Bristol City Council

Parks & Greenspace Strategy

Discussion Paper

Landscape Infrastructure in Balanced & Sustainable Communities:

Water Environment

July 2007

"For generations we shunned water. Draining marshland, reclaiming coastal areas and squeezing rivers, we gave it fewer and fewer places to go. And that made flooding worse."
Fred Pearce, for Environment Agency, Your Environment, April 2007

"Claims relating to the UK's June floods will total £1.5bn"
Chartered Institute of Loss Adjusters, July 2007

1. European, National, Regional and Local Planning and Legislation Context

PPS 25 - Development and Flood Risk

- PPS25 and associated Practice Guide (PPS25PG) require that any proposals for new development in flood risk areas demonstrate how the residual risk (i.e. risk which remains after existing risk avoidance, reduction and mitigation measures have been implemented) will be managed.

Bristol's Supplementary Planning Document 5 – Sustainable Building Design & Construction

- Sets out Bristol's commitment to achieving sustainable development through the planning process. The aim, for the water environment, is to conserve water resources, enhance water quality, incorporate water-sensitive design and minimise vulnerability to flooding.

Draft Regional Spatial Strategy for the South West, 2006 - 2026

- The strategy recognises that new development is vulnerable to climate risks unless water resources are sustainably managed. The document advises local authorities to consider water resources as an element of sustainable construction, so requiring the introduction of water conservation measures and sustainable drainage systems in all development through supplementary planning guidance.

Bristol Local Plan, Adopted Dec. 1997

- Policy NE4 aims control development which would cause unacceptable harm to the natural watercourse system or the loss of natural flood-plain. It is necessary to safeguard or enhance water quality; ensure there is no unacceptable damaging run-off from hard surfacing; and retain wetland habitats and natural waterside vegetation and ensure their future management. ME2 sets out policy on controlling impact on the environmental amenity or wildlife by air, water or land pollution, including measures to stop unacceptable levels of run-off and emissions. ME9 also addresses the control of development that would increase the risk of flooding, or which is likely to cause unacceptable effects arising from surface water run-off. In addition ME10 addresses development adjacent to existing rivers and watercourses, with a requirement that works should respect the character of the river or watercourse.

Royal Commission on Environmental Pollution, Twenty-sixth Report, The Urban Environment, 2007

- Provides an overview of the environmental issues associated with the UK's urban areas, and describes current conditions and trends, especially those that relate to new urban areas.

Making Space for Water, DEFRA, 2004

- Implements a more holistic approach to managing flood and coastal erosion risks in England. Supports taking action to ensure that adaptability to climate change becomes an integral part of all flood and coastal erosion management decisions, adopting a whole catchment and whole shoreline approach.

Water Framework Directive (WFD)

- The EU WFD is an overarching programme to deliver long-term protection and improve the quality of groundwater, surface water and associated wetlands. WFD demands that we look at the whole water environment and all of its complex interactions.

Natural Environment and Rural Communities Act

- Sets out that Natural England's general purpose is to ensure that the natural environment is conserved, enhanced and managed for the benefit of present and future generations, thereby contributing to sustainable development

EC Floods Directive

- Contains a requirement to produce flood risk maps and draw up plans to manage these risks. Special emphasis is placed on the role of flood plains and sustainable land-use practices. Formal adoption by the European Council is expected in late 2007.

2. Background

In urban situations, the water environment has tended to be viewed as a drainage 'problem' to be overcome, rather than a core component of the processes that make up a city and its landscape. There is increasing acknowledgement that contact with the water environment is a contributory factor to health, well-being and quality of life, in addition to a role in supporting biodiversity and addressing climate change. There are growing demands to reverse past negative effects eg. 'daylighting' (de-culverting) of urban watercourses .

Urbanisation leads to decreased ground permeability and fast hydraulic transport in artificial channels and conduits. Consequently, it affects surface runoff in three ways:

(a) increasing the runoff volume,
(b) increasing the speed of runoff leading to higher flow peaks, and
(c) reducing the catchment response time, allowing higher rainfall intensities to generate local runoff peaks.

It is reported that urban development increases runoff peaks 1.5 to 10 times, depending on storm intensity. Other factors that contribute to this pattern are the paving over of front gardens and infill residential development.

The sediment and chemicals which accumulate on urban surfaces are washed off during rainfall. More than 600 chemical substances have been identified in urban runoff, and the number is growing. The list of pollution sources includes:

- atmospheric deposition,
- land-use activities (residential, commercial and industrial sources, open land - parks, traffic, road maintenance, spills, pets), and
- surface attrition/corrosion/elution (road wear and tear, corrosion of structures, and elution of chemicals from construction materials, sediment deposits and soils).

As a result, the contribution of water is now seen positively and may be seen as significant in urban design in a number of ways:

- the integration of natural water courses into the built environment;
- ecological rainwater management;
- the incorporation of water elements in urban areas for climatic purposes; and
- the integration of features such as pools or fountains, whose psychological contribution can range from calming to exciting.

In seeking to achieve balance and sustainability, the role of water must, in conjunction with that of trees and greenspace, be fully taken into account, when planning and designing the city's communities.

3. The importance of Designing With Water

The term '*Designing With Water*' is adopted here to represent the broader strategic aims of re-integrating water in urban design. Inherent in the approach is a respect for the existing physical and hydrological context. Until recently, the general goal of urban drainage was to collect (into pipes) and quickly remove stormwater from urban areas and discharge it into nearby receiving waters, relying on passive control of drainage systems by gravity flow.

Designing With Water can be viewed as the antithesis of this approach which has led to river culverting, downstream flooding, poor water quality and wetland habitat-loss in many urban areas. Major changes in drainage design philosophy were introduced in the late 1980s and the early 1990s, as a result of: (a) introduction of the sustainable development concept, (b) acceptance of the ecosystem approach to water resources management, (c) improved understanding of drainage impacts on receiving waters, and, (d) acceptance of the need to consider the components of urban drainage and wastewater systems (drainage, sewage treatment plants, and receiving waters) in an integrated manner.

Sustainable Drainage Systems (SuDS) is a related, subsidiary term, which refers to a number of specific design components or techniques.

In the widest sense, **Designing With Water** includes:

- total urban water cycle management, with reuse of stormwater and other effluents, integrated management of stormwater, groundwater, and wastewater; and water conservation, resulting in reduced water demand.
- minimizing development impacts by preserving natural resources/ecosystems and maintaining natural drainage, minimizing land clearing and grading, reducing imperviousness, and controlling urban sprawl.
- maintaining pre-development water balances on site by promoting rainwater/ stormwater infiltration and evapo-transpiration.
- maintaining, recreating or enhancing distributed detention and retention storage on sites, by using swales, flat slopes, rain gardens, bio-retention areas and water butts.
- maintaining predevelopment times of concentration and travel times by strategic routing of runoff flows.

Benefits to the Environment

- Producing a physically greener, more attractive and liveable environment.
- Designing-in a buffer capacity for intense rainfall events. Tree canopies also play a valuable role in intercepting rainfall before it reaches the ground, allowing it to gradually drip or evaporate, thereby reducing the risk of flash flooding, whilst conserving ground water.
- Improved stormwater quality, and hence improved water quality in the city's watercourses.
- Improved habitat and biodiversity through the establishment of wetlands and other 'natural' treatment alternatives; environmental gain may arise where green areas not only provide natural water attenuation capacity, but accommodate existing or new habitats that will be beneficial for wildlife.
- Connecting spaces along rivers to the countryside - 'green fingers'.
- Reduced greenhouse gas emissions by reducing water consumption, increasing rainwater harvesting and 'natural' treatment alternatives.

Benefits to the Urban Setting

- To act as a focus for development planning
- Providing an important amenity for active and passive recreation.
- Integration of natural drainage techniques, such as the incorporation of wetlands, instead of pipes.
- Opportunities for greater diversity in vegetation, including aquatic planting.
- Enabling landscape architects to introduce techniques that will bring a more diverse aesthetic contribution to development.
- Creation of a 'visible infrastructure' combining functionality and natural elements.
- Bridging the gap between the urban and natural environments, and using river corridors for walking, cycling and nature-focussed activities.
- Opportunities for education in school grounds & parks.

Economic Benefits

- Low cost techniques when compared with typical constructed drainage systems. The cost benefits of SUDS schemes over conventional drainage construction are borne out by research.
- Reedbed pollution control/treatment as a cost-effective approach in the long term

Optimum *Designing-with-Water* will arise from a recognition of the importance of the incorporation of these principles at the earliest project planning stage, and a clear client brief that requires the fullest collaboration within multi-disciplinary design teams. Most typically, this will involve landscape architects working alongside architects, engineers and quantity surveyors. Community engagement is central in achieving a wider appreciation of how *Designing-with-Water* will result in a sustainable environment in which to live. This point is particularly important in the case of de-culverting/ 'day-lighting' of watercourses.

The design of specific measures will depend upon opportunities and constraints, including those relating to topography, hydrology and geology, that are inherent to the site and its context. Particular techniques will also need to respond to the type (e.g. residential, mixed-use, commercial), and scale of development, and that of individual building function. All this will have a bearing upon design factors such as:

- Character of the site and its setting,
- Water use and demand, and
- Water catchment area (roof surface area and site ground area).

4. Specific Design Solutions - Sustainable Drainage Systems

Sustainable Drainage Systems (SuDS) are a well-developed group of solutions for creating functional green infrastructure. SuDS aim to minimise the quantity and improve the quality of water before it is discharged from a site, helping to prevent flooding and pollution. In terms of sustainability rating, the most desirable are those measures, which address stormwater problems close to the source (e.g. managing rainwater before it is converted into runoff), provide the highest number of environmental benefits, require low capital and operation and maintenance costs, and contribute to lower greenhouse emissions.

Systems include:

- source-control techniques that treat water close to the source, and maximise the quantity of water collected/ held at source. These include:
  - green roofs
  - rainwater harvesting, and
  - infiltration trenches/ basins
- porous pavements
- permeable systems that store, filter and dispose of some run-off before the water is discharged:
  - filter/ french drains, and

- grass swales

- passive treatment systems that use natural processes to remove pollutants, including:
- detention (balancing) ponds, and
- reed beds and artificial wetlands.

Development can, through adding to the area of impermeable ground and thereby increasing the amount of run-off, contribute to flooding of lower lying land. SuDS will help to reduce these problems whilst enabling more effective drainage, and bringing the many benefits described above.

Current policy/ guidance on SuDS in Bristol is contained within SPD5 – Sustainable Building Design and Construction (adopted Feb 2006). SuDS techniques must meet a number of criteria:

- the drainage triangle - meeting (1) quantity, (2) quality and (3) amenity objectives
- the management train - techniques used in series to improve quantity and quality

5. Flooding & Climate Change

The national floods of October 2000 and June 2007, the flooding of Boscastle in August 2004 and Carlisle in January 2005 have dramatically highlighted the economic and social consequences of the over-topping, breach or bypassing of primary flood defences. Rising sea levels, increases in average winter precipitation and in the frequency, duration and intensity of heavy downpours will increase flood risks. Impervious surfaces in urban areas will exacerbate the risks by preventing rainwater from percolating into the ground. Changes within the catchment, such as field drainage and channelisation of watercourses, add to the problem. Areas where drainage capacity cannot cope with current levels of precipitation will be at greatest risk. Flood risk management measures should provide added health, ecology and leisure benefits by enhancing the quality of public space.

Hotter temperatures will lead to greater demand for urban greenspace, blue (water) infrastructure, open spaces and shading. Many of the climatic changes forecast for the next 30–40 years are 'locked in'– the result of past greenhouse gas emissions. Regardless of the success, or otherwise, of emissions reduction efforts, some climate change is therefore inevitable. In order to help communities adapt, planners, urban designers, architects, and developers need to take into account predicted climates over this century at the design stage of any new development, refurbishment or regeneration programme. Opportunities will be presented to create or remodel outdoor spaces and buildings that are resilient in the face of future climates. These adaptations will enhance the liveability of, and quality of life in, communities in future.

In the face of the long-term risks from climate change, urban development/ expansion should not exacerbate flood risk, or create a legacy of difficult to defend areas for the future. Designing-with-Water can help deliver solutions that holistically manage water flows so that flood and pollution risks are reduced.

"*Urban areas face distinctive risks compared with the wider rural river catchments. For example, surface drainage systems that have been modified through urbanization, cannot respond to excessive rainwater in the same way as natural channels. In extreme events, urban surface pathways - not least roads - become important relief systems, but with significant potential for damage to property."*
Royal Commission on Environmental Pollution, 2007

The UKCIP02 scenarios (www.ukcip.org.uk/scenarios) show that, by the 2080s, our summers will be much hotter and drier, but winters are predicted to become wetter. An extreme wet winter's day by the 2080s will deliver almost 50 percent more rain than is currently experienced. Recent research suggests that these more powerful storms would increase the amount of runoff from urban areas by more than 80 percent. Once a year winter daily storms - that is, the biggest average storm in any given year - presently produce 18 millimeters of rainfall. By the 2080s, once a year winter daily storms may deliver 28 mm of rainfall.

The likelihood of different kinds of flooding is set to increase as climate change leads to rising sea levels, changes in precipitation patterns and more intense rainfall. In 2004 the Foresight Future Flooding report estimated that annual average flood damages could increase by 2 to 20 times by the end of this century, once the increase in global average temperatures reaches 3 or 4º.

Development can increase the risk of flooding elsewhere by reducing the storage capacity of the floodplain, and/ or the flow of floodwaters. Floods, and flood prevention works, can endanger wildlife and impact upon amenity value, as well as causing chronic disruption to the city, e.g. due to multiple road closures.

The Adaptation Strategies for Climate Change in Urban Environments Project (ASCCUE), led by the Centre for Urban and Regional Ecology (CURE) at Manchester University, suggests four key roles for green spaces:

- allowing natural drainage (infiltration capacity),
- detaining floodwater,
- providing shade under a tree canopy, and
- cooling through lower surface temperatures.

Flood Maps

Protection of flood plains is required so that they can fulfil their primary function as effective flood flow conveyance and floodwater storage areas. The Environment Agency has developed new flood mapping information for priority areas. These new Extreme Flood Outline (EFO) maps show the potential extent of an extreme flood (which might in future become more 'normal' as a result of climate change). They show areas that may be vulnerable to a one in a thousand annual probability flood.

Such flood risk maps, used to inform the planning process, take into account fluvial and coastal flooding. However, they do not cover the risks posed by sewers and surface flow, and it is the failure to effectively manage these impacts which contributes to such a large number of insurance claims. The current planning system is also largely unable to strategically determine optimum surface flood pathways and storage associated with building, highway, or other urban development schemes.

Flood Alleviation and Adaptation Techniques

Improved techniques, governing the design of the built environment in relation to the landscape infrastructure, can contribute significantly to the reduction of flood risk.

Some countries (notably the US, Australia, Scotland) have already developed the concept of overland flood-flow pathways by identifying surface routes for water to follow, and linking them together like a conventional drainage system. Surface routes, such as roads, convey water to 'sacrificial' areas such as parks & car parks, which act as temporary flood storage areas. As an example of this, Glasgow's City Structure Plan now identifies new and existing parks that can absorb water in time of flood. Holding water in the upper parts of catchments is especially beneficial in reducing downstream flooding. Bristol too needs to make space for water – using green infrastructure for flood storage, conveyance and SUDS, re-creating functional floodplains.

6. Rivers and Wetlands

Rivers

Rivers are dynamic systems and under natural conditions they continually re-route within their floodplains. However, over several hundred years, many of Bristol's rivers and streams have been diverted, straightened, contained or culverted. Reasons for this included: the maximising of the amount of land available for development, reduction of the risk of flooding, and separation of people from what were once polluted and unhealthy watercourses. Long-term effects have been detrimental ecological impact (their value to wildlife having been substantially reduced) and significant loss of watercourse attractiveness to people.

As a result of urbanisation, rivers are subject to significant flow-variability, with extremes that are quite different from those of a rural river, and this has a bearing upon their contribution both ecologically and as amenities. In recent years, low flows have left many river-beds exposed. High levels of diffuse pollution may also occur where there is run-off of oils, salt, metals and other pollutants from roads and other hard surfaces. In addition, fertilizers, herbicides and pesticides may be washed off managed grassland, parks and gardens.

Local consciousness of the importance of the city's rivers, and the landscapes through which they pass, is now being raised by the *Bristol Living Rivers Project (www.bristol.gov.uk/rivers).*

Wetlands

In the Bristol Area, designed reed-beds are used for pollution reduction e.g. at Stockwood Tip, and Henry Sleed Stream (Oldbury Court). Also there are many instances of constructed reed-bed systems in use for small-scale sewage treatment in this region. More and more solutions involving applied ecological design are being developed, but there is an even more significant role for natural wetlands in holistic water management.

Natural areas such as flood plain wetlands can buffer hydrological flows and ameliorate the effect of environmental fluctuations. They offer flood and storm protection and prevent run-off damage. Inter-tidal habitats such as saltmarsh and mud flats provide similar roles on the coast, providing a buffer from the energy of the sea's waves. It has been estimated that an 80m depth of saltmarsh, such as that at Avonmouth, can save roughly £4,600 per metre, when compared with defensive structures, in additional floodwall protection.

Natural management of catchments is important to water quantity and quality. Natural processes can provide water quality benefits, for example, by preventing sediment run-off into rivers. Water quantity benefits can be provided by preventing valuable water resources being drained too quickly and washed out to sea. It is likely that ecological filtration will play an increasingly significant role in reversing the effects of the more diffuse pollutants.

6. Water & Sustainable Construction

Due to changing flood management needs, alternative 'non-structural' flood management responses (or measures) that further reduce the residual risk of flooding for both existing and new development and infrastructure require identification and evaluation for their suitability. These include:

- green roofs to reduce runoff and ease pressure on drainage systems.
- managing flood pathways and removing 'pinchpoints' so that heavy rainfall can drain away.
- One-way valves permanently fitted in drains and sewage pipes to prevent backflow and, as a last resort, widening drains to increase capacity.
- flood resilient measures, including raising floor levels, electrical fittings and equipment; rain-proofing and overhangs to prevent infiltration of heavy rain around doors and windows; temporary free-standing barriers which hold back floodwater from properties.
- flood resilient materials can withstand direct contact with floodwaters for some time without significant damage. These include concrete, vinyl and ceramic tiles, pressure-treated timber, glass block, metal doors and cabinets.

Green Roofs, Rainwater Harvesting & Grey-water Recycling

Green Roofs are vegetated roofs, or roofs with vegetated spaces. The main benefits include:

- stormwater management, and hence potential savings to developers since the number of drainage outlets required on a building can be reduced.
- reduced urban heat island effect by reducing building heat loss and increasing evapo-transpiration.
- creating natural green spaces in urban areas bringing benefits for biodiversity.
- reduced energy consumption and fuel costs, since green roofs provide cooling in summer and thermal insulation in winter.
- reduced air pollution.
- extended roof life. The green roof protects the roof's waterproofing membrane, almost doubling its life expectancy.

Green Roofs, though part of the built environment, can be considered as a type of sustainable drainage system which, if well designed, provide valuable wildlife habitats and have a range of other qualities that make them a useful component of the urban natural environment. They are the modern day successors to the traditional turf roofs, which have been widespread across northern Europe for hundreds of years.

Today's green roofs are made up of a natural or semi-natural habitat planted in an artificial membrane. Peak run-off reductions of up to 90% are commonly recorded, and pollutant removal is achieved. Techniques may involve the use of low-growing herbs and grasses, or specialised plants, adapted to drier conditions. They may also simulate open stony or rubble-based habitats with scattered wild flowers (brown roofs). Some applications require little or no maintenance, although more complicated designs can require irrigation and maintenance. In all cases, additional roof layers need to be constructed to ensure they protect the building underneath from moisture and do not overload the structure.

Rainwater Harvesting captures and diverts rainwater. The captured water can be used for irrigation purposes, car washing or toilet flushing. It is beneficial for two reasons:

- It reduces water demand, easing pressure on the mains water supply.
- It helps to reduce the risk of flooding during storms by storing rainwater and buffering run–off before it reaches the drainage system.

Typically, rainwater is collected from rooftops and is diverted into barrels or storage tanks. The amount of rainwater collected from a rooftop can be significant. A 100m2 roof can catch 500 litres of water from rainfall of just 5mm.

Grey-water Recycling has long been practiced in areas where water is in short supply and includes water from baths, sinks and laundry. It can be re-used for toilet flushing provided filtration and disinfection mechanisms are in place. The benefits include reducing household water demand and easing pressure on the mains water supply, reducing upstream energy and environmental costs. These systems require maintenance to ensure that they function correctly. When properly managed, grey-water can also be a valuable resource for horticultural and agricultural growers as well as home gardeners. It can also be valuable to landscape architects, builders, developers and contractors because of the design and landscaping opportunities afforded by on-site grey-water treatment and management. Where maintenance and safety can be assured, there is scope for grey-water recycling technology on larger sites such as residential and commercial developments.

7. Landscape & Highway Design

Open space areas can potentially incorporate conveyance and treatment systems as landscape features. Key principles to be considered in locating green space areas are:

- aligning green space along natural drainage lines.

- protecting/ enhancing areas containing natural water features and other environmental values by locating them within green space.

Road layouts and streetscape: Roads account for a significant percentage of the overall impervious hard surfaces created within a typical urban, or urban-edge development and therefore can significantly change the way water is transported through an area. These areas also generate water-borne contaminants that can adversely impact on water quality (e.g. fine sediments, metals and hydrocarbons). Consequently, it is important to mitigate the impact of storm water runoff generated from road surfaces. By carefully planning road alignments and streetscapes, drainage elements such as bio-retention systems and vegetated swales can be used to collect, attenuate, convey and treat the runoff before discharge. Highway elements such as roundabouts, central reservations, bays, street trees and car parking areas can be designed to be lower than the road level to collect run-off. Other features such as kerbs and channels can be replaced with grass swales, so that water is diverted into the planter box and treated prior to discharge.

8. Current Issues

- Changes in planning, legal and regulatory frameworks to deliver a more flexible approach to environmental problems, making effective use of green infrastructure (such as SuDS and green roofs) rather than relying heavily on hard engineering;
- A variety of authorities are responsible for different parts of the drainage system and the lack of overall responsibility creates difficulties in taking a long-term strategic approach. Maintenance considerations are important. Adequate budgets need to be allocated. The Environment Agency has noted that the adoption post-development of SuDS is a key concern. Adoption by the local authority is preferred as there is more chance that the essential maintenance of the system necessary to ensure the ongoing operation as designed, will be carried out.
- Threats ranging from invasive weeds to the appropriation of river corridors for development (buildings and transport infrastructure).
- Development of competencies for planners and land managers on understanding & managing SuDS
- The establishment of partnerships to create and manage green infrastructure projects as part of a wider network. For example, individual sustainable drainage systems may be relatively simple in themselves, but they need to be integrated in a way which works at the catchment as well as the local level, and complements existing infrastructure

9. Conclusion

For any significant development project, it is recommended that a multi-disciplinary team be established at the earliest stage of planning and design, in order that site planning can fully exploit opportunities for the water environment, in conjunction with greenspace design and other criteria, towards the creation of a balanced and sustainable community.

Author:
Antony Lyons, Sustainable City and Environmental Quality Team, PT&SD

Advisers:
Steve Hardiman Landscape Design Team Manager, Planning Services, PT&SD
Kathy Derrick, Sustainable City and Environmental Quality Team, PT&SD
Lorraine Hudson, Sustainable City and Environmental Quality Team, PT&SD