Author version of paper published as:
Goonetilleke, Ashantha and Thomas, Evan (2003) Urban water quality and the Triple Bottom Line – Can we reconcile the irreconcilables?.
Internet Conference, 'In search of Sustainabilit'y', February – November 2003.

Urban water quality and the Triple Bottom Line – Can we reconcile the irreconcilables?

Ashantha Goonetilleke[1] and Evan Thomas[2]

Abstract
The adoption of a triple-bottom line approach is advocated to safeguard urban water quality. Ecosystem functions need to be addressed initially followed by social and then economic needs. This calls for a cultural change towards urban water resources rather than the current piecemeal approach. Water and water environments are valuable community assets. Urban land use coupled with anthropogenic activities alters the stream flow regime and degrade water quality. Urban water pollution is difficult to cost in terms on conventional monetary measures. True costs extend beyond immediate human or the physical boundaries of the urban area and affect the function of surrounding ecosystems. Current approaches to safeguard water quality are largely ineffective. They are generally based either on, insufficient design knowledge, faulty value judgements or inadequate consideration of life cycle costs. The problem of urban water pollution can only be remedied through innovative planning and the courage to implement sustainable practices.

Status quo

Water environments are greatly valued in urban areas as ecological and aesthetic assets. However, it is the water environment that is most adversely affected by urbanisation. Land use modifications associated with urbanisation are invariably reflected in the stream flow regime such as increased volume and peaks. Additionally, anthropogenic activities introduce numerous pollutants to the environment that are eventually conveyed to receiving waters. The deterioration of water quality, degradation of the stream habitats and flooding, are the most tangible of the detrimental impacts of urban stormwater runoff.

The sources and causes of urban stormwater pollution are widely known and related more to human activities within the catchment than just to the expansion of the urban landscape itself. However pollution control constitutes an intractable challenge. These activities not only contribute to pollutant build-up on catchment surfaces, but are also a significant contributor to atmospheric pollution. Atmospheric pollutants return to ground through wet and dry deposition and are available for wash-off during rainfall.

Changes to the hydro-dynamics of the catchment due to urbanisation increases average water flow velocities and hence stream power. This in turn mobilises and transports greater concentrations of pollutants from surfaces. However stormwater is only a part of the transport mechanism for conveying pollutants to receiving waters. While fine particulates in urban pollution may constitute only about 5% of the total sediments, they carry over 60% of the pollutants through physical and chemical processes. The interrelationships between various factors and the build-up and wash-off processes of pollutants are complex and little understood.

[1]School of Civil Engineering, Queensland University of Technology, Brisbane.
E-mail: a.goonetilleke@qut.edu.au
[2]Gold Coast City Council

Where are we now?

There have been significant advances in the control of point sources of pollution such as sewage effluent outfalls. However, it is the non point-sources which are the most damaging, the least visible and the most difficult to control. The pollutant impact and 'shock load' associated with stormwater runoff can be significantly higher than secondary treated domestic sewage effluent.

Current approaches to stormwater control center around conventional concepts of volume and peak flow reduction, primary forms of treatment and reuse. These concepts in themselves are admirable, but their application is open to criticism. Table 1 provides a brief evaluation of the common structural measures adopted in Australia in the implementation of these concepts.

Table 1: Issues associated with conventional approaches to stormwater management

Treatment device	Primary function/s	Issues
Retention, detention basins	Volume, peak flow reduction	1. Can only afford to detain relatively small volumes. 2. Sediment build-up, weed infestation entail regular maintenance. 3. During dry periods collected water can become anaerobic, breed pests becoming a health hazard and pollutant generator. 4. Water feature can attract birds, contributing to pollutant export.
Wetlands	Quality improvement	1. Can only afford to treat relatively small volumes. 2. Efficiency in quality improvement not completely proven, particularly removal of very fine sediments, dissolved nutrients. 3. Adequate design guidelines for stormwater treatment not available and dependency on wastewater treatment systems. 4. Adequate guidelines for weed removal and maintenance not available.
Gross pollutant & sediment traps, Vortex devices	Quality improvement	1. Can only afford to treat relatively small volumes. 2. Do not have the capability to remove very fine sediments. 3. During dry periods collected water can become anaerobic, breed pests becoming a health hazard and pollutant generator. 4. Maintenance costs can be very high.
Grass swales	Quality improvement	1. Can be effective in removal of particulate pollutants but not necessarily fine sediment. 2. Adequate design guidelines are not available. 3. Most paved surfaces such as streets do not have space for grass swales.
Rainwater tanks	Volume reduction	Effective in handling only small flows.

As illustrated above, commonly adopted measures are based either on, insufficient design knowledge, faulty value judgements or inadequate consideration of life cycle costs. The various structural measures are costly, largely ineffective when dealing with large flows or in dealing with the 'real world' problems and even be counter productive. Implementation of structural measures is also often interpreted as being 'seen to be doing something' in response to community pressure. Use of gross pollutant traps for litter removal is a prime example. Litter, though conspicuous is not a major source of water pollution and its major impact is visual aesthetics. Unfortunately, due to its high visibility, it attracts the most publicity and the maintenance effort rather than the more environmentally harmful pollutants. Similarly street sweeping is purely for cosmetic purposes. The standard street sweeper cannot remove the fine particulates on the road surface that contribute significantly to water pollution.

Modelling is one way where improved design outcomes may be developed. However, based on the current state of knowledge, stormwater pollution does not fit into neat mathematical models which engineers and scientists can use for predictive purposes. Predictive errors of over 100% are common in the use of various models. This is due to the difficulty in mathematical formulation of key anthropogenic activities and the questionable mathematical formulation of key concepts. The quantification of relationships that support quantitative models of urban systems is fundamental to the performance of many current models and is crucial for developing improved designs that will work in concert with surrounding natural and constructed systems.

The ‘sleeper’ will awaken!

More and more frequently, the life-cycle costs of poorly designed urban and industrial systems are found to be extremely high in financial, social and ecological terms. These costs are often slow to impact and cumulative such as increased levels of heavy metals in fish and crustaceans. Without scientific quantification and understanding of system dynamics, the effects of quantity and quality changes in stormwater flows may be the ‘sleeper’ that awakes. When it awakes it will be far from benign. The effect of global warming provides an example of such a cumulative but largely ignored impact.

Calculation of life-cycle costs and forms of environmental accounting is a developing area of research. There is no consensus on an appropriate method for reconciling all benefits and costs to a single unitary measure such as dollars. True costs to a community for water quality degradation extend beyond immediate human or the physical boundaries of the urban area and can affect the functioning of surrounding ecosystems from which the community may derive income, such as tourism, fishing or agricultural production.

Until consensus can be reached on methodology to integrate the different value systems associated with Ecological, Social and Economic systems, a triple-bottom line (TBL) is ignored by default. TBL is far from perfect and appears to place equal emphasis on each area. However, it has long been shown that the economy is contained within our society and in turn society is contained within the ecosystem. Hence to move towards sustainable urban forms, the ecosystem functions need to be addressed first followed by social and then economic needs.

After ordering the TBL, the divergence from the known sustainable performance of the system, in this case the pre-settlement hydrology should be modelled despite the errors, and used as a benchmark. In turn, key social and financial parameters should be considered in order to provide an objective view of progress and ‘costs’ on a TBL.

The way forward

Urban waterways should not become open sewers. Similarly, stormwater is a valuable resource to be utilised and not wasted. The problem of urban water pollution can only be remedied through innovative planning and the courage to implement sustainable practices. At a cost of being ‘utopian’, the following is a broad recipe for protecting urban water resources:

- Planning of human settlements should encompass the concept of sustainable development in its entirety and satisfy the TBL.
- Achieving sustainability relies on human managed systems, such as urban systems, mimicking natural systems. As urban systems are associated with particular soils and climates, the only models for sustainability are the pre-settlement fluxes that existed for millennia and supported and interfaced successfully with neighbouring systems.

- A ‘technofix’ is not the solution to the problem. Treatment measures should be underpinned by strong scientific understanding and an enlightened approach to the lifecycle costs, inherently taking into consideration environmental costs.
- There has to be a strong nexus between research and regulatory agencies as urban water quality management is still in the realm of the unknown.
- It is necessary to challenge conventional practices. Why should roads have kerb and channelling? This is only designed to convey stormwater to the urban waterway as expeditiously as possible. An alternative would be to provide grass swales on either side for providing a measure of treatment.

What is advocated above is a cultural change towards urban water resources rather than the piecemeal approach of today.

Conclusions

Current approaches for handling stormwater and water quality issues in urban landscapes are focused on ‘end-of-pipe’ solutions. Sustainable urban landscapes must be designed to match the triple-bottom line needs of the community starting with ecosystem services first such as the water cycle, then addressing the social and immediate health needs, and finally the economic performance of the catchment.

Bibliography

1. Daly, H. E., 2000, ‘Uneconomic Growth’, Chapter 3 in Schmandt, J. and Ward, C. H. (Eds), Sustainable Development, the challenge of transition, Cambridge University Press, pp63-77
2. Duncan, H. P., 1995, ‘A review of urban stormwater quality processes’, Report No. 95/9, Cooperative Research Centre for Catchment Hydrology, Melbourne.
3. Hall, M. J. and Ellis, J. B., 1985, ‘Water quality problems of urban areas’, GeoJournal, Vol. 11, No. 3, pp. 265-75.
4. House, M. A., Ellis, J. B., Herricks, E. E., Hvitved-Jacobsen, T., Seager, J., Lijklema, L., Aalderink, H. and Clifforde, I. T., 1993, ‘Urban drainage-impacts on receiving water quality’, Water Science and Technology, Vol. 27, No. 12, pp. 117-58.
5. Knetsch, J. L., 1993, ‘Environmental Valuation: Some Practical problems of Wrong Questions and Misleading answers’, Occasional paper No. 5, Resource Assessment Commission, Australian Government.
6. Makepeace, D. K., Smith, D. W. and Stanley, S. J., 1995, ‘Urban Stormwater quality: Summary of contaminant data, Critical Reviews in Environmental Science and Technology, Vol. 25, No. 2, pp. 93-139.
7. Sartor, J. D., Boyd, G. B., 1972, ‘Water pollution aspects of street surface contaminants’, Report No. EPA-R2-72/081, US Environmental Protection Agency, Washington, DC, USA.
8. SoderBaum, P., 2000, Ecological Economics, EarthScan.