Flood Commission

Review of Evidence - Citiswich Development

Prepared by Tony Loveday

INTRODUCTION

As requested, I have undertaken a review of a number of documents provided by the commission. My review is related to the following documents:

- Bremer Business Park Masterplan - Flooding Investigation dated August 2007 (Masterplan Flood Report – MFR)
- Citiswich Masterplan - Local Flooding Investigation
- Statement of Gary Ellis (without attachments)
- Transcript of evidence of Gary Ellis at the Commission's hearing in Ipswich on 19 October 2011
- Annexure GE-4 to the statement of Gary Ellis - Citiswich Masterplan - Local Flooding Investigation

SCOPE OF REVIEW

My review was initially to provide comments on the following topics:

1. Whether the conclusion in the Bremer Business Park Masterplan - Flooding Investigation dated August 2007 (Masterplan Flood Report) is accurate, in that the proposed development "will not impact adversely on flood levels external to the site and the flood immunity of the Warrego Highway has not been reduced";

2. With respect to topic 1, if no determination can be made as to accuracy, whether it was reasonable for the Ipswich City Council to rely on the Masterplan Flood Report in support of the development approval;

3. Whether there is any aspect of the Master Flood Report which ought to have caused the Ipswich City Council to have the Masterplan Flood Report reviewed by someone external to the council or seek a further report;

4. Whether the assertion that placing fill on land that is affected by flood flows of low or zero velocity would result in no impacts, or a negligible impact on flood levels is accurate, both in general terms and with respect to the Citiswich site; and

5. The circumstances in which flood levels and the area of land inundated by floods are not affected by reduction in the flood storage capacity of a river.

Subsequently, the scope was enlarged to include review of the Citiswich Masterplan - Local Flooding Investigation (June 2008 - Job No. LJ8714/R 6) (Local Flooding Investigation).

The supplementary scope required comment on:

6. whether the contents of the Local Flooding Investigation alter any of the conclusions drawn in response to the Commission's initial scope of work; and

7. whether the combined contents of the Masterplan Flood Report and the Local Flooding Investigation support a conclusion that the proposed development will have no adverse flood impacts external to the site.

OPINIONS

My opinions, outlined below, are based on my assessment of the textual, tabulated and plan information in the relevant documents. No check modelling has been carried out.

In respect to topic 1.

The conclusion in the Masterplan Flood Report that the proposed development "will not impact adversely on flood levels external to the site and the flood immunity of the Warrego Highway has not been reduced" cannot be supported.

The Report is incomplete and unclear in a number of respects. The major deficiencies, listed in the order in which they can be identified as one progresses through the report, are as follows:

- No staging plan is provided, even though it is mentioned in the fourth paragraph of *1. Introduction (MFR page 1).*

  A staging plan is necessary in order to manage progressive construction of the flood storage and detention components.

- An increase in post development peak flow rates in the eastern tributary is identified *(table 6.6, MFR page 9)* but no detention is provided on the basis that the increase is "deemed not significant".

  Full detention should have been provided. Refer to my comments on incremental effects below.

- A stage/storage relationship for the proposed detention basin on the western tributary is provided *(table 6.9, MFR page 11)* and the accompanying text suggests that the "resulting storage will be distributed throughout the site as detailed design proceeds".

  This needs more clarity in respect to the timing of construction of each storage as the construction of detention storages must keep pace with the increase in impermeable area with each individual stage of the development.

- Hydraulic modelling has looked at flooding in the Bremer and Brisbane Rivers as individual occurrences (i.e. Brisbane River flooding with no significant flow in the Bremer, and vice versa). The modelling appears not to have considered coincidental events.

  It is improbable that a 1 in 100 year event would occur in the Brisbane River without some significant flow in the Bremer (and vice versa) and coincidental events should have been considered in determining peak flood levels over the subject property. (This is not to say that 1 in 100 year events would necessarily occur in both rivers simultaneously).

  Refer to my comments on coincidental occurrence in adjoining waterways below.

- The description and plans of the flood level impact modelling are confusing and unclear.

  For example, figure I2 purports to show "additional storage" but the locations are very strange - one storage appears to be placed on the Warrego Highway and two others appear to be on land not part of the masterplan? If these were intended to be schematic "model" storages, it seems strange to illustrate them on a topographic water levels plan?

- The drawings which purport to show the filling and compensatory earthworks (Burchill VDM drawings in the appendix titled "Reference Drawings") are very unclear.

  Firstly, the drawings are too small, they contain no legend, the contours are unlabelled, and it is difficult to understand exactly what is being illustrated.

  Secondly, filling and compensatory earthworks need to stand alone for each stage of a multistage development. It is clearly not acceptable, for example, to fill a floodplain in early stages and leave the compensatory cut till the end stages.

  As they stand, the drawings are not suitable for use in monitoring subsequent details fill and compensatory earthworks proposals.

In respect to topic 2

The inadequacies of the Masterplan Flood Report should have been obvious to any reasonably experienced hydraulic engineer.

The document, as presented, should not have been relied upon in support of the development approval.

In respect to topic 3

The inadequacies of the Masterplan Flood Report, as outlined above, should have been obvious to any reasonably experienced hydraulic engineer. Identification of the defects does not require expert knowledge or specialist modelling skills. Whilst identification of some of the defects requires hydraulic knowledge, at least one (the lack of clarity of the cut/fill plans) requires only commonsense.

I would have expected that the necessary skills (to identify the defects) would be available in Council's engineering section. The obvious defects should have flagged to Council that further information was necessary.

In respect to topic 4

The assertion that placing fill on land that is affected by flood flows of low or zero velocity would result in no impacts, or a negligible impact on flood levels is <u>not</u> accurate.

Whether there is flow or not is irrelevant in that situation. Except in the trivial situations outlined below, loss of flood storage volume always causes impacts downstream.

In respect to topic 5

The only situations in which flood levels and the area of land inundated by floods would not be affected by reduction in the flood storage capacity of a river are:

- the trivial situation of a very small loss of volume in a very large river, and
- where flood flows are fully contained within defined waterways and do not break out across floodplains during large events. (This presumes, of course that there are no floodplains downstream).

However, note also my comments on incremental effects below.

In respect to topic 6

The Local Flooding Investigation appears to supersede the Masterplan Flood Report in respect to the proposals for the eastern and western local waterways. It also provides a small amount of additional detail in relation to the proposed bulk earthworks (stage 1 only). It does not provide any further information with respect to Bremer or Brisbane River floods.

For the western waterway, the Local Flooding Investigation provides more details of the sizing and location of the proposed mitigation structures and channel alterations.

The detail provided raises a new area of concern - the mitigation structures appear to be largely below flood levels that occur in the area of the western waterway with Brisbane and Bremer River floods. Clearly, for a mitigation structure to achieve its purpose of reducing flow rates, it must not, itself, be flooded by flows in the waterway to which it is discharging.

As far as can be ascertained from the plans provided, the mitigation structures proposed for the western waterway would all be inundated by both Bremer and Brisbane River flooding. They would then not provide mitigation of the increased post-development flows off site.

For the Eastern waterway, the Local Flooding Investigation details mitigation measures in respect to the widening of the existing waterway. The copy of the plans that I was provided with are a little unclear but it appears that the proposed widening is to be located immediately to the south of the Warrego Highway.

The modelling is claimed to show that this channel widening will mitigate the post-development increase in peak discharge rates. However, the modelling results are a little perplexing as they predict:

- increased peak flow rates downstream of the channel widening mitigation, and
- significant reductions in peak flow rates approximately 700 metres downstream of the enlarged channel ?

The predicted peak flow rate reductions occur immediately downstream of a model inflow point and might be related to hydrograph peaks in the Eastern waterway and inflow point (from an external catchment?) occurring at different times. Some further explanation in the report on this point would be beneficial.

In respect to topic 7

Apart from providing better detail for the mitigation proposals in the eastern and western waterways (but no information on construction timeframes relative to staging), the Local Flooding Investigation does not provide any additional information in respect to adverse flood impacts external to the site.

The details provided for the western waterway mitigation structures are concerning as it appears they will be inundated during Bremer or Brisbane River flooding, and therefore ineffective.

The combined contents of the Masterplan Flood Report and the Local Flooding Investigation do not support a conclusion that the proposed development will have no adverse flood impacts external to the site.

ADDITIONAL COMMENTS

Comments on incremental effects

It is well known in hydraulic engineering circles that small or "negligible" impacts, individually occurring as a result of a number of unrelated developments across a waterway or floodplain can, in fact, accumulate to result in an overall net adverse impact somewhere on the waterway.

As a result, most Councils are wary of allowing discernible but claimed "negligible" impacts, particularly in areas with known flooding problems, or in areas where future problems might be anticipated. This issue is less important where flood flows are fully contained within defined waterways and do not break out across floodplains during large events.

I note that Mr Ellis appears to be aware of this situation as he explains this "accumulation effect" in his evidence to the commission *(Transcript page 4248, second paragraph).*

Comments on coincidental occurrence in adjoining waterways

In hydraulic modelling of an individual waterway, boundary conditions at the limits of the model must be set as part of the model structure. At the downstream end of a river model, the boundary condition is often a defined water level (as it was in this specific case).

Where the section being modelled is near to the confluence with an adjoining waterway, the downstream boundary condition (water level) is potentially influenced by the flow conditions in the combined streams. In my opinion, this situation would probably occur in the Brisbane River/Bremer River system in the vicinity of the subject development.

A reference for determining the respective design frequencies for coincidental occurrence of flows in a main stream and tributary is the Urban Drainage Design Manual published by the US Federal Highway Administration and commonly known as HEC 22. A copy of the relevant section is attached (Attachment 1).

I am not aware of a specific Australian reference to this issue.

With a catchment area ratio (Brisbane/Bremer) of, very roughly, 7:1, HEC 22 table 7-3 suggests that coincidental flows of 1:100 in one river and 1:50 in the other (and vice versa) should be considered.
An internet search shows that the recommendations in HEC 22 are adopted in a number of other jurisdictions.

I have personally used the HEC 22 recommended frequencies for coincidental occurrence in the hydraulic modelling of a waterway near a confluence for a project near Caboolture in the last couple of years.

Comments on flood storage

The effects of loss of flood storage are well known.

Regulatory authorities all over the world require compensatory earthworks where filling on a floodplain is proposed. Specific details sometimes vary, but the Brisbane City Council compensatory earthworks guidelines, contained in the Brisbane City Plan 2000, are typical. A copy of the relevant section of the BCC document is attached (Attachment 2).

Typically, the proposed filling and compensatory cut are required to be in the same general area of the waterway. If they are separated, there will be impacts in the waterway between (and potentially elsewhere in the waterway).

Also, filling and compensatory earthworks must stand alone for any particular stage of the development. They should also be carried out at least concurrently, or, preferably, with the cut first.

I don't recall ever seeing any specific development conditions requiring such concurrence, but it is a logical and commonsense requirement.

[redacted]

AE Loveday
RPEQ 2210

Attachment 1

HEC 22

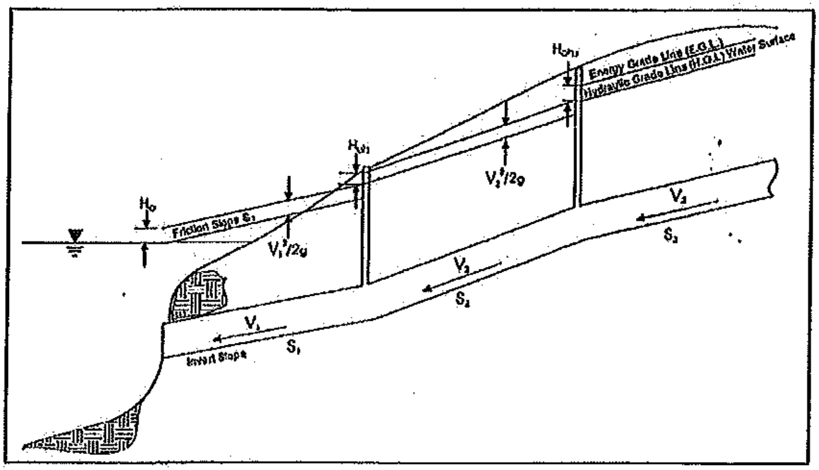
U.S. Department
of Transportation
Federal Highway
Administration

FHWA-SA-96-078

Office of Engineering
Office of Technology Applications
400 7th Street, SW
Washington, DC

URBAN DRAINAGE DESIGN MANUAL

Hydraulic Engineering Circular No. 22



November 1996

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Table 7-3. Frequencies for coincidental occurrence.

AREA RATIO	FREQUENCIES FOR COINCIDENTAL OCCURRENCE			
	10 Year Design		100 Year Design	
	main stream	tributary	main stream	tributary
10,000 to 1	1 10	10 1	2 100	100 2
1,000 to 1	2 10	10 2	10 100	100 10
100 to 1	5 10	10 5	25 100	100 25
10 to 1	10 10	10 10	50 100	100 50
1 to 1	10 10	10 10	100 100	100 100

7.1.6 Energy Losses

Prior to computing the hydraulic grade line, all energy losses in pipe runs and junctions must be estimated. In addition to the principal energy involved in overcoming the friction in each conduit run, energy (or head) is required to overcome changes in momentum or turbulence at outlets, inlets, bends, transitions, junctions, and access holes. The following sections present relationships for estimating typical energy losses in storm drainage systems. The application of some of these relationships is included in the design example in section 7.6.

7.1.6.1 Pipe Friction Losses

The major loss in a storm drainage system is the friction or boundary shear loss. The head loss due to friction in a pipe is computed as follows:

$$H_f = S_f\,L \tag{7-2}$$

where: H_f = friction loss, m (ft)
S_f = friction slope, m/m (ft/ft)
L = length of pipe, m (ft)

The flowline or invert elevation of the proposed outlet should be equal to or higher than the flowline of the outfall. If this is not the case, there may be a need to pump or otherwise lift the water to the elevation of the outfall.

The tailwater depth or elevation in the storm drain outfall must be considered carefully. Evaluation of the hydraulic grade line for a storm drainage system begins at the system outfall with the tailwater elevation. For most design applications, the tailwater will either be above the crown of the outlet or can be considered to be between the crown and critical depth of the outlet. The tailwater may also occur between the critical depth and the invert of the outlet, however, the starting point for the hydraulic grade line determination should be either the design tailwater elevation or $(d_c + D)/2$, whichever is highest.

An exception to the above rule would be for a very large outfall with low tailwater where a water surface profile calculation would be appropriate to determine the location where the water surface will intersect the top of the barrel and full flow calculations can begin. In this case, the downstream water surface elevation would be based on critical depth or the design tailwater elevation, whichever was highest.

If the outfall channel is a river or stream, it may be necessary to consider the joint or coincidental probability of two hydrologic events occurring at the same time to adequately determine the elevation of the tailwater in the receiving stream. The relative independence of the discharge from the storm drainage system can be qualitatively evaluated by a comparison of the drainage area of the receiving stream to the area of the storm drainage system. For example, if the storm drainage system has a drainage area much smaller than that of the receiving stream, the peak discharge from the storm drainage system may be out of phase with the peak discharge from the receiving watershed. Table 7-3 provides a comparison of discharge frequencies for coincidental occurrence for a 10 year and 100 year design storm. This table can be used to establish an appropriate design tailwater elevation for a storm drainage system based on the expected coincident storm frequency on the outfall channel. For example, if the receiving stream has a drainage area of 200 hectares and the storm drainage system has a drainage area of 2 hectares, the ratio of receiving area to storm drainage area is 200 to 2 which equals 100 to 1. From table 7-3 and considering a 10 year design storm occurring over both areas, the flow rate in the main stream will be equal to that of a five year storm when the drainage system flow rate reaches its 10 year peak flow at the outfall. Conversely, when the flow rate in the main channel reaches its 10 year peak flow rate, the flow rate from the storm drainage system will have fallen to the 5 year peak flow rate discharge. This is because the drainage areas are different sizes, and the time to peak for each drainage area is different.

There may be instances in which an excessive tailwater causes flow to back up the storm drainage system and out of inlets and access holes, creating unexpected and perhaps hazardous flooding conditions. The potential for this should be considered. Flap gates placed at the outlet can sometimes alleviate this condition; otherwise, it may be necessary to isolate the storm drain from the outfall by use of a pump station.

Energy dissipation may be required to protect the storm drain outlet. Protection is usually required at the outlet to prevent erosion of the outfall bed and banks. Riprap aprons or energy dissipators should be provided if high velocities are expected. See HEC-14, "Hydraulic Design of Energy Dissipators for Culverts and Channels"[35] for guidance with designing an appropriate dissipator.

The orientation of the outfall is another important design consideration. Where practical, the outlet of the storm drain should be positioned in the outfall channel so that it is pointed in a downstream direction. This will reduce turbulence and the potential for excessive erosion. If the outfall structure can not be oriented in a downstream direction, the potential for outlet scour must be considered. For example, where a storm drain outfall discharges perpendicular to the direction of flow of the receiving channel, care must be taken to avoid erosion on the opposite channel bank. If erosion potential exists, a channel bank lining of riprap or other suitable material should be installed on the bank. Alternatively, an energy dissipator structure could be used at the storm drain outlet.

Attachment 2

Extract from BCC Guidelines

Compensatory Earthworks Planning Scheme Policy

Contents

1 Introduction

This Planning Scheme Policy explains Brisbane City Council's requirements when reshaping of land is proposed within a Waterway Corridor. Earthworks within the Waterway Corridor will only be considered when they do not conflict with the **Waterways Code** or the **Filling and Excavation Code.**

2 Objectives

The objective of this policy is to ensure that earthworks reduce neither the flood–storage capacity nor flood–carrying capacity of the area within a Waterway Corridor.

3 Balanced vs Compensatory Earthworks

For earthworks to be acceptable within a Waterway Corridor they must not adversely impact the hydraulic characteristics of the watercourse. Adverse impacts may be direct, indirect or cumulative and include:

- reducing the flood–carrying capacity of a watercourse; and/or
- reducing flood storage; and/or
- altering the hydraulic control of the stream and thus causing scour and sedimentation.

It is too simplistic to assume that earthworks will have a negligible impact on the hydraulics of a waterway if the works are *balanced*. That is the total volume of 'fill' (material added within a Waterway Corridor) equals or is less than the total volume of 'cut' (material excavated from within a Waterway Corridor). Hydraulic processes are complex, a simple 'total fill ≤ total cut' equation will not guarantee that the flood–storage capacity and flood–carrying capacity of a Waterway Corridor are maintained. These requirements ensure that that the hydraulic characteristics of the waterway are maintained.

To preserve the hydraulic characteristics within a Waterway Corridor, the volume of 'cut' and 'fill' must be *compensatory* between incremental flood levels. In Example 2, the volume of 'fill' is equal to or less than the volume of 'cut' between each incremental level. If more 'fill' than 'cut' were added between levels (see Example 1, 5.2 – 5.4m AHD) then the flood–storage capacity and flood-carrying capacity within a Waterway Corridor would be reduced for certain flood events with adverse consequences to flooding.

Example 1: Balanced Earthworks

Level (m AHD)	Cut (m^3)	Fill (m^3)
5 – 5.2	600	200
5.2 – 5.4	300	500
5.4 – 5.6	400	600
Total	*1,300*	*1,300*

Example 2: Compensatory Earthworks

Level (m AHD)	Cut (m^3)	Fill (m^3)
5 – 5.2	600	≤600
5.2 – 5.4	300	≤300
5.4 – 5.6	400	≤400
Total	*1,300*	*1,300*

Balanced earthworks can reduce the hydraulic capacity of a watercourse for large floods. The increase arising from a single development may be small; however, once allowed on one property, history has shown that neighbouring properties seek the same relaxation on the basis of the precedent set. The cumulative effect leads to unacceptable rises in flood levels. For this reason applications to develop within a floodplain must be based on compensatory earthworks rather than balanced earthworks.

4 Prelodgement Guidance

Compensatory earthworks are not to be carried out below the 1 in 20 year Average Recurrence Interval (ARI) flood inundation level based upon ultimate catchment development. Excavation below this limit is known to lead to erosion problems on the floodplain and watercourse banks that can be difficult to repair or stabilise. This has occurred on previous developments.

Compensatory earthworks will not be approved in areas close to the watercourse within the waterway that is subject to high velocity water currents. This is because altering the geometry of the watercourse in these areas is likely to raise upstream flood levels. Scour problems can also occur to the newly exposed surfaces (whether they be cut or fill surfaces). Scour problems can also occur to undisturbed areas nearby caused by swirling eddies as a result of the ground surface changes.

Areas subject to backwater flooding are more amenable to have compensatory earthworks approved as impacts are likely to have less impact on storage and conveyance.

If the proposed compensatory earthworks involve excavation outside the Waterway Corridor, then the Waterway Corridor mapping will be amended in order to encompass the excavated area. This requirement protects the excavated area from being refilled at a later date and thus worsening flooding.

5 Application Requirements

Investigation to justify compensatory earthworks involves:

- **detailed survey** of the area to be affected by the earthwork operations so that existing land features are reflected in the data
- calculation of **earthwork volumes** in accordance with the methods outlined below
- **hydraulic modelling** to determine pre– and post–development flood levels for a range of floods up to and including the defined flood to test the development proposal on its own and in combination with other development.

5.1 Item (a) Detailed Survey

Detailed survey of the area to be affected by the earthwork operations is required so that earthwork volumes (Item b) can be calculated with confidence.

5.2 Item (b) Compensatory Earthwork Volumes

Applicants must provide a table of earthwork volumes to demonstrate that the hydraulic characteristics within a Waterway Corridor are not adversely affected by the proposed development. The method to determine whether 'cut and fill' volumes are compensatory between specific flood levels is described below and illustrated in *Table 1* and *Figure a*.

1. Determine the lowest limit of the proposed earthworks (either 'cut' or 'fill' level) remembering that compensatory earthworks are not to be carried out below the anticipated 1 in 20–year ARI flood level.
2. Acquire from Council the pre–development flood levels for the 1 in 100–year ARI design event based upon ultimate catchment development. If unavailable, the developer needs to determine this.
3. Determine the increment *y*, where *y* is either 200mm or approximately one quarter of the difference between the anticipated 1 in 100 year ARI flood level and the Low Earthwork Limit, whichever is smaller.
4. The first increment between which to calculate cut and fill volumes is the Low Earthwork Limit plus *y* (refer to *Table 1*).
5. Determine cut and fill volumes for each increment up to a level equal to the anticipated 1 in 100 year ARI flood level, based on ultimate catchment development.
6. In order to be compensatory, fill volumes must be equal to or less than the cut volumes at the corresponding increments.

Table 1 Calculating Compensatory Cut and Fill Volumes

Incremental Level (m AHD)	Proposed	
	Cut (m^3)	Fill (m^3)
Start at Low Earthwork Limit – always > the 1 in 20 year ARI flood level		
Lowest Earthworks to EL 1 *(EL 1 = Lowest Earthworks Limit + y)*	a	A (≤a)
EL 1 to EL 2 *(EL 2 = EL 1 + y)*	b	B (≤b)
EL 2 to EL 3 *(EL 3 = EL 2 + y)*	c	C (≤c)
Continue with increments as appropriate upto the 1 in 100 year ARI flood level		
EL… to 1 in 100 year ARI level	z	Z (≤z)

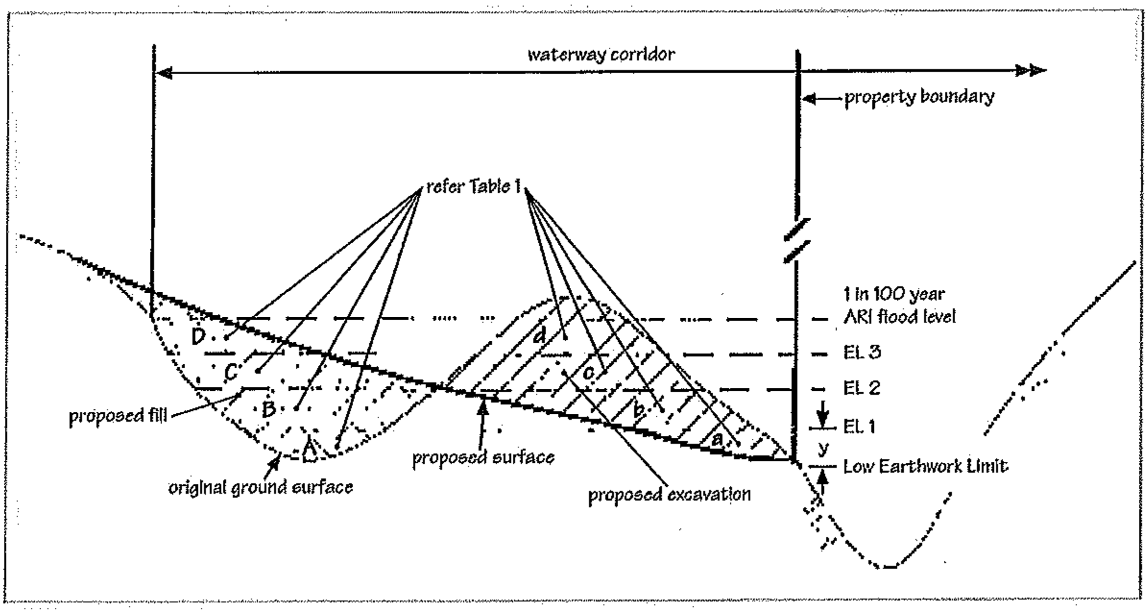

Figure a Calculating Compensatory Cut and Fill Volumes – Cross Section

Typical Compensatory Earthworks

Typical layouts for compensatory earthworks are shown in *Figure b* and *Figure c*.

Figure b shows excavation of a 'high area' within a Waterway Corridor. (For cross–section of 'high area' refer to *Figure a*). No adjustment of a Waterway Corridor is required because all 'cut and fill' occurs within the Waterway Corridor.

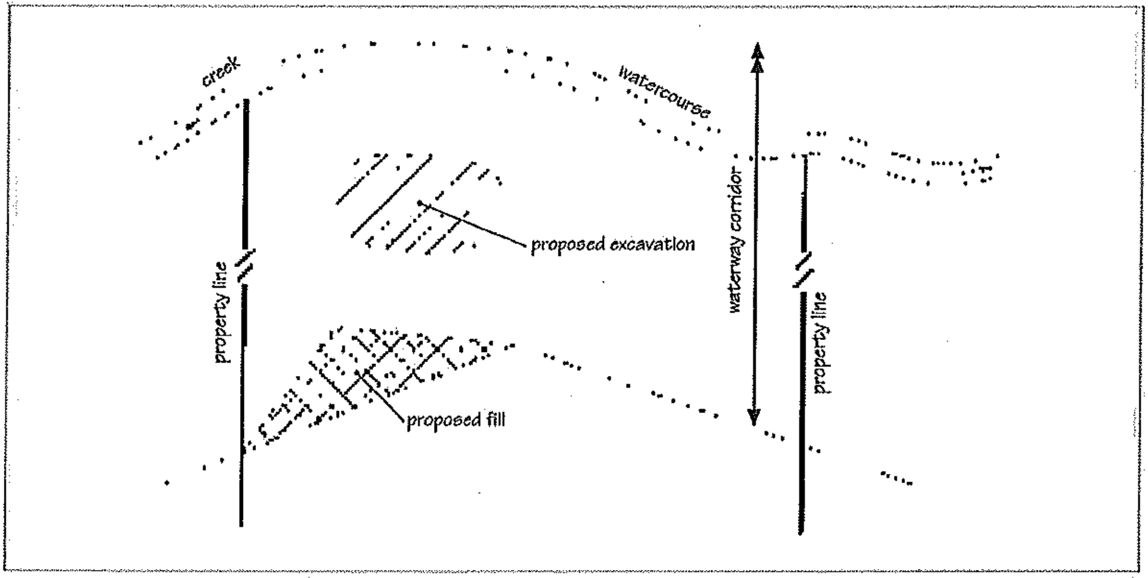

Figure b   Compensatory Earthworks layout, no change to Waterway Corridor required – Plan View

In contrast, *Figure c* shows where excavation outside the existing Waterway Corridor is required to meet the compensatory earthworks standard. In this latter case, the Waterway Corridor must be extended to encompass the excavation. This requirement helps to protect the excavated area from being refilled at a later date and thus worsening flooding.

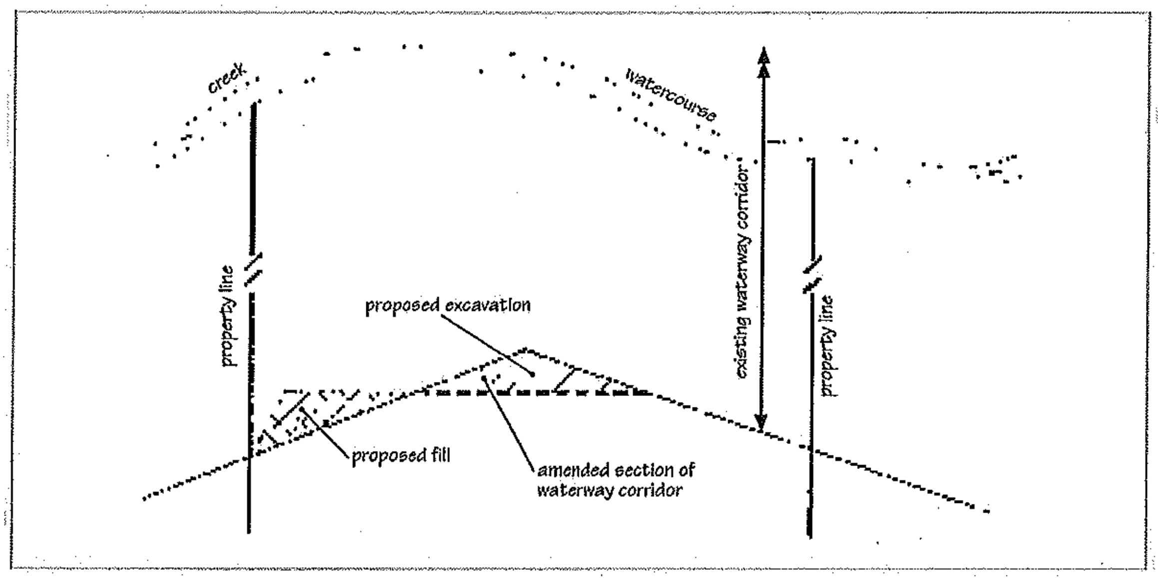

Figure c   Compensatory Earthworks layout, change to Waterway Corridor required – Plan View

Typical Example of 'Balanced Earthworks' that is Unacceptable

Figure d shows a 'cut and fill' operation within a Waterway Corridor that would be unacceptable. Even though the total volume of 'cut' equals the total volume of 'fill', these earthworks are unacceptable because at some *incremental levels* the volume of 'fill' exceeds the volume of 'cut'. The earthworks therefore will change the storage characteristics of the watercourse, increasing flood levels downstream for some flood events. The increase arising from a single development may be small; however, once allowed on one property, it is a natural and equitable process for the neighbouring properties to seek the same relaxation on the basis of the precedent set. The cumulative effect leads to unacceptable rises in flood levels.

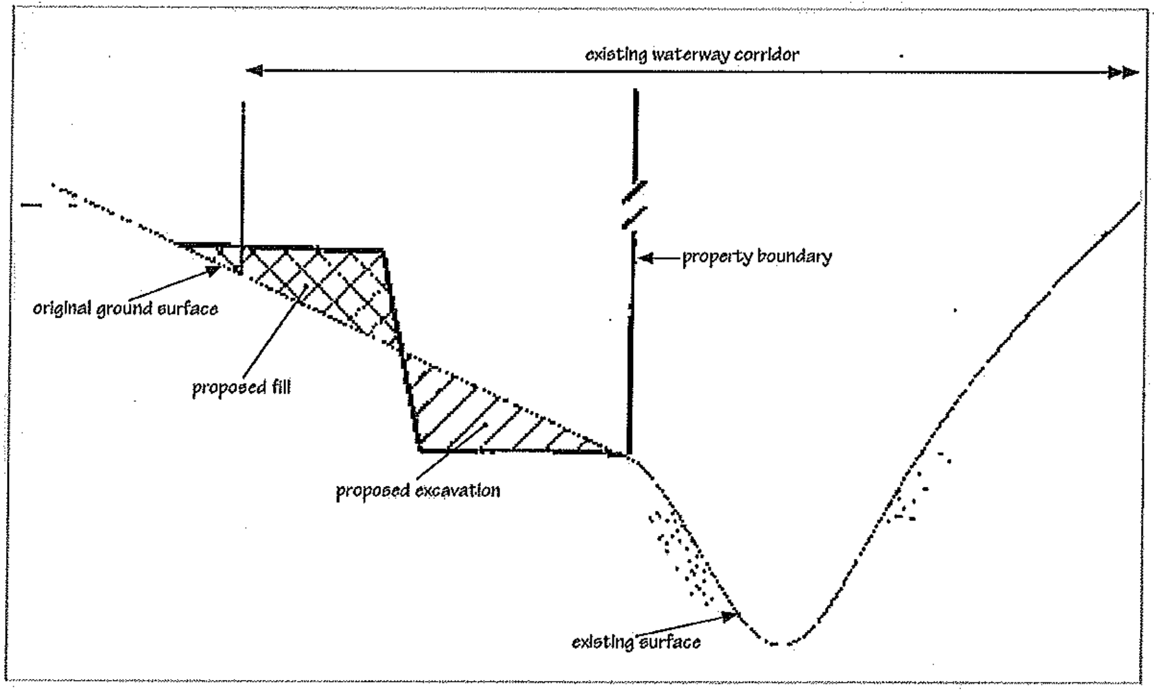

Figure d Unacceptable Balanced Earthworks – Cross Section

5.3 Item (c) Hydraulic Modelling

Calculating compensatory 'cut and fill' volumes at incremental levels (5.2 Item b) helps to identify the impact of earthworks on the storage capacity of a watercourse. The method does not, however, clearly show the likely impacts of the earthworks on a watercourse's conveyance capacity.

Therefore, development applicants are required to model pre– and post–development flood levels for a range of flood events up to and including the defined flood event to test that the development proposal causes no increase or decrease in flood level immediately upstream of the proposed compensatory earthworks.

Earthworks that increase or decrease the conveyance capacity of a watercourse are likely to be unacceptable. This is because increasing the conveyance capacity of the watercourse at the site of the earthworks reduces the effectiveness of flood storage and is likely to increase flooding downstream. Conversely, reducing the conveyance capacity of the watercourse at the site of the earthworks is likely to increase flooding upstream.