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Dear David

I have had chance to review the documentation relating to the Sandon Point Development. With respect to my previous report for Sandon Point (COI) I do not (at this point) see the need to deviate from my findings. These were made after extensive discussions with DIPNR (now DNR), Stocklands and Brown Consulting and yourselves.

I would like to clarify my comments on the third paragraph of pp. 63 of our COI submission. Hewitts Creek is relatively urbanised (43%) and the system is already significantly affected by development. It is not well linked or connected to the upper reaches where remnant native vegetation exists. The 10% rule in urban ecology is a well understood concept – this being that once a catchment becomes urbanised above ~10% then creek systems display a significantly degraded ecological condition (Ladson et al., 2004).

It is understood by all parties that Woodlands Creek slightly exceeds this value of urbanisation (16.8%) but I still would suggest that this is the most significant system within the development site. While DNRs comment that wider buffer widths equal greater biodiversity is generally true (Ives et al., 2005), there remains a significant paucity of evidence from Sydney streams to support this argument. However, absence of evidence should not be taken to mean evidence of absence but the context of this development needs to be considered.

If DNR and other government agencies consider the riparian lands to be of such high value and ecological significance I wonder why they were not purchased for perpetuity by the government on behalf of the NSW public? With regard to development and environment issues I refer to the *Miltonbrook v Shellharbour [2004]* NSWLEC 86 (16 March 2004) case which stated that "certain areas are set aside for conservation, others for regeneration and yet others for development. This site has been designated for development". This situation seems to apply to Sandon Point development.

I will be return from my overseas work trip on October 6th.

Kind regards

Dr Mark P Taylor

4 PROPOSED FLOOD MITIGATION MEASURES

The Hewitts Creek Floodplain Risk Management Study (HCFRMS), draft August 2002, has identified the existing flood hazard for the catchment and has described the hazards as:

- High Flood Risk — Being identified as land subject to a high hydraulic hazard in 100 year ARI event. This is to include all land within 10m of the top of the creek bank as a setback for erosion risks.
- Medium Flood Risk — Being identified as land at a level below the 100 year ARI flood level plus 500mm freeboard.
- Low Flood Risk — All other land within the floodplain (ie within the limits of PMF flooding) but not identified as high or medium flood risk.

The draft HCFRMS has recommended a range of mitigation measures to reduce the impact of the designated flood on the catchment. The mitigation measures that impact on the site are:

- Provide a high flow culvert under the railway line at Tramway Creek (T5) – High Priority.
- Re-divert Woodlands Creek from Hewitts Creek to Tramway Creek (W5) – High Priority.
- Enlarge and stabilise the existing creek from Woodlands to Tramway Creek (W6) – Low Priority.
- Provide a high flow culvert under the railway line at Woodlands Creek (W4) – High Priority.
- Construct a levee along the northern bank of Hewitts Creek near Corbett Avenue (H10) – High Priority.
- Close the access road from Lawrence Hargrave Drive to the railway line and create a creek channel with offline water quality pond and sediment trap (H9) – Low Priority.

The study has recommended that the high priority actions should occur over a 1 to 5 year horizon. The impacts of these proposed mitigation measures have been incorporated into the development of the design of the stormwater drainage and creek systems.

5 GEOMORPHIC ASSESSMENT OF THE CREEK CORRIDORS[3]

5.1 General Context and Proposal

The management of urban stream channels require the application of 'soft engineering' methods that satisfy flood mitigation policies and are also sympathetic to the nature and geomorphic structure of the catchment. In order to ascertain the most practical and environmentally acceptable solution for the redesigning of Hewitt's and Woodland's Creeks within the constraints of the proposed development plan, it is necessary to consider the reaches within the context of the remainder of the catchment. A catchment perspective enables one to determine the relative potential for long-term rehabilitation of Woodlands and Hewitt's creeks. The different structure of reaches with regard to their potential for long-term recovery is listed in **Table 4** and the implications for Hewitt's and Woodland's creeks are discussed in detail below.

Table 4. Reach based descriptions for river recovery potential

1.	**Conservation Reaches** – These are the least disturbed parts of a catchment (e.g. upper reaches of both Woodland's and Hewitt's creeks). Management strategies should aim to maintain or improve the physical integrity of the river/catchment to ensure that these areas can act of conduits for flora and fauna migration to other parts of the system.
2.	**Strategic reaches** – These are reaches of river that may be sensitive to disturbance, triggering impacts that my have off-site secondary responses. Proactive (or pre-emptive) management strategies are the most effective means of river conservation, particularly where disturbances may threaten the integrity of remnant or Conservation Reaches.
3.	**Connected reaches with high recovery potential** – If a reach displays signs of natural recovery – i.e. self adjustment in a manner which matches boundary conditions and the landscape setting/river style, there is a high probability that appropriate management practices that work with the natural behaviour of the river will achieve rapid and visible success.
4.	**Isolated reaches with high recovery potential** - These reaches have high inherent recovery potential (akin to 3), but are relatively isolated within the catchment.
5.	**Potential rehabilitation reaches** – These moderately degraded reaches have reasonable potential to recover and can be rehabilitated at reasonable cost. They are usually isolated with the catchment and river structure and vegetation associations require improvement.
6.	**Highly degraded rehabilitation reaches** - Highly degraded reaches within a catchment have limited natural recovery potential – i.e. the river shows signs of continued degradation such as accelerated sedimentation or erosion or has developed a river style that does not fit the natural landscape setting due to disturbance.

It is worth recognising that the long-term viability of the two creeks is substantially different. The high degree of urbanisation and the absence of catchment connectivity to high quality, undegraded reaches in Hewitt's Creek would indicate that the long-term investment on returns (i.e. rehabilitation works) would be relatively poor. In contrast, Woodland's Creek has a very high chance of retaining and sustaining any replanted native vegetation because the upstream seed banks are natural and the system will not be under constant bombardment from exotic seeds and water enriched in phosphorous and nitrates. It would therefore be prudent to take these factors into account when deciding upon:

- The long-term vision for the creeks;
- The effort (time and money) spent on rehabilitating each of the two systems; and
- The long-term prognosis for the two creeks.

Whenever restoration is being applied to urban systems that have been heavily degraded it is important to accept that it may not be possible to restore the various components of the fluvial system to some previous condition. This might be due to a variety of reasons e.g. lack of scientific data detailing previous conditions, changed boundary conditions; alteration of flood frequency and magnitude relationships due to changes in catchment hydrology, and the impact of development and urbanisation. Therefore, in urban zones it is more reasonable to aim for a more modest outcome, one that is based on providing a functional riparian zone and a channel system that mimics natural form to the maximum extent possible (Gregory and Chin, in press). Given that the creeks lie adjacent to proposed urban development the aim should be to establish a natural looking, multifunctional riparian zone (i.e. one that satisfies the proposed development, the flood mitigation requirements and safely transmits extreme) such that the river can function with minimal maintenance.

In some segments, hard engineering may remain the only viable solution, whereas creative engineering, although not necessarily the most aesthetic can often be the most expedient procedure to adopt. The adoption of a catchment perspective means that the management of urban channels can be much more effective through assessing the ways in which different reaches interrelate to the geomorphological structure and character of the catchment as a whole.

[3] This Chapter has been prepared by Dr Mark Patrick Taylor, Macquarie University

Hewitt's Creek – is a heavily urbanised catchment (43%), which will be a limiting factor on the long-term natural regeneration of the creek. The two main reasons for this are:

- The upstream seed bank is dominated by exotic vegetation; and
- Nutrient levels (in particular phosphorous and nitrates) are likely to be elevated above natural levels and thus favour the growth of exotic over native vegetation.

In its current state this reach equates to a "Highly Degraded" reach (Table 4). The reach is not closely linked or connected to upstream reaches, which are in poor condition, which would provide a source of seeds, organic matter and nutrients. This therefore, will be a limiting factor in the long term future of the creek.

Downstream, the situation is a little better, with the creek being in reasonable condition although it is a distal remnant and could be viewed as being an "Isolated reach with high recovery potential". It is possible that *typha* and *phragmatis* will migrate upstream and occupy the channels that are created by the rehabilitation works. These emergent vegetation types will provide habitat and also protect the channel during flows in two ways:

- They will bind the soil and channel boundary materials reducing direct erosion; and
- During high flows they will lie down and actually reduce channel roughness (in channel Manning's n values will therefore be less during peak flows) by smoothing the creek bed.

Should rehabilitation works be carried out downstream of the Stockland site it would be logical and advisable to also consider addressing the spread and concentration of exotics immediately upstream of the proposed rehabilitation reach.

Woodland's Creek – is a predominantly 'natural' creek with only 16.8 % given over to urban development. Of the two creeks (Hewitt's and Woodland's), Woodland's has the best potential for sustained recovery because the upstream catchment is predominantly bush or rural in nature.

In its current condition the creek is "Highly Degraded", but because it is well connected to stable, self maintaining systems up and downstream it should also be viewed as a "Strategic Reach" (Table 4). The management strategies proposed by Stockland are an effective and pragmatic means of achieving river conservation. Without intervention, the reach will never recover because disturbance has diminished and removed any semblance of suitable biophysical structure. The reach will be almost entirely created from scratch, one that incorporates the maximum possible biophysical diversity as well as integrating the requirements for flood mitigation, within the agreed confines of the riparian corridor.

Unnamed Creek – This small, stable creek appears in relatively good condition and requires no major engineering or changes to the current fluvial geomorphological structure in order to naturalize or create a more desirable structure.

5.2 River Recover Potential

Once the status of the creek system with respect to the catchment has been determined (Table 4), assessment of where that stream lies with respect to its long term 'geomorphic recovery potential' can be conducted. This can be done through using a conceptual framework (**Figure 1**):

- The vertical line from Intact River System through to Degraded is a conceptual, dimensionless continuum of "river condition".
- At the Transitional point there are four potential pathways:
- The first pathway is a restored condition where the river is self-equilibrating to a condition similar to its intact state.
- The second pathway is towards a created condition, where geomorphic change is irreversible and a new "idealised" condition is created.
- The third pathway is for the river to remain in a degraded state with little apparent opportunity for recovery to any viable form (similar to that at Woodland's Creek).
- The fourth pathway is one of human intervention. Following assessment of the system, management intervention and appropriate plans are developed to redesign a channel that mimics natural forms.

Ultimately both Hewitt's and Woodland's Creeks will lie on this latter pathway – they will undergo human intervention and be created reaches, developed using a combination of pragmatic (hydraulic and flood mitigation) and biophysical (appropriate vegetation and self-sustaining width: depth ratios) guidelines. However, it is relevant to note that it is very unlikely that either of the creeks will reach this stage without human intervention.

A reasonable target for the end point of channel recovery of these two creeks is to consider whether the end point, the "created condition", is self-sustaining within the modelled physical processes that characterise the catchment. It accepted (by DLWC and ourselves) that there would be damage to riparian vegetation, some soil loss and associated changes in channel geomorphology as flow increases above the 1:5 year ARI storm event. Within the riparian zone, agreed to between Stockland and DLWC in the Deed of Agreement, this is achievable – flood mitigation concerns can be met and a suitably created geomorphic structure can be developed that offers acceptable form and function such that the upstream and downstream reaches will not be negatively affected.

Overall, it would appear that the long-term prognosis (riparian vegetation, geomorphic function and habitat) is far better for Woodland's rather than Hewitt's Creek. It is worth noting that while one may devise a suitable biophysical structure for Hewitt's Creek, similar to Woodland's Creek, the caveat is that in the long term one can expect Woodland's to retain more of the naturalised and created condition than Hewitt's because of inherent catchment factors, which lie beyond Stockland's control.

Table 5. Stages of river recovery and potential changes in river character (after Fryirs and Brierley, 2000).

River Condition	Physical Attributes
Intact	Geomorphic characteristics and behavioural attributes are consistent with the pre-disturbance condition. Reaches often have intact or remnant riparian vegetation and the geomorphic conditions are such that recovery will occur following major environmental disturbances e.g. fire and flood.
Degraded	River has been altered such that it is a long way from its intact condition and has not yet commenced along a recovery pathway.
Turning point	A transitional stage – the river may move in any of three directions – it shows signs of recovery (physical and riparian vegetation) but it is in a state of disequilibrium with respect to its boundary conditions.
Restoration	River shows signs of natural recovery and has developed some resistance to change. River structure and vegetation are robust and operate in a self-adjusting manner and are able to withstand environmental disturbance.
Creation	Changes to catchment boundary conditions are so profound that recovery processes dictate that the river is moving toward a new condition. Although the system is self-adjusting and in equilibrium (as for restoration reaches), they lack the form and function of the pre-disturbance river reach.
Human Intervention – created condition	River system is so badly degraded that the only opportunity for some form of naturalisation is to 'create' a river form preferably using 'soft engineering' techniques to produce a channel that mimics natural forms to the maximum extent possible such that the channel requires minimal maintenance.

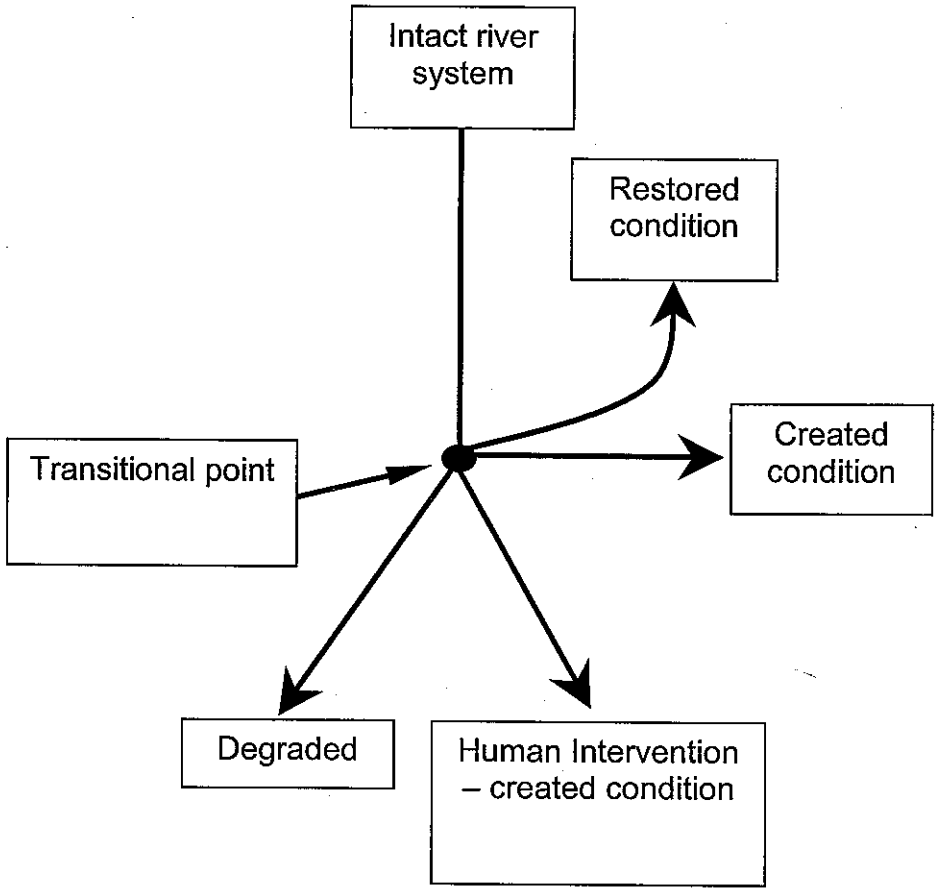

Figure 1 **Conceptual framework to assess relative geomorphic condition along the degradation/recovery continuum (figure adapted from Fryirs and Brierley, 2000).**