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LESSONS FROM A WATER SENSITIVE SUBDIVISION - ELAMBRA ESTATE, GERRINGONG

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Abstract:

Kiama Municipal Council is currently developing a 213 lot residential subdivision known as Elambra Estate on the southern outskirts of Gerringong on the New South Wales south coast. Council's vision for the 22 Ha site is sustainable development that yields significant environmental benefits and a competitive return on investment.

This report details aspects of the water sensitive design components of the development - from the initial planning phase to the development of detailed designs. The project involved the development of a cost effective stormwater treatment train for the estate which incorporates source, conveyance and end of pipe controls in combination with riparian zone management.

Land take for stormwater treatment processes was to be minimised to demonstrate that water sensitive land development is economically viable. Rainwater tanks utilised for combined rainwater harvesting and on-site detention to provide at source control. Harvested roof water is to be plumbed into properties for a full range of domestic uses, including drinking.

A two-pipe system was incorporated into the design that separates 'clean' and 'dirty' runoff. The clean pipe system conveys runoff from tank overflows and other paved surfaces within individual allotments. The dirty pipe system conveys runoff from roads and footpaths to end of pipe water quality treatment devices. Despite an increase in the number of pipes from a two-pipe system, there is a net cost saving due to smaller land take and reduced size of end of pipe treatments.

Water sensitive approaches were only fully considered in the final stages of estate planning once road and lot layouts had been established. A critical lesson learnt here by Council was the need to integrate water sensitive principles into the planning phase of a development to ensure that the full range of water sensitive techniques are available for consideration in later development.

Because of the intended potable consumption of roof water, the subdivision faced an array of institutional barriers posed by Sydney Water and Department of Health. This paper provides commentary on this process as well as other key lessons that may facilitate the planning and design of other water sensitive designs.

1 INTRODUCTION

Elambra Estate is a 213 lot residential subdivision currently under development by Kiama Municipal Council on the southern outskirts of Gerringong on the New South Wales south coast.

The site was purchased by Council in 1999 with a view to demonstrate that residential development embedded with environmentally sustainable practices and advanced urban design policy could yield a competitive return on investment.

A key aspect of the environmental sustainability of the estate is the management of stormwater. A Water Sensitive Design approach was adopted by Council resulting in a treatment train to manage runoff quantity and quality. Council engaged STORM_CONSULTING to assist with the planning and design of the water sensitive design strategy for the estate.

Initial stages of the development are under construction and the lots released to date were sold with sales promotions highlighting the sustainable design aspects of the subdivision.

2 OBJECTIVES OF THE WATER SENSITIVE DESIGN STRATEGY

The water sensitive strategy had the following objectives:

- Development of a treatment train incorporating source, conveyance and end of pipe controls in association with riparian zone management;
- Achievement of the stormwater treatment objectives included in Council's Stormwater Management Plan (Tables 1 and 2, Kiama Council 1999);
- Examine options for resource conservation by stormwater harvesting;
- Limit post development peak flow rates to pre-development levels

Other factors considered in the development of water sensitive design options were the whole of life cost, the land requirements and the ease of maintenance for Council's day labour staff of each proposed management option.

Table 1: Quantitative stormwater objectives for new development (Kiama Municipal Council Stormwater Management Plan, 1999)

Pollutant/Issue	Retention Criteria
Coarse Sediment	80% of average annual load for particles $\leq$ 0.5mm
Fine Particles	50% of average annual load for particles $\leq$ 0.1mm
Total Phosphorus	45% of average annual pollutant load
Total Nitrogen	45% of average annual pollutant load
Litter	70% of average annual litter load > 5mm
Hydrocarbons, motor fuels, oils and grease	90% of average annual pollutant load

Table 2: Qualitative stormwater objectives for new development (Kiama Municipal Council Stormwater Management Plan, 1999)

<table>
<tr><th>Pollutant/Issue</th><th>Management Objective</th></tr>
<tr><td rowspan="2">Runoff Volumes</td><td>Limit impervious area directly connected to the drainage system</td></tr>
<tr><td>Reuse of stormwater for non-potable purposes maximised</td></tr>
<tr><td rowspan="2">Stormwater Quality</td><td>Use of vegetated flow paths maximised</td></tr>
<tr><td>Use of stormwater infiltration ‘at source’ where appropriate</td></tr>
<tr><td>Riparian Vegetation and Aquatic Habitat</td><td>Protect and maintain natural wetlands, watercourses and riparian corridors. All natural (or modified) drainage channels within the site which possess either:
(a) base flow
(b) defined bed and/or bank or;
(c) riparian vegetation
are to be protected and maintained. Natural channel designs should be adopted in lieu of floodways in areas where there is no natural channel.</td></tr>
<tr><td>Flow</td><td>Alterations to natural flow paths, discharge points and runoff volumes from the site are to be minimised. The frequency of bank-full flows should not increase as a result of development. Generally no increase in the 1.5 year and 100 year peak flows.</td></tr>
<tr><td>Amenity</td><td>Multiple use of stormwater facilities to the degree compatible with other management objectives.</td></tr>
<tr><td>Urban Bushland</td><td>Impact of stormwater discharges on urban bushland areas minimised.</td></tr>
</table>

3 EXISTING SITE CONDITIONS

The 22 hectare site is dominated by a north easterly trending ridge along the eastern site boundary. A north westerly trending spur and two intermittent drainage depressions are located on the western ridge flank. The two intermittent creeks are substantially cleared of vegetation, though they are thought to have supported rainforest species. Union Creek forms the western boundary of the site. Site levels fall generally in a north westerly direction at grades up to 1 in 4 with an overall site elevation difference of approximately 50m. A large rural subcatchment contributes runoff flow into the estate.

Like most catchments near the Illawarra Escarpment, the hydrology of the Elambra Estate catchment can be characterised by high rainfall intensities and frequent rainfall. The annual average rainfall depth for Gerringong is 1,334mm over an average number of 121 rain days per year.

Due to the expected presence of areas of probable high water table with periodic water logging and possible shallow slumping and near surface creep, parts of the estate were classified as having a high risk of slope instability.

4 CONSTRAINTS TO WATER SENSITIVE DESIGN

Several constraints were placed on the water sensitive design due to the nature of the site, including:

- soil types not conducive to infiltration (high clay content);
- geotechnical investigations recommended that due to slope stability issues, infiltration be minimised and that the volume of runoff currently draining across the site should not be allowed to increase post-development;
- steep slopes with associated high erosive velocities, which would need to be checked or slowed if stormwater conveyance was in an open channel or swale.
- DIPNR required all water quality improvement measures to be placed outside the defined riparian corridor areas (riparian zone setbacks were prescribed at either 12.5m and 25m from the top of stream banks)

Socio-economic considerations posed significant constraints. To satisfy the key objective of the estate to demonstrate that land development containing principles of ecological sustainable development is economically viable, Council sought to minimise the area of land required for stormwater treatment. Additionally, stormwater treatments could not adversely affect property prices (i.e. they had to be widely accepted by the community and integrated into the estate in an aesthetically pleasing manner). Further, sustainability as applied to new developments is in its infancy and is therefore a socio-political constraint on development itself.

There were competing objectives when aiming to achieve both water quality and energy efficiency objectives. These compete because water sensitive urban design can be optimised with housing running parallel to contours while energy efficiency is optimised by solar orientation and exposure to a northerly aspect. These competing objectives have lead to several streets in the estate being laid out perpendicular to slope contours to maximise solar access. A critical lessons learnt here by Kiama Council was the need to integrate WSUD principles into the planning phase of a development to ensure that the full range of WSUD techniques are available for consideration in later development. WSUD was only fully considered in the final stages of estate planning once road and lot layouts had been established, somewhat limiting the choice of techniques available.

5 DEVELOPING A CONCEPTUAL WATER SENSITIVE STRATEGY

A water sensitive design strategy was developed with the supplied street and lot layout with lot sizes varying between 500 m^2-700m^2 and with a small amount of dual occupancy. The density of development could be described as low to medium density residential.

Site conditions dictated that infiltration of stormwater be minimised which conflicted with Council's SMP objective to maximise infiltration. The minimisation of infiltration on the estate ruled out the use of permeable paving, which had been a consideration on some flat-graded road sections. Other means of maintaining a similar post and pre-development hydraulic regime had to be implemented so that the stability of Union Creek was not threatened by an increase in either peak flow rate or volume of runoff from the estate.

On-site detention at the allotment scale was seen as a means of implementing storage requirements and minimising Council's initial capital investment while maximising the potential developable land. It has been well demonstrated by others that on-site detention at this scale is a much more effective means of detention storage as less volume is required at source than any point further downstream in the catchment. Therefore, a combination of on-site detention and rainwater harvesting using above ground rainwater tanks was selected.

The steep slopes at Elambra did not allow for the inclusion of vegetated swales on the whole development and as such, the majority of the site will be serviced by a conventional piped drainage system. Additionally, due to geotechnical constraints on infiltration, swales were not considered ideal as they were likely to increase the rate of infiltration and would therefore require to be internally lined, significantly adding to their cost. Swales were, however, selected in key areas to derive a stormwater quality benefit, generally on the lower portion of the site adjacent to Union Creek where it was difficult to achieve grade from these areas back towards end of pipe treatments. Increased infiltration as a result of the presence of unlined swales along the foot of the developable area adjacent to Union Creek was not seen to be a major issue. Such areas were generally rated as having a low to medium risk of slope instability and any increase in infiltration would be unlikely to affect the stability of developable land.

6 DEVELOPING A DETAILED WATER SENSITIVE STRATEGY

6.1 AT-SOURCE CONTROLS

A combination of on-site detention and rainwater harvesting in above ground rainwater tanks was selected at Elambra Estate for the following reasons:

- Rainwater harvesting was to be considered within the WSUD strategy in accordance with Council's SMP Objectives;
- Airspace would be available in the tank for detention storage due to the effect of daily water draw down. This available space could be used to offset the OSD requirements. Further detention storage could be achieved by introducing a low level overflow which is controlled by an orifice;
- Due to the steepness of the site, separating the OSD and rainwater harvesting systems would generally require the installation of below ground detention storage. Surface storage opportunities would be limited and could lead to infiltration, which was to be avoided on this site.
- Economically it was seen as being more cost effective to combine detention and rainwater harvesting - even if installing a low level overflow controlled by an orifice meant that some tank volume available for rainwater harvesting was sacrificed to the benefit of OSD.

A water balance analysis established the following nominal tank sizes for Elambra Estate;

- Detached Housing Sites – 10kL per site.
- Dual Occupancy and Integrated Development Sites – 3kL per dwelling unit.

The detailed design of rainwater tanks for combined rainwater harvesting and on-site detention has been the most arduous design task of all the water sensitive elements at

Elambra Estate. Constant policy changes from State Government, Health NSW and Sydney Water lead to the investigation of myriad configuration scenarios.

The effectiveness of various different rain tank configurations was modelled using the Probabilistic Urban Rainwater and Wastewater Reuse Simulator (PURRS) developed by Dr. Peter Coombes at the University of Newcastle. All configurations were modelled with a 10kL tank connected to a 240m^2 roof area.

When Sydney Water advised of their "no rainwater for potable purposes policy" based on recommendations from Health NSW, the following two utilisation regimes were investigated:

a) Rain tank plumbed to utilise 87% of household water use (including hot water, outdoor, toilet and laundry).

b) Tank plumbed to utilise 48% of household water use (hot water excluded).

It soon became obvious to Council that Sydney Water's stance on the provision of roof water for hot water was in conflict with sustainable development principles. Under this policy the maximum benefit of rain tanks was not able to be achieved by either future property owners or Council as the developer. Council repeatedly attempted to negotiate an acceptable sustainable outcome through representations to both Sydney Water and the Minister for Energy and Utilities over this issue. Elambra Estate thus became the test case for use of rain water for potable consumption in NSW. Council believe their actions directly led to the state government's announcement of 13 September 2003 regarding the unrestricted utilisation of rainwater. Frank Sartor, the Minister is to be recognised for his pragmatic leadership on this issue.

This negotiation process occurred while the estate was under development with housing construction imminent. In an attempt to minimise further delays, an additional configuration was developed in an attempt to finalise rainwater tank guidelines for adoption. In addition to the high level overflow (1), the second tank configuration (2) included a low level overflow controlled by a small orifice in order to increase the volume available to detention storage. This was done in an effort to satisfy the SMP objectives relating to the increase in flows. The results of the modelling are presented in Table 3.

Table 3: Modelling results of rain tank configurations at Elambra Estate

Configuration	Utilisation Regime	Average daily demand met by rainwater tank	Percent of storage available for detention 3 month ARI	Peak flow reduction compared to no tank 3 month ARI
1 (Single staged overflow)	a	59%	14%	5%
	b	47%	9%	3%
2 (with low level overflow)	a	53%	25%#	43%
	b	44%	23%#	43%

a 87% of household water use b 48% of household water use

Does not include the 33% storage volume created by the low level orifice

As expected PURRS modelling demonstrated that under both tank configurations the percentage of household demand met by utilisation regime ‘b’ is reduced as compared with utilisation regime ‘a’. For Configuration ‘1’ a reduction of 12% was observed whilst for Configuration ‘2’ the effect was a 9% reduction. The reduced utilisation rate also reduces the amount of storage available for OSD. As expected, peak flow rates for the 3 month ARI without a low level overflow were only reduced to about 3% when compared to the no tank situation.

The significant difference observed with the addition of the low level overflow was the reduction in peak flows at the proposed water quality treatment area. For both regimes a 43% reduction in peak flows for the 3 month ARI was observed. This reduction in peak flows was seen as significant in the overall context of sizing and the associated cost of the stormwater treatment devices.

Peak flows for the 5 yr ARI were not reduced as a result of the presence of combined rainwater harvesting and on-site detention tanks in either configuration, presumably because of the large rural sub-catchment at the top of the catchment which contributed approximately one third of the peak flow.

The mandatory use of rainwater for household demands on every allotment within the estate has been applied through a Development Control Plan (DCP) for the estate. The DCP requires the utilisation of rainwater for all outdoor uses, washing machine and toilet flushing only. The utilisation of rainwater supply for hot water is optional but is strongly encouraged. Mandating the use of hot water was seen as a contentious issue with Council concerned over the possibility of litigation as a result of illness created by contaminated water. This represents a softening on Council's initial intention.

6.2 CONVEYANCE CONTROLS

The piped systems at Elambra Estate have been separated into two systems wherever possible. One system is a 'clean' pipe system that conveys relatively clean runoff from roofs and other paved surfaces within individual allotments. These flows are piped into the receiving waters without passing through any treatment processes. The second is a more conventional 'dirty' water system that conveys runoff from roads and footpaths (and in the absence of the clean pipe system, that runoff as well). Flows from the conventional system are directed to end of pipe water quality treatment devices. Despite the increase in the pipe network, the result is a net cost saving due to smaller land take and reduced size of end of pipe treatments.

Road runoff from parts of the estate directly above areas of public open space and riparian corridors is discharged freely across the verge and allowed to filter through vegetated areas - a treatment which has been demonstrated to be extremely effective in managing nutrient and sediment removal.

6.3 END OF PIPE CONTROLS

Elambra Estate essentially contains two large catchments - northern and southern. The end of pipe treatments proposed for both catchments are similar. The first stage of treatment is in a proprietary treatment device such as a CDS unit to intercept litter, oil and coarse sediment, followed by a sand filter as the final stage of treatment. The southern catchment, however, will have an additional middle treatment stage that involves a wet detention basin aimed at further facilitating sedimentation and thereby increasing the life of the sand filter. Not enough space was available for wet detention in the northern catchment.

A linear sand filter is proposed for the southern catchment, running parallel to the road. This sand filter is designed such that runoff firstly enters special *Hydrocon* pipes. *Hydrocon* pipes are permeable pipes that allow for water to be treated through a number of complex mechanisms. As these pipes fill and water flows out through semi-permeable walls, pollutants are filtered or adsorbed by the pipe matrix. The *Hydrocon* pipes are bedded in a sand matrix, through which the water surcharges. When the sand matrix is at capacity, flow enters a piped outlet with an orifice sized to allow surcharge into an above ground, grassed channel where it is stored temporarily. During larger rainfall events, the water will continue to surcharge until it reaches the top of the embankment, where it will spill *via* a constructed natural channel into the creek.

7. CONCLUSIONS AND RECOMMENDATIONS

Council is to be applauded for prescribing and then complying with its stormwater objectives for new developments. While the objectives appear in many SMPs, Council has interpreted the objectives for their true intent, thereby providing leadership to other developers and Councils alike.

A critical lesson learnt during this project is the need to integrate water sensitive design principles into the planning phase of a development. When water sensitive design is considered at later stages, it tends to comprise a limited water sensitive retrofit of conventional subdivision layouts and therefore is constrained by various factors. This closes off many water sensitive options and tends to make it difficult to achieve water quality and quantity objectives.

Another issue that was highlighted during the initial stages of this project was the often conflicting objectives and strategies for achieving sustainability. There were competing objectives for water quality and energy efficiency with road layouts selected for energy efficiency which compromised water sensitive approaches and outcomes. This further highlights the need to integrate water sensitive design principles into the earliest and ongoing planning phases of developments.

The detailed design of rainwater tanks for combined rainwater harvesting and on-site detention was the most arduous water sensitive element to resolve at Elambra Estate. Constant policy changes by State Government, Health NSW and Sydney Water all lead to the establishment of many varied options and configurations. Detailed analysis also indicated that institutional regulations on the utilisation of hot water were in conflict with the principles of sustainable development. As shown by modelling work completed for this project, sustainability outcomes were compromised when hot water was excluded from rainwater use. These are example of the various institutional and legislative barriers faced by Councils and developers, and which may prove to be hindrances for the adoption of water sensitive design into mainstream urban development.

However, given the State Government's September 2003 announcement advocating the unrestricted utilisation of rainwater, tenacity and patience can be rewarded leading to the further removal of stumbling blocks for water sensitive design in future developments.