, 4,000 m³/s and 5,000 m³/s respectively, so the cumulative flows are 1,700 m³/s, 5,700 m³/s and 10,700 m³/s respectively. Crucially, once fuse plugs erode, flows continue through the fallback (auxiliary) spillway until the dam level returns to 67m (although it isn't clear if the flow rates stay the same).

However the impact of the design of the fuse plugs greatly reduces the dam's mitigation capabilities. The problem is that the consequences of fuse plug erosion (flow rates, duration) are so unavoidably punitive that avoiding fuse plug erosion effectively replaces dam overtopping as the "avoid at all costs" dam structure security priority. And if two or three of the fuse plugs are triggered the current 74m "avoid reaching 75.7m at all costs" point would have to be lowered to a 65.3m "avoid reaching 67m at all costs" point until the fuse plugs were rebuilt (which apparently can't happen during a wet season). This may be fine from the point of view of the engineering principle of redundancy, but it unnecessarily overdoes that and at the same time unnecessarily distorts and constrains the (rephrased) second priority of avoiding major flooding. And of course it causes that huge temporary reduction in capacity post fuse plug triggering.

The fuse plugs are designed the way they are to cater for a situation where gates in the main spillway get blocked or malfunction somehow. Therefore the idea is that there be no possible impediment to the fuse plug enabled flows, hence the use of a temporary, eroding structure with a concrete base at 67m. But if a situation were to arise where, once some or all of the fuse plugs were eroded, inflows then reduced greatly and forecasts predicted no imminent rain, there is no means by which fallback (auxiliary) spillway flows could be slowed until dam levels returned to 67m, and yet doing so would not imperil the dam, nor reduce redundancy (providing the slowing device was properly designed).

It must certainly be possible to devise and construct a method that could slow or block those flows (only under clearly defined conditions) without breaching the original gate blockage / malfunction issue that spurred the inclusion of fuse plugs. What this would do would be to remove the aversion to triggering fuse plugs whilst not impeding their important function (flows from them, whether slowed or not, would then simply be calculated in the overall releases). This in turn would permit the (rephrased) second priority of avoiding major flooding, in the situation of greatly improved conditions mentioned above, to continue with little interruption after fuse plug triggering. Furthermore the 74m decision point would be much less important. That decision point could be moved up much closer to the trigger level for the first fuse plug (having just fuse plug 1 eroded for the balance of a wet season is not so bad).

Of course this suggestion falls into the same category as raising the dam wall (ie major works). But it's also a possible improvement, extracting better value from the existing. Adding that feature may also then make it easier to reconstruct the temporary fuse plug structures under otherwise more difficult conditions. Of course dam management rules would also have to be carefully designed to avoid the ease of recourse to fuse plug triggering creating any unintended distortions to implementation of priorities (especially dam protection). Finally the cost (and time to replace) fuse plugs would be recurrent, though infrequent (but one can confidently assume that the cost is not remotely of the order of magnitude of that of major flooding).

6. WHAT WENT ON BEHIND CLOSED DOORS? COST CUTTING? MUTUAL PROTECTION? IT IS RELEVANT TO THE ENQUIRY'S AIMS AND DOESN'T CONSTITUTE DESCENT INTO POLITICS. (AVOID THAT BY STOPPING AT EXPOSURE AND LEAVING THE REST TO THE ELECTORATE)

The thousands of Brisbane ratepayers who were flooded might be shocked to see what appears to be the counsel for the Brisbane City Council, Mr Dunning, cross examining the Engineers as though he were representing them (ie accepting and bringing to the fore all the Engineer's arguments). There seems not to have been even one moment of criticism of the Engineers from Mt Dunning as far as we can tell from a very quick scan of the transcripts (apologies if we have missed any). If that observation truly reflects the reality of what transpired, the question should be asked, given the publicly vented doubt as to the Engineers actions as well as as to what role, if any, the BCC played in having the Engineers amend their actions, did SEQWater (and / or the State government as its owner) and the BCC agree to a strategy of mutual protection? Even though the Commissioner has stated that this enquiry is rightly going to avoid politics, surely if such an agreement has been struck, that is relevant to the topic of identifying problems with the Engineer's actions (and by implication, their Manual), because, by definition, such an agreement would have the potential to alter or avoid testimony as to material facts (even if that potential weren't actually realised). We need to be sure.

In a similar vein, the possibility that the Engineers, in reality, may have been aware of some of the issues raised herein but were hamstrung by financial constraints imposed by the state government should be investigated. Clearly, choosing to raise the dam wall (and the fallback spillway holding the fuse plugs) adds to the dam's capabilities. Choosing to raise low bridges and roads greatly reduces the threat from low level flooding. Widening constrictions in the river increases the ability to separate flows and thus makes it easier to avoid major flooding. Dredging the river increases its holding capacity and helps avoid all flooding. It seems pointless to merely identify the direct causes of the mistakes that were made if greater forces prevented then, and would be likely to prevent again in the future, best possible actions. It all comes back to cost benefit risk analysis.

7. THE RISK OF BASING THINGS PURELY ON MODEL DOMINATED THINKERS DESIGNS

Over twenty years ago a client of mine who was a very experienced senior engineer who had designed mega projects around the world told me he was concerned by some of the engineers he had encountered who had gained their qualifications in the 80's. He observed that the engineers in question were over reliant on models and had a poorer grasp of concepts which in turn feed the common sense driven cross checking that serves engineers well. The Engineers are all products of that era and obviously it is not known if they suffer or ever have suffered from that deficiency, but the point is that it is an issue that one must generally constantly be on the lookout for. Things must be cross checked as well as being subjected to all the other areas of expertise rather than left to a small group of like minds *especially* expert like minds.

8. CLIMATE CHANGE - FALLBACK EXCUSE? ... LESSON WE HAD TO LEARN?

A comment in his testimony by one of the Engineers that we would have to get used to bigger and more frequent floods (assuming he meant it and it wasn't just a convenient hook to hang other challenged comments on) brings to mind another largely model driven issue, namely climate change (where the relevant models remain, as far as we can tell, a secret). This is raised here only because it has been observed that those who are disposed to argue the most vigorously in support of claims that climate change is the drastic issue of our time (and, we suggest other "millenial" or apocalyptic issues) tend also to be disposed to regarding those who do not share their views as being in need of being taught a lesson (and history has shown that such attitudes can go a lot further than that). Even though the Commission has a huge amount of ground to cover, it would be relevant, we believe, to ascertain if indeed such a culture contributed in any way to the events under investigation.

9. NOT BASING DESIGNATED FLOOD LINES ON BETTER DAM MANAGEMENT (PER ABOVE) EQUATES TO MAKING OWNERS OF UNNECESSARILY AFFECTED PROPERTIES SUBSIDISE DISPROPORTIONATELY AVOIDANCE OF EFFORT / COST OF PROPER FLOOD MANAGEMENT

We argued in our previous submission that the deemed rarity of the flood, taken together with the likely flood levels under our suggested improved dam management rules being below existing Q100 levels, meant that in fact Q100 levels should be *lowered* (representing the consequences of the suggested much better use of the dam's inherent flood mitigation capabilities). We also argued that long term cumulative costs (in terms of finance, insurance, property values and property development) of not doing so would eventually greatly outweigh the enormous direct impacts of the flooding. Finally we warned that it would be all to easy for councils to ignore the issue of better dam management and simply take the 2011 flood levels at face value thereby unnecessarily including many more properties or parts of properties in the "death zone" of impossible insurance, impossibility or massive worsening of terms of finance (the impossible insurance being a requisite - already happening), consequent property value (hence wealth) reductions, and greatly diminished property development potential (that being a cost to the community as well). Two questions have to be asked:-

Is it fair that the group of property owners unnecessarily included in such a "death zone" be so included in the absence of what would seem like a modest effort, in the scale of government capabilities, to identify and enact better dam management rules (and surely the above will help them)? Given the scale of impact on such people it seems ludicrous to answer in the affirmative.

Also is that fair in the sense that (ignoring the dam management issue) it effectively substitutes for expenditure on physical measures such as identified above (dam raising, low bridges etc)? Why should this relatively small group of people heavily subsidise a cost saving to the rest? (On the surface, the question could be posed the other way around, ie why should the rest pay for measures to help the few? But this is flawed because it breaches government's duty to protect all its citizens from systemic disaster if that can be reasonably done, because the alternatives such as property buy outs would be much more expensive if done fairly ie pre adjustment of Q100, and because that expenditure would actually benefit the rest, eg adding water storage capacity, reducing bridge / road closures etc). In fact one could expand that line of reasoning (and effect both dam management improvement as well as infrastructure works) to thereby remove many more people from that "death zone" than just those unnecessarily included by an adverse Q100 adjustment.

10. THE BREMER RIVER IS DYSFUNCTIONAL AND WORKS IMPROVING ITS FLOOD CARRYING CAPACITY WOULD SERVE VERY IMPORTANT OTHER PURPOSES AS WELL

The Bremer river should, like most urban rivers, serve as the focal point of development and activity that the Ipswich City Council says it wants it to be. And yet the fear of liability (and / or perhaps the lack of belief in the measures suggested below) makes the ICC push the boundary of developments that would constitute or enhance such focus further and further back from the river (their likely reaction to this flood despite the foregoing arguments being just the latest case) rather than having the foresight to push for more radical ways of accomplishing the desired goal.

Firstly the Bremer should be dredged. This will have the excellent extra benefit of making the river navigable, which in turn will change the whole way Ipswich people view the river and significantly increase their desire to be on it or around it. This in turn is the one key ingredient of the ICC's vision for the Ipswich CBD which currently lacks any realistic chance of being achieved, barring such a measure. And yet, based on experience virtually everywhere else, it is the absolute key to creating the vibrant environment that vision aims for. The recent profusion of coffee shops and other uses consistent with such vision attests to the inherent potential (and why wouldn't it exist?). But the ICC has refused despite repeated prompting to give such a measure the high priority it deserves. It seems to believe that an entirely passive interaction with the river will suffice. That may work if a place has other major things going for it, but, unless you count the characteristics the ICC lists as constituting such things (most of which would seem pleasant but unremarkable), that isn't the case in Ipswich, especially given its proximity to Brisbane and the Gold Coast.

Secondly, the Bremer should be widened. This can be done easily in many places. The most difficult are the constriction points, and engineering solutions (or even property buy backs to enable widening, where possible) should be sought for these points. Soil removed should be pulled up the slope so that development can come close to the river, where appropriate (in and near the CBD in particular), creating the right atmospherics. In the process, much needed attention can be given to river banks. This will also further add to navigability, increasing the attractiveness of regular commuter or at least tourist marine services. So the same things that will help protect Ipswich people from the Bremer will encourage them to embrace it. If the Qld government is serious about the Western corridor's role it must attend to this or admit that the Ipswich CBD is not the real intended long term heart of it (or that its vision is based on dreary price point alone).

Best Regards,

Phil and Koula HASSID

APPENDIX 1 - PROPOSED DAM MANAGEMENT RULES

PRIORITIES

Priority 1 - Avoid imminent overtopping　　　　　　　(based on without dam catchment rain forecast
　　　　　　　　　　　　　　　　　　　　　　　　　 or very short term catchment rain forecast)
Priority 2 - Avoid imminent fuse plug triggering　　　(based on without dam catchment rain forecast)
Priority 3 - Avoid more distantly projected overtopping　(based on with dam catchment rain forecast)
Priority 4 - Avoid causing or worsening major flooding　(based on with downstream rain forecast)
Priority 5 - Avoid projected fuse plug triggering　　　(based on with dam catchment rain forecast)
Priority 6 - Avoid river bank slumping
Priority 7 - Prepare for possibility of imminent subsequent
　　　　　　major rain event (ie fast post-flood drain down)
Priority 8 - Prepare for wet season (anticipatory releases)　(based on long term catchment / SEQ rain forecast)
Priority 9 - Avoid causing / worsening moderate flooding　(based on with downstream rain forecast)
Priority 10 - Avoid causing / worsening low level flooding　(based on with downstream rain forecast)

It is suggested that the above are sufficient and that any other issues would have lower priority than those listed above. As to order, one could argue that 2 and 3 should be reversed, that 4 and 5 should be reversed, that 6 should be lower, that 7 should be lower or higher, and that 8 should be lower. References to flooding refer to Brisbane and Ipswich. One could separate priorities referring to flooding into Brisbane priorities and Ipswich priorities but of course this would, in unusual circumstances, have the effect of pitting their fates against one another. Nevertheless it is suggested that if one were to do such a separation, the outcome could look like the following:-

Priority 1 - Avoid imminent overtopping　　　　　　　(based on without dam catchment rain forecast
　　　　　　　　　　　　　　　　　　　　　　　　　 or very short term catchment rain forecast)
Priority 2 - Avoid imminent fuse plug triggering　　　(based on without dam catchment rain forecast)
Priority 3 - Avoid more distantly projected overtopping　(based on with dam catchment rain forecast)
Priority 4 - Avoid causing or worsening major Brisbane　(based on with downstream rain forecast)
　　　　　　flooding
Priority 5 - Avoid causing or worsening major Ipswich　(based on with downstream rain forecast)
　　　　　　flooding
Priority 6 - Avoid projected fuse plug triggering　　　(based on with dam catchment rain forecast)
Priority 7 - Avoid river bank slumping
Priority 8 - Prepare for possibility of imminent subsequent
　　　　　　major rain event (ie fast post-flood drain down)
Priority 9 - Prepare for wet season (anticipatory releases)　(based on long term catchment / SEQ rain forecast)
Priority 10 - Avoid causing or worsening moderate　　(based on with downstream rain forecast)
　　　　　　Brisbane flooding
Priority 11 - Avoid causing or worsening moderate　　(based on with downstream rain forecast)
　　　　　　Ipswich flooding
Priority 12 - Avoid causing / worsening low level flooding　(based on with downstream rain forecast)

It seems unnecessary to split minor flooding between Brisbane and Ipswich. However one could similarly further split major and moderate flooding if really necessary but that seems to be overdoing it (not that other areas aren't important but the possibilities for impacts there coincide with those on Brisbane or Ipswich). It also seems unnecessary to split fuse plug related priorities into separate ones for each of the 3 fuse plugs.

RULES

Rule 1 (Controlled Release Rates) - Primary definition rule

　　　"At all times target controlled release rate is defined by the following formula

$$R_G = \max \{ \min (O_R , O_{max}) - R_E, 0 \}$$

　　　where
　　　R_G is **Release** rate through the **Gates** of the main spillway
　　　O_R is **Reactive** rate of total spillways outflow ("*Outflow*") (responding to actual,
　　　　　impending & maybe forecast inflow rates, as well as dam levels, river levels and
　　　　　Previous outflow rates)
　　　O_{max} is the **Maximum** possible **Outflow** rate that the dam is capable of
　　　R_E is **Release** rate through the fallback (auxiliary) spillway due to fuse plug **Erosion**

　　　the above to be recalculated hourly"

Rule 2 (Reactive Releases) - Definition rule

Reactive Outflow rate is based on inflow rates (actual, future modelled from fallen rain, & possibly future modelled from forecast rain); on current dam level & future level from modelled inflows; on Brisbane and Bremer river levels predicted from modelling downstream inflow & rainfall; and on previous outflow rate; all to be recalculated hourly. Can add river flow rates & volumes if needed.

(The **MAIN FORMULA** when combined with the section formulas below acts like a menu of relationships and inputs to select from in various situations, by zero scaling ones not used. Those used seem intuitively useful, but others can be added / substituted (logarithmic, trigonometric, higher power, differential, integral, probabilistic). All should be modelled by thinking through more scenarios & testing real cases. Eventually a single model patches together best fit relationships for all the scenarios, leading effectively to one "rule".)

$$O_R = Y_{\Psi 1,x}\, \boldsymbol{\Psi}_{1,x}(all) + Y_{min,x}\, \textbf{min}\, \{\textbf{max}\, (Y_{\Psi 2,x}\, \boldsymbol{\Psi}_{2,x}(all)\, ,\, Y_{\alpha,x}\alpha\, ,\, Y_{\beta,x}\beta\, ,\, Y_{\varphi 1,x}\varphi_1\, ,\, Y_{\delta 1,x}\delta_1\, ,\, Y_{P,x}\, O_P)\, ,$$
$$\boldsymbol{\Psi}_{3,x}(all)\, ,\, Y_{\varphi 2,x}\varphi_2\, ,\, Y_{\delta 21,x}\delta_{21}\, ,\, Y_{\delta 22,x}\delta_{22}\}$$

where   (Ψ's not used much here as they need most research, but model fine without)

All subscripts refer to variables being acted on, and to the situation.
O_R is **Reactive Outflow** rate
O_P is the anticipatory (**Predictive**) **Outflow** rate.
x is the situation to which the formula is being applied
$\boldsymbol{\Psi}_{?,x}$ are multivariable functions of all the inputs (α, β, φ_1, φ_2, δ_1, δ_{21}, δ_{22})
α is the inflow rate contribution to the formula
β is the dam level contribution to the formula
φ_1 is the river level contribution requiring outflows (ie setting minimum outflow rates)
φ_2 is the river level contribution limiting outflows (ie setting maximum outflow rates)
δ_1 is the previous outflow rate contribution requiring outflows (sets min for riparian prot)
$\delta_{2?}$ previous outflow rate contributions limiting outflows (max1 - dam safety; 2 - riparian)
$Y_{?(??),x}$ are **Yes** or no (in or out) constants (ie 0 or 1)

and

$\alpha = \alpha_1\, \alpha_2$ (**INFLOW RATE** section of formula where the intuitive primary relationship is to inflow rate maximised across contingencies).

$\alpha_1 = \textbf{max}\, \{S_{RIA,x}\, I_A\, ,\, S_{RIF,x}\, I_F\, ,\, \mathbf{B}_x(h_x)\, S_{RIP,x}(h_x)\, \mathbf{I}_{P,x}(h_x)\} + G_{RII,x}$ (inflow elements)
$\alpha_2 = \textbf{max}\, \{\mathbf{T}_{RIA,x}(D_A),\, \mathbf{T}_{RIF,x}(D_F),\, \mathbf{B}_x(h_x)\, \mathbf{T}_{RIP,x}(\mathbf{D}_P(h_x))\}$ (use inflows ... yes or no? ... ie are inflows applicable or not?)
$\mathbf{T}_{RI?,x}(D_?) = 0$ if $D_? < D_{?,x}$
$\phantom{\mathbf{T}_{RI?,x}(D_?)} = 1$ otherwise   (which contingencies are triggered [if being considered]?)
$\mathbf{B}_x(h_x) = 0$ or 1   (are we open to considering forecasts or not?)

where

S is a **Scaling** (multiplicative) constant.
G is a **Gain** (additive) constant.
I_A is **Actual** maximum **Inflow** rate not yet fully responded to in accordance with this formula due to the limitation of maximum flow increase limits
I_F is maximum future **Inflow** rate attributable to **Fallen** rain derived from modelling
$\mathbf{I}_{P,x}$ is maximum future **Inflow** rate attributable to fallen rain plus **Predicted** rain derived from modelling for the subsequent period of length prescribed under situation "**x**"
h_x is the length of the ensuing period in **Hours** which predicted rain is modelled for
$\mathbf{B}_x$ is Basis of situation "**x**" & takes value 0 if "without forecast" and 1 if "with forecast"
D_A is the actual (current) **Dam** lake level
D_F is maximum projected **Dam** lake level based on further inflows from **Fallen** rain only, ie "without forecast" basis
$\mathbf{D}_P$ is the maximum projected **Dam** lake level for the ensuing h_x hours based on fallen rain plus **Predicted** rain, ie "with forecast" basis
$D_{A,x}$ is the **Dam** lake level which triggers release calculations on the basis of **Actual** (ie current) dam lake level.
$D_{F,x}$ is the **Dam** lake level which triggers release calculations on a **Fallen** rain only, ie "without forecast", basis in situation "**x**"
$D_{P,x}$ is the **Dam** lake level which triggers release calculations on a fallen plus **Predicted** rain, ie "with forecast", basis in situation "**x**"
$\mathbf{T}_{A,x}$ is the activation **Threshold** function for situation "**x**" on the **Actual** dam lake level basis and takes the value 0 or 1 depending on whether D_A is below the threshold value $D_{A,x}$ or not.
$\mathbf{T}_{F,x}$ is activation **Threshold** function for situation "**x**" on the **Fallen** rain only basis and takes value 0 or 1 depending on whether D_F is below the threshold value $D_{F,x}$ or not
$\mathbf{T}_{P,x}$ is the activation **Threshold** function for situation "**x**" on the fallen + **Predicted** rain basis and takes the value 0 or 1 depending on whether the maximum value of $\mathbf{D}_P(h_x)$ during the ensuing h_x hours is below the threshold value $D_{P,x}$ or not

and

(**DAM LEVEL** section of formula where the intuitive primary relationship is to the more demanding, release wise, of height below danger and height above target level, maximised across contingencies. Functions shown work but more complex functions should be modelled.)

$\beta = \mathbf{max}\,(S_{RD1,x}\,\beta_1\,,\ S_{RD2,x}\,\beta_2)$

$\beta_1 = G_{RD1,x} + \mathbf{max}\,\{S_{RD1A,x}\,\boldsymbol{\mu}_n(D_A\,,\,D_{targ,x})\,\mathbf{T}_{RD1,x}(D_A)\,,\ S_{RD1F,x}\,\boldsymbol{\mu}_n(D_F\,,\,D_{targ,x})\,\mathbf{T}_{RD1,x}(D_F)\,,$
$\qquad\qquad \mathbf{B}_x(h_x)\,S_{RD1P,x}\,\boldsymbol{\mu}_n(\mathbf{D}_P(h_x)\,,\,D_{targ,x})\,\mathbf{T}_{RD1,x}(\mathbf{D}_P(h_x))\}$ (height above target)

$\beta_2 = G_{RD2,x} + \mathbf{max}\,\{\lambda_A(D_A)\,,\ \lambda_F(D_F)\,,\ \mathbf{B}_x(h_x)\,\lambda_P(\mathbf{D}_P(h_x))\}$ (height below danger)

$\lambda_?(D_?) = S_{RD2?1,x}\,\mathbf{T}_{RD2,x}(D_?)\,(S_{RD2?2,\,x}\,D_? - S_{RD2?3,\,x})\,/\,(Y_{?1,\,x} + Y_{?2,\,x}\,(D_{dang,x} - D_?))$
for $? = P$, $D_?$ is $\mathbf{D}_P(h_x)$

$\mathbf{T}_{RD1,x}(D_?) = 0$ if $D_? < D_{targ,x}$ (use height above targets? ... ie applicable?)
$\qquad\qquad = 1$ otherwise
$\mathbf{T}_{RD2,x}(D_?) = 0$ if $D_? > D_{dang,x}$ (use height below danger? ... ie applicable?)
$\qquad\qquad = 1$ otherwise

where

S, G, D_A, D_F, $\mathbf{D}_P$, h_x and $\mathbf{B}_x$ are as defined earlier

$D_{targ,\,x}$ is the target **Dam** lake level (ie **Low** significant level) for situation "**x**"
$D_{dang,\,x}$ is the dangerous **Dam** lake level to be avoided (ie **High** significant level) for
$\qquad$ situation "**x**"
$\mathbf{T}_{RD?,x}$ are activation **Threshold** functions as defined above
$Y_{??,\,x}$ are **Yes** or no (in or out) constants with values 0 or 1
$\boldsymbol{\mu}_n(m_1,D_{targ})$ = (m³ of water stored by the m_1 metres above D_{targ} of dam wall) / 86400 n
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (86400 seconds in one day)
n is number of days to reduce dam lake level by m_1 metres to D_{targ} metres
$\quad$ if no inflows and water released at the rate of $\mu_n(m_1,D_{targ})$ m³/s

and

(**RIVER LEVEL** section of the formula, where the intuitive primary relationship is to the capacity of the rivers to accept outflows released now without causing or worsening a flood of the category being considered, compared to the same capacity later, considering all contingencies. The tricky logic makes this section the most complex.)

$\varphi_1 = S_{RL01,x}\,\mathbf{max}\,(Y_{L101,\,x}\,\varphi_{min,both,maj}\,,\ Y_{L102,x}\,\Omega_{102,x}\,\varphi_{min,both,mod}\,,\ Y_{L103,x}\,\Omega_{103,x}\,\varphi_{min,both,min})\ +$
$\qquad S_{RL02,x}\,\mathbf{max}\,(Y_{L104,\,x}\,\varphi_{ideal,both,maj}\,,\ Y_{L105,x}\,\Omega_{105,x}\,\varphi_{ideal,both,mod}\,,\ Y_{L106,x}\,\Omega_{106,x}\,\varphi_{ideal,both,min})\ +$
$\qquad S_{RL03,x}\,\mathbf{max}\,(Y_{L107,\,x}\,\varphi_{min,Bris,maj}\,,\ Y_{L108,x}\,\Omega_{108,x}\,\varphi_{min,Bris,mod}\,,\ Y_{L109,x}\,\Omega_{109,x}\,\varphi_{min,Bris,min})\ +$
$\qquad S_{RL04,x}\,\mathbf{max}\,(Y_{L110,\,x}\,\varphi_{ideal,Bris,maj}\,,\ Y_{L111,x}\,\Omega_{111,x}\,\varphi_{ideal,Bris,mod}\,,\ Y_{L112,x}\,\Omega_{112,x}\,\varphi_{ideal,Bris,min})\ +$
$\qquad S_{RL05,x}\,\mathbf{max}\,(Y_{L113,\,x}\,\varphi_{min,Ipsw,maj}\,,\ Y_{L114,x}\,\Omega_{114,x}\,\varphi_{min,Ipsw,mod}\,,\ Y_{L115,x}\,\Omega_{115,x}\,\varphi_{min,Ipsw,min})\ +$
$\qquad S_{RL06,x}\,\mathbf{max}\,(Y_{L116,\,x}\,\varphi_{ideal,Ipsw,maj}\,,\ Y_{L117,x}\,\Omega_{117,x}\,\varphi_{ideal,Ipsw,mod}\,,\ Y_{L118,x}\,\Omega_{118,x}\,\varphi_{ideal,Ipsw,min})$

$\varphi_2 = S_{RL07,x}\,\mathbf{min}\,(Y_{L201,\,x}\,\varphi_{max,both,maj}\,,\ Y_{L202,x}\,\varphi_{max,both,mod}\,,\ Y_{L203,x}\,\varphi_{max,both,min})\ +$
$\qquad S_{RL08,x}\,\mathbf{min}\,(Y_{L204,\,x}\,\varphi_{ideal,both,maj}\,,\ Y_{L205,x}\,\varphi_{ideal,both,mod}\,,\ Y_{L206,x}\,\varphi_{ideal,both,min})\ +$
$\qquad S_{RL09,x}\,\mathbf{min}\,(Y_{L207,\,x}\,\varphi_{max,Bris,maj}\,,\ Y_{L208,x}\,\varphi_{max,Bris,mod}\,,\ Y_{L209,x}\,\varphi_{max,Bris,min})\ +$
$\qquad S_{RL10,x}\,\mathbf{min}\,(Y_{L210,\,x}\,\varphi_{ideal,Bris,maj}\,,\ Y_{L211,x}\,\varphi_{ideal,Bris,mod}\,,\ Y_{L212,x}\,\varphi_{ideal,Bris,min})\ +$
$\qquad S_{RL11,x}\,\mathbf{min}\,(Y_{L213,\,x}\,\varphi_{max,Ipsw,maj}\,,\ Y_{L214,x}\,\varphi_{max,Ipsw,mod}\,,\ Y_{L215,x}\,\varphi_{max,Ipsw,min})\ +$
$\qquad S_{RL12,x}\,\mathbf{min}\,(Y_{L216,\,x}\,\varphi_{ideal,Ipsw,maj}\,,\ Y_{L217,x}\,\varphi_{ideal,Ipsw,mod}\,,\ Y_{L218,x}\,\varphi_{ideal,Ipsw,min})$

(The above enables using both rivers, just Brisbane, just Bremer, combinations, as well as "ideal" outflow rates instead of, or with, maximums and minimums)

$\varphi_{ideal,loc,flood} = (S_{RL16,loc,flood,x}\,\varphi_{min,loc,flood} + S_{RL17,loc,flood,x}\,\varphi_{max,loc,flood})\,/\,(S_{RL16,loc,flood,x} + S_{RL17,loc,flood,x})$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (weighted mean of min and max)

$\Omega_{102,x} = 0$ if $\varphi_{min,both,mod} > \varphi_{max,both,maj}$ (less important minimum can't exceed
$\qquad\quad = 1$ otherwise $\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ more important maximum)
$\qquad$ same for $\Omega_{108,x}$, $\Omega_{114,x}$ with respect to Bris and Ipsw respectively
$\Omega_{105,x} = 0$ if $\varphi_{ideal,both,mod} > \varphi_{max,both,maj}$ $\qquad\qquad\qquad\qquad\qquad$ (as above)
$\qquad\quad = 1$ otherwise
$\qquad$ same for $\Omega_{111,x}$, $\Omega_{117,x}$ with respect to Bris and Ipsw respectively
$\Omega_{103,x} = 0$ if $\varphi_{min,both,min} > \varphi_{max,both,maj}$ or $> \varphi_{max,both,mod}$ (as above but 2 maxima
$\qquad\quad = 1$ otherwise $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ to compare to)
$\qquad$ same for $\Omega_{109,x}$, $\Omega_{115,x}$ with respect to Bris and Ipsw respectively
$\Omega_{106,x} = 0$ if $\varphi_{ideal,both,min} > \varphi_{max,both,maj}$ or $> \varphi_{max,both,mod}$ (as above)
$\qquad\quad = 1$ otherwise
$\qquad$ same for $\Omega_{112,x}$, $\Omega_{118,x}$ with respect to Bris and Ipsw respectively

where

Rule 3 (Imminent Overtopping) -
Outflow requirement rule

(We now give examples of situations that could exist under the above rule and that would thus be responded to based on Rule 2. We also suggested ways to respond, & later do that for some other priorities. These are not meant to be definitive or exhaustive. Any number of situations can be added, but, as with the rules, they are not meant to be mutually exclusive. They should appear in order of priority. The operative mechanism applying to the rules [lower order doesn't detract from higher order] also applies to situations within a rule. Each priority has one rule associated with it for requiring outflows and one, if appropriate, requiring limiting outflows, with the relevant situations being grouped within each rule. The profusion of identified situations with designed responses within a rule can eventually morph into a sub-model, thus effectively a single response for that rule. For clarity the situation number matches the rule number, with variants denoted with letters following the situation number.)

Situation 3 - At least one fuse plug blown. Dam lake level above 75.7m & rising or about to rise.

General Relevance of Inputs:
Inflow Rate (I) - high;   Dam Lake Level (D) - high;   River Levels require (L1) - low;
Previous Outflow Rate require (O1) - nil;   River Levels limit (L2) - nil;   Prev Outflow
Rate limit - dam safety (O21) - high;   Prev Outflow Rate limit - riparian (O22) - nil

A. x = "3a"   (ie situation 3a)
Dam lake level 78m or predicted (with or without forecast) to be 79.5m over next 2 days.

Relevance of inputs:-
I - high;   D - high;   L1 - low;   O1 - low;   L2 - nil;   O21 - high;   O22 - nil

Main formula:-

$Y_{min,3a}$ = 1   (activating min [max] function)
$Y_{\Psi?,3a} = Y_{P,3a}$ = 0   (not using multivariable func's - no time to research - or antic - no need)
other $Y_{?(??),3a}$'s are 1, 1, 0, 0, 0, 1, 0   (so outflow based on min of dam safety limit and
max of input based and dam lake level based responses)
so main formula is:- $O_R = \textbf{min} \{\textbf{max} (\alpha,\beta),\delta_{21}\}$ (rule 1 formula will take care of itself as
it can only increase R_G which is ok for 3a)

Inflow Rate formula (α):-

$B_{3a}(h_{3a})$ = 1   (we do want to consider rain forecasts)
h_{3a} = 48 hours   (we are interested in forecasts for next 48 hours)
$D_{A,3a}$ = 78 metres   (ie current dam lake level = 78m triggers this situation)
$D_{F, 3a} = D_{P, 3a}$ = 79.5 metres   (trigger level in both "with" and "without forecast" cases)
$S_{RIA,3a} = S_{RIF,3a}$ = 1.5   (outflow rate 50% more than inflow
rate now or max from fallen rain)

$S_{RIP,3a}$ = 1.2   (Outflow rate 1.2 times max inflow rate from fallen rain plus
forecast rain. Lower scaling because start release well before max)

$G_{RI1, 3a}$ = 0   (no gain constant)
so inflow rate formula is:- $\alpha = \textbf{max} \{1.5 \, I_A \, , 1.5 \, I_F \, , 1.2 \, I_{P, 3a}(48)\}$

Dam Lake Level formula (β):-

in the β formula both S's = 1   (keep it simple)

in the β_1 formula   (height above target)
$D_{targ, 3a}$ = 67 metres   (full supply level)
the T's are all 1   (because dam lake level is in the designated range for all contingencies)
$G_{RD1, 3a}$ = 0   (keep it simple)
n = 7 days   (ie rate of drain down returns to target in 7days if no extra inflows)
$S_{RD1A, 3a} = S_{RD1F, 3a}$ = 1.1   (far from target so start faster)
$S_{RD1P, 3a}$ = 0.75   (lower scaling because start release well before max)
so $\beta_1 = \textbf{max} \{1.1 \, \mu_7(D_A \, , 67) \, , 1.1 \, \mu_7(D_F \, , 67) \, , 0.75 \, \mu_7(D_P[48] \, , 67)\}$

in the β_2 formula   (height below danger)
$Y_{?1, 3a} = S_{RD2?2, 3a}$ = 0 , $Y_{?2, 3a}$ = 1   and $S_{RD2?3, 3a}$ = -1   (use inverses of differences only)
$D_{dang, 3a}$ = 80 metres   (level at which overtopping)
the T's are all 1   (as per T's for β_1)
$G_{RD2, 3a}$ = 0   (keep it simple)
$S_{RD2A1, 3a} = S_{RD2F1, 3a} = O_{max}$ (want max possible release as get very near to overtopping)
$S_{RD2P1, 3a} = 0.7 \, O_{max}$ (lower scaling because start release well before max)
(O_{max} is the maximum possible outflow rate that the dam is capable of)   (as per rule 1)
so $\beta_2 = \textbf{max} \{O_{max} / (80\text{-}D_A) \, , O_{max} / (80 \text{-} D_F) \, , 0.7 \, O_{max} / (80 \text{-} D_P[48])\}$

River Level formula (φ):- not relevant to this situation   (since input L has nil relevance)

Previous Outflow Rate formula (δ):-
$z_{incr}(O_{prev})$ is a dam structural issue the Engineers can specify   (always applies)

(We give below a couple of examples of possible extra situations that could follow situation 3a under this rule. They are in descending priority order, and they show how situations are not meant to be mutually exclusive. Explanation is brief and describes differences from situation 3a)

B. x = "3e" (ie situation 3e ... because other situations below would be higher priority)
Fuse plug 1 just blown (so dam lake level 75.7m)

The following differences to 3a:-
• relevance of input L1 is mod instead of low (further from overtopping but still too close)
• in main formula input $Y_{?(??),3e}$'s are 1, 1, 1, 0, 0, 1, 0 (open to some influence by all 3 main inputs but river level issues can't reduce outflows in this situation, only increase)
• so main formula is $O_R = \mathbf{min}\ \{\mathbf{max}\ (\alpha, \beta, \varphi_1)\ ,\ \delta_{21}\}$ (more operands)
• in the inflow rate formula:- $D_{A,\,3e} = 75.7$ metres, and (actual level 75.7 triggers this sit)
• $D_{F,\,3e} = D_{P,\,3e} = 80$, and (means only inflow rate trigger is actual blowing of fuse plug 1)
• $S_{RIA,\,3e} = S_{RIF,\,3e} = 1.2$, and (lower than for 3a since further from overtopping)
• $S_{RIP,\,3e} = 0.9$ (lower than 3a for same reason as above)
• so inflow rate formula is $\alpha = \mathbf{max}\ \{1.2\ I_A\ ,\ 1.2\ I_F\ ,\ 0.9\ I_{P,\,3b}(48)\}$
• in the dam lake level formula:- in the β_2 formula:- (β_1 is unchanged)
• $Y_{A1,\,3e} = Y_{I1,\,3e} = S_{RD2P2,\,3e} = 0$, and (use inverses of differences for
• $Y_{A2,\,3e} = Y_{I2,\,3e} = Y_{P?,\,3e} = 1$, $S_{RD2P3,\,3e} = -1$ and forecast, but direct for actual & fallen)
• $S_{RD2A2,\,3e} = S_{RD2I2,\,3e} = 1000$, $S_{RD2A3,3e} = S_{RD2I3,\,3e} = 66650$ and (defines direct relatn)
• so dam lake level β_2 formula is:-
• $\beta_2 = \mathbf{max}\ \{1000\ D_A - 66650\ ,\ 1000\ D_I - 66650\ ,\ 0.7\ O_{max}\ /\ (81 - \mathbf{D}_P[48])\}$
• the river level formula is active:-
• φ_2 is inactive (because river level issues can't reduce outflows)
• for φ_1 just use "min" constraint and "both" location (not essential but seems sensible)
• so all Y's = 0 except $Y_{L101,3e} = Y_{L102,3e} = Y_{L103,3e} = 1$ (only stipulated items included)
• $S_{RL01,3e} = 1$ (keep it simple)
• $k_1 = 3$ ("stay the same", "reduce 10% per hour", "increase 10% / hr") (outflow for both "Bris" and "Ipsw" continuation scenarios)
• $k_2 = 2$ ("the whole receipt period", $\varepsilon_{loc} \pm \Delta_{loc}$, and "half that", $\varepsilon_{loc} \pm 0.5\Delta_{loc}$) (simple for both "Bris" and "Ipsw" outflow receipt periods at "loc")
• give "stay the same" double the weight of other outflow continuation scenarios (simple)
• give "whole receipt period" double the weight of "half that" (simple)
• give equal weighting to with and without forecast for ($S_{RL14,?,?,3e} = 0.5$) (simple)
• so, for example

$\varphi_{min,Bris,max} = (6\ \varphi_{min,Bris,max,1,1} + 3\ \varphi_{min,Bris,max,1,2} + 2\ \varphi_{min,Bris,max,2,1} + \varphi_{min,Bris,max,2,2} + 2\ \varphi_{min,Bris,max,3,1} + \varphi_{min,Bris,max,3,2})\ /\ 15$

$\varphi_{min,Bris,max,1,1} = 0.5\ \mathbf{min}\ _{h\,=\,\varepsilon b-\Delta b}^{\varepsilon b+\Delta b}\ \{\hat{\mathbf{O}}_{F,Bris,max,1}(L_{Bris,max}\ ,\ \mathbf{L}_{F,Bris,1}[h])\}\ +$
$0.5\ \mathbf{min}\ _{h\,=\,\varepsilon b-\Delta b}^{\varepsilon b+\Delta b}\ \{\hat{\mathbf{O}}_{P,Bris,max,1}(L_{Bris,max}\ ,\ \mathbf{L}_{P,Bris,1}[h])\}$

(We now list a couple of potential scenarios under this rule without going through specifications. Due to limited time, much better ones should be able to be thought up. Each time another scenario is added to a rule, its priority must be carefully thought through and the situations renumbered to reflect where it has been inserted.)

C. x = "3b"
Dam lake level predicted to be 78m within next 24 hours

D. x = "3c"
Fuse plug 2 just blown (so dam lake level 76.2m)

E. x = "3d"
Fuse plug 2 blown but dam level since lowered but now rapidly escalating again

... etc

Rule 4 (Imminent Fuse Plug Triggering) -
Outflow requirement rule

Situation 4 - No fuse plugs blown and approaching trigger level of first fuse plug and dam lake level still rising or about to rise.

A. x = "4a"
Dam lake level 74m or predicted to be 75.5m over next 2 days, river levels at moderate flood levels and predicted to go higher.

Relevance of inputs:-
I - high; D - high; L1 - moderate; O1 - low; L2 - nil; O21 - high; O22 - nil

Main formula:-

$Y_{min,4a} = 1$
other non-Ψ $Y_{?(??),4a}$'s are 1, 1, 1 , 0, 0, 1, 0   (open to all three main inputs + part 4th)
$Y_{\Psi?,4a} = Y_{P,4a} = 0$ (not using multivariable func's or anticipatory outflow, for simplicity)
so main formula is:- $O_R = \mathbf{min} \{\mathbf{max}(\alpha,\beta,\varphi_1), \delta_{21}\}$ (rule 1 formula takes care of itself
                                                                                    as it can only increase R_G which is ok for 4a)

Inflow Rate formula (α):-

$B_{4a}(h_{4a}) = 1$ (we do want to consider rain forecasts)
$h_{4a} = 48$ hours   (we are interested in forecasts for next 48 hours)
$D_{A,4a} = 74$ metres   (ie current dam lake level = 74m triggers this situation)
$D_{F,4a} = D_{P,4a} = 75.5$ metres   (trigger level in both "with" and "without forecast" cases)
$S_{RIA,4a} = S_{RIF,4a} = 1.05$ (outflow rate 5% more than inflow
                                                                              rate now or max from fallen rain)
$S_{RIP,4a} = 0.8$ (Outflow rate 0.8 times max inflow rate from fallen rain plus
                                forecast rain. Lower scaling because start release well before max)
$G_{RI1, 3a} = 0$ (no gain constant)
so inflow rate formula is:- $\alpha = \mathbf{max} \{1.05\ I_A, 1.05\ I_F, 0.8\ I_{P,4a}(48)\}$

Dam Lake Level formula (β):-

in the β formula both S's = 1   (keep it simple)

in the β_1 formula   (height above target)
$D_{targ, 4a} = 67$ metres   (full supply level)
the T's are all 1   (because dam lake level is in the designated range for all contingencies)
$G_{RD1, 4a} = 0$ (keep it simple)
$n = 7$ days   (ie rate of drain down returns to target in 7days if no extra inflows)
$S_{RD1A, 4a} = S_{RD1F, 4a} = 1.05$ (far from target so start faster)
$S_{RD1P, 4a} = 0.7$ (lower scaling because start release well before max)
so $\beta_1 = \mathbf{max} \{1.05\ \mu_7(D_A, 67), 1.05\ \mu_7(D_F, 67), 0.7\ \mu_7(D_P[48], 67)\}$

in the β_2 formula   (height below danger)
$S_{RD2?2, 4a} = 0$, $Y_{?1, 4a} = 3$, $Y_{?2, 4a} = 1$, $S_{RD2?3, 4a} = -3$ (use inverses of differences only)
$D_{dang, 4a} = 75.7$ metres   (level at which first fuse plug triggered)
the T's are all 1   (as per T's for β_1)
$G_{RD2, 4a} = 0$ (keep it simple)
$S_{RD2A1, 4a} = S_{RD2F1, 4a} = 8000$ (want max possible release as get very near to overtopping)
$S_{RD2P1, 4a} = 0.7 * 8000 = 5600$ (lower scaling because start release well before max)
so $\beta_2 = \mathbf{max} \{24000 / (78.7-D_A), 24000 / (78.7 - D_F), 16800 / (78.7 - D_P[48])\}$
(This formula works for the specified range and gets overruled by situation 3 much beyond fuse plug trigger)

River Level formula (φ):-

φ_2 is inactive   (because river level issues can't *reduce* outflows in this situation)
for φ_1 just use "ideal" constraint and "both" location   (not essential but seems sensible)
so all Y's = 0   except $Y_{L104,4a} = Y_{L105,4a} = Y_{L106,4a} = 1$ (only stipulated items included)
$S_{RL02,4a} = 1$ (keep it simple)
$k_1 = 3$ ("stay the same", "reduce 10% per hour", "increase 10% / hr") (simplest outflow
    for both "Bris" and "Ipsw"   continuation scenarios)
$k_2 = 1$ ("the whole receipt period", $\varepsilon_{loc} \pm \Delta_{loc}$)   (keeping it very simple
    for both "Bris" and "Ipsw"   outflow receipt periods at "loc")
give "stay the same" triple the weight of other outflow continuation scenarios   (simple)
give "without forecast" double the weighting of "with forecast" so $S_{RL14,?,?,4a} = 0.67$
so, for example   (simple)
$\varphi_{min,Ipsw,max} = (3\ \varphi_{min,Ipsw,max,1,1} + \varphi_{min,Ipsw,max,2,1} + \varphi_{min,Ipsw,max,3,1}) / 5$ and

$\varphi_{min,Ipsw,max,1,1} = 0.67\ \mathbf{min}_{h = \varepsilon i - \Delta i}^{\varepsilon i + \Delta i} \{\hat{O}_{F,Ipsw,max,1}(L_{Ipsw,max}, L_{F,Ipsw,1}[h])\} +$

$\qquad\qquad 0.33\ \mathbf{min}_{h = \varepsilon i - \Delta i}^{\varepsilon i + \Delta i} \{\hat{O}_{P,Ipsw,max,1}(L_{Ipsw,max}, L_{P,Ipsw,1}[h])\}$

Previous Outflow Rate formula (δ):- applies as previously

B.   x = "4b"
Dam lake level predicted to be 74m over next 24 hours, river levels at minor flood levels and predicted to go higher.

... etc

(Due to lack of time, I only offer suggested specific formula element values for a few of the following situations for the remaining rules. They are still randomly chosen without much thought, and just for illustrative purposes).

Rule 5 (Projected Overtopping) -
Outflow requirement rule

Situation 5 - Dam lake levels predicted to reach 79.5m within 4 days (ie "with forecast" must be involved)

A.   x = "5a"
Dam lake level 72m and predicted to reach 79.5m within 3 days, both rivers already at moderate flood levels and predicted to rise.

B.   x = "5b"
Dam lake level predicted to reach 79.5m within 3 days, river at Brisbane already at moderate flood levels and predicted to rise, river at Ipswich at low flood levels and predicted to only rise from Brisbane river backflow.

C.   x = "5c"
Dam lake level predicted to reach 78m within 4 days, river at Brisbane already at minor flood levels and predicted to rise, river at Ipswich at moderate flood levels and predicted to rise rapidly mainly due to inflows more than backflow.

Rule 6 (Avoidance of Causing or Worsening [Projected] Major Floods) -
Outflow limiting rule

(As an outflow limiting rule this rule can not have any impact on higher priority rules as they are all outflow requiring rules. The only exceptions would be for situations where φ_1 is specifically activated, but even then this rule can't increase the limiting effect. However, equally, lower priority outflow requiring rules can not reduce the limiting effect this rule has).

Situation 6 - Any significant outflows released now will cause or worsen major flooding in Brisbane or Ipswich as predicted by modelling of downstream inflows and predicted downstream rainfall.

A.   x = "6a"
Rivers at both Brisbane and Ipswich are already at, or within 24hrs will be at, major flood levels and predicted to rise even without releases.

B.   x = "6b"
River at Brisbane already at, or within 24hrs will be at, major flood levels and predicted to rise even without releases, and river at Ipswich already at moderate flood levels and predicted to rise even without releases.
                              (6c would be the reverse - Brisbane moderate, Ipswich major)
For all the above

Relevance of inputs:-
I - nil / low;   D - nil / low;   L1 - low;   O1 - mod;   L2 - high;   O21 - high;   O22 - mod

Main formula:-

$Y_{min,6?} = 1$ and $Y_{\Psi?,6?} = 0$ *(use min [max] but not multivariable functions)*
either zero out α and β or scale them down heavily in the α and β formulas

River Level formula (φ):-

Much heavier weight placed on "with forecast" (P) than "without forecast" (F)
                              (insurance that the situation, if priorities permit, makes affordable)
Have S in φ_2 equal 1 and in φ_1 much smaller (or zero).
                              (Makes the limiting function active, and makes limiting to avoid imminent effects much more important than releasing to avoid later effects)
Selection of constraints, locations, weightings, periods and outflow continuation scenarios to be carefully tailored to fairly narrowly defined situations
Previous Outflow Rate formula (δ):- as defined

C.   x = "6d"
Rivers at both Brisbane and Ipswich are already at moderate flood levels and predicted to rise rapidly to major flood levels even without releases.
(Then you have to add situations with best release patterns for Brisbane in conflict with that for Ipswich)

Rule 7 (Avoidance of Causing or Worsening [Projected] Major Floods) -
Outflow requirement rule
(This is the rule that most closely covers the controversial period in the 2011 flood pertaining to which it is claimed here that outflows were too low in response to the first inflow spike. The general idea here is that there is a window of opportunity to release significant amounts of water now without causing major flooding, in an effort to avoid the significant risk that significant releases later would cause major flooding).

Situation 7 - Major flooding, or minor to moderate flooding capable of being elevated to major flooding by dam water outflows likely to be needed if predicted conditions materialise, or by any significant outflows, is predicted for Brisbane and/or Ipswich by modelling of downstream inflows and predicted downstream rainfall but such flooding would largely not coincide with arrival of waters released up till and including now.

A. x = "7a"
Dam lake level is over 67m AND both river levels are at or below minor flooding levels AND are predicted to remain there until after the great majority, if not all, of any current and previous dam water outflows (up to the end of the ensuing hour) arrive at those respective locations, AND a significant likelihood exists that, after such potential arrival, river levels at one or both locations will rise significantly, thereby greatly reducing the ability in the coming days to release dam waters without causing or worsening major flooding. (situations should be as specific and precise as possible)

Relevance of inputs:-
I - high; D - high; L1 - high; O1 - mod; L2 - low/mod; O21 - high; O22 - low/mod
(all main ones high because they all impact future release dynamics greatly in this scenario)

Main formula:-

$Y_{min,7a} = 1$ (activate min [max])
other non-Ψ $Y_{?1,7a}$'s are 1, 1, 1, 1, 0, 1, 0 (open to all three main inputs + part 4th)
$Y_{\Psi1,7a} = Y_{\Psi3,7a} = Y_{P,7a} = 0$ $Y_{\Psi2,7a} = 1$ (use multivar func in max only, no anticipatory)
main formula is:- $O_R = \min \{\max (\Psi_2(all),\alpha,\beta,\varphi_1,\delta_1) , \delta_{21}\}$ (rule 1 takes care of itself as it can only increase R_G which is ok for 4a)

Inflow Rate formula (α):-

$B_{7a}(h_{7a}) = 1$ (we do want to consider rain forecasts)
$h_{7a} = 72$ hours (we are interested in forecasts for next 48 hours)
$D_{A,7a} = 67$ metres (ie current dam lake level = 67m triggers this situation)
$D_{F,7a} = D_{P,7a} = 70.5$ metres (trigger level in both "with" and "without forecast" cases)
$S_{RIA,7a} = S_{RIF,7a} = 0.33$ (outflow rate is one third of inflow rate now or max from fallen rain)
$S_{RIP,7a} = 0.25$ (Outflow rate one quarter of max inflow rate from fallen rain plus forecast rain. Lower scaling because start release well before max)
$G_{RI1, 7a} = 0$ (no gain constant)
so inflow rate formula is:- $\alpha = \max \{0.33 I_A , 0.33 I_F , 0.25I_{P,7a}(72)\}$
(this formula contains the simple assertion I made in my first submission re outflows)

Dam Lake Level formula (β):-

in the β formula both S's = 1 (keep it simple)

in the β_1 formula (height above target)
$D_{targ, 7a} = 67$ metres (full supply level)
the T's are all 1 (because dam lake level is in the designated range for all contingencies)
$G_{RD1, 7a} = 0$ (keep it simple)
n = 7 days (ie rate of drain down returns to target in 7days if no extra inflows)
$S_{RD1A, 7a} = S_{RD1F, 7a} = 1$ (simple)
$S_{RD1P, 7a} = 0.7$ (lower scaling because start release well before max)
$\beta_1 = \max \{\mu_7(D_A ,67) , \mu_7(D_F ,67) , 0.7 \mu_7(D_P[48] ,67)\}$

in the β_2 formula (height below danger)
$S_{RD2?2, 7a} = 2000 ,   Y_{?1, 7a} = 3 , Y_{?2, 7a} = 1 ,   S_{RD2?3, 7a} = 127400$
(use inverses of differences only)
$D_{dang, 7a} = 75.7$ metres (level at which first fuse plug triggered)
the T's are all 1 (as per T's for β_1)
$G_{RD2, 7a} = 0$ (keep it simple)
$S_{RD2A1, 7a} = S_{RD2F1, 7a} = 1$ (want max possible release as get very near to overtopping)
$S_{RD2P1, 7a} = 0.7$ (lower scaling because start release well before max)
$\beta_2 = \max \{(2000 D_A - 127400) / (78.7 - D_A) , (2000 D_F - 127400) / (78.7 - D_F) ,$
$(1400 D_P[48] - 89180) / (78.7 - D_P[48])\}$ (works well for specified range.)

River Level formula (φ):-

φ_2 is inactive $\qquad$ (because river level issues can't *reduce* outflows in this situation)
for φ_1 just use "ideal" constraint and "both" location $\quad$ (could use "min" instead of "ideal")
so all Y's = 0 $\quad$ except $\quad Y_{L104,7a} = Y_{L105,7a} = Y_{L106,7a} = 1 \qquad$ (only stipulated items included)
$S_{RL02,7a} = 1 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (keep it simple)
$k_1 = 3$ $\quad$ ("stay the same", "reduce 10% per hour", "increase 10% / hr") $\quad$ (simplest outflow
$\qquad$ for both "Bris" and "Ipsw" $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ continuation scenarios)
$k_2 = 1$ $\quad$ ("the whole receipt period", $\varepsilon_{loc} \pm \Delta_{loc}$) $\qquad\qquad$ (keeping it very simple
$\qquad$ for both "Bris" and "Ipsw" $\qquad\qquad\qquad\qquad\qquad$ outflow receipt periods at "loc")
give "stay the same" 1.5 times the weight of other outflow continuation scenarios (simple)
give "with forecast "double the weighting of "without forecast" so $\quad S_{RL14,?,?,7a} = 0.33$
so, for example $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (simple)

$\varphi_{min,Ipsw,max} = (1.5\, \varphi_{min,Ipsw,max,1,1} + \varphi_{min,Ipsw,max,2,1} + \varphi_{min,Ipsw,max,3,1}) / 4.5 \qquad$ and

$\varphi_{min,Ipsw,max,1,1} = 0.33\, \mathbf{min}\,_{h = \varepsilon i - \Delta i}^{\varepsilon i + \Delta i} \{\hat{\mathbf{O}}_{F,Ipsw,max,1}(L_{Ipsw,max}, \mathbf{L}_{F,Ipsw,1}[h])\} +$

$\qquad\qquad 0.67\, \mathbf{min}\,_{h = \varepsilon i - \Delta i}^{\varepsilon i + \Delta i} \{\hat{\mathbf{O}}_{P,Ipsw,max,1}(L_{Ipsw,max}, \mathbf{L}_{P,Ipsw,1}[h])\}$

Previous Outflow Rate formula (δ):-

As defined

Multivariable Function formula ($\Psi_{2,7a}$):-

$\Psi_{2,7a}(all) = \alpha\, (3D_A - 185)/20$ $\quad$ (an example of using dam lake level to amplify inflow rate)

B. $\qquad$ x = "7b"
$\qquad\qquad$ As per 7a but likelihood of river rises after potential outflow arrival is moderate.

C. $\qquad$ x = "7c"
$\qquad\qquad$ As per 7a but extent of likely river rise after potential outflow arrival is enough to cause
$\qquad\qquad$ major flooding but only just. $\qquad$ (Probabilistic issues to deal with for proper enunciation)

Rule 8 (Projected Fuse Plug Triggering) -
$\qquad$ Outflow requirement rule

$\qquad$ **Situation 8** - $\qquad$ Dam lake level predicted to reach 75.7m (trigger level of first fuse plug) within 4
$\qquad\qquad\qquad\qquad\qquad$ days (ie "with forecast" must be involved)

$\qquad$ **A.** $\qquad$ x = "8a"
$\qquad\qquad$ Dam lake level 70m and predicted to reach 75.7m within 3 days, both rivers already at
$\qquad\qquad$ moderate flood levels and predicted to rise.

$\qquad$ **B.** $\qquad$ x = "8b"
$\qquad\qquad$ Dam lake level predicted to reach 75.7m within 3 days, river at Brisbane already at
$\qquad\qquad$ moderate flood levels and predicted to rise, river at Ipswich at low flood levels and
$\qquad\qquad$ predicted to only rise from Brisbane river backflow.

$\qquad$ **C.** $\qquad$ x = "8c"
$\qquad\qquad$ Dam lake level predicted to reach 74m within 4 days, river at Brisbane already at minor
$\qquad\qquad$ flood levels and predicted to rise, river at Ipswich at moderate flood levels and predicted
$\qquad\qquad$ to rise rapidly mainly due to inflows more than backflow.

Rule 9 (Maximum Rates of Increase of Controlled Releases) -
$\qquad$ Outflow limiting rule

$\qquad$ **Situation 9+** - $\quad$ Rules 1 - 8 not triggered.

$\qquad$ **A.** $\qquad$ x = "9+" $\qquad\qquad$ (Only need one situation. "+" signifies it applies to all subsequent rules)

$\qquad\qquad$ $S_{R,9+} = 1$
$\qquad\qquad$ $Y_{\delta 21} = Y_{\delta 22} = 1$

Rule 10 (Maximum Rates of Outflow Rate Reduction) -
$\qquad$ Outflow requirement rule

$\qquad$ **Situation 10+** - $\quad$ Rules 1 - 8 not triggered.

$\qquad$ **A.** $\qquad$ x = "10+" $\qquad\qquad$ (Only need one situation. "+" signifies it applies to all subsequent rules)

$\qquad\qquad$ $S_{R,10+} = 1$
$\qquad\qquad$ $Y_{\delta 1} = 1$

Rule 11 (Minimum Outflow Rate) -
    Outflow requirement rule

    Situation 11+ - Rules 1 - 8 either not triggered, or triggered but inflow or dam lake level inputs zeroed out or not defined.

    A.   x = "11+"   (Only need one situation. "+" signifies it applies to all subsequent rules)

$S_{R,11+} = 1$
$Y_\alpha = Y_\beta = 1$
$S_{RD1,11+} = S_{RD2,11+} = 1$ (making sure that
$S_{RDA1,11+} \neq 0$ inflow rate and dam
$S_{RD2A1,11+} \neq 0$ lake level inputs
$S_{RD2A2,11+} \neq 0$ or $S_{RD2A3,11+} \neq 0$ are active in all
$Y_{A1,11+} \neq 0$ or $Y_{A2,11+} \neq 0$ subsequent rules)
(Could even be more prescriptive and specify exact values or minimum values)

Rule 12 (Anticipatory Releases) -
    Outflow requirement rule

    A.   Predicted inflows for the purposes of determining anticipatory releases are calculated as follows:-

$P_{Avg,1} = (S_C* (P_{C1}+ P_{C7}/7+ P_{C30}/30+ P_{C90}/90) + (1- S_C) * (P_{Q1}+ P_{Q7}/7 + P_{Q30}/30 + P_{Q90}/90))/4$
$I_{Vol,P} = M_{WD}(P_{Avg,1})$

(or alternatively a simpler version ... $P_{Avg,1} = S_C * P_{C90}/90 + (1-S_C) * P_{Q90}/90$ if preferred)

where
$P_{Avg,1}$ is the deemed period-averaged daily (**1** day) **Predicted** rainfall (deemed to be mid range runoff impact temporal and spatial distribution, but current actual saturation)
S_C is the **Scaling** factor (between 0 and 1) for period-averaged dam **Catchment** predicted rainfall
P_{Cn} is the **Predicted** average rainfall in the dam **Catchment** for the ensuing **n** days
P_{Qn} is the **Predicted** average rainfall in South East **Queensland** for the ensuing **n** days
$I_{Vol,P}$ is the modelled daily **Inflow** from deemed period-averaged **Predicted** rainfall,
M_{WD} is the rain **Water** runoff **Model** for the **Dam** lake (in this case using the same assumptions re distribution and saturation as for $P_{Avg,1}$)
It is suggested $S_C = 0.5$ (but just as a starting point)

The above calculations to be done daily.

    B.   The threshold dam lake level at which anticipatory releases may begin to be required is as follows:-

$D_{P,Antic,start} = 67$ metres
$\mathbf{D}_{P,Antic}(24y) = \mathbf{D}_{P,Antic}(24[y-n])) + U_n + V_n - n * P_{Avg,1}$

where
$D_{P,Antic}$ is the **Dam** lake level which triggers anticipatory (**Predictive**) release calculations
$\mathbf{D}_{P,Antic}(24y)$ is the value of $D_{P,Antic}$ at day "**y**"
$D_{P,Antic,start}$ is the value of $D_{P,Antic}$ just before the beginning of each wet season (day **0**)
n is the frequency (in days) of revision of D_P
U_n is the amount of dam water drawn down for **Usage** in a typical **n** day period under current conditions
V_n is the amount of dam water evaporated (**Vaporised**) in a typical **n** day period under current conditions, and
$P_{Avg,1}$ is deemed period-averaged daily (**1** day) **Predicted** rainfall (see rule 12)
It is suggested that the default value of $D_{P,Antic}$ be 67m and be revised weekly or monthly.
It is further suggested that it not be adjusted to below 64m or above 69m.

C.   Anticipatory Outflow is based on predicted inflows from averaged predicted rainfall

$O_P = S_P \, I_{Vol,P} \, T_{P,Antic}(D_A)$

$T_{P,Antic}(D_A) = 0 \quad \text{if} \quad D_A < D_{P,Antic}$
$\qquad\qquad\quad = 1 \quad \text{otherwise}$

where

O_P is anticipatory (**Predictive**) **Outflow** rate

S_P is the **Scaling** factor for inflows deriving from deemed **Predicted** rainfall,

$I_{Vol,P}$ is the modelled averaged daily **Inflow Volume** from deemed **Predicted** rainfall,

D_A is the current **Dam** lake level

$D_{P,Antic}$ is the **Dam** lake level which triggers anticipatory (**Predictive**) release calculations

$T_{P,Antic}$ is the activation **Threshold** function for anticipatory (**Predictive**) releases and
takes the value of 0 or 1 depending on whether D_A is below the threshold value
$D_{P,Antic}$ or not

It is suggested that $S_P = 1$

The above calculations to be redone and acted on daily.

D.   So to put O_P into the overall O_R formula the following applies:-

Situation 12 -   Significant inflows are expected over the ensuing 3 months.

D1   x = "12"   (probably only need one situation)

$Y_{P,12} = 1$ and $Y_{min,12} = 1$ (activates O_P in O_R formula)

Rule 13 (Avoidance of Causing or Worsening [Projected] Moderate Floods) -
     Outflow limiting rule

Situations and responses similar to that of rule 6 but taking account of different priority compared to other factors.

Rule 14 (Avoidance of Causing or Worsening [Projected] Moderate Floods) -
     Outflow requirement rule

Situations and responses similar to that of rule 7 but taking account of different priority compared to other factors.

Rule 15 (Avoidance of Causing or Worsening [Projected] Minor Floods) -
     Outflow limiting rule

Situations and responses similar to that of rule 6 but taking account of different priority compared to other factors.

Rule 16 (Avoidance of Causing or Worsening [Projected] Minor Floods) -
     Outflow requirement rule

Situations and responses similar to that of rule 7 but taking account of different priority compared to other factors.

APPENDIX 2 - SCHEMATIC REPRESENTATION OF COMBINING FLOOD SCENARIOS OF BRISBANE AND IPSWICH TO DETERMINE OVERALL ACTIONS

max - is maximum releases can make now without causing or worsening the selected category of flood

min - is the minimum releases to make now so as to avoid later releases causing or worsening the selected category of flood.

B - referring to flood levels of the Brisbane River at the Brisbane CBD

I - referring to flood levels of the Bremer River at the Ipswich CBD

black - colour of line and dots representing scenarios where Min is less than Max

red - colour of line and dots representing scenarios where Min is greater than Max

dots - shows where the "ideal" constraint would be if twice the weighting for Max as for Min (see rules)

dashed lines - shows where Max and Min would be for the "both" location category (see rules)

Min will often be less than Max but can exceed Max so need to determine approach for all scenarios. If Min less than Max then any value between satisfies both. But if Min exceeds Max no value can satisfy both and a compromise is required between them. Similarly if the Min-Max range of one location is contained within or overlaps that of the other and they both have Min less than Max, there are values that satisfy all four requirements (the requirements being Min Bris, Max Bris, Min Ipsw and Max Ipsw). In other cases there aren't and compromises are required.

APPENDIX 3 - HOW SUGGESTED DAM MANAGEMENT RULES WOULD HAVE WORKED IN THE 2011 FLOOD WITH VERY ROUGH ESTIMATES OF OUTCOMES

It is asserted that by the evening of Sunday the 9th Rule 7 would have become the primary driver of responses under situation 7a.

$$O_R = \textbf{min} \{\textbf{max} (\Psi_2(all), \alpha, \beta, \varphi_1, \delta_1), \delta_{21}\}$$

Due to lack of time to lodge this submission just look at Ψ_2 (other contributions could have only served to accentuate the advantage of this scheme).

$$\Psi_2(all) = \textbf{max} \{0.33\ I_A, 0.33\ I_F, 0.25\ I_{P,7a}(72)\} (3D_A - 185)/20$$

Leaving aside I_F and $I_{P,7a}$ (they could only have served to accentuate the advantage of this scheme), I_A spent about 20 hours over 7,500 m^3/s and peaked at over 10,000 m^3/s in that first inflow spike. In the process, D_A increased from a bit over 69 metres to a little under 73 metres (with the releases that the Engineers made).

The above means that $\Psi_2(all)$ and hence O_R would have ranged approximately from a starting range of 2,750 m^3/s or so up to about 4,400 m^3/s then only back down to about 4,250 m^3/s. It is estimated that D_A would have remained at about 73 metres as the second inflow spike hit, and that D_A would not have attained 74 metres until I_A had reduced to less than 6,000 m^3/s.

It is asserted that Rule 4 would not have been invoked until D_A actually reached 74 metres because the preceding releases would have meant that dam levels were not rising as rapidly as actually was the case until the last few hours before arriving at 74 metres (at which point 4a would have applied), and that a lower priority situation than the suggested 4a and 4b would have been in operation soon after, as inflows were beginning to decrease rapidly and dam lake level would have stabilised.

Then, the intersection of ramping up release rates with rapidly diminishing inflow rates would have occurred at less than 4,500 m^3/s (possibly much less), virtually ensuring that the second release spike would have had to have been a "nudge" at most (somewhere between 4,000 m^3/s and 4,500 m^3/s).

It is estimated that the impact at Brisbane CBD of this approach would have seen the Brisbane river breach minor flood levels early on Tuesday the 11th and moderate flood levels in the middle of that same day, and that after that, the rate of increase would have flattened significantly and peaked early on the 13th at or a bit below the major flood level (a metre or more lower than the peak levels that actually occurred).

It is also estimated that the impact at Ipswich CBD of this approach would have seen the Bremer river rise more rapidly than it did from early on Monday the 10th with the rate of increase significantly slowing from early on the 11th reaching a peak somewhere between 13 and 16 metres late morning of the 12th (3.5 to 6.5 metres lower than actually occurred).

Even though the above estimates have not been modelled, it is confidently asserted that they will prove to be accurate in the depiction of there being a marked and significant difference between what actually happened and what should have happened (moreso than in the exact details), for reasons explained herein. The three relevant graphs from the Report are included here with coloured markings showing a reasonable expected range of outcomes using the approach suggested here.
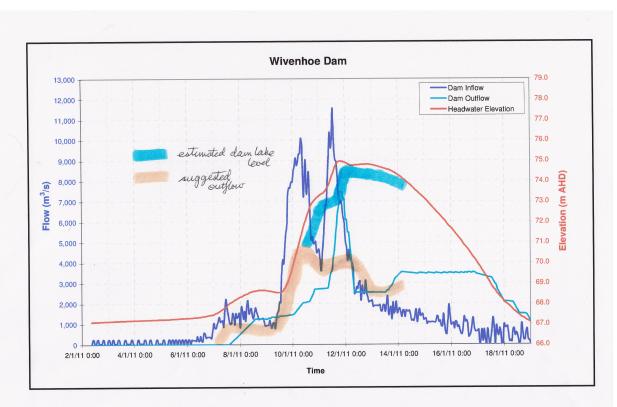
Figure 9.1.2 – Wivenhoe Dam inflow and release summary for the January 2011 Flood Event

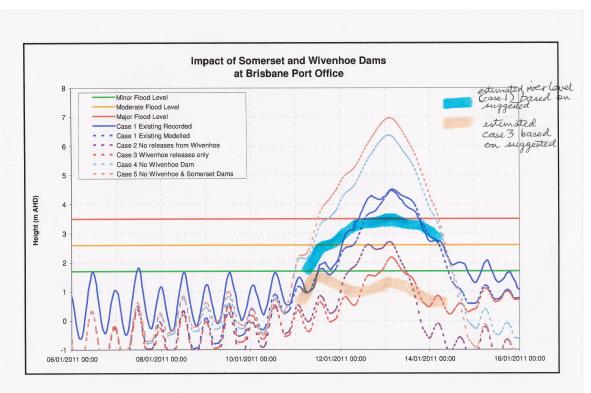*Figure 8.10.3 – Impact of Somerset and Wivenhoe Dams at Brisbane Port Office, showing peak height*

Bremer River at Ipswich
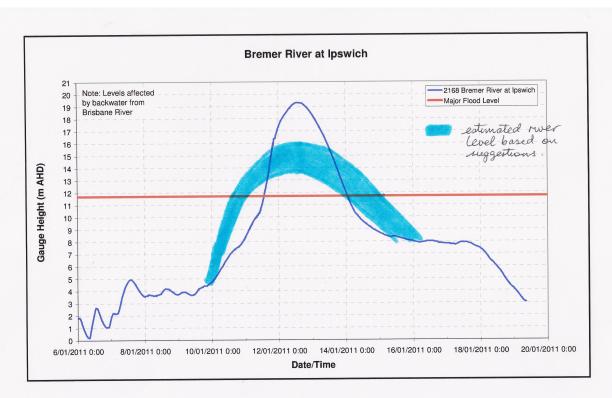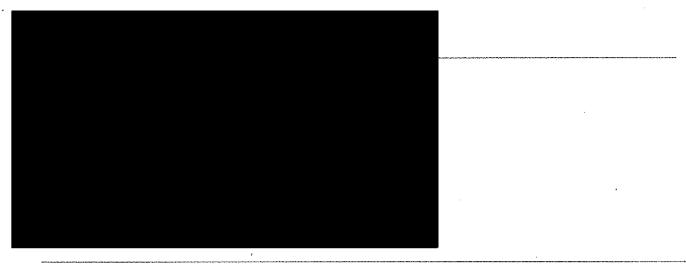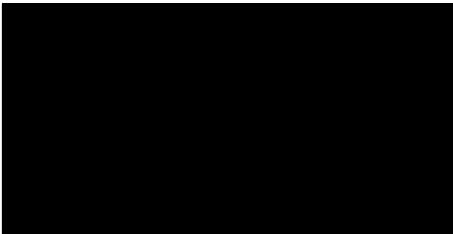
Note: Levels affected by backwater from Brisbane River

2168 Bremer River at Ipswich
Major Flood Level

estimated river level based on suggestions.

Gauge Height (m AHD)

Date/Time

Figure 6.5.11 – Gauge height, Bremer River at Ipswich

███████████████████████████

███████████████████████████

Subject: Key flood enquiry evidence contradicted

Mr Callaghan,

I sent the following to Susan Hedge, but given the absence in Exhibit 408 (list of suggested works to review the manual) of points reflecting my important suggestions made in my 2nd submission, then in the public interest I feel I must send this to you directly. From the transcripts I get the sense you and the commissioner are frustrated at a lot of what technical people are telling you and I think I can help.

Summary of observations and discoveries:-

Discoveries:-

1. Testimony by independent expert Rory Nathan of SKM that no dams in Australia use rain forecasts as part of their methodology for dictating releases was contradicted by ███████████████ who is a senior officer of ANCOLD (the representative body of owners of large dams in Australia) in a conversation I had with him on Friday. He said he had seen Rory's claim and "didn't know where he got that idea from" as he ████████ himself uses forecasts in his capacity involving Tasmanian dams (and apparently others use them as well).

2. I also asked ████████ about another matter that appears to be the case from the testimony, namely that the various hydrological models used by SEQWater are only tested against the very small number of historical events which they use to calibrate and validate the model parameters (as opposed to also running the model under a wide range of hypothetical scenarios and thus deriving clearly

25/10/2011

predetermined strategy patterns and plans to make the engineers better prepared for unprecedented events). ███████ said that that
would be very unusual if that were the case, as SKM themselves generate synthetic data specifically for that purpose which he certainly uses and, if I understand him correctly, most other dam owners use.

Observations:-

3. The technical people have succeeded in completely and utterly bamboozling the entire collection of barristers arrayed against them (sorry!) on fundamental and yet easily misunderstood matters of probablity and logic.

If you are in a situation where you know there is a theoretical potential for the imminent occurrence of something that will significantly worsen things, then the less confident you are about predictions as to the occurrence of that thing, the *more* you should make contingent allowance for that thing (not *less* as the engineers argue)!

So if you are above FSL (67m) and you get significant inflows, then in the absence of solid reliable forecasts that there *won't* be large, following, inflow-producing rain you have to act as though there *will* be (the actual actions to be decided analytically, but the clear intent *must* be there)!

So do you see what has happened? The engineers et al have succeeded in inverting the correct logic (by saying instead that in the absence of solid reliable forecasts that there *will* be large following rain you have to act
as though there *won't* be) and the barristers have not been up to picking this up and really nailing the point (sorry again).

4. Then, when the engineers et al attempt to offer an explanation for this undetected inversion, the barristers have missed picking up a second travesty. We have heard repeatedly that releasing on the basis of unreliable forecasting is dangerous because you don't know if you are going to significantly worsen things or not (the mechanism for worsening being the causing of a significant confluence between released water and other
downstream inflows).

The barristers apparently failed to grasp that this lack of knowledge is not where the decision making process ends, it is simply a partial statement of the situation which can be analysed further in a general and conclusive way. This is where it gets a bit tricky and is probably really beyond the unprompted capacity of barristers who don't have a science or maths background.

You have to counterbalance risks (remember we are talking about the above situation of above FSL and significant inflows):-

Case A - release now and cause significant confluence causing or worsening major flood

Case B - release later and cause significant confluence causing or worsening major flood

(these are obviously not exhaustive possibilities, other cases could involve no or little confluence, or significant confluence and major flooding in Ipswich but not Brisbane etc etc, but A and B are sufficient to make the
point).

Looking in simple terms at the probability components, the major ones would be:-

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- probability of significant degree of confluence
- probability of significant magnitude of overall consequent confluent flows

"Degree" is essentially the probability of occurrence of one of the requisite patterns of downstream inflows. This is impacted by existing flows and flows from future events.

"Magnitude" derives from magnitude of release and probability of requisite magnitude of downstream inflows.

So we need to compare these three sub components across A and B.

Probability of occurrence - There is less opportunity in case A than in case B (potential contribution to opportunity from existing flows would be the same in each case, but potential flows from future events can come from further afield in B, because A is sooner than B, so more future events can cause confluence in B) thus the probability is greater in B (remember we are assuming forecasts are not reliable enough, so we ascribe equal weight to them all, so opportunity doesn't need to be weighted by forecasts).

Magnitude of release - At first one would say that magnitude of release should be kept constant between A and B in order to compare apples with apples, but this is not correct. The point of comparing Cases A and B is to analyse the utility of releasing an amount of water now versus withholding it to be possibly released later (the reason for release is not important here). But in the defined situation, the mere act of withholding an amount water increases the chance of arriving later at a situation where there is no choice but to make significant releases. So a proper comparison would have the magnitude of release greater in case B (the quantum of difference doesn't matter, it's just the principle).

Probability of requisite magnitude of downstream inflows - Once again the initial thought would be that this should be kept constant to make a fair comparison, but again this is wrong. The mere fact that magnitude of releases is larger in B means that lower magnitude downstream inflows are required compared to case A to have the same overall impact as case A. This in turn means there is a greater probability of having the requisite magnitude of downstream inflows for any given conditions under B (because it is "easier" to achieve).

So if we are assuming forecasts can't be relied upon each component of probability in Case B is greater than the corresponding component in Case A, by definition !!!

5. The barristers collectively have also failed to nail the issue of risk. Firstly there are many different matters within the topic that are rightly the subject of risk and risk analysis, yet nowhere has the terminology been clarified to ensure that questions are addressed and answered properly (many weren't). The appropriate term for what was being discussed for much of the time should be something like Damage Cost Risk (DCR).

Nowhere in this process has anyone spelled out or been induced to spell out the simple but obvious process that is needed in relation to DCR:-

(i) Determination of maximum possible inundation levels up to agreed AEP (suggest 1 in 10000 or 20000). Big enough AEP to cover any event we need to try to prepare for.

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(ii) Full audit of at-risk assets under max poss inundation (public and private) together with maximum potential repair / replacement costs, executed by independent professionals.

(iii) Opportunity for public input as to costs and inclusion and AEP.

(iv) Construction of DCR model input involving identifying total cost, by catchment segment (ie subject to a single principle dynamic), associated with every flood level (and flow level if needed) within that catchment segment.

(v) Constructing model (hydrodynamic) converting inputs of dam releases, current catchment conditions and rainfall forecasts into output of consequent flood levels and flows in all catchment segments.

(vi) Construction of DCR model (incoprorating above hydrodynamic model) converting primary input of releases into output of total damage costs, thus enabling dam to be operated at or near least cost mode at all times.

The above would also make it blatantly obvious as to whether it was acceptable to not increase the height of the dam wall or take other major mitigation measures.

6. A cynic would struggle to tell the difference between the "defendants" (the Wivenhoe dam related technical people) and the independent experts, based on their respective testimonies. There is an urgent need to go outside this small closed shop for some advice in the more general mathematical / logical issues I have raised in my various submissions and correspondences. The manual structure is faulty (you can make a staged structure correct but it is simpler to do as I suggest in my second submission and have concurrent, non-mutually-exclusive-situation-based rules). The absence of principles tying releases to major inputs is pure arbitrariness.

The group think, silo effect and overdependence on models is alarming. A classic moment was when Mr Babister, the independent hydrologist engaged by the commission, wasn't prepared to concede, without first doing modelling, that making releases from the outset after drawing down to 75% (as opposed to waiting till rearrival at 100% before making releases) would create more capacity to absorb inflows!

7. The bottom line with Wivenhoe is that, unless the dam's capacity is going to be significantly increased (either directly or by means of linkages with a hugely increased North Pine Dam or a hugely increased Borumba Dam), the fact that it has conflicting aims together with an inability to structurally survive a maximum possible event means that operating methods must improve dramatically. My suggestions are the only systemic ways to achieve that. Improved forecasting will help but could still be poorly utilised absent my suggestions.

Mr Callaghan, my second submission (especially 3rd & 4th paragraphs on page 2 and all of point 4 - pages 3,4) contains important observations re the Manual that simply haven't been addressed. I am sure, based on the commissioner's comments that she would appreciate understanding where I am coming from. Please either draw her attention to it or arrange for me to meet her for a few minutes in one of your quieter weeks.

The maths I did in my second submission was just a basic quick stab at beginning the layout of a framework for building a mathematical model to operate the dam (and guiding its operation whilst the model was being built).

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Best Regards,

Phil Hassid
Phil Hassid Flats Sales
27yrs as a specialist flats seller