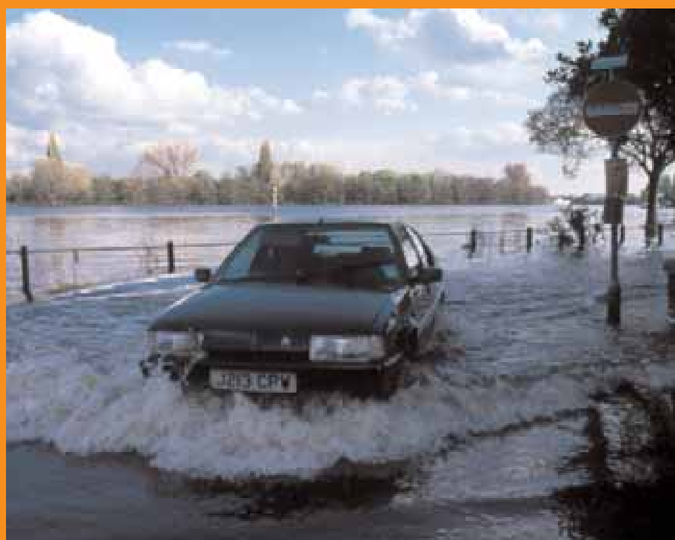
LONDON
climate change
PARTNERSHIP

Adapting to climate change
Lessons for London

July 2006



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This report should be referenced as
London Climate Change Partnership. 2006. Adapting to climate change: Lessons for London.
Greater London Authority, London.

Published by
Greater London Authority
City Hall
The Queen's Walk
London SE1 2AA

This report can be downloaded from www.london.gov.uk/climatechangepartnership/

ISBN 1 85261 882 5

The members of the London Climate Change Partnership are

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- Environment Agency,
- Thames Water Utilities Ltd,
- Association of British Insurers,
- acclimatise,
- Corporation of London,
- Association of London Government,
- London Sustainability Exchange,
- London Development Agency,
- London Climate Change Agency,
- London Resilience,
- Transport for London,
- Thames Gateway London Partnership,
- Housing Corporation,
- Regional Public Health Group – London,
- UK Climate Impacts Programme.

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This document is printed on 75 per cent recycled paper, 25 per cent from sustainable forest management

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foreword

My vision is to make London an exemplary, world class, sustainable city. Climate change will present challenges and opportunities to achieving that vision. It is important that London looks and learns from the best international examples, adopting those which work well, and sharing our knowledge with the rest of the world.

We are almost at the point where for the first time in history, the number of people living in cities exceeds those living outside cities. This urbanisation of the world's population is projected to continue throughout the coming century. It is vital that cities adapt to climate change and right that they lead the development of adaptation options.

The London Climate Change Partnership is doing excellent work in helping London prepare for unavoidable climate change, and in this review of international cities, brings together pertinent information and timely analysis to produce recommendations for London. I commend this report to all, but particularly to those organisations identified in the key recommendations. I will ensure that my officers take note of the report's recommendations to the Greater London Authority and encourage other organisations to follow up on recommendations against them.

Ken Livingstone

Ken Livingstone
Mayor of London

introduction

In the last few years, awareness of climate change as a major issue has increased enormously. The Prime Minister Tony Blair made it a central theme for the UK Presidency of the G8 last year, while in London the Mayor Ken Livingstone has put the city at the forefront of addressing climate change. In particular he hosted a conference of world cities in October 2005 which showed both how significant cities are in contributing to climate change and what they are doing to tackle the issue.

The London Climate Change Partnership aims to help ensure that London is prepared for its changing climate. We have commissioned this report on the different measures some cities around the world are taking to protect their citizens and their economies from extreme weather which will, in most cases, become more extreme due to climate change. We hope London, and indeed other cities, can learn from these examples.

This stimulating report shows that with a combination of commitment, investment, technology and communication, schemes can be put in place to keep cities thriving despite higher temperatures, changing rainfall patterns and a rising sea level.

There are specific lessons to be learnt from each case study, but there are also some common threads:

- There is often a need for city-wide planning, but London is now in a strong position in this regard.
- There is often a need for partnerships between different organisations, and across geographic boundaries.
- There is a need for clear communications and engagement to achieve success.
- Thinking about climate change needs to be included in all long-term decision making.

The Partnership will now be looking to see how these case studies can be applied in London. I hope this report will prompt thinking by strategic authorities in London and elsewhere, and that this thinking will lead to action soon enough to let our cities continue to thrive through the 21st century.

Gerry Acher CBE LVO
Chair, London Climate Change Partnership

Part 1
Recommendations from the London Climate Change Partnership

Executive summary

The London Climate Change Partnership aims to help ensure that London is prepared for its changing climate. The Partnership is made up of a range of public and private sector organisations across London, who have responsibilities that will be affected by the impacts of climate change. The Partnership commissions research to improve knowledge among London's decision-makers of how to respond to these changing risks, and Partnership members feed this information into their own decision-making and policy-making processes. In 2002, the Partnership published a study into the overall impacts of climate change on London[1] . More recently, it produced a detailed study investigating impacts on London's transport systems[2] , and, with the South East and East of England regions, a checklist for development taking account of climate change[3] (see Annex A for further details).

In early 2006, the Partnership commissioned the consultants, acclimatise, to review how other major international cities are managing climate risks. The aim of this review was to:

- contribute to the evidence base of the Partnership; and
- inform the formation of climate adaptation planning policies for London, especially the forthcoming review of the London Plan.

1 *London's warming: the impacts of climate change on London, Technical Report, London Climate Change Partnership, 2002*

2 *The impacts of climate change on London's transport systems, Greater London Authority, 2005*

3 *Adapting to climate change: a checklist for development, Greater London Authority, 2005*

Some major international cities are beginning to prepare for climate change, and some are dealing with climatic conditions today that London will experience in the coming decades. The Partnership wants to ensure that London can learn from good practice in these cities on how to cope with climate risks.

The review examined eighteen cities, to understand how they are addressing the following climate risks, which are expected to intensify in London over the coming decades due to climate change:

- flooding,
- high temperatures,
- limited water resources.

The review, together with the Partnership's response to the policies and measures identified in the review, are presented in this report.

The primary audiences for this report are London's policy-makers and decision-makers, including the members of the London Climate Change Partnership, the Mayor of London, the Greater London Authority (GLA), government departments, the London Boroughs, developers, utilities, their regulators and decision-makers in other cities.

Structure of this report

This report is in two parts:

Part 1

This part of the report outlines the Partnership's view of the 'applicability to London' of the policies and measures adopted in other cities, by addressing the following questions:

- Does London face a similar climate risk issue now or in the future?
- Does London already have policies/measures in place to manage the risk?
- Which of the policies/measures should be considered further in London, taking account of opportunities and challenges?

In particular, it presents the Partnership's key recommendations, based on analysis of the city case studies.

Part 2
Part 2 presents the review of the policies and measures adopted in other cities. It provides a brief summary then presents the eighteen city case studies in turn.

General conclusions and key recommendations from the London Climate Change Partnership

The case studies presented in this report show that with a combination of political commitment, planning and policy change, fiscal incentives, legislation and communication, together with investment and appropriate use of technology, interventions can be put in place that not only adapt cities to the impacts of inevitable climate change, but can make them more sustainable overall.

There are specific lessons to be learnt in London from each case study, but there are also some common threads:

- There is a need for city-wide planning.
- There is a need for partnerships between different organisations, and across geographic boundaries.
- Climate change adaptation needs to be considered in short, medium and long-term decision-making, recognising the interaction between different measures.
- Holistic, integrated thinking is required to manage climate risks most effectively – for instance, water harvesting measures can also help to manage flood risks.
- Retrofit of climate adaptation measures to existing buildings, infrastructure and systems presents an enormous challenge for London and mechanisms to do so need to be implemented immediately.
- The opportunities for ‘climate-proofing’ new development are easier to realise, and must be driven through the planning process.
- There is a need for clear communication and engagement with authorities, business and the public to achieve successful preparedness for changing climate risks.

Based on an analysis of the city case studies, the Partnership makes the following key recommendations:

Flood risk management

1. **The Environment Agency (EA) should ensure that flood risk management options developed through the TE 2100 programme are integrated into regional and local planning as soon as possible.**

2. **The EA, London Development Agency (LDA), Thames Gateway Urban Development Corporation (UDC) and east London Boroughs should incorporate flood water management opportunities, where feasible, into all new and existing green spaces so as to reduce the residual flood risk to surrounding properties.**

3. **The Mayor should facilitate a forum of agencies with a responsibility for surface water drainage, involving the Thames Tideway steering group (which includes Thames Water, Environment Agency, Department for Environment, Food and Rural Affairs (Defra), Water Services Regulation Authority (WSRA, formerly Ofwat), Government Office for London and the Greater London Authority), as well as Transport for London, the London Boroughs and the Highways Agency, to share information on drainage and flooding. The forum should identify opportunities and delivery agencies to manage flood risk through a range of measures, from rainwater capture and storage, through to increasing permeability of the urban realm and drainage capacity.**

Heat risks

4. **The Department for Communities and Local Government (DCLG) with the Health and Safety Executive should develop overheating standards that would be applicable to homes, workplaces and public facilities, including schools, health and social care premises and public transport.**

5. **The GLA, London Boroughs and developers should ensure that new development reduces the impacts of and the further intensification of London's urban heat island (UHI) effect, through appropriate design and construction.**

6. **The needs of vulnerable populations, including older people and those with existing illness, must be considered by emergency planning agencies (eg Local Authorities, Primary Care Trusts, the Health Protection Agency and London Resilience), and they must produce a co-ordinated and tested plan to reduce the impact of heatwaves in London.**

7. **The London Boroughs and London Resilience Forums should ensure that their Civil Risk Registers adequately identify and rank the risk of heatwaves and ensure coordination with the National Heatwave Plan.**

Water resources

8. **The GLA, EA and water companies should ensure that there is a sustained and co-ordinated public awareness-raising campaign regarding water use and water efficiency. This must not just occur during times of drought, but continually, to ensure water efficiency gains are maintained. The example of the current drought and its impacts should be used as an illustration of the type of event that will occur more frequently as our climate changes.**

9. **National government should take the lead by making water metering compulsory for all households, which will help to raise awareness of water as a precious resource and reduce water consumption. WSRA, the water companies and the Consumer Council for Water must ensure that a socially fair and equitable tariff structure is developed if water metering becomes compulsory for all.**

10. **National, regional and local planning policy and the Code for Sustainable Homes must require that all new build and developments – both domestic and commercial – incorporate water efficiency best practice and design.**

11. **Defra should introduce a programme to label household appliances with a rating for water use, like the existing 'A to G' energy labels, and carry out a market transformation programme similar to the one for energy labelling.**

12. **Defra, DCLG and the Treasury should investigate methods to incentivise increased water efficiency in existing development. Options to provide financial rebates through the housing stamp duty should be considered.**

 

Addressing flood risk management

This report presents nine case studies of policies and measures adopted in other cities to manage flood risk. They cover risks from tidal, river and stormwater flooding. An overview of the flood management case studies is provided in Table 1, together with a description of the risks faced by London, and the policies/measures already in place in London to address these risks.

Table 1: Case studies addressing flood management

Case study overview	Applicability to London 1. Does London face a similar climate risk issue now or in the future? 2. Does London already have policies/measures in place to manage the risk?
New York: Managing flood risks – Staten Island Bluebelt Programme • Inadequate storm sewer system led to localised flooding problems on Staten Island • The Bluebelt programme provides stormwater detention ponds, and creates or enhances streams, ponds and wetlands • Large areas of wetland were purchased by the City to	1. London experiences frequent flash flooding during heavy rainfall and has existing problems with storm water management. • There are significant numbers of combined sewer overflows into the Thames, due to the impermeability of urban areas, the limited capacity of the surface water sewer network and the 'flashy' nature of the some of the engineered water courses and their catchments. 2. London currently has no strategic programme for storm water management but does have policies promoting Sustainable Drainage through the London Plan and more detailed advice will be set out in the forthcoming Supplementary Planning Guidance (SPG) on Sustainable Design and Construction. • The Thames Tideway Steering Group has recommended that a super sewer should be constructed under the Thames to capture sewer overflows. The decision to implement the recommendation is currently with government.

<table>
<tr><td rowspan="2">Antwerp: Managing Flood Risk - The Sigma Plan

• Land next to the Scheldt Estuary, including Antwerp, is prone to flooding

• Continuing to increase dike heights is not considered a sustainable solution

• The Sigma Plan aims to manage flood risk through a system of Controlled Inundation Areas and dike heightening

• The plan involves important changes in land use, mostly from agriculture to natural estuarine habitat</td><td>1. London lies on a tidal river with an extensive floodplain in which government, business, transport and communications assets critical to the national economy are located, potentially at significant risk of tidal and fluvial flooding.

• Without action, climate change will increase the probability of a flood, whilst London’s growth will increase the consequence of any flood.</td></tr>
<tr><td>2. Though London is currently well defended, the Thames Estuary Tidal defences will need to be improved to continue to provid a high standard of defence. This work is being led through the Thames Estuary 2100 (TE2100) project.

• Similar options to those in the Sigma Plan are being considered as part of TE2100 for future flood management for London, and findings have been shared with the Antwerp Sigma Plan.

• The Department for Communities and Local Government (DCLG) is currently consulting on a new draft planning policy for flood risk, PPS25, which clarifies and strengthens planning policy on development and flood risk. PPS25 puts an emphasis on reducing existing flood risk, e.g. by re-creating and safeguarding functional floodplain and wash lands and by designing-in green space and sustainable drainage systems.

• PPS25 proposes that the Environment Agency (EA) becomes a statutory consultee on planning applications submitted for developments in higher risk flood zones (flood zones 2 and 3), for which they will require a flood risk assessment to be undertaken.</td></tr>
<tr><td rowspan="2">The Netherlands: Multifunctional land use for flood management

• The Netherlands faces growing problems in managing flood risks

• Multifunctional land uses can be created, where land floods occasionally, but can be used for other functions too, such as for floating greenhouses and sports fields

• A pilot floating greenhouse has been constructed, as well as ‘amphibious’ and floating homes</td><td>1. London lies on a tidal river with an extensive floodplain and valuable parts of the city are at risk of tidal and fluvial flooding. Significant areas of London are at high flood risk (flood zone 3) and face restrictions in developing certain land uses within these areas.

• Without action, climate change will increase the number of homes and the value of property at risk.

• Flood risk management measures that also store water for drought periods provide a double benefit, as water resources in London become more constrained.</td></tr>
<tr><td>2. Options for multifunctional land use, similar to those in the Netherlands, are being considered as part of the Thames Estuary 2100 project, and findings have been shared with the Netherlands.

• Flood storage space has already been incorporated into some parks in London, for instance, at Chinbrook Meadows, Lewisham, where an underused park was transformed through de-culverting the river (previously hidden in a concrete channel) and making it part of the landscape. At Riverview Walk, Bell Green, Lewisham, a concrete-channelled river was replaced with a meandering watercourse.</td></tr>
</table>

Tokyo: Flood Management in the Tsurumi River Basin • Rapid urbanisation has led to flooding problems next to the Tsurumi River • A large rainwater retention reservoir provides temporary storage for flood water • The Yokohama International Stadium sits in the reservoir basin and has been built on pillars, so that flood waters can flow underneath it	1. London is not expected to be subject to severe wet tropical windstorms, but climate change is expect to result in a higher proportion of rainfall being delivered in intense downpours, requiring better management of storm water. 2. There are no water retention basins in London on the scale of the Tsurumi River Basin, but some smaller schemes are in place, such as at Chinbrook Meadows (see above).
Seattle: Managing stormwater • Increased stormwater runoff in Seattle due to urbanisation caused water pollution, affecting local freshwater ecosystems • Drainage fees are based on the amount of impervious land, and discounts will soon be given to customers who have private drainage systems on site • Pilot projects have replaced inadequate stormwater systems with natural drainage systems, and are being monitored	1. London experiences frequent flash flooding during heavy rainfall and has existing problems with storm water management. There are significant numbers of combined sewer overflows into the Thames, due to the impermeability of urban areas, the limited capacity of the surface water sewer network and the 'flashy' nature of the some of the engineered water courses and their catchments. • With climate change, these events are likely to become more frequent and severe in the future. 2. The Mayor's Further Alterations to the London Plan and the Mayor's Supplementary Planning Guidance on Sustainable Design and Construction promote the incorporation of SuDS in new developments to reduce run-off.
Basel, Linz, Toronto: Green Roofs • In Basel, two campaigns have provided subsidies for installing green roofs • Basel's Building and Construction Law was amended in 2002 to require all new buildings with flat roofs to have green roofs • Linz introduced green roof policies in 1985 in its Development Plan • Linz also provides subsidies for green roofs, provided they are properly maintained • Toronto's recent green roof strategy commits the council to installing green roofs on city-owned buildings and includes a pilot programme of financial incentives • Toronto undertook a detailed cost benefit analysis for green roofs	1. Surface water flooding from heavy rainfall is already an issue in London and is expected to increase in the future, as climate change brings heavier downpours. • See also discussion on green roofs for managing heat risks, in Table 2 below. 2. The GLA has published a paper on green roofs and there is encouragement for them in new buildings in both the Supplementary Planning Guidance on Sustainable Design and Construction and the Checklist for Development published with the South East and East of England regions. • The London Borough of Barking and Dagenham has issued a Planning Advice Note on Green Roofs.

New York: Climate Change Task Force • The New York Climate Change Task Force supports institutional decision-making on climate change for the city's water supply and wastewater treatment systems	1.	London already faces challenges in providing water supply and wastewater treatment. • In the future a growing population and rainfall changes due to climate change will aggravate this situation. • This increases the importance of reducing consumption and tackling leakages more effectively. • See Table 3, Melbourne case study
	2.	The London Climate Change Partnership works to ensure that adaptation to climate change is addressed for all risk areas in London, making use of the latest developments in climate change science. The Partnership includes organisations with responsibility for water management, who are working to ensure that their systems are fit for changing climatic conditions.

Partnership recommendations on flood risk management policies and measures that London should consider further: Opportunities and challenges

The Partnership considers that there are useful lessons to be learned from the approaches to managing flood risk identified in the case studies listed above, and there are opportunities and challenges to adopting such policies in London.

The Partnership recommends that:

- **The Environment Agency (EA) should ensure that flood risk management options developed through the TE 2100 programme are integrated into regional and local planning as soon as possible.**

- **The EA, London Development Agency (LDA), Thames Gateway Urban Development Corporation (UDC) and east London Boroughs should incorporate flood water management opportunities, where feasible, into all new and existing green spaces so as to reduce the residual flood risk to surrounding properties.**

- **The Mayor should facilitate a forum of agencies with a responsibility for surface water drainage, involving the Thames Tideway steering group (which includes Thames Water, Environment Agency, Department for Environment, Food and Rural Affairs (Defra), Water Services Regulation Authority (WSRA, formerly Ofwat), Government Office for London and the Greater London Authority), as well as Transport for London, the London Boroughs and the Highways Agency, to share information on drainage and flooding. The forum should identify opportunities and delivery agencies to manage floodrisk through a range of measures, from rainwater capture and storage, through to increasing permeability of the urban realm and drainage capacity.**

Managing tidal and river flooding risks

The Department for Communities and Local Government (DCLG) is currently consulting on a new draft planning policy statement on flood risk and development (PPS25). The statement provides stronger, clearer guidance on managing flood risk through:

- ensuring flood risk is taken into account at all stages in the planning process,
- ensuring flood vulnerable development is located away from high flood risk areas,
- requiring planners and developers to consider emergency planning and flood resilience issues,
- proposing that the Environment Agency should be a statutory consultee on planning applications,
- proposing that the Environment Agency have 'call in' powers where development proceeds against EA objection on the grounds of flood risk.

The full application of PPS25 provides a strong mechanism for addressing current and future flood risk in London in a more sustainable way. DCLG are also proposing to develop a planning policy statement (PPS) on climate change.

Findings from the **Sigma Plan** covering **Antwerp** have been shared with the Thames Estuary 2100 project. London does not have available the extensive undeveloped spaces required to provide sufficient flood storage in the future. Integrated catchment management and a greater adoption of SuDs will be required to reduce London's surface flood water risk. The Partnership wants to see PPS25 strictly applied in London, so that new development contributes to managing, if not reducing, residual flood risk. London's Green Grid programme of green space enhancement offers a good opportunity to encourage strategic flood risk management using green space.

Turning to the **Netherlands**, buildings that float in a flood and also store water, (not necessarily limited to houses and greenhouses), may be considered extreme, but should be given further consideration for London, especially in areas at too high risk for flood-vulnerable developments. The London Flood Resilience Project, which includes the London Fire and Emergency Planning Authority, Environment Agency, GLA, Thames Gateway London Partnership, London Thames Gateway Development Corporation and the London Borough of Barking and Dagenham, has begun to discuss these approaches.

The Partnership notes that managing risks to these structures in the relatively controlled conditions of a flooding polder (as in the Netherlands) is very different from dealing with a tidal surge up the Thames estuary, so it is important that the feasibility of such developments including the risks involved in such properties are carefully considered, including the risks they present if they were to break loose.

The Partnership recommends that DCLG, Environment Agency, GLA and London boroughs actively seek opportunities to deliver projects such as Chinbrook Meadows and Sutcliffe Park that demonstrate multi-functional land use to reduce flood risk.

The provision of a temporary flood storage reservoir in **Tokyo** demonstrates what can be achieved when space is at a premium. In common with Tokyo, the Thames Estuary 2100 project is already examining opportunities for raising arterial roads above flood levels, as well as parks that can be used for temporary flood storage.

Tokyo's approach also demonstrates the fact that when developing a major project, there is the opportunity to address a larger area in a holistic fashion. Any major project offers this opportunity, and the Partnership encourages consideration of these measures in the Thames Gateway and the Lower Lea Valley / Olympics. The riparian brownfield development sites to the east of London provide extensive opportunities for developments that incorporate significant flood storage, and capacity for flood storage should be prioritised in these areas.

Managing stormwater flooding risks

The complex and unclear responsibilities for drainage in London, and nationally, provide challenges to developing a London-wide policy on stormwater management. However, these difficulties must be overcome. The **Seattle** case study demonstrates that it is possible to retrofit sustainable drainage systems into existing built-up areas. While there is less space at the edges of roads in London than in Seattle for SuDS, there are many other spaces in London that could be made more pervious to assist with managing stormwater runoff - for instance, car parks, including at large superstores, shopping centres and stations, as well as private driveways. There may also be capacity to replace central raised flowerbeds in dual carriageways with swales across London.

The Partnership recommends that these measures are considered in work that is underway on urban realm improvements carried out by the boroughs, Transport for London and the Highways Agency as well as exemplar initiatives, such as the Mayor's '100 Public Spaces' .

The UK can also learn from the approach to drainage fees in Seattle, where they are based on the proportion of impervious surface area. The Partnership recommends that the Government's National Water Savings Group's Incentives Subgroup examines the Seattle approach to drainage fees, and develops incentives that reward on-site management of stormwater.

To avoid worsening stormwater risks in the future, the Partnership will lobby for SuDS to be compulsory in new developments where appropriate, especially the Growth Areas and the Opportunity Areas.

Green roofs provide multiple benefits, managing stormwater runoff, as well as providing thermal insulation. Extensive green roofs could replace rare brownfield habitat that is vital to some of London's rarest species in the Thames terraces. With over 28 times the size of Richmond Park able to be retrofitted with green roofs (the majority in central London) the Linz, Basel and Toronto green roof case studies suggest that a London green roof policy is achievable not only on new developments but on existing buildings. The Central London Partnership and the Green Landlords scheme could help to promote green roofs – for instance, when new leaseholders take on a building in central London, they should be asked to consider green roofs.

The Partnership recommends that financial incentives for green roofs on private sector buildings (as in Linz) should be considered through business rates, at a national level. Incentives for green roofs should also be considered as part of council tax rebates for environmental improvements. The Partnership also recommends that local authorities in London consider greening of municipal roofs.

London can learn from the regulations that were developed in Germany, in response to concerns over fire risks to green roofs. A requirement for all flat roofs to be green roofs might have unintended consequences in promoting pitched roofs. Green roof policies must be aware of this, and further research is needed to understand how other cities have overcome this problem.

Addressing heat risks

The report presents nine case studies of policies and measures adopted in other cities to manage risk from high temperatures. They cover planning policies to reduce the Urban Heat Island as well as Heat Health Warning Systems. An overview of the heat risk case studies is provided in Table 2, together with a description of the risks faced by London, and the policies/measures already in place in London to address these risks.

Table 2: Case studies addressing heat risks

Case study overview	Applicability to London 1. Does London face a similar climate risk issue now or in the future? 2. Does London already have policies/measures in place to manage the risk?
Basel, Linz, Toronto: Green Roofs • In Basel, two campaigns have provided subsidies for installing green roofs • Basel's Building and Construction Law was amended in 2002 to require all new buildings with flat roofs to have green roofs • Linz introduced green roof policies in 1985 in its Development Plan • Linz also provides subsidies for green roofs, provided they are properly maintained • Toronto's recent green roof strategy commits the council to installing green roofs on city-owned buildings and includes a pilot programme of financial incentives	1. Higher temperatures are only rarely a problem in London at the moment, but are expected to become the norm by the middle of the century as average temperatures rise. • London has a distinct Urban Heat Island (UHI) that can cause summer night-time temperatures to be high enough to cause health problems and encourage the installation of air conditioning in homes (as passive cooling through ventilation becomes less effective). This is particularly true in the city centre, where the UHI is most intense. • See also discussion on green roofs for flood management, in Table 1 above. 2. The Mayor has published a paper on green roofs[4] and there is encouragement for them in new buildings in the Further Alterations to the London Plan, the Supplementary Planning Guidance on Sustainable Design and Construction and the Checklist for Development published with the South East and East of England regions. • The London Borough of Barking and Dagenham has issued a Planning Advice Note on Green Roofs.

[4] *Building Green: A guide to using plants on roofs, walls and pavements, Greater London Authority, 2004.*

<table>
<tr><td>Various US cities: Cool roofs

• Risks of high temperatures are exacerbated in cities by the Urban Heat Island (UHI) effect

• Cool roofs have light coloured coatings that reflect and emit heat, reducing the UHI

• Some US cities provide rebates for installing cool roofs

• Others have changed building codes and regulations to promote cool roofs</td><td>1. London already has a strong UHI. The UHI and higher overall temperatures due to climate change will become an increasing problem, with the potential to cause significant numbers of deaths from heat stress during heat waves, as well as longer periods of uncomfortably high temperatures affecting larger numbers of people.

2. We are not aware of any systematic measures to implement cool roofs in London, although Transport for London has commenced a programme of reducing solar energy absorption on buses by painting the roofs white.</td></tr>
<tr><td>Tokyo: Managing the urban heat island

• Temperatures in Tokyo have risen by 3ºC over the past century

• Tokyo Metropolitan Government (TMG) produced a Thermal Environment Map, to better understand the factors affecting the city's (UHI)

• Using the map, TMG has designated areas of the city for measures to reduce the UHI, such as introducing greenery and creating ventilation paths for breezes</td><td>1. Anticyclonic conditions that create a strong UHI also favour high ozone and particulate (PM10) concentrations, which in combination strongly affect public health.

• Anticyclonic weather is predicted to increase in frequency and duration under climate change, which will increase the frequency and duration of intense UHI episodes.

• Many people living in overcrowded, poor quality housing do not have access to air conditioning and could not afford to run it. Measures to reduce citywide temperatures through targeted interventions would particularly benefit these people.

2. London is undertaking research into how to manage the intensification of the Urban Heat Island. Early indications from the research support the need for more green roofs and street trees.

• The GLA and London Borough policies of protecting existing green space from development helps offset the UHI effect.</td></tr>
<tr><td>Newark and Camden: The benefits of urban trees

• Newark and Camden both experience an Urban Heat Island (UHI) effect

• Research has shown that planting trees in urban areas is a viable and economically efficient way to reduce the UHI, as well as helping to remove pollutants from the air</td><td>1. London already has a strong UHI. The UHI and higher overall temperatures due to climate change will become an increasing problem, with the potential to cause significant numbers of deaths from heat stress during heat waves as well as longer periods of uncomfortably high temperatures affecting larger numbers of people.

• Solar gain is beneficial in the winter in London, reducing heating demand, but in summer can lead to overheating in buildings and demand for mechanical cooling.

• London also has existing air pollution problems, which could be exacerbated by climate change. There are significant concerns (and uncertainties) about increasing emissions of volatile organic compounds (VOCs), including isoprene and other ozone precursors, from trees under hotter conditions.</td></tr>
</table>

	2. Overall London has lots of green spaces, but some areas, especially in central London, lack good quality green spaces and greenery. • The GLA is currently identifying and mapping 'areas of deficiency', where the public does not have access to good quality green space. Based on this information, the GLA will be working with local authorities to enhance green space provision and quality. • The GLA's air quality and cleaner transport initiatives should reduce emissions from transport and improve general air quality, and consequently reduce environmental stress on Londoners. However climate change will increase summer air pollution episodes (often simultaneously with peak urban heat islands). It is anticipated that air quality will improve, but whether it improves sufficiently during peak UHI episodes to bring appreciable reduction in health impacts is uncertain.
Philadelphia, Shanghai, Lisbon: Heat Health Warning Systems • Heat Health Warning Systems predict the risk of dangerous heat waves using meteorological information. Health departments and other agencies then implement intervention activities with the public • Philadelphia publishes warnings via the media, has a 'buddy' system of visits to the elderly and a telephone 'Heatline' • Measures in Shanghai include media announcements, preparing hospitals and ensuring availability of water, power and air-conditioned facilities. • Lisbon's ÍCARO surveillance system triggers intervention measures by the General Health Directorate and Civil Protection Service, including media announcements and a telephone advice line reinforced with nursing personnel	1. In London, there is a significant potential for harm from heatwaves in terms of excess deaths from heat stress, and this potential will grow due to climate change. • At least 600 people died in the August 2003 heatwave in London[5]. 2. The GLA has recently commissioned research to study and map the UHI in London. This research will identify combinations of factors, e.g. physiological and socio-economic factors that increase vulnerability to extreme heat. • In the UK a National Heatwave Plan was introduced in 2005 by the Department of Health. Strategic health authorities, primary care trusts and local authorities then develop plans for their local setting. The UK Met Office provides forecasting for the heatwave plan and a temperature threshold is used to trigger different 'warning levels'.

[5] *Office for National Statistics, 2005.*

(See http://www.statistics.gov.uk/cci/nugget.asp?id=480)

Partnership recommendations on heat risk policies and measures that London should consider further: Opportunities and challenges

London, like the rest of the UK, has not traditionally been preoccupied with managing the risk of overheating. The common perception is that our climate is temperate, and most people initially greet the expectation of higher temperatures with some enthusiasm. However, as the summer of 2003 showed, high temperatures can have very adverse effects, and climate change will exacerbate the situation. London needs to recognise and prepare for this evolving risk.

The Partnership considers that London can learn from the approaches to managing heat risks in other cities.

The Partnership recommends that:

- **The Department for Communities and Local Government (DCLG) with the Health and Safety Executive should develop overheating standards that would be applicable to homes, workplaces and public facilities, including schools, health and social care premises and public transport.**

- **The GLA, London Boroughs and developers should ensure that new development reduces the impacts of and the further intensification of London's urban heat island (UHI) effect, through appropriate design and construction.**

- **The needs of vulnerable populations, including older people and those with existing illness, must be considered by emergency planning agencies (eg Local Authorities, Primary Care Trusts, the Health Protection Agency and London Resilience), and they must produce a co-ordinated and tested plan to reduce the impact of heatwaves in London.**

- **The London Boroughs and London Resilience Forums should ensure that their Civil Risk Registers adequately identify and rank the risk of heatwaves and ensure coordination with the National Heatwave Plan.**

Reducing the urban heat island

Green roofs provide insulation in winter and reduce summer overheating. Green walls bring similar benefits. The Partnership supports the use of green roofs and walls, as discussed in the flood management section above.

Many buildings in London do not have air conditioning, though the numbers of buildings with air conditioning is increasing all the time.

The Partnership considers that **cool roofs** could provide a useful mechanism for reducing overheating risks in the city and preventing increased uptake of air conditioning. However, before cool roofs are promoted, an analysis needs to be undertaken to establish their impact on winter-time temperatures in London, to ensure that they will provide overall benefits in reducing energy demand. Cool roofs can be retrofitted to buildings that do not have the structural integrity to support a green roof, and are also compatible with rainwater harvesting systems.

The groups most vulnerable to overheating risks are the elderly and those with existing health conditions. If analysis shows that cool roofs are beneficial in London, they should be considered especially for social housing. The Mayor will soon have new powers to develop a housing strategy for London, and strong consideration should be given to supporting climate change adaptation measures such as cool roofs in the strategy.

Following the UHI research being undertaken in London, it may be possible to define action areas for the UHI, drawing on the measures adopted in **Tokyo**. The Mayor should consider the feasibility of creating an 'Urban Heat Island Action Area' in the centre of London, where the UHI is strongest and exploit the opportunities to minimise the UHI offered by regeneration projects. Tokyo has created 'ventilation paths' to provide cooling breezes through the city. At present, the ventilation pathways in London are not well understood, and research should be undertaken to overcome this. In particular, the design of new high density developments should take account of the need to create ventilation paths.

As identified in the **Newark and Camden** case study, deciduous street trees provide shading when it is most required – in the summer. However, to reduce the effects of wind tunnels between buildings throughout the year, a mixture of conifers and deciduous trees may be more appropriate in London. Street trees would tend to improve the image and property values of an area, as well as helping with adaptation to climate change. It will be important to know how to plant the right tree in the right place, considering issues such as subsidence, root penetration, shading in summer, water use, longevity and growth under a changing climate, as well as the effects of street trees on air pollution.

The Partnership supports the recommendations in the London Tree and Woodland Framework, and encourages Transport for London and the London boroughs to consider the placement of urban trees in locations that will maximise UHI and air pollution benefits to London's residents, especially in areas where greenery is currently deficient.

Heat Health Warning Systems
The UK National Heatwave Plan was introduced by the Department of Health in 2005, and the main intervention activities highlighted in the **Heat Health Warning Systems (HHWS)** case studies are included in the UK National Heatwave Plan. However, making a HHWS work effectively requires a high degree of cross-agency co-operation. Some of the agencies in London who need to take most action to care for people during heatwaves have the most stretched budgets, for example care services for the elderly. The needs of vulnerable populations including older people and those with existing illness must be considered by all agencies and they should actively plan to reduce the impact of heat waves in London.

Drawing on the three HHWS described in this report, the LCCP recommends that the following measures are considered in London:

- London's homeless population is a high risk group (as in Philadelphia) and Primary Care Trusts (PCTs) in London should specifically address their needs in their heatwave plan.

- 'Cool' centres (air-conditioned public buildings) should be provided during heatwaves, with extended opening hours for vulnerable people. Local Authorities should work with other public bodies including health care providers to plan 'cool centres' for London and include them in emergency plans.

- Local authorities and PCTs should consider setting up a 'buddy system' for vulnerable people, as in Philadelphia.

- Guidelines should be developed for the appropriate care of vulnerable individuals during heatwaves in health and social care institutions, and perhaps legally enforced (as part of homes registration).

- Risk assessment for a range of institutions, including hospitals, secure units and prisons, should be undertaken to ensure the measures are taken to prevent high indoor temperatures.

- Intervention measures, such as media warnings, need to be designed to work across all the communities they address, considering language and cultural barriers. Novel ways of reaching all communities should be considered, including, for instance, making use of the networks provided by faith groups. A variety of communications options need to be planned for, since during a sustained heat wave the media may lose interest in public health messages.

Importantly, emergency planners in London need to be prepared for heatwaves and integrate risk management measures into their plans, in the same way that they currently address flood risk management.

Addressing limited water resources

The report presents four case studies of policies and measures adopted in other cities to manage water resources. An overview of the water resources case studies is provided in Table 3, together with a description of the risks faced by London, and the policies/measures already in place in London to address these risks.

Table 3: Case studies addressing water resources

Case study overview	Applicability to London 1. Does London face a similar climate risk issue now or in the future? 2. Does London already have policies/measures in place to manage the risk?
Melbourne: Efficient use of water resources • Melbourne has developed policies to promote efficient water use, including Drought Response Plans and Permanent Water Saving Rules backed up by penalties • Variable water tariffs are used so that low water use is cheap, with much higher tariffs for excessive use • Rebates are available for water saving devices like rainwater tanks	1. London experiences a water resources deficit. • In the future a growing population and rainfall changes due to climate change will aggravate this situation. • This increases the importance of reducing consumption and tackling leakages more effectively. • Londoners use more water per capita than the UK or EU average. • Despite the common belief that we live in a very wet region of the world, London actually receives less rainfall than Istanbul, Rome and Dallas. The Thames catchment, which supplies London's water, is already one of the most heavily utilised in the world, with less available water per person than Portugal, Italy and Spain.

	2. The Mayor recognises that water resources are a key issue for London, but due to his limited powers, he is developing a Water Framework and has established a Water Resources Working Group incorporating key stakeholders such as Thames Water Utilities Ltd and the Environment Agency. • Water companies in London have drought management plans and water resources plans (which include water efficiency). • There are interesting parallels between Melbourne and some of the work in London: o the four tier drought response o fines of £1,000 for failing to adhere to water restrictions (hosepipe and sprinkler bans) o water efficiency campaigns for both domestic and business customers, which have been significantly stepped up in response to the current drought [www.thameswateruk.co.uk/waterwise], and o education initiatives. • The Environment Agency has published several advice notes on water efficiency measures. • All new houses in England are metered, and about one in every five households in London currently has a water meter • A water company can make metering compulsory for its customers if it is granted water scarcity status. Otherwise a water company can install a meter: o if the household opts for one o on change of ownership o for selected high water users, e.g. swimming pool owners. • The Government's Water Saving Group is looking to improve the understanding and delivery of metering. • The Vulnerable Groups regulations allow vulnerable customers to switch to a reduced tariff where they have an above average charge.
Gold Coast: Waterfuture strategy • The Gold Coast's Waterfuture strategy provides a range of measures aimed at ensuring sufficient water until 2056, by when the population of the Gold Coast is expected to double • The strategy includes water from dams as the main water source, as well as new initiatives on: desalination, recycled water, rainwater tanks, water leakage and pressure management, and water conservation measures	1. See Melbourne case study above.
	2. In recent years London has benefited from a range of new and innovative water resource option developments, including artificial aquifer recharge in North London and the East London Water Resource Development Scheme, which removes water from the tunnelled section of the Channel Tunnel Rail Link. • The London Plan already calls for the increased used of grey water and rainwater harvesting. • Thames Water has already started work across London to stabilise and reduce pressures within the water distribution network. The benefits of this work will be to: reduce the numbers of bursts and supply interruptions, allow the system to be operated more effectively, and also significantly reduce the level of leakage.

Germany and Belgium: Train depot rainwater harvesting systems • To manage water resources, Germany has installed rainwater harvesting systems in industrial facilities, office buildings and residential areas • Flanders in Belgium has introduced an obligation to install combined rainwater harvesting and attenuation systems in new buildings	1. Climate change and development are increasing pressures on London's water resources. Measures that capture rainwater run-off provide a useful water resource, and also reduce the amount of rainfall released into the drainage systems, reducing risks of overflow during heavy downpours. 2. Rainwater harvesting is encouraged in the in the forthcoming Supplementary Planning Guidance (SPG) on Sustainable Design and Construction.
New York: Climate Change Task Force • The New York Climate Change Task Force supports institutional decision making on climate change for the city's water supply and wastewater treatment systems	1. London already faces challenges in providing water supply and wastewater treatment. • In the future a growing population and rainfall changes due to climate change will aggravate this. • This increases the importance of reducing consumption and tackling 2. The London Climate Change Partnership works to ensure that adaptation to climate change is addressed for all risk areas in London, making use of the latest developments in climate change science. The Partnership includes organisations with responsibility for water management, who are working to ensure that their systems are fit for changing climatic conditions. • The Water Resources Working Group includes key stakeholders such as Thames Water Utilities Ltd and the Environment Agency.

Partnership recommendations on water resource policies and measures that London should consider further: Opportunities and challenges

Londoners are becoming more aware that water is a precious resource, particularly in the face of the current drought, but a step-change in attitudes to using water wisely is required, to ensure that London faces up to a future where water resources are increasingly constrained.

The Partnership recommends that:

- **The GLA, EA and water companies should ensure that there is a sustained and co-ordinated public awareness-raising campaign regarding water use and water efficiency. This just not just occur during times of drought, but continually, to ensure water efficiency gains are maintained. The example of the current drought and its impacts shouldbe used as an illustration of the type of event that will occur more frequently as our climate changes.**

- **National government should take the lead by making water metering compulsory for all households, which will help to raise awareness of water as a precious resource and reduce water consumption. WSRA, the water companies and the Consumer Council for Water must ensure that a socially fair and equitable tariff structure is developed if water metering becomes compulsory for all.**

- **National, regional and local planning policy and the Code for Sustainable Homes must require that all new build and developments – both domestic and commercial – incorporate water efficiency best practice and design.**

- **Defra should introduce a programme to label household appliances with a rating for water use, like the existing 'A to G' energy labels, and carry out a market transformation programme similar to the one for energy labelling.**

- **Defra, DCLG and the Treasury should investigate methods to incentivise increased water efficiency in existing development. Options to provide financial rebates through the housing stamp duty should be considered.**

As outlined in the **Melbourne** and **Gold Coast** case studies, water efficiency and leakage control measures can help to offset the increase for water demand as a consequence of population growth and loss of water resources due to climate change. These measures can also help influence the timing and nature of new water resource developments.

London will not be able effectively to address water efficiency levels without metering installed wherever possible on existing housing and commercial properties, recognising that it will not be technically feasible to install meters in all domestic properties such as tower blocks. The promotion of universal metering accompanied by an appropriate flexible tariff structures that encourage water efficiency and investment by consumers in water efficient products, and also penalises excessive water use and wastage is recommended. Any new approach to setting tariffs will need to be agreed with the Water Services Regulation Authority (formerly Ofwat).

Water efficient technology already exists, but to improve take-up for existing development, the Government, WSRA and water companies should investigate options to incentivise the retrofitting of best practice systems and devices. Water efficient technologies should also be incorporated into all new developments.

The **Gold Coast Waterfuture Strategy** includes a programme of pressure reduction, to reduce leakage and water use in homes and businesses. In order to be able to manage the large water distribution network that it operates more effectively, Thames Water has started a Network Improvement Programme (NIP), which will stabilise and reduce pressures within the distribution network. In combination with Victorian Mains Replacement, finding and fixing leaks and developing sustainable innovative resources, the benefits of the NIP will be: reduced numbers of bursts, fewer interruptions to supply, an improvement in Thames Water's ability to move water to where there is most demand, a reduced level of leakage, contributing to a more sustainable water supply.

In implementing the NIP, Thames Water have proactively engaged stakeholders to promote the benefits of the NIP and provide financial support where implementation of the NIP has had cost implications for building owners and managers. In doing this, Thames Water has gone beyond its statutory duty.

The Partnership recommends that all large scale developments (both existing and new) investigate incorporating **rain water harvesting systems** linked to greywater recycling, to supplement site-based water uses, such as cleaning and for flushing toilets. In particular, the Partnership recommends that rainwater harvesting should be integrated within all Olympics development. Network Rail should identify opportunities at train depots and at London terminals, as and when these sites are redeveloped. The Partnership notes that Network Rail has plans for redeveloping Euston, Victoria and Waterloo. Rainwater harvesting may also prove beneficial at smaller new and existing developments.

Part 2
City case studies

Summary

Context

London is facing up to the challenge of climate change. It will have to cope with similar climate risks to other world cities - rising temperatures, changing rainfall patterns and rising sea levels. A lot of work is already underway in London to help prepare for the impacts of these climatic changes, within the framework of the London Climate Change Partnership (LCCP) (see Annex A for further details).

Other world cities are also beginning to prepare for climate change, and some are dealing with climatic conditions today that London will experience in the coming decades - for instance, southern European cities are well-versed in coping with the high temperatures that are expected to hit London by the middle to the end of this century. London wants to learn from good practice in these cities on how to cope with climate risks so that it can continue to thrive. This report has been commissioned by the London Climate Change Partnership to provide examples of good practice in managing climate risks from other world cities.

The primary audiences for this report are London's policy-makers and decision-makers, including the members of the London Climate Change Partnership (see Annex A for a list of members), the London Plan team, the London Climate Change Adaptation strategy team, government departments and the London Boroughs. The audience includes politicians (the Mayor of London and MPs etc). Other audiences for the report include developers, utility companies, and decision-makers in other cities.

Scope of this report

This report presents case studies of policies, systems and guidance in cities that could help inform London on how to adapt to future climate change, covering the following climate risk areas:

flooding: tidal, fluvial (river), pluvial ('flash'), groundwater, sewerage and combined effects,

high temperatures,

water resources.

The following table shows which of these climate risks is addressed by each case study. The table also outlines the types of measures adopted in each case study, covering: changes to planning policy, fiscal incentives/ disincentives, regulation/legislation, and communication with the public.

Climate risks addressed and measures adopted in the case studies

Case study	Climate risk			Type of measure adopted				Page
				Planning policy	Fiscal incentive/ disincentive	Regulation/ legislation	Public comms emphasised	
New York: Managing flood risks – Staten Island Bluebelt Programme								47
Antwerp: Managing flood risk - the Sigma Plan								52
The Netherlands: Multifunctional land use for flood management								62
Tokyo: Flood management in the Tsurumi River Basin								66
Seattle: Managing stormwater								72
Basel: Green roofs								84
Linz: Green roofs								90
Toronto: Green roofs								97
Various US cities: Cool roofs								106
Tokyo: Managing the urban heat island								109
Newark and Camden: The benefits of urban trees								115
Philadelphia: Heat Health Warning System								118
Shanghai: Heat Health Warning System								123
Lisbon: Heat Health Warning System								127
Melbourne: Efficient use of water resources								132
Gold Coast: Waterfuture strategy								142
Germany and Belgium: Train depot rainwater harvesting systems								148
New York: Climate Change Task Force								150

This report does not by any means provide a complete view of what other world cities are doing to address climate risks. It provides a snapshot of various cities across the world where good practice has emerged. There are many other cities that could have been included – for instance, many cities have heat health warning systems and Germany has enormous experience in green roofs which is only briefly mentioned here. There are also examples closer to home: significant progress in adopting sustainable drainage systems has been made in Scotland for instance. However, even this limited review has demonstrated a wide range of both traditional and innovative approaches to managing climate risks.

The level of detail in the information provided for each case study is variable. For some case studies, only a brief treatment is given, based on the information that could be found in the short time period over which this project was undertaken. In other cases, a greater depth of information was readily available, and has been reported. The local case study partners have reviewed their city's case studies, but not those of other cities, so no attempt at comparing the cities has been made.

Where financial information on costs and benefits is shown in foreign currencies, these are also presented in UK£, using exchange rates on 31st March 2006.

Discussion

Addressing current climate risks or future climate change?

Most of the case studies describe approaches to managing existing climate risks faced by cities. Only in seven of the case studies was climate change specifically cited as a driver:

- New York's Staten Island Bluebelt Programme,
- Belgium's Sigma Plan,
- The Netherlands' multifunctional land use for flood management,
- Tokyo managing the urban heat island,
- Newark and Camden's urban trees,
- Gold Coast's Waterfuture strategy,
- New York's Climate Change Task Force.

Climate change scenarios were used explicitly to develop Belgium's Sigma Plan and are being utilised by the New York Climate Change Task Force.

Case studies addressing flood risk
The key feature common to theflood management case studies is that they emphasise approaches aimed at working in harmony with the natural environment, rather than purely controlling water through 'hard' man-made flood defences or piped systems (though these are often important components of the systems too). The case studies emphasise the use of natural drainage systems, and some, such as the Sigma Plan in Belgium, explain that simply continuing to raise the height of man-made flood defences (e.g. dikes) is not sustainable in the long term.

New York's Staten Island Bluebelt Programme aims to reduce the risks of flooding on the island from stormwater, by constructing stormwater detention ponds as well as creating and enhancing streams, ponds and wetlands. The programme also includes new separate storm and sanitary sewer infrastructure networks. Large areas of wetland are being purchased by the city to deliver the programme, which was developed through extensive stakeholder engagement.

The Sigma Plan in Belgium is a large-scale initiative that aims to manage flood risks along the Scheldt Estuary, including Antwerp, through a system of Controlled Inundation Areas (CIAs) and dike heightening. CIAs are parcels of land close to the River Scheldt that flood occasionally, protecting Antwerp and other built up areas from tidal flooding during storm surges. The plan involved important changes in land use – mostly from agriculture to natural estuarine habitat. It was developed using a detailed risk-based approach, involving a Social Cost Benefit Analysis. To help develop the Sigma Plan, the first trans-boundary Strategic Environmental Assessment in Flanders was undertaken, extending onto Dutch soil.

The Netherlands is investigating novel ways of 'living with water' by combining land use for water storage with other functions, such as floating greenhouses and sports fields that can flood occasionally. A pilot floating greenhouse has recently been constructed, and some 'amphibious' homes and floating homes have been built along the Maas River.

In Tokyo, rapid urbanisation has led to increased runoff of rainwater and causes flooding problems next to the Tsurumi River. The Tsurumi River 'retarding basin' is a large rainwater retention reservoir that has been built to address this problem.

The International Stadium in Yokohama, which hosted the final game of the 2002 Football World Cup, sits within the basin. The stadium has been built on pillars, so that flood waters can flow underneath it.

Seattle has also found novel ways of dealing with increased stormwater runoff due to urbanisation. The city's Comprehensive Drainage Plan emphasises localised solutions to stormwater risks, with a preference for natural drainage systems where appropriate. Pilot natural drainage system projects have already been developed and are being monitored so that lessons can be learned for further projects. In addition, Seattle has a system of drainage fees based on the amount of impervious land that a customer has, since this is one of the most important factors determining the volume of stormwater runoff. In 2007 the city expects to introduce a new system of drainage rate 'credits' (discounts) and grants for customers who install private drainage systems on their land.

Basel has been constructing green roofs since the 1970s. These are vegetated roofs that provide multiple benefits in terms of addressing climate risks: they reduce stormwater runoff, provide cooling of the building in the summer and thermal insulation in winter, as well as delivering a range of other non-climate-related benefits, such as for nature conservation. Basel has had two green roof campaigns, funded by the city government, which provide subsidies to building owners or developers who install green roofs. In 2002, Basel Canton also amended its Building and Construction Law, to require all new buildings with flat roofs to have green roofs. This amendment was driven by nature conservation objectives, though it clearly also provides benefits for managing climate risks.

Linz in Austria introduced green roof policies in 1985, as part of its legally-binding Development Plan, to counteract the large and rapid loss of green areas in the city to commercial and industrial development. These policies require green roofs on new buildings with flat roofs, as well as on underground structures like underground car parks. The city also provides subsidies for green roofs, provided that they are properly maintained.

In both Basel and Linz, it is long-established wisdom that green roofs are beneficial.

In contrast, Toronto has approved its green roof strategy much more recently, early in 2006. This strategy commits the council to installing green roofs on City-owned buildings, as well as a pilot programme of financial incentives for constructing green roofs. The City commissioned a detailed cost benefit analysis to inform the strategy.

The strategy development process also included workshops with stakeholders, which identified barriers to green roofs, and ways of overcoming them. This stakeholder feedback was also used to inform the strategy development process.

In New York, a Climate Change Task Force has been established to support institutional decision-making on climate change, evaluating adaptation and mitigation options. The Task Force is addressing a range of climate risks that affect the city's water supply and wastewater treatment systems. It is a collaboration between New York City's Department of Environmental Protection and the Center for Climate Systems Research at Columbia University.

Case studies addressing high temperatures

The case studies addressing high temperatures fall into two main types: First, measures that can be implemented to make buildings cooler or to reduce the urban heat island (UHI) across a wider area, and secondly, Heat Health Warning Systems, where weather forecasting on heat waves is linked to health intervention measures.

Green roofs in Basel, Linz and Toronto (see above) provide cooling in summer.

Various US cities have promoted 'cool roofs', which have a light-coloured coating that reflects and emits heat, reducing the risks of high temperatures. This has been achieved through rebates for installing cool roofs, as well as changes to building codes and regulations. Research across 11 US cities has estimated the benefits of cool roofs in terms of lowering demand for air conditioning.

Tokyo has produced a Thermal Environment Map, showing the factors that affect the city's urban heat island, such as built up areas and heat radiated from buildings. Based on this map, the city government has designated areas of the city for measures to reduce the UHI, including introducing greenery on walls, roofs and roadsides, as well as creating 'ventilation paths' so that breezes can pass through parts of the city.

In Newark and Camden research has demonstrated that urban trees are a viable and economically efficient way to reduce the urban heat island. The work also showed that urban trees can lower health hazards associated with the UHI by removing pollutants from the air. It also demonstrated that less affluent neighbourhoods have most to gain from tree planting, but have the least space available for planting them.

To manage health risks from high temperatures, Philadelphia developed a Heat Health Warning System (HHWS) in 1995. The system uses weather forecasts to predict periods when there is a risk of particular types of 'airmass' occurring over the city that are associated with heat-related deaths. The local National Weather Service office then decides whether to issue a warning to the city's Department of Health. The Health Department and other agencies then implement a series of 'intervention activities' such as publicising information via the media, a 'buddy' system whereby volunteers visit elderly people, and a telephone 'Heatline' for the public.

Shanghai has a Heat Health Warning System which is similar in its approach to that in Philadelphia. Research for Shanghai's Heat Health Warning System has demonstrated that more elderly women die in heat waves than any other group.

Lisbon's Heat Health Warning System, the ÍCARO surveillance system, has been in operation since 1999. A postal survey of the general public revealed that 92.5% of those surveyed had read or heard the advice about how to take care of themselves during the heat wave in 2003. However, the survey showed that the elderly (75+ years) and lower educated individuals were less likely to pick up the advice. Furthermore, there were problems in conveying warning messages to the public late in the 2003 heat wave period, when the media were more interested in reporting on forest fires.

The thresholds for issuing warnings for the three Heat Health Warning Systems described here are different, reflecting the different sensitivities of the populations of Philadelphia, Shanghai and Lisbon to climatic conditions, and also the different decisions made in each city about how to operationalise the systems. To date, the effectiveness of HHWS as a whole or of specific health interventions have not been properly evaluated, although there is evidence that they have been effective during major events in Philadelphia.

Case studies addressing water resource risks

Melbourne has developed a range of policies to promote efficient use of water resources: Drought Response Plans are used to introduce staged water restrictions when water levels are running low. Permanent Water Saving Rules control the use of watering systems in gardens, and are backed up by penalties for non-compliance. Variable water tariffs are used to reward low water use, with much higher water rates for excessive water use. The Water Smart Gardens and Homes Rebate Scheme provides a rebate off water bills for customers who purchase water saving devices like rainwater tanks.

These policies are backed up by numerous public communication campaigns encouraging water-efficient behaviour, including television adverts, poster campaigns, competitions and community events.

The Gold Coast's Waterfuture strategy provides a range of measures aimed at ensuring sufficient water until 2056, by which time the city's population is expected to double. Traditionally, the Gold Coast has relied heavily on water from dams. These will continue to be the main water source in the future, but the strategy also includes new water-resource management initiatives such as: desalination, recycled water, rainwater tanks, water leakage and pressure management, and water conservation measures. The Gold Coast has an extensive range of water conservation measures aimed at the general public, similar to those employed in Melbourne.

In Germany and Belgium, rainwater harvesting systems have been installed at train maintenance depots. Rainwater is collected from the depot roofs into storage tanks, from where it can be used to clean trains. Flanders in Belgium has introduced an obligation to install combined rainwater harvesting and attenuation systems in any type of building.

Conclusion

This report shows that with a combination of political commitment, planning and policy change, fiscal incentives, legislation and communication, together with investment and appropriate use of technology, schemes can be put in place to keep cities liveable despite higher temperatures, changing rainfall patterns and rising sea levels.

There are specific lessons to be learnt from each case study, but there are also some common threads:

- There is often a need for city-wide planning.
- There is often a need for partnerships between different organisations, and across geographic boundaries.
- Thinking about climate change needs to be included in all long-term decision-making.
- There is a need for clear communication and engagement with the public to achieve success.

New York: Managing flood risks
Staten Island's Bluebelt Programme [1]*

Overview

- Inadequate storm sewer system led to localised flooding problems on Staten Island
- The Bluebelt programme provides stormwater detention ponds, and creates or enhances streams, ponds and wetlands
- Large areas of wetland were purchased by the City to deliver the programme

Context and policy drivers

The South Richmond region of Staten Island, one of New York City's five boroughs, is marked with an inadequate or in some places, non-existent storm-sewer system. Because of a lack of sanitary sewers, residences relied upon on-site septic tanks for sanitary waste disposal. During periods of heavy rain, several areas in this region routinely experienced localised flooding and septic tank failures due to groundwater conditions. This often led to water quality degradation in nearby streams.

To address these concerns, New York City Department of Environmental Protection's (NYCDEP) Bureau of Water and Sewer Operations conceived of the Staten Island Bluebelt as part of the Storm Water and Sanitary Drainage Management Plan for South Richmond. The decision to create the Bluebelt came from the Commissioner of NYCDEP, and included the support of the Mayor and several other city agencies involved in land acquisition.

As a part of the Bluebelt there was a comprehensive and focused initiative to include elected officials and community groups in the Bluebelt planning and design processes, through the initiation of a Citizens Advisory Committee (CAC). The Committee consists of dozens of community members representing a wide range of interests. Membership in the CAC continues to grow as the geographic focus shifts to new watersheds. An active community maintenance partnership also exists via the 'Adopt-A-Bluebelt Program', and has a significant benefit to the City. The response to these initiatives has so far has been extremely positive.

*Case study written by Cynthia Rosenzweig, David Major, and Melissa Stults, of Goddard Institute for Space Studies at Columbia Earth Institute, and Kate Demong and Jack Vokral of the New York City Department of Environmental Protection, USA, 2006.

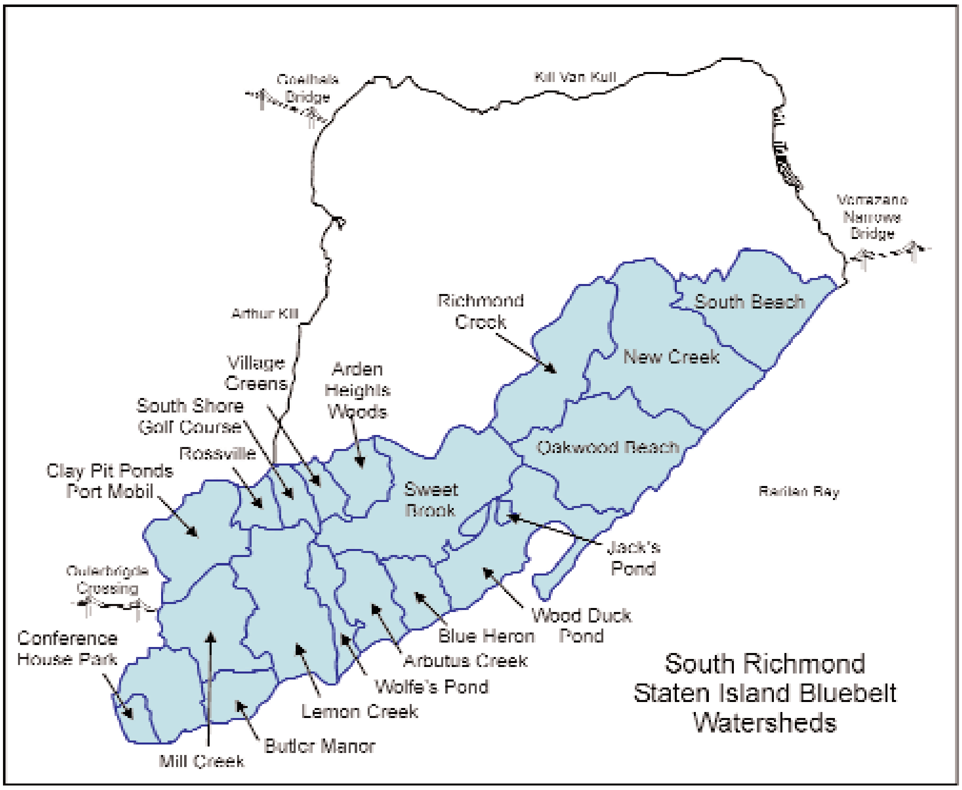

Figure 1: South Richmond Staten Island Bluebelt Watersheds. (Source: New York City Department of Environmental Protection [2])

Description of the programme

The Staten Island Bluebelt programme provides non-traditional storm water management in the form of storm water detention ponds, as well as wetland creation and enhancement, to provide some additional 'buffering' in the event of increased frequency and intensity of rainfall. The system is designed to provide solutions to current problems, but is also designed to accommodate full build-out of all lands within each watershed based on current zoning densities.

The goals are to preserve the natural drainage corridors, called Bluebelts, including streams, ponds, and other wetland areas to allow them to perform their functions of conveying, storing, and filtering storm water. This also includes the creation of new wetlands, meandering streams, and stilling basins to alleviate negative effects of channelling storm water into the natural environment. DEP has also worked closely with the New York State Department of Environmental Conservation (NYSDEC), which has regulatory jurisdiction over the wetland areas. NYSDEC has developed a component of the Bluebelt system to provide diverse wildlife habitats, which also contribute to community open space. The preservation of natural Bluebelts and creation of new wetlands are complemented by the creation of separate storm and sanitary sewer infrastructure networks in the Bluebelt regions to further enhance drainage, thus making the Bluebelt programme one that advances both stormwater and sanitary (sewage) drainage management plans.

Figure 2: An extended detention basin constructed in Staten Island's Bluebelt, after a single growing season (Source: New York City Department of Environmental Protection)

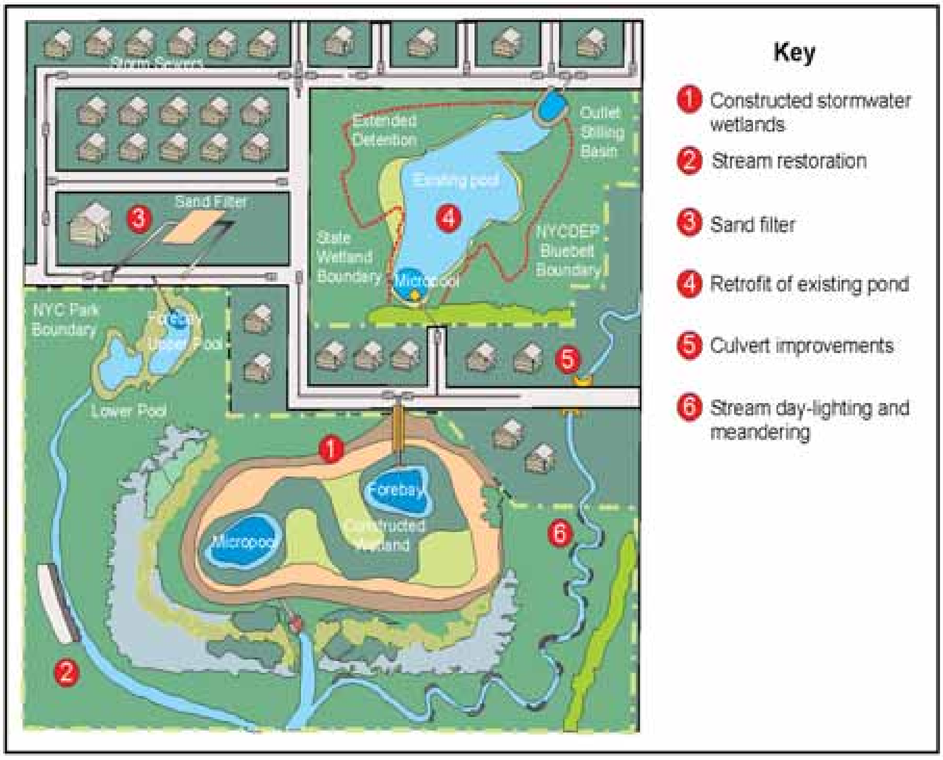

Figure 3: Stormwater management in Staten Island's Bluebelt through wetland preservation and infrastructure improvements. (Source: New York City Department of Environmental Protection[3])

At first, there was some general scepticism about the initial Bluebelt proposal, because of its non-traditional approach. However, the creation of the initial Bluebelt generated immense support due to its success, and has led to the continual purchase of additional wetlands throughout Staten Island to contribute to expanding the Bluebelt system. Some fifteen watersheds, clustered at the southern end of Staten Island, plus the Richmond Creek watershed, drain into the current Bluebelt system. These initial 16 watersheds are estimated to have completed drainage systems by 2018. The total area of these 16 watersheds is approximately 10,000 acres. In three additional watersheds, wetlands acquisition is currently ongoing, totalling approximately 4,000 acres. There is not yet an established date for when these watersheds will have completed drainage systems.

The total areas covered by the Bluebelt programme are therefore 14,000 acres, or 36% of Staten Island's land area.

Initial barriers to the Bluebelt Programme surrounded the need to expend funds to acquire additional lands necessary to implement the overall drainage system. However, once a clear cost-benefit relationship was established, this barrier was overcome.

Figure 4: A typical outlet stilling basin in Staten Island's Bluebelt (Source: New York City Department of Environmental Protection)

Assessment of the effectiveness of the programme

The Bluebelt programme saves tens of millions of dollars in infrastructure costs when compared to the alternative of providing 'conventional' storm sewers for the same land area. To date, the Bluebelt programme has saved the City of New York an estimated US$80 million (£46 million) in infrastructure costs. In addition, property values in the immediate vicinity of the completed Bluebelt drainage corridors have consistently appreciated, providing the City with an increased tax base.

Success has been measured by a decrease in flooding in low-lying areas, elimination of septic-system overflows, and an improvement in overall water quality of receiving waters. Success has also been demonstrated by the enormous amount of support the Bluebelt programme has received both locally and nationally.

The programme has demonstrated that wetland preservation can be economically prudent and environmentally responsible. The United States EPA recognized the leadership of the Bluebelt by awarding it a 2005 Environmental Quality Award.

Footnotes

1. Case study written by Cynthia Rosenzweig, David Major, and Melissa Stults, of Goddard Institute for Space Studies at Columbia Earth Institute, and Kate Demong and Jack Vokral of the New York City Department of Environmental Protection, USA, 2006.
2. www.nyc.gov/html/dep/html/news/bbeltfeat2.html
3. www.nyc.gov/html/dep/html/news/bbeltfeat2.html

Antwerp: Managing flood risk
The Sigma Plan[4]

Overview

- Land next to Scheldt Estuary, including Antwerp, is prone to flooding
- Continuing to increase dike heights is not considered a sustainable solution
- The Sigma Plan aims to manage flood risk through a system of Controlled Inundation Areas and dike heightening
- The plan involves important changes in land use, mostly from agriculture to natural estuarine habitat

Context and policy drivers

In northern Belgium, the Scheldt River and its tributaries form a tidal river system with an overall length of more than 250 km and a tidal range of up to 5.5 m in normal circumstances. Some 20,000 hectares (ha) of land is currently prone to inundation. Until the mid-1970s, the response to increasing flood risk was to repair the dikes and to build them ever higher. However, mean high tide levels have been increasing and in Antwerp, they have risen by 56 cm over the past century. At the same time, the frequency of storm events has increased, and it has gradually become clear that continuing to increase the height of the dikes is not a sustainable solution.

A storm tide in Belgium on 3 January 1976 flooded almost 900 houses. However, in the Netherlands, where the Delta plan had been put in place, no damages occurred. This disaster created a high (but short-lived) public awareness of the risk of inundation along the tidal reach of the Scheldt, called the 'Sea Scheldt' in Belgium, and to the conception of the Belgian Sigma plan for the Sea Scheldt at the beginning of the 1980s. The design criterion for the Sigma plan drew on the design criterion for the Dutch Delta plan: protection against a 1 in 10,000 year storm tide. This Sigma plan (referred to as the 1978-Sigma plan) included a tidal storm surge barrier downstream of Antwerp, combined with dike heightening. From the Dutch-Belgian border to Antwerp, crest levels of river dikes had to be raised up to the 1 in 10,000 year water level (including wave reflection) of + 11 m above sea level. Upstream of Antwerp, dikes also had to be strengthened and raised (to lower levels: +8.35 m and +8 m above sea level). Furthermore, a number of Controlled Inundation Areas (CIAs) had to be constructed to provide some protection against flooding during the barrier construction period. By 1982, the barrier was designed and ready for construction.

However, economic difficulties led the Belgian government to undertake an economic analysis of the Sigma plan. This analysis demonstrated that a storm surge barrier could not be economically justified, and as a result, the construction of the barrier was postponed indefinitely[5].

As of 2005 under the 1978-Sigma plan, about 405 km of dikes had been strengthened (corresponding to about 80% of the total dike length). About 500 ha of small Controlled Inundation Areas, distributed on 12 different sites, had been constructed. A large Controlled Inundation Area of 600 ha, called KBR, was under construction.

Once KBR is operational, the current probability of inundation in the tidal reach of the Scheldt will be a 1 in 350 year event. However, the Scheldt is experiencing stronger tides, more storms and rising sea levels, and the authorities are concerned about the risks of sea level rise from climate change. For the Belgian coast, the authorities recommend a design value of 60 cm to account for sea level rise between 2000 and 2100. With this amount of sea level rise, the standard of protection offered by the 1978 Sigma plan will be reduced from 1 in 350 years to just 1 in 20 years in the year 2100. This was considered unacceptable by the authorities (although there is no legislation regarding levels of flood protection in Belgium) and these concerns led the authorities to review the Sigma plan[6].

In 2001, the Flemish Parliament made the decision to develop a Long Term Vision for the Scheldt Estuary addressing three key objectives in a sustainable manner:

- Safety against flooding in the densely populated catchment,
- Ecosystem health, and
- Accessibility of the port of Antwerp.

The Long-Term Vision is for ''the development of a healthy and multifunctional estuarine water system that can be utilised in a sustainable way for human needs.''

Their resolution stated that flood risk management measures for the Scheldt Estuary needed to be updated, allowing a non-homogeneous standard of protection in the basin of the Sea Scheldt, with higher risk assets having a higher standard.

The revised Sigma plan
The Flemish Waterways Administration (W&Z) has embarked on the process of updating the Sigma plan. A risk-based approach to developing the vision was required. As part of this risk-based decision-making process, a Social Benefit Cost Analysis (SBCA) for updating the Sigma plan was undertaken[7].

Assessment of the effectiveness of the revised Sigma plan

A 'top down' SCBA examined the following options:

1. A 'zero option' (or zero reference scheme), defined as the finished original 1978-Sigma plan, with all dikes at the planned level and the 13 CIAs operational, but without the storm surge barrier,

2. Solutions with storm surge barriers combined with dike heightening downstream,

3. Solutions with dike heightening only,

4. Solutions combining Controlled Inundation Areas with local dike heightening,

5. As above, but using the Controlled Inundation Areas also as Controlled Reduced Tide Areas (see Boxes below).

Allowing rivers to occupy more space: Controlled Inundation Areas (CIAs)

Controlled Inundation Areas provide storage capacity adjacent to rivers. They are separated from the river by a submersible levee at a lower level than the safety level for the areas to be protected against inundation, but higher than normal spring tide. This ensures that the storage capacity within these areas is intact at the moment it is needed, i.e. during storm floods. The frequency at which they inundate is typically between once a year and once every three years, mostly during winter periods. This poses some limits to the type of land use that remains possible in CIAs. Agricultural activities can generally be maintained, although mostly in a less intensive form than before. As an alternative to agricultural use, conversion to wetlands is also possible.

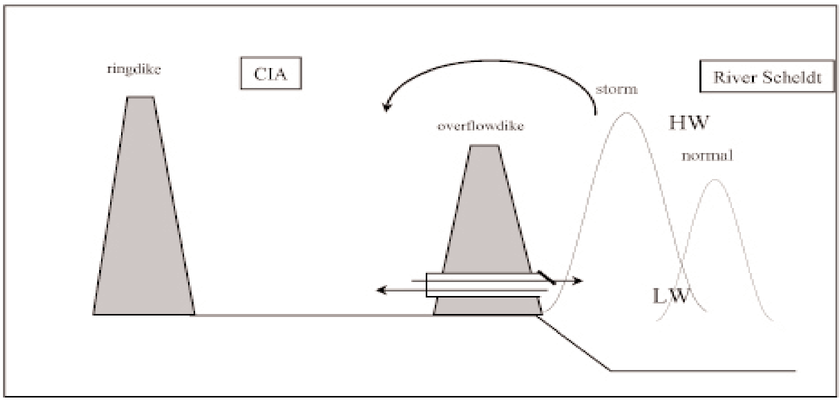

Figure 5: Diagram showing how a Controlled Inundation Area functions

Allowing rivers to occupy more space: Controlled Reduced Tide Areas (CRTs)

Controlled Reduced Tide Areas (CRTs) are a variant of CIAs. In a CRT, the tidal influence is felt continuously in the controlled inundation area. During high floods, the CRT operates as a CIA, with floodwater spilling over the crest into the area. During normal periods however, inlet sluices in the dikes ensure that the tidal movements of the river are transferred to the other side of the dike, so the water level in the CRT rises and falls in rhythm with the river, though it does not rise and fall as high/low. This turns the inundation area into a river-influenced wetland. The area is unsuitable for agricultural activities, even though it may not be completely flooded at all times.

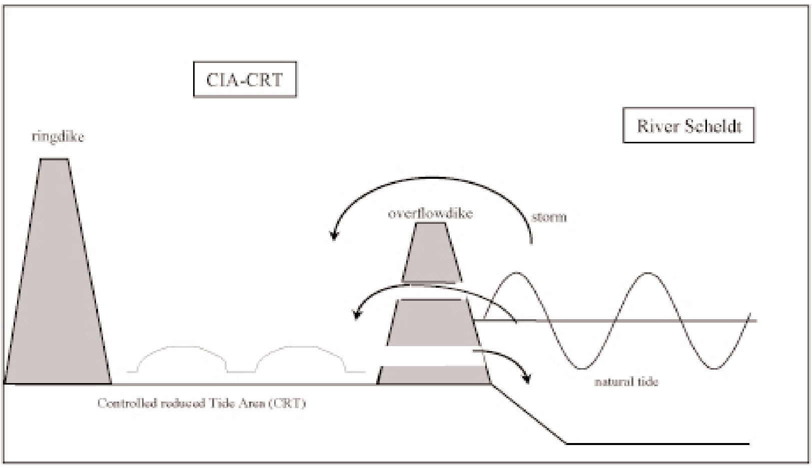

Figure 6: Diagram showing how a Controlled Reduced Tide Area functions

Potential locations for Controlled Inundation Areas (CIAs)

The Social Cost Benefit Analysis (SCBA) identifies some 180 potential locations for CIAs along the tidal reaches of the Scheldt and its upper tributaries (see Figure 7 – light blue areas), which were classified using a multi-criteria analysis. The total surface area available is approximately 15,000 ha.

According to the Social Cost Benefit Analysis, the optimal scheme would be the result of the best balance between the extra costs necessary to provide higher protection level, and the extra benefits from these investments, as compared to the zero option.

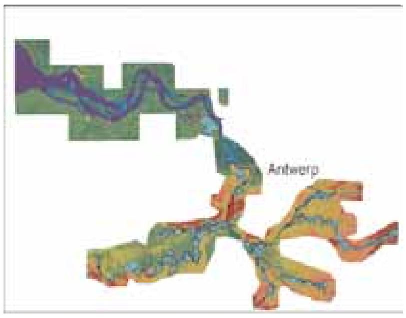

Figure 7: Potential locations for Controlled Inundation Areas (Source: Bulckaen et al, as above).

The cost side of the SCBA included:

- investment costs for the flood protection works,
- all necessary maintenance and operation costs during the project life time (100 years),
- loss of agricultural areas or forests.

On the benefit side, the SCBA identified:

- avoided flood risks in the river basin,
- avoided investment costs,
- benefits resulting from nature development and recreation (translated into monetary values).

The SCBA analysed the average annual flood risk during the 100 year project life under each option, allowing for a sea level rise of 60 cm over this period, and developed quantified costs and benefits. The map on the right (Figure 8) shows the areas with predicted highest average annual flood risk in 2100 (in the zero-reference case).

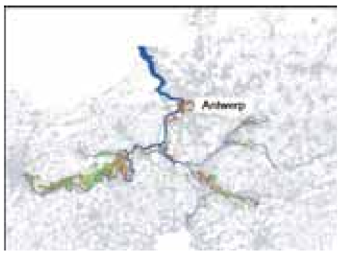

Figure 8: Areas of flood risk along the Scheldt predicted for 2100 in the zero-reference case (highest risk areas shown in red)[8]

The top down SCBA concluded that the optimal solution for the updated Sigma plan would involve a combination of dike heightening with CIAs. It also concluded that additional use of the Controlled Inundation Areas as Controlled Reduced Tide Areas was beneficial overall. A further, 'bottom-up' SCBA identified an optimal combination of dike heightening and CIAs, with a Pay Back Time of only about 16 years. This solution requires an investment of about 150 million Euros (£100 million), and requires about 1,350 ha of CIAs.

The locations of the CIAs are still under discussion. One consequence of this approach is that not all areas along the Scheldt are protected to the same standard. The standards of protection estimated for the solution - not including sea level rise of 60 cm - were as follows:

- 1 in 4,000 year events for important locations (large cities),
- 1 in 2,500 year events for less important damage centres, and
- 1 in 1,000 year events for rural areas.

Taking account of 60 cm sea level rise to 2100 showed a dramatic decrease in levels of protection in the future. The SCBA calculated that an additional 660 ha would be economically justified to address this sea level rise, resulting in a total of about 2,000 ha of new CIAs being required in the Scheldt basin.

One specific issue of concern within the revised Sigmaplan is the flood protection of Antwerp. A site of about 450 ha, but located some 15km on the seaward side of Antwerp, has been identified as the only possible site for a major CIA to address the effects of major storm tides and disperse water before it reaches this city. Hydraulic studies demonstrated however very limited hydraulic effects of this CIA in terms of resulting storm tide water level reduction and inundation risk in Antwerp. This can be explained by the location of the CIA, being too far downstream from Antwerp and also already located in a river reach close to the estuary, where the width of the Scheldt is considerably larger than in Antwerp. This results in an increase of the flood discharge being conveyed through the Scheldt at the CIA location. The CIA also has to compensate for this change in the hydraulic behaviour of the river, which reduces even further the water level reduction effects of the CIA. Analysis of the costs for building this CIA related to the benefits in term of flood risk reduction, led to the conclusion that in the case of Antwerp city, protection by means of local dike heightening was economically more justifiable.

A Strategic Environmental Assessment (SEA) of the top down defined alternative Sigma schemes has also been undertaken[9]. This showed that Controlled Inundation Areas can make an important contribution to water quality and biodiversity (see Box below for further information).

In line with the findings of the SCBA, the Flemish Government has opted for a solution for the updated Sigma plan that uses CIAs supplemented with local dike adaptation. The final choice of CIAs will be made by the Flemish Waterway Administration, working to find a locally-supported optimal scheme layout for the updated Sigma plan.

According to the Strategic Environmental Assessment, this solution combines two of the three pillars of the Long Tem Vision (safety against inundations and nature development) in one project. It created the conditions, in a cost-effective and politically acceptable way, for the third and economically most important pillar, namely improving access to the Port of Antwerp, to be realised[10].

Findings of the SEA of options for the updated Sigma plan

For the various elements identified in the top down SCBA, the following impacts were identified through the SEA process:

- Storm surge barriers alone had relatively little positive or negative environmental impact.
- Dikes force tidal waters into a narrow channel, causing impoverishment of the estuarine environment and diminishing the estuary's capability to break down pollutants.
- Controlled Inundation Areas can not be used for 'hard' land use types - buildings, and certain kinds of infrastructure. When filled, they may prevent the free discharge of brooks into the main river system, creating secondary inundation problems further upstream. The dikes around CIAs take up significant areas of land (both agricultural and natural habitats). They also create some visual intrusion.
- Controlled Reduced Tide Areas (CRTs) have many similar environmental impacts to CIAs. The main difference between CIAs and CRTs is that CRTs allow the river to expand on each tidal cycle, improve water quality, and allow for a more natural estuarine development, forming the habitat for the development of typical and rare ecosystems. However, all economic activities on the land in the CRT have to cease - some land of very high agricultural value would be lost.

Overall, the SEA demonstrated the complexity of evaluating options, revealing tensions: options with strong benefits (e.g. creation of new rare habitat areas) also had significant negative impacts, such as loss of agricultural land. The SEA process involved engagement with key stakeholders, including consultation with groups representing nature and agricultural interests, as shown in the figure below. Their views and preferences were used in the design of the final 'optimised' Sigma plan.

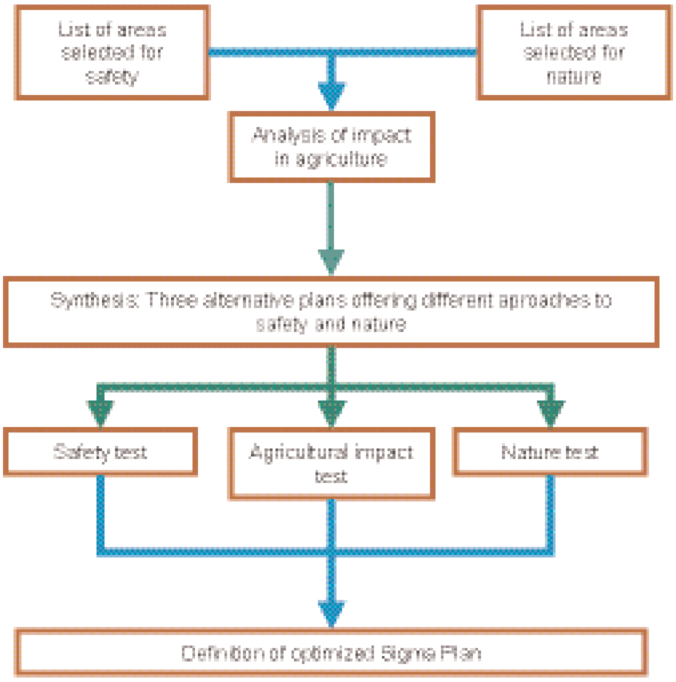

Figure 9: Development of the SEA for the Sigma Plan. (Source: Couderé, K. and Dauwe, W. 2005, as above)

The Sigma plan implies important land use changes: about 6,000 hectares of land will be required in total for its implementation, to deliver on flood protection and nature conservation objectives, much of which will have to undergo a change in land use (mostly from agriculture to natural habitat) and thus requires changes in land use plans. The realisation of the plan is, however, expected to take 25 years, and the decision has been made to update land use plans in a 'piecemeal' fashion starting with the most urgent projects. This approach has clear benefits in terms of its political acceptability, but presents the risk that the Sigma plan project as a whole may never be realised, as pressure on land use grows[11].

Footnotes

4 Bulckaen, D., Smets, S., De Nocker, L. Broekx, S., and Dauwe, W. 2004. Updating of the Belgian Sigma plan on a risk-assessment basis, IMDC-VITO-RA.

5 Bulckaen et al (as above).

6 Bulckaen et al (as above).

7 Bulckaen et al (as above).

8 Bulckaen et al (as above).

9 Couderé, K. and Dauwe, W. 2005. Strategic environmental assessment of the Sigma plan: a test for the "space for rivers" concept, RA.

10 Couderé et al (as above).

11 Couderé et al (as above).

The Netherlands: Multifunctional land use for flood management

Overview

- The Netherlands faces growing problems in managing flood risks
- Multifunctional land uses can be created, where land floods occasionally, but can be used for other functions too, such as for floating greenhouses and sports field
- A pilot floating greenhouse has been constructed, as well as 'amphibious' and floating homes

Context and policy drivers

Water issues have gained increasing recognition in recent years within the Dutch national government. The importance of creating more space for water was acknowledged after floods and extremely high (river) water levels in 1993 and 1995. The Dutch cabinet also issued the directive 'Dealing with water differently' in 2000, in which it indicated its desire to use spatial development for water management.

Description of the project

The manual 'Guiding Models for Water Storage'[12] has been developed to assist water managers and spatial planners in The Netherlands and surrounding countries to 'weave' land use for water storage with other land use functions. The 'Guiding Models' project is part of the European ESPACE[13] (European Spatial Planning: Adapting to Climate Events) project. Its central focus is dealing with climate risks to water management in spatial planning.

The manual is exclusively aimed at water storage in regional water systems and not the main river system. It refers to the three stages of water management as shown in Figure10:

- retention,
- storage, and
- drainage.

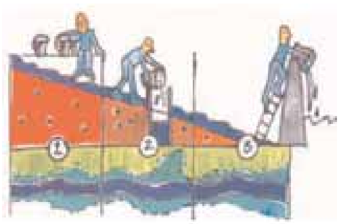

Figure 10: Three stages of water management. (Source: Guiding models for water storage[14].)

The emphasis of the manual is on the second part of the process: water storage. Storage can be defined as making modifications in the spatial planning of an area to create more room for water, such as increased surface water or the temporary inundation of a field.

'Guiding models for water storage' provides practical examples of possible combinations between water storage and other functions. A few examples are outlined below.

Water and glass guiding model

Horticulture businesses place a high demand on water for irrigating their crops. Locations for greenhouse horticulture are often characterised by the different components (greenhouse, production facility, water reservoir) being situated close to each other, which requires a large surface area. Nowadays, concepts have been developed that integrate water storage in the foundations of the greenhouse, or where the greenhouse itself has become a floating structure on the water storage (see Figures 11-12).

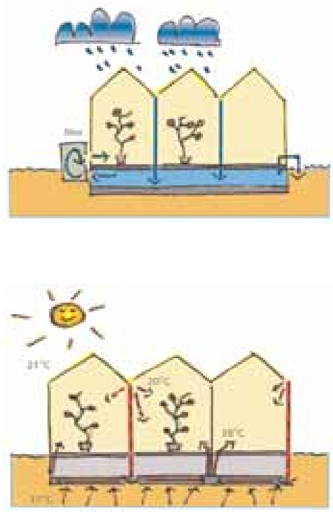

Figure 11: Water technology in greenhouses: recycling water (above) and heat (below) (Source: Guiding models for water storage, as above.)

Demonstration projects

This technology has recently been applied in the Netherlands. The country's first fully-functioning demonstration floating greenhouse was completed in 2005[15], sitting in the water storage area next to the FloraHolland flower auction in Naaldwijk. It consists of a floating raft or pontoon made of expanded polystyrene and steel fibre reinforced concrete. The pontoon covers an area of approximately 900 m^2 and the greenhouse measures roughly 600 m^2 (see Figure 13).

A new development of 34 'amphibious' and 14 floating houses has been built on the banks of the Maas River in the village of Maasbommel by the construction company, Dura Vermeer (see Figure 14).

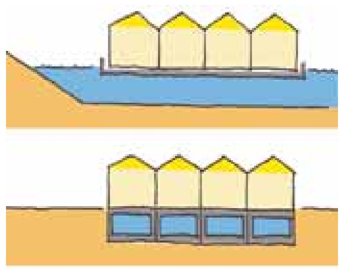

Figure 12: Floating greenhouses (above) and water storage in the foundations under a greenhouse (below). (Source: Guiding models for water storage, as above.)

The amphibious houses have foam built into a hollow concrete basement. When the water rises or falls, the houses can float up to 5.5 m by sliding along two mooring posts at the front and rear of the building (see Figure 14). The posts are driven deep into solid ground, and are strong enough to withstand currents found on the open seas[16]. Flexible PVC piping means that the plumbing, electrical, and natural gas connections to the properties can also cope with water level fluctuations. The floating houses manage rising and falling water levels in much the same way, but are built to float year-round.

Figure 13: The Netherlands' first floating greenhouse. (Source: Dura Vermeer Groep NV.)

In 2005, the Netherlands Ministry of Housing, Spatial Planning and the Environment announced that it was accepting proposals to develop amphibious and other types of flood-resilient structures in 15 flood-prone areas, where construction has never been permitted before.

Dura Vermeer is also designing a 'floating city' for 12,000 people near Schiphol Airport, Amsterdam. The design of the city is being part-funded by the government.

Figure 14: Amphibious houses in Maasbommel, Netherlands. (Source: Dura Vermeer Groep NV.)

Sports Water Park Guiding Model

Sports and recreational areas are often situated at the city limits and cover large areas. Due to their location and periodic use, a combination with water storage is possible, especially since these facilities are used less in the winter, which is the time of year when the largest water surplus occurs. It may be possible to modify sports and grass fields so that they can be temporarily inundated during this period. The inundation should not limit the activities and facilities.

Figure 15: Park before (above) and after (below) inundation. (Source: Guiding models for water storage, as above.)

Footnotes

12 Novio Consult and Robbert de Koning Landschapsarchitect BNT. 2004. Guiding models for water storage. ESPACE project report. Nijmegen/Oosterbeek, September 2004.
13 www.espace-project.org
14 Novio Consult and Robbert de Koning Landschapsarchitect BNT. 2004, as above
15 www.drijvendekas.nl/
16 Dick van Gooswilligen, Dura Vermeer, quoted in Der Spiegel, 26 September 2005. See http://service.spiegel.de/cache/international/spiegel/0,1518,377050,00.htm

Tokyo: Flood management in the Tsurumi River Basin[17]

Overview

- Rapid urbanisation has led to flooding problems next to the Tsurumi River in Tokyo
- A large rainwater retention reservoir addresses this problem, by providing temporary storage for flood water
- The International Stadium in Yokohama, which hosted the final game of the 2002 Football World Cup, sits in the reservoir basin
- The stadium has been built on pillars, so that flood waters can flow underneath it

Context and policy drivers

In 2004, some 27 typhoons affected Japan, ten of them hitting many parts of the nation severely. In addition, seasonal rain-fronts brought concentrated heavy rain in some regions. These events had serious effects on the local population and caused extensive damage to property and the economy.

Population growth and socio-economic development during the latter half of the 20th century mean that rapid urbanisation has occurred in many parts of Japan, particularly in the metropolitan areas of Tokyo, Osaka and Nagoya. A series of large-scale development projects in the alluvial plains downstream of the Tsurumi River, which flows through the southern part of Tokyo, resulted in a high concentration of population and properties. Farmland and forests accounted for 90% of the total basin in 1958, but this had decreased significantly to about 15% in 2000.

These urbanised alluvial plains have therefore become much more vulnerable to flood disasters, and there are serious concerns about the increased flood risk.

Description of the project

To reduce the risk of urban flood disasters, the Government of Japan started a national integrated flood management programme in 1979: the Comprehensive Flood Disaster Management of Urbanised River Basins (CFDMURB).

This includes river improvement projects to secure sufficient capacity for floodwaters, and also basin improvement measures and damage control measures to alleviate flood damages in the basin. Since the introduction of the CFDMURB, urban flood management measures have been promoted through designing basin management plans and organising basin councils.

Under the framework of the CFDMURB, river managers, local governments and private land developers are encouraged to make effective basin improvement measures. One of the most important structural measures is rainwater retention ponds or reservoirs, situated in various parts of the basin to temporarily store rainwater and to control outflow into the river. These facilities are utilised as multi-purpose recreation areas or sports facilities when they are not flooded, and are termed 'multi-purpose retarding basins'.

Figure 16: Surrounding levee

Figure 17: Separating levee

What is a 'multipurpose retarding basin'?

A retarding basin is a flood control device used to collect temporarily a portion of the water that accumulates during a flood, to reduce downstream flooding. The basin is excavated deeper than the surrounding area, and several types of embankments or levees are installed around it (see Figures 16-18), as follows:

- The 'surrounding levee' is located between the retarding basin and neighbouring land,
- The 'separating levee' lies between the retarding basin and the river,
- Some 'overflow levees' are built between the retarding basin and the river, to allow overflow from the river into the basin.

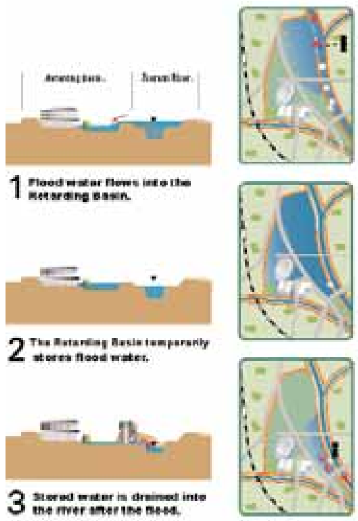

Figure 18: How a retarding basin functions. (Source: Keihin Office of River Kanto Regional Development Bureau, Ministry of Land, Infrastructure and Transport, Japan. http://www.keihin.ktr.mlit.go.jp/english/tsurumi/oasis/.)

Other structural measures under the CFDMURB include:

- installing rainwater storage capacity on facilities such as school grounds or parks,
- constructing permeable pavements to facilitate infiltration of rainwater into the ground,
- promoting flood-proof 'elevated-floor' buildings to avoid damage from inundation,
- preserving natural land and forests to regulate rainwater runoff.

As well as structural measures, non-structural measures are also utilised to reduce the impact of flood disasters. These include publicising flood hazard maps and establishing flood forecasting and early warning systems. By incorporating the simulated inundation areas and evacuation information, flood hazard maps enhance the public's preparedness and capability to cope with flood disasters, and they also facilitate smooth evacuations in the case of emergencies. Flood forecasting and early warning systems have been developed involving relevant organisations, such as meteorological agencies and the media, and they now make a significant contribution to reducing flood damages and facilitating early evacuation of the public.

The Tsurumi multi-purpose retarding basin project and Yokohama Sports Stadium

The Tsurumi River flows in the southern part of the Tokyo metropolitan area. Because of its favourable location for commuting to the central district of Tokyo, this river basin experienced rapid urbanisation in the 1960s and natural forests have been replaced with housing and roads. This land use change led to an increase in the amount of surface runoff flowing into the Tsurumi River, and flood disasters have become much more serious as a consequence. Therefore the CFDMURB has been applied to manage the river basin in an integrated manner.

The Tsurumi multi-purpose retarding basin project has been implemented as one of the pillar river improvement projects under the CFDMURB. It aims to prevent flood disasters in downstream areas as well as to create multi-purpose spaces for recreation and sports and a lush natural park for local residents[18].

The retarding basin is separated by an overflow levee and separation levees from the river itself, and is encompassed by a surrounding embankment. It has been excavated so that it can hold a maximum of 3.9 Mm^3 of floodwater. The overflow levees are constructed 3 m lower than the embankment and allow floodwaters to flow into the basin. Aimed at reducing the flood peak discharge by 200 m^3 per second, which is the estimated immediate flow magnitude (one in 10-year event), this retarding basin prevents flood damage in downstream areas.

The International Stadium Yokohama and the Yokohama Comprehensive Care Continuum are located inside the retarding basin. The stadium is the largest sports stadium in Japan with a capacity of 70,000 and is well known as the venue for the final game of the 2002 Football World Cup. This stadium utilises the 'piloti' method, whereby its floors are elevated on pillars to prevent inundation even if floodwaters flow into the retarding basin.

Figure 19: The Tsurumi River multipurpose retarding basin, with the International Stadium Yokohama as its centerpiece. (Source: Keihin Office of River Kanto Regional Development Bureau[19])

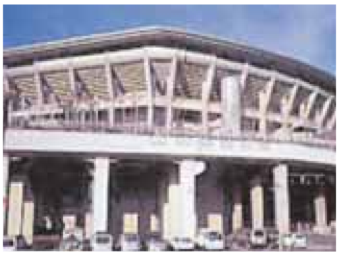

Figure 20: The International Stadium Yokohama was built elevated on pillars so that flood water can flow under it. (Source: Keihin Office of River Kanto Regional Development Bureau[20]).

Figure 21: Yokohama rainwater detention reservoir under normal (dry) conditions (above) and flooded after a period of heavy rainfall (below). (Source: Ikeda, T. 2005, as above.)

Communication with the public

The multipurpose retarding basin has also been equipped with information devices that can detect and warn people about dangerous situations during a flood. River information display boards have been installed in three locations in the basin, and are intended to provide flood-related information very rapidly to local residents.

Assessment of the effectiveness of the project

In 2004, when Typhoon no. 22 struck the area in October, the basin functioned effectively to decrease flood peak discharge and reduce damages. It reduced the flood water level by 1.5 m, storing about 1.25 Mm^3 of floodwater.

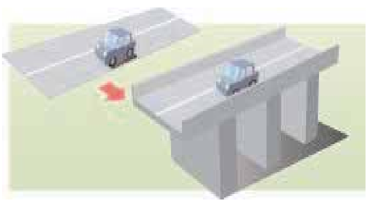

Figure 22: Elevated roads in the Tsurumi River retarding basin. (Source: Keihin Office of River Kanto Regional Development Bureau[21].)

Footnotes

17 Ikeda, T., Public Works Research Institute, Tsukuba, Ibaraki, Japan. 2005. 'Weather Warnings'. See www.waterpowermagazine.com/story.asp?sectionCode=166&storyCode=2026292

18 Keihin Office of River Kanto Regional Development Bureau, Ministry of Land, Infrastructure and Transport, Japan. http://www.keihin.ktr.mlit.go.jp/english/tsurumi/oasis/

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Seattle: Managing stormwater

Overview

- Increased stormwater runoff in Seattle due to urbanisation caused water pollution, affecting local freshwater ecosystems
- Drainage fees are based on the amount of impervious land, and discounts will soon be given to customers who have private drainage systems, to incentivise them to deal with stormwater on site
- Pilot projects have replaced existing inadequate stormwater systems with natural drainage systems, and are being monitored so that lessons can be learned

Context and policy drivers

The city of Seattle, situated on Puget Sound between the Cascade and Olympic mountain ranges, is well known for its lush natural setting. Among the city's celebrated natural resources are rich local fisheries. Pacific salmon, steelhead trout, and other species return from the open ocean to spawn in Seattle's rivers and streams. However, rapid growth and sprawl has led to increased stormwater runoff from new buildings, parking lots, and roads, generating concerns about the impact of water pollution on the local aquatic habitat. Dwindling fish runs have resulted in several species of Pacific salmon being added to the federal endangered species list[22]. As a result, the City of Seattle and the Washington Department of Ecology have launched programmes to protect and improve the health of Seattle's freshwater ecosystems, particularly through management of stormwater in urban areas.

In response to flooding in 1986, Seattle City Council expanded the responsibilities of the existing Sewer Utility to include drainage, forming the Drainage and Wastewater Utility (DWU). This new utility was tasked with regulating stormwater runoff, alleviating flooding, reducing water pollution caused by runoff and responding to federal stormwater regulations, in addition to managing the City's sewer system. To gain efficiencies and consolidate City functions, Seattle Public Utilities (SPU) was formed in 1997 by combining the DWU, Seattle Engineering Department, Seattle Water Department and Seattle Solid Waste Utility[23]. SPU provides more than 1.3 million customers in King County with a water supply, as well as sewer, drainage, and solid waste services for the City of Seattle.

Description of Seattle's Comprehensive Drainage Plans (CDPs)

The City completed two Comprehensive Drainage Plans (CDPs) in 1988 and 1995, focused on major flooding problems in specific drainage basins in the city. However, a major storm in 1996 resulted in 300 landslides during the winter and spring of 1996/1997, causing damages of more than $30 million (£17 million) to city facilities and millions of dollars in damages to private properties. This storm meant that the scope of the drainage programme was expanded. The 2004 CDP charts a long-term course for drainage in Seattle with a specific emphasis on 2005-2010 Capital Improvement Programmes. It was adopted by the Seattle City Council in January 2005 and SPU is now moving forward to implement the policies and direction laid out in the Plan.

The 2004 CDP expands Seattle Public Utilities' (SPU) role in stormwater management from a conveyance focus to include other elements associated with drainage management, and has created four distinct programmes each with its own goals and objectives. These are:

- Stormwater conveyance and flow control (discussed further below),
- Aquatic resource protection:
    - Water quality,
    - Habitat,
- Public asset protection.

The 2004 Comprehensive Drainage Plan emphasises localised solutions to stormwater problems in the city right-of-way, with a preference for natural drainage system design over catch basin and pipe systems where there will be a cost-effective benefit to aquatic systems and where site conditions are appropriate. This policy shift provides flexibility for creation of new drainage infrastructure that provides higher levels of environmental protection in key watersheds that do not currently have piped drainage systems.

As part of the 2004 Seattle Comprehensive Drainage Plan, projects are being undertaken to address stormwater management, through the Stormwater Conveyance and Flow Control programme. Key policy changes in the Stormwater Conveyance and Flow Control programme from earlier CDPs include[24]:

- Expanding service beyond the trunk, or mainline stormwater conveyance system, to cover local stormwater conveyance from non-arterial streets and surrounding neighbourhoods (see Figure 23 below),
- Varying the level of flood protection according to city service priorities,
- Emphasising Natural Drainage Systems (NDS) (see section below),
- Protecting existing informal drainage systems (ditches) that drain to creeks, because of their critical function in stormwater quality and quantity management.

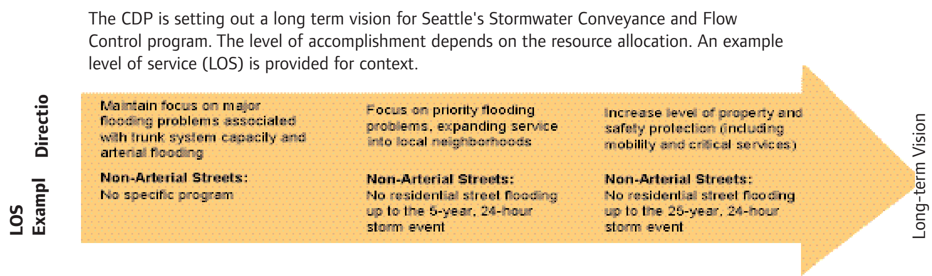

Figure 23: Seattle's vision for its Stormwater Conveyance and Flow Control Programme. (Source: Seattle Public Utilities, City of Seattle, WA[25].)

Seattle drainage fees

Drainage fees fund 99% of the drainage operating revenue requirement for SPU. Drainage fees are collected from seven classes of customers, of which six are in the commercial sector. All properties in Seattle, except city streets and state highways, are charged the drainage fee. Properties are charged based on percentage of impervious surface area and land parcel size (see table below[26]). Impervious surface area is a common basis for drainage fees, and has been chosen because it is one of the most important factors in determining the volume of stormwater runoff. The open space category is primarily reserved for city greenbelts. A new rate structure is being introduced in 2007 (see further details below).

Drainage fees based on impervious are

Rate Category	Percentage Impervious Area	Annual Charge per Acre* of Total Parcel Area	
		2005	**2006**
Single Family Residential & Duplex*		$121.64 (£70)	$136.10 (£78)
Open Space**	0 – 2%	$139.88 (£80)	$173.77 (£100)
Undeveloped	0 – 15%	$243.48 (£140)	$302.19 (£174)
Light	16 – 35%	$404.02 (£232)	$501.84 (£289)
Medium	36 – 65%	$730.89 (£420)	$908.01 (£522)
Heavy	66 – 85%	$953.02(£548)	$1183.79 (£681)
Very Heavy	86 – 100%	$1182.89 (£680)	$1468.73 (£844)
*Single Family rates are per parcel. Rates for other properties are per acre.			
**A run-off of 10% is expected even where no impervious surface is present.			

Payment assistance[27]

The city assists qualified senior citizens, disabled customers and low-income customers by providing discounts on their utility services.

Senior citizens and disabled customers can save up to 50% of their SPU drainage bill (and their water, sewer and garbage bills) if they are:

- A senior citizen over age 65,
- A disabled person who receives certain disability payments,
- Blind,
- On life support,

AND their income is at or below 70% of the state median income.

Low-income customers can save up to 50% of their SPU drainage bill (and their water, sewer and garbage bills) regardless of age or disability if their household income is at or below 200% of federal poverty level. Residents of federally subsidised public housing are not eligible.

Rainwater harvesting discount

SPU offers a 10% reduction in the drainage fee for any new or remodelled commercial building that uses a qualifying rainwater harvesting system. The rainwater harvesting system must be sized to use or infiltrate the amount of rain that falls on the roof of the building during a one-year, 24 hour storm event in order to qualify for the 10% discount.

Systems that incorporate indoor uses of rainwater must be permitted by Seattle-King County Department of Public Health in order to qualify for the rate reduction. Systems that rely solely on the capture and indoor use of rainwater may qualify for the reduction, provided that the system is sized to meet the performance requirement. Qualifying for the 10% reduction does not exempt the property from the applicable stormwater and drainage code requirements for the building and site. Again, a new rate structure is being introduced in 2007 (see further details below).

Changes to the rate structure from 2007[28]

SPU has recently reviewed its drainage rates, as it wants to incentivise commercial and private property landowners to install systems that manage water flows and water quality on-site. Private stormwater management systems reduce the need for SPU infrastructure and so reduce the cost to SPU of serving these customers. The new rate structure is expected to come into effect in 2007. The existing system of tiered drainage rates shown in the table above will continue to operate, and in addition to this a new system of drainage rate 'credits' (discounts) will be provided to customers with private drainage systems on their land. These credits are offered only if the customer installs particular approved technologies that meet defined performance goals for:

- water quality treatment, and/or
- reductions in the runoff of water from the site – including annual average volume and peak flow rates.

Customers will be rewarded with credits for each performance goal that they achieve. Seattle has modelled the performance of a wide array of traditional and non-traditional technologies, and intends to credit both Code-required and other technologies that provide a demonstrable benefit to the City's stormwater management system.

The rate credits have been set based on the average embedded cost to SPU of providing drainage services. However, SPU estimates that the cost of private treatment facilities will probably far outweigh the rate credit benefits. To augment the rate credit and further encourage customers to manage stormwater on-site, SPU has developed additional non-rate incentives, including:

- Geographically-targeted grants for customers in parts of Seattle where there are particular existing problems with stormwater runoff, if they install the technologies listed above. The intention of these grants is to enable SPU to avoid constructing new capital facilities.

- Technical assistance from SPU staff and guidance materials: In the past, a lack of design and installation guidance has been a barrier to residents and developers installing on-site stormwater management systems.

- Regulatory incentives: The City regulates on-site stormwater management for new developments through its Stormwater Code, which outlines requirements for flow control and water treatment. The drainage rate credits and the Stormwater Code will be aligned – i.e. they will have the same performance goals and the same list of approved technologies.

Seattle pilot projects: Natural drainage systems (NDS)

Context and policy drivers

In 1998, the City of Seattle announced that it would fund a series of small and innovative projects to celebrate the coming millennium. Employees of SPU proposed pilot projects replacing existing inadequate stormwater systems using natural drainage systems. A team of engineers, architects, planners, and staff drawn from a wide range of City agencies set out to demonstrate that natural drainage systems could meet or exceed the performance of existing stormwater infrastructure, improve aquatic ecosystem health, and remain cost-effective[29].

Description of the pilot projects

Natural drainage systems are civil structures and biological systems engineered to use soil and plants to fulfill the function of traditional infrastructure, such as gutters, catch basins, and sewage pipes. Impervious surfaces are replaced by surfaces that absorb water, and therefore avoid concentrating surface pollutants from passing cars in runoff waters.

Principles of the NDS approach adopted for the pilot projects in Seattle include the following[30]:

- Addition of natural vegetation along city streets, in a network of swales, gardens, and cascades, allowing stormwater to be absorbed directly into the ground or channels for drainage,
- Replacement of impervious surfaces by porous surfaces and stormwater gardens that result in less runoff,
- Traffic and street reconfiguration: Narrower streets generate less runoff, so streets were redesigned not only to be narrower, but also to include new sidewalks (pavements) for pedestrians and slaloming curves to slow traffic. Although municipal traffic engineers and emergency-response professionals were initially concerned that narrower streets would slow traffic and the response of emergency services, the success of the pilot project gradually gained their acceptance and approval[31].

The first application of these principles was called the Street Edge Alternative (SEA) project, which began in a low-density residential neighbourhood of single-family homes. The City of Seattle has also gone on to apply these principles to increasingly large and dense urban projects, including the Broadview Green Grid, an entire neighbourhood encompassing 15 city blocks; the High Point Project,one of the largest mixed-income housing redevelopments in Seattle's history, with 1,600 units on 34 blocks of new streets; and the Pinehurst Green Grid, a second large scale neighborhood project including 12 blocks. Three of these projects are described in the Boxes below. The municipal government is also examining application of the NDS approach in a variety of industrial, commercial, residential and mixed land use types[32]. All of these projects will be monitored to evaluate their performance. This monitoring, in combination with detailed tracking of project costs, will provide PSU with a template for applying NDS improvements elsewhere in the city.

Assessment of the effectiveness of the pilot natural drainage system projects[33,34]

Stewardship of natural resources

Studies of the SEA programme suggest that over the two-block area that was monitored during the first two years of operation, the transmission of pollutants through stormwater runoff was reduced by 98% and stormwater flow velocities were reduced by approximately 20%, compared to a conventional street and gutter system[35]. These sizeable reductions in runoff significantly reduce environmental pollutants, including such toxic organic compounds as hydrocarbons and pesticides, as well as oils and greases, nutrients, and heavy metals.

Health and productivity

Residents and community activists have enthusiastically supported the NDS approach in their neighbourhoods because it improves quality of life by adding trees and plantings that have visual and aesthetic appeal, by adding sidewalks where there were none before, and slowing the speed of local traffic. Some residents believe that their property values have risen after installation of the NDS systems, though no study has been done to date to evaluate this.

Efficient government

In addition to the inherent environmental benefits of using the NDS approach, the City of Seattle has found that it is also more cost-effective. Seattle Public Utilities estimates that the construction of infrastructure based on the NDS approach costs 25% less than traditional roadside stormwater systems, because reducing runoff at source reduces the need to build additional pipes and holding tanks. These cost savings do not include the additional economic benefits of carbon sequestration, additional trees and other plantings, cleaner water, and replenished groundwater.

Education

Seattle's NDS projects have built local and international awareness of sustainable infrastructure, while also creating a body of research materials suitable for use by professionals and scholars. At the local level, residents have been involved in many stages of planning and implementation of individual NDS components. The strong link between the City and researchers from the University of Washington ensures that the effectiveness of the programme is studied quantitatively and can be rigorously applied elsewhere.

SPU also made active efforts to engage resident's organisations in the regular clean-up and maintenance of street gardens, minimising the ongoing costs of government maintenance.

Figure 24: 'Before' and 'after' photos of the Street Edge Alternative Project, constructed in 2000. (Source: © 2005, Seattle Public Utilities, City of Seattle, WA)

Seattle's Street Edge Alternatives Project, 'SEA Streets'

The Seattle Street Edge Alternative Project, SEA Streets, is located in the Pipers Creek watershed in northwest Seattle. For the project, impervious surfaces were reduced to 11% less than a traditional street, and surface retention was provided in swales. Over 1,100 shrubs and 100 deciduous trees were planted, all native vegetation and hardy cultivars.

Lessons learned

The original intention of the project was to retain flows and allow infiltration into the native soils throughout the length of the block, but this was not possible as some homes had an existing groundwater intrusion problem. To limit the potential for stormwater to adversely impact these residences, geotechnical engineers identified some swales that needed an impermeable liner. A six inch depth of natural clay material was the preferred material.

Broadview Green Grid Project

The Broadview Green Grid Project, involving 15 city blocks, created natural drainage systems to manage stormwater flow from approximately 32 acres, and is almost an entire sub-basin of the Pipers Creek watershed. SPU partnered with Seattle Department of Transportation (SDOT) to provide neighbourhood improvements as part of this project including integrating landscaping, calming traffic, and adding a sidewalk (pavement) on each north-south street into the natural drainage system design.

Natural drainage features on the project include swales, stormwater cascades, small wetland ponds, larger landscaped areas and smaller paved areas. Construction began in late August 2003 and completed in May 2004. Monitoring is being conducted and preliminary results should be available in late 2006.

Figure 25: Narrow streets, bordered by beds of dense planting, minimise runoff and promote natural infiltration in the Broadview Green Grid neighbourhood. (Source: © 2005, Seattle Public Utilities, City of Seattle, WA)

High Point Redevelopment

Seattle Public Utilities (SPU) is partnering with Seattle Housing Authority (SHA) to integrate a natural drainage system into the High Point project - a 129 acre mixed-income housing redevelopment located in the Longfellow Creek Watershed in West Seattle. The High Point project is one of the largest Seattle residential developments in recent history. The project will create 34 blocks of new streets, complete with new utilities, street trees and sidewalks, and provide a total of 1,600 housing units. The project brings Seattle Public Utilities' Natural Drainage System Program to a new level, as the City attempts to integrate NDS throughout a large and higher density residential area. It will serve as an example for other large scale developments. Construction began in June 2003 and continues until 2008.

The High Point project makes up an independent sub-basin, and is estimated to be about 10% of the Longfellow Creek watershed, providing an unprecedented opportunity to improve the water quality and stream flows at a large scale for Longfellow Creek. Longfellow Creek is one of Seattle's priority watersheds, with the highest Coho salmon return counts for Seattle creeks. Longfellow Creek is one of Seattle's priority watersheds, with the highest Coho salmon return counts for Seattle creeks.

Figure 26: High Point Redevelopment. (Source: Mithun Architects and Planners.)

Natural system design for High Point Redevelopment

The natural system design proposes to integrate 22,000 lineal feet (6,700 m) of vegetated and grassy swales throughout the development within the planting strip of the street right-of-way. These swales include sub-surface engineered soil to provide storage and infiltration opportunities. Each swale is designed to treat the runoff from the road and housing of the adjacent block.

At a system scale, natural drainage systems will provide water quality treatment for the six-month storm and ease the two-year, 24-hour storm to pre-developed pasture conditions, which will better protect Longfellow Creek. This distributed block-scale system provides much greater opportunity to cleanse, cool and infiltrate stormwater runoff than the traditional piped and centralised management approach.

The design team has developed a block-scale continuous hydrologic model to refine the design performance and predict how the system will perform under different storm events. Seattle Public Utilities will be working with the University of Washington to monitor the performance of the system at the block and sub-basin scale.

This project also differs from other natural drainage system projects because the redevelopment's street layout goals limited Seattle Public Utilities to a very traditional curb, gutter, and sidewalk approach.

Source:
www.ci.seattle.wa.us/util/About_SPU/Drainage_&_Sewer_System/Projects/Natural_Drainage_Systems/HIGHPOINT_200312031213514.asp

Footnotes

22 Levitt, James N. and Lydia K. Bergen. 2004. Using Nature's Plumbing to Restore Aquatic Ecosystems: The City of Seattle's Natural Drainage System. Report on Conservation Innovation. Available from Program on Conservation Innovation at the Harvard Forest, Harvard University. See http://harvardforest.fas.harvard.edu/research/pci/RCI_Fall_2004.pdf/

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24 Seattle Comprehensive Drainage Plan, 2004.

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26 www.seattle.gov/util/Services/Drainage_&_Sewer/Rates/DRAINAGER_20 0312020900545.asp

27 http://www.seattle.gov/util/Services/Billing/Payment_Options/COS_002 481.asp

28 Seattle Public Utilities Drainage Rates and Incentives. Executive Response to Council Resolution 30720. Recommendations to the City Council, July 11, 2005, Seattle Public Utilities, City of Seattl, WA.

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30 Hsu, D., Dickinson, J., Kulikowski, R.R., Marton, D., Mauldin, C. 2006. Sustainable New York City. Design Trust for Public Space and the New York City Office of Environmental Coordination.

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32 Horner, Richard et al (2002). Hydrologic Monitoring of the Seattle Ultra-Urban Stormwater Management Projects. Water Resources Series: Technical Report No. 170.

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35 Horner et al (as above).

Basel: Green Roofs[36]

Overview

- Basel has been constructing green roofs since the 1970s, to help reduce stormwater runoff, provide summer cooling and thermal insulation in winter, and benefit nature conservation
- Two campaigns have provided subsidies for installing green roofs
- An amendment to Basel's Building and Construction Law in 2002 requires all new buildings with flat roofs to have green roofs

Figure 27: The green roof on Basel's University Hospital, which has been in place since the mid-1980s. (Source: Pia Zanetti).

Context and policy drivers

Basel begun constructing some green roofs in the 1970s, and many more were created in the 1980s. At that time, the main drivers for creating them were that they delivered energy savings (less winter heating), promoted health, well-being and 'ecological construction', and reduced stormwater runoff and overheating.

1995 was the EU year of Nature Conservation, and this provided the impetus for Basel's first campaign for green roofs, which started in 1996. A second campaign commenced in 2005. Between these two campaigns, Basel Canton passed a Building and Construction Law requiring green roofs on all new developments with flat roofs. This law was driven by the need to address the conservation importance of brownfield invertebrates on prime development sites, and to ensure that enhancement for biodiversity was incorporated into buildings. It was also intended that green roof policies would encourage high tax earners to remain in the city, in Basel Stadt, rather than moving out to the rural Basel Canton.

An introduction to green roofs

Green Roofs are vegetated roofs, or roofs with vegetated spaces. Modern green roofs have largely developed in the last 50 years, with increasing sophistication to meet a growing range of needs.

The main benefits of green roofs include:

- Reduced stormwater runoff, (and hence potential savings to developers, as the number of drainage outlets required on a building can be reduced),
- Reduced urban heat island effect (by reducing building heat loss and increasing evapotranspiration),
- Creating natural green spaces in urban areas,
- Reduced energy consumption and fuel costs, since green roofs provide cooling in summer and thermal insulation in winter,
- Benefits for biodiversity,
- Reduced air pollution,
- Extended roof life, since the green roof protects the roof's waterproofing membrane, almost doubling its life expectancy.

Many of these benefits help to address climate-change related risks.

Green roofs can also provide opportunities for food production.

There are two main types of green roof: extensive and intensive. Extensive green roofs have a shallow growing medium and require minimal maintenance, and in general do not require irrigation, though some require irrigation initially. They are usually less costly to install than intensive green roofs, but are generally not accessible.

Intensive green roofs have a deep growing medium, which allows the use of trees and shrubs. They are accessible and can be considered as open space. The depth of the growing medium requires extra loading requirements within the holding structure and an irrigation system for maintenance. They are generally quite costly and require extra structural design to the building.

Source: www.livingroofs.org and www.toronto.ca/greenroofs

Description of the campaigns and the law on green roofs

Basel's first green roof campaign was paid for from a government fund for measures that provide energy savings. Some 4% of all customers' energy bills are put into the fund. This first green roof campaign, led by the Basel Construction Ministry, had SFr1,000,000 (£440,000) of funding and lasted one and a half years. Recipients of the fund were given SFr20 per m^2 (£8.80 per m^2) of green roof installed, whether for a new development, or for retrofitting green roofs to an existing building.

After the first green roofs campaign, Basel Canton passed an amendment to its Building and Construction Law (paragraph 72) in 2002, to require all new buildings with flat roofs to have green roofs. This amendment was made in recognition of research demonstrating the potential for green roofs to support biodiversity and species conservation. It is supported by additional specific guidelines on implementing green roofs in Basel to maximise their nature conservation potential (see Box overleaf). When a new development receives planning permission, the permission includes detailed instructions on how to maximise the nature conservation properties in the development. Personal advice from a green roof expert is also made available, funded by the government. The Building Control Officer checks to ensure that these instructions have been taken on board. In addition, the Law for Nature Conservation and Landscape Protection 2000 stresses the importance of nature conservation in new developments, and provides an added impetus for green roofs in the city. It applies both to existing developments (when they are undergoing a major refurbishment and need a construction permit) and to new developments.

The recognition that green roofs provide valuable habitats and support nature conservation objectives was one of the drivers for Basel's second campaign, which started in 2005. This second campaign funds both green roofs and roof insulation, and will last until 2006/07. It is funded in the same way as the first campaign, but has more money, totalling some SFr1,500,000 (£660,000). In this second campaign, recipients receive SFr30-40 per m^2 (£13 - £18 per m^2) of green roof installed. Since the Building and Construction Law requires all new flat-roofed buildings to have green roofs, this fund is only available for retrofitting green roofs to existing buildings.

Assessment of the effectiveness of the campaigns and the law on green roofs

A small study, conducted before the first green roof campaign, evaluated the effectiveness of green roofs, and found that they provided benefits both in terms of reduced energy needs for heating in winter, as well as keeping buildings cooler in summer. It is estimated that, as a result of the first campaign, some 4 million kWh of energy is saved each year in Basel, and SFr14,000,000 (£6,000,000) have been invested in green roofs[37], leveraged by the SFr1,000,000 (£440,000) of funding from the first campaign.

After the first green roofs campaign, which ended in 1998, an analysis was undertaken of the area of flat roofs in Basel, and of the percentage of these that had green roofs[38]. The total flat roof area in Basel was 2.4km^2, and the total city area is 23 km^2, so some 10% of the city had flat roofs. Of these flat roofs, about 0.29 km^2 (290,000 m^2) had green roofs. About one-third of these green roofs (85,000m^2, equivalent to 8 football fields) had been constructed on some 120 buildings as a result of the first green roofs campaign, the remaining two-thirds having been in existence prior to the campaign.

The Building and Construction Law has since provided a major impetus for more green roofs in Basel. Furthermore, the second green roofs campaign (which is still underway) has already led to the retrofit of an additional 10,000m^2 of green roofs onto existing buildings. As a result, at present, approximately 20% of Basel's flat roof area is green roof.

The general public in Basel still finds green roofs 'special and exciting', but for developers, installing green roofs is now considered routine, and developers make no objections to installing them.

Experience in Basel has demonstrated that successful implementation of green roofs requires close cooperation between the local authority and nature conservation experts, as well as architects, construction and landscape planners, green roof companies and contractors. Basel's experience has also shown that a successful urban biodiversity strategy on green roofs should be based on regional research on specific conditions that local species require to colonise green roofs (see Box). These green roofs may help to provide 'corridors' for species' movements in the face of climate change. Basel has also developed habitat and design concepts for its green roofs, as well as techniques to install specific substrates on roofs.

Figure 28: Green roofs on Peter Merian-Building in Basel. (Source: Zwimpfer Partner Architects.)

Maximising nature conservation benefits of green roofs in Basel

Design criteria for green roofs in Basel stipulate the creation of different habitats, with varying substrate thickness, as well as requiring that the roofs use natural soil from the region.

By varying the substrate depth, different habitat conditions are created, from open, spar vegetated areas with geophytes, succulent plants like sedum species, crossover forms with annual and biennial therophytes, to dry herb and grass communities. As the roof evolves over time, an increasing number of species colonise them. 'Unstructured' roofs, which do not provide these varying conditions, do not seem to result in new colonising species.

On the most biodiverse of Basel's green roofs, the Rhypark building, a range of micro-habitats have been created, which support 79 beetle and 40 spider species. 13 of the registered beetle and 7 of the spider species are Red Data Book endangered species.

The use of natural local soil has also been proved to be a major factor benefiting locally and regionally endangered species of spider and beetle. Their adaptation to natural local soil and other substrates like sand and gravel from riverbanks seem to be a factor for successful colonisation.

Figure 29: Different substrate levels create various vegetation forms as a further base for the colonisation of a diverse range of fauna

Source: Brenneisen, S. 'Green Roofs and Biodiversity – International Context'. Contribution to conference: Delivering Sustainable Buildings, 21-22 April 2005 Birmingham.

Figure 30: Newly constructed green roof on 'Klinikum 2' of Basel University Hospital, following the new guidelines in Basel's green roofs and urban biodiversity strategy (see Box). (Source: Stephan Brenneisen).

Figure 31: The green roof on 'Klinikum 2' of Basel University Hospital, 6 months after installation. (Source: Pia Zanetti).

Footnotes

36 Stephan Brenneisen, 2006, Pers. Comm.

37 www.aue.bs.ch/aa-flachdach

38 Brenneisen, S. 2003. Ökologisches Ausgleichspotenzial von extensiven Dachbegrünungen – Bedeutung für den Arten und Naturschutz und die Stadtentwicklungsplanung Dissertation, Institute of Geography, University of Basel.

Linz: Green Roofs[39]

Overview

- In the 1980s, Linz in Austria was becoming highly industrialised and the public was concerned about the impacts of the loss of green space on health and quality of life
- Linz introduced green roof policies in 1985, as part of its legally-binding Development Plan, requiring green roofs on new buildings with flat roofs, as well as underground structures
- Subsidies are also provided for green roofs, provided that they are properly maintained

Context and policy drivers

Linz is the capital of Upper Austria, one of the nine counties of Austria, with about 180,000 inhabitants. It is situated on the River Danube. Linz has an important steel and chemical industry, but is also famous for its cultural events and buildings.

The main drivers for the development of Linz's green roof policies in the 1980s were:

- the large and rapid loss of green areas to industrial and commercial development, and
- serious environmental concerns over air quality, mainly due to Linz's steel and chemical industrial processes.

Figure 32: Extract from Linz Green Space Plan, 2001[41]. The purple colour indicates a deficient level of greening, dark orange an adequate level, and light orange a good level.

At that time, Linz was becoming highly industrialised and Linz's citizens were becoming increasingly concerned over the impacts of industrialisation on health and quality of life. Since the environmental situation in Linz was viewed as 'disastrous' in the 1980s, and the public were so concerned, the arguments for creating a greener city were very strong, and the public were supportive of the concept.

In Austria, each of the nine counties has its own Regional Development Planning Act, setting out mandatory and optional regulations to be included in local development plans. The value of green space in the city of Linz was first recognised in the City's 1984 Green Space Plan, for its positive influence on urban climate and ventilation, reduction of dust, promotion of ecology, psychological health, recreation and local visual character[40]. The plan included objectives to increase greening in built-up areas (see Figure 32).

Description of the policies

Green roofs were seen as effective solutions to 'greening' in areas of Linz where land use was not compatible with open space development, such as commercial and industrial zones, and underground structures[42]. As a result, green roof policies were introduced in Linz in 1985 as part of legally-binding Building Plans and they are now regularly included in Linz within local development plans. They are obligatory for the whole city area.

A new Green Space Plan for Linz is created every 10 years. The Linz Green Space Plan for 2001 provides standard policies for different kinds of land use, which are included in local development plans. The standard text for green roofs is shown below[43].

For buildings:

- *"New and proposed buildings with an area of over 100 m² and a slope of up to 20°, excluding shed roofs, are to be greened. The uppermost layer of the green roof construction shall as growing medium have a thickness of at least 12 cm and the coverage of living plant material shall be at least 80%."*

For underground parking:

- *"The roof surfaces of underground structures are to be greened. The uppermost layer of the green roof construction shall as growing medium have a thickness of at least 50 cm and the coverage of living plant material shall be at least 80%."*

- *"Green roofs of underground structures must be built flush with adjacent neighbouring properties."*

- *"When erecting underground structures, at least 30% of the site shall be left free for green areas over native soil."*

Figure 33: Green roof on a 2-storey underground garage. (Source: Municipal Planning board of Linz, Austria.)

The green roof policies aim to deliver the following objectives:

- reclaim recreation areas,
- substitute for greening lost in over-developed areas,
- improve the city microclimate,
- reduce the urban heat island effect,
- retain rainwater,
- protect the roof surface,
- guarantee sustainable urban development.

The fundamental principle behind the green roof policies was the 'polluter pays' principle. However, in the beginning, the green roof policy was met with concerns from developers over the higher installation costs of green roofs compared to conventional roofs. To address these concerns, the city council introduced a green roof subsidy. This was implemented in 1989 and marked the first direct financial incentive for green roofs in Austria. The public funding required for the subsidy is determined on an annual basis.

Initially, there were also some concerns about the danger of fire on extensive green roofs during hot, dry summers, since at the start of the green roof policy in Linz there was one fire accident on a green roof in Germany. During a long summer period without rain, the dry, uncut grass of an extensive green roof on a supermarket caught fire and caused serious damage. However, it was obvious (even to green roof opponents) that this disaster was caused by very poor maintenance of the green roof. The fire accident was thoroughly investigated, and technical rules were soon developed. Obligatory regulations for issues like maintenance, distance between plant areas and buildings, have been passed to prevent such accidents happening again.

Figure 34: The Schachermayer factory has the largest area (more than 14,000 m²) of extensive green roof in Linz and was the first to establish a self-funded green roof. (Source: Municipal Planning board of Linz, Austria.)

Assessment of the effectiveness of the policies

Costs and benefits

Eligible costs for the green roof subsidy are construction costs from the roof deck upwards and additional costs associated with upgrading the structural loading capacity of the roof. The scale of costs for green roofs in Linz varies from tens of Euros per m^2 for extensive roofs up to several hundred Euros per m^2 for intensive green roofs. Until 2005, up to 30% of eligible costs were reimbursable, and the average subsidy varied from Euros 13 per m^2 (£9 per m^2) (extensive roofs) to Euros 25 per m^2 (£17 per m^2) (intensive roofs). However, in 2005 the sponsorship was cut back to Euros 2 – 4 per m^2 (£1.40 - £2.80), as the City diverts funds in preparation for becoming the European City of Culture in 2009. (Budgets have been cut across government, not just those for green roofs). Costs for design and contract administration are not eligible for the green roof subsidy. The subsidy is offered regardless of whether the roof greening is voluntary or mandatory (i.e. integrated in a development plan), and whether it is an extensive or intensive green roof[44]. The payback period is estimated at 20 years (with split sewage tariff system) to 40 years (without split sewage tariff system).

Figure 35: The green roof on Körner High School, Linz, designed by architects and teachers, built 10 years ago. (Source: Municipal Planning board of Linz, Austria.)

Ensuring compliance and maintenance

The public subsidy requires that the roof be maintained over the long term. This is partially ensured by the provision that only 50% of the subsidy is paid upon completion of construction and planting, with the balance being paid out when the vegetation has established (dependent on progress)[45].

An inspection is conducted and the inspector looks at the condition and care of the vegetation, as well as checking the costs on the invoices submitted. One of the main difficulties encountered is the lack of city council personnel for consultation and monitoring. As a result, long-term monitoring of the state of green roofs is irregular. Even with the subsidy holdback of 50%, owners occasionally do not maintain green roofs properly, and the City Planning Department would like to have an annual monitoring programme. In the mean time, sample inspections have enabled the authorities to monitor the condition of some green roofs. These have revealed that some extensive green roofs are in a poor condition, due to lack of maintenance, whereas intensive green roofs tend to be in a better condition.

Linz's experience of the difficulty of ensuring that extensive green roofs are adequately maintained indicates that stricter financial regulations may be required.

Figure 36: Green roofs on residential properties in Linz. (Source: Municipal Planning board of Linz, Austria.)

Effectiveness

Since inception of the subsidy program in 1989 until the end of 2001, 237 projects received green roof subsidies. The subsidies totalled Euros 4.77 million (£3.3 million)[46]. At present, Linz has about 400,000 m^2 of green roofs. Implementation of the first green roof regulations was difficult because many contractors tried to find ways around them. However, green roofs are no longer a topic of debate in Linz, and many submitted building plans already include green roofs.

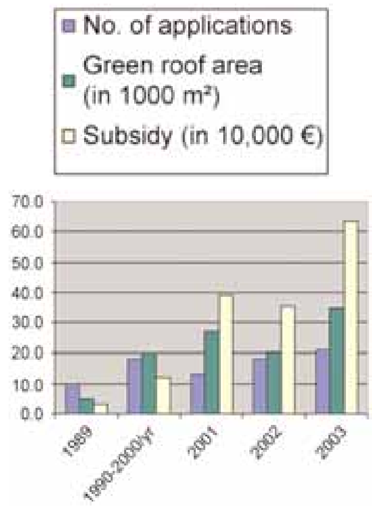

Figure 37: Development of the green roof subsidy in Linz from 1989 to 2003[47].

Different German cities have different green roof requirements, as shown in the table below.

Green roof requirements in Germany

Name of jurisdiction	Requirements specific to green roofs
North Rhine Westphalia	Runoff coefficient as tested for specific green roof systems to be less than 0.3 or have a minimum depth penetrable by roots of 15 cm.
City of Cologne	No specific requirements for runoff coefficient or minimum depth. However a stormwater fee discount is applied on a sliding scale, with 90% discount for roofs with a runoff coefficient of 0.1 or less decreasing to a discount of 30% for a runoff coefficient of 0.7. In addition each applicant is required to submit a stormwater infiltration data form providing details of the runoff characteristics of the green roof and the drainage management of the building and the site.
City of Berlin	Green roofs should meet industry standards such as Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL) (a landscape industry organisation in Germany)guidelines.
Source: Banting, D., Doshi, H., Li, J., Missios, P., Au, A., Currie, B.A., Verrati, M. October 31, 2005. Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto, Dept. of Architectural Science, Ryerson University, Toronto, Ontario, Canada.	

Footnotes

39 Edmund Maurer, Planning Department – Development Planning, Municipal Board of Linz, 2006, Pers. Comm.
40 Linz. 2002. Grünflächenplan der Stadt Linz 2001. Available from Magistrat der Landeshauptstadt Linz, Planungsamt.
41 Linz. 2002 (as above).
42 Ngan, G. 2004. Green Roof Policies: Tools for Encouraging Sustainable Design.
43 Linz. 2002 (as above).
44 Linz. 2000. Dachbegrünung. Available from Magistrat der Landeshauptstadt Linz, Planungsamt.
45 Linz. 2000 (as above).
46 Linz. 2002 (as above).
47 Maurer, Edmund. 2004. Förderungen von Dachbegrünungen in der Landeshauptstadt Linz (Oberösterreich). In Proceedings of the 2. EFB-FBB (Europäische Föderation der Bauwerksbegrünungsverbande – Fachvereinigung Bauwerksbegrünung e.V.) Gründachsymposium, Ditzingen, 25 March 2004. pp. 12-15.

Toronto: Green roofs[48]

Overview

- Toronto recognised that green roofs could help to manage stormwater runoff, save energy (by reducing air-conditioning), reduce the Urban Heat Island effect and help to 'green' the city
- Toronto approved its green roof strategy in early 2006
- The strategy commits the city council to installing green roofs on city-owned buildings and includes a pilot programme of financial incentives for constructing green roofs

Context and policy drivers

In the early 1990s volunteers under the Rooftop Garden Resource Group (RGRG) started to promote green roof development in Toronto. This has been taken over by Toronto-based 'Green Roofs for Healthy Cities', a not for profit organisation, which carries out world-wide education on green roofs.

The City of Toronto (government) interest in green roofs can be traced to the City's Environmental Plan in 2000, which recommended that the City prepare a strategy to encourage green roofs and rooftop gardens. The Official Plan approved by the City Council in 2002 also promotes green building designs and construction practices by supporting and encouraging the development of innovative green spaces such as green roofs. The City recognised that green roofs could provide benefits including managing stormwater runoff, saving energy, reducing the urban heat island effect, and adding more green to the built environment.

In September 2005, City staff hosted two workshops to get feedback from stakeholders on the barriers and solutions to build more green roofs[49]. Attendees included green roof designers and suppliers, developers, building owners and City staff. The outcomes of the workshop are summarised in the boxes below.

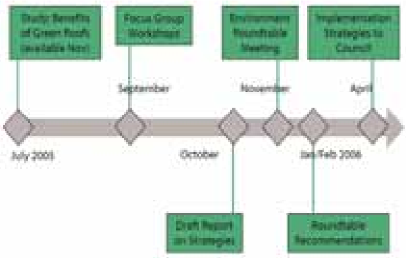

Figure 38: Overview of Toronto's green roofs policy-making process. (Source: City of Toronto).

In November 2005, City staff completed a difficult milestone by producing, "A Discussion Paper Presented to Toronto's Roundtable on the Environment, Making Green Roofs Happen".

Barriers to green roofs in Toronto: Outcomes from two stakeholder workshops in September 2005

Cost, structural concerns and maintenance

- Ranked by 79% of participants as the biggest or second biggest barrier to green roof development. Cost was often broken down into capital and operating costs, which are closely related to structural and maintenance concerns, respectively.
- *Capital/initial costs and structural/loading capacity*
  - o Concerns about capital costs for retrofits - difficulties of increasing loading capacity of an existing building.
  - o Some concerns about the higher capital cost of green roof installation on new construction, for additional expertise and non-standard roofing materials.
- *Long-term operating costs and maintenance issues*
  - o Establishing who is responsible for maintenance and its costs in condo developments.
  - o Finding skilled labour.
  - o Practicalities of repairing buried components, like the waterproof membrane.

Ability to finance, lack of standards, and warranty concerns

- Difficulty financing the higher costs of green roofs compared to conventional roofs.
- Lack of accepted professional standards for green roof technology.
- Lack of clarity about responsibility for failure and its impacts, including issues of warranties, liability and insurance.
- Green roofs will therefore be considered risky by developers and building owners.

Barriers to green roofs in Toronto: Outcomes from two stakeholder workshops in September 2005 (cont.)

The approvals process and lack of sufficient information, skills and experience

- Concerns about how an application for a development with a green roof would proceed through the approval process - not a standard approval, and may conflict with parts of the Ontario Building Code.
- Concerns about delays if City staff did not have experience dealing with applications with green roofs.
- Shortage of building professionals, labourers, and maintenance workers with appropriate knowledge and experience with local conditions and issues.
- Shortage of green roof materials that are locally appropriate.

Lack of awareness about green roofs

- General lack of public awareness about green roofs and their benefits.
- Many developers and building owners have not seen enough information about the local costs and benefits to convince themthat green roofs are a viable option in Toronto.

Source:
http://www.toronto.ca/greenroofs/pdf/makingsection3_nov16.pdf

Possible solutions to overcome barriers against green roofs in Toronto: Outcomes from two stakeholder workshops in September 2005

Incentives

Financial incentives:

- Property tax reduction or rebate for the implementation of a green roof.
- Short- and long-term subsidies or grants to help owners or developers cover initial and ongoing costs.
- Reduction in development charges for developments with green roofs.
- Rebates on utility bills per demonstrated savings on energy use or reduction in stormwater runoff.
- Low-interest green loan programme.

Procedural incentives

- Density bonuses for buildings with green roofs.
- Fast-track building applications with green roofs.
- Reduce stormwater management requirements for developments with green roofs.
- Levy fees for stormwater runoff and exempt buildings with green roofs.
- Flexible zoning and/or building code requirements for developments with green roofs.
- Allow green roof space to be included as part of parkland dedication if it is an accessible and maintained amenity space.

Education and marketing

- General public,
- Developers and building owners,
- City staff,
- Professional and labour force.

Possible solutions to overcome barriers against green roofs in Toronto: Outcomes from two stakeholder workshops in September 2005 (cont.)

Development approval process

- Approval process for buildings with green roofs needs to be standardised and streamlined.

Further research and development (R&D)

- Information on costs and benefits of green roofs for Toronto building owners.
- R&D on green roof materials to make green roofs more effective and viable for more buildings.
- Green roof standards (especially concerning fire, wind and water absorption).

Warranties

- The City needs to address warranty issues for green roofs before implementing City programmes.

Regulation

- A few participants suggested that the City should require green roofs through regulation.

Source:
http://www.toronto.ca/greenroofs/pdf/makingsection3_nov16.pdf

Description of the policy

Toronto City Council approved its Green Roofs strategy at a meeting on 31 January – 2 February 2006. The strategy was informed by the Green Roof Technology study, as well as the input from stakeholders described above.

The recommendations that Council approved include a commitment to install green roofs on new and existing buildings owned by the City, whenever practical to do so. For example, green roofs are to be considered for existing municipal buildings when roofs are due to be replaced. For new City-owned buildings, the Green Roofs strategy sets a target of green roofs covering 50% to 75% of a building's footprint.

At the same time, the Council recommended that a pilot programme of financial incentives be initiated in 2006 for the construction of green roofs.

City officials will also work with Toronto Hydro and the Toronto Atmospheric Fund on the possibility of offering building owners additional financial incentives for retrofits. From a planning perspective, green roofs will be achieved through zoning bylaw amendments and site plan controls.

Assessment of the effectiveness of the policy

Clearly, it is too soon to evaluate the effectiveness of Toronto's green roof policy. However, some green roofs had already been constructed in Toronto prior to the policy, but remain unknown since they are located out of sight on roof tops. City staff recently undertook a survey and counted approximately 59 existing public and private green roofs and 17 more planned or under construction.

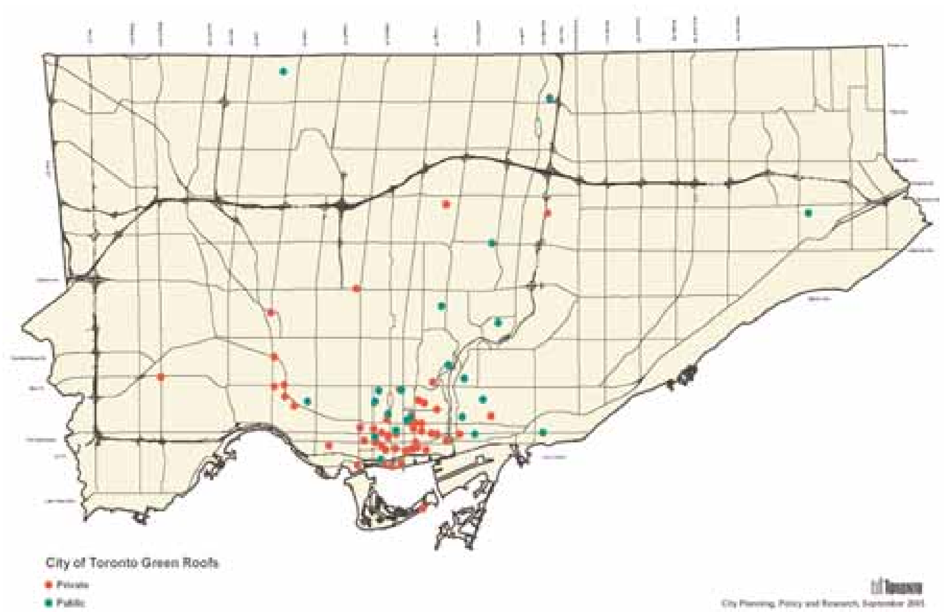

Figure 39: Location of existing private and public-owned green roofs in Toronto (Source: City of Toronto)

To gain practical knowledge of green roofs and help develop its green roof policy, the City of Toronto became involved in two demonstration projects in the city. The positive results from these demonstration projects proved that there were benefits at the individual building level. However, city staff recognised the need to quantify the citywide benefits of green roofs, before policies and programmes could be developed to actively promote green roofs. The Green Roof Technology study was commissioned to calculate these benefits for Toronto[50]. Benefits were determined as initial cost saving related to capital costs or an amount of annually recurring cost savings. They are summarised below[51].

Benefits and costs of green roofs in Toronto: The Green Roof Technology Study

Category of benefit	Initial cost saving	Annual cost saving
Stormwater	Can $118,000,000 (£58,000,000)	
Combined Sewer Overflow (CSO)	Can $46,600,000 (£23,000,000)	Can $750,000 (£370,000)
Air quality		Can$2,500,000 (£1,230,000)
Building energy	Can $68,700,000 (£33,800,000)	Can $21,560,000 (£10,600,000)
Urban heat island	Can $79,800,000 (£39,300,000)	Can $12,320,000 (£6,070,000)
Total	Can$313,100,000 (£154,300,000)	Can$37,130,000 (£18,290,000)

Benefits from stormwater flow reduction were:

- Infrastructure savings (i.e. infrastructure measures that could be replaced by green roofs, including pervious pavements in residential high rise and commercial areas and underground stormwater storage in commercial areas) worth $79 million (£39 million),
- Erosion control measures savings worth $25 million (£12 million),
- Pollution control cost avoidance worth $14 million (£7 million).

Benefits for Combined Sewer Overflows (CSOs) included:

- Reduced requirement for underground water storage, saving $46.6 million (£23 million),
- 3 additional "beach open" days per year, worth $750,000 (£370,000).

Air quality benefits identified were:

- Reduction in levels of pollutants including carbon monoxide, nitrogen dioxide, ozone, particulates (PM_{10}) and sulphur dioxide, with an associated value of $2.5 million (£1.2 million) in terms of improvements to health and the environment,
- Reduction in carbon dioxide emissions.

Benefits from reduced building energy consumption included:

- Cost avoided due to reduced demand at peak times of $68.7 million (£33.8 million),
- Citywide savings from reduced energy for cooling of about $21 million (£10 million) per year, equivalent to 4.15kWh/m² of green roof per year.

The reduction in the UHI was estimated to have the following benefits:

- Reduced local ambient temperatures by between 0.5 to 2ºC, depending on the time of year,
- Citywide savings from reduced energy for cooling of $12 million (£6 million), equivalent to 2.37 kWh/m² of green roof per year,
- Cost avoided due to reduced demand at peak times of $80 million (£39 million).

These benefits were calculated based on the assumption that 100% of available green roof area be used across the city. The available green roof area included flat roofs on buildings with more than 350 m² of roof area, and assuming at least 75% of the roof area would be greened. The total available green roof area city-wide was determined to be 5,000 hectares (50 million m²), which is 8% of the total land area of Toronto.

The report also presents the minimum considerations for the type of green roof to achieve the stated benefits. The key considerations include that: an 'extensive' roof system is used, that it covers a significant portion of the roof, has a maximum runoff coefficient of 50%, and has at least a 150 mm depth where structural loads permit. Green roofs with less depth could be used on roofs where structural loading does not permit the 150 mm depth.

This study also considered the costs of green roof implementation, which are primarily borne by private building owners. Based on work by the City of Waterloo, the incremental cost of re-roofing with an extensive green roofing system were found to be of the order of $75 to $90/m² of roof (£37 to £44/m²), over and above the cost of a traditional roof. The costs identified at the municipal level were costs for programmes to promote green roofs. No other costs were identified at the municipal level in relation to green roof implementation.

Footnotes

48 www.toronto.ca/greenroofs/

49 http://www.toronto.ca/greenroofs/pdf/makingsection3_nov16.pdf

50 Banting, D., Doshi, H., Li, J., Missios, P., Au, A., Currie, B.A., Verrati, M. October 31, 2005.
Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto, Dept. of Architectural Science, Ryerson University, Toronto, Ontario, Canada.

51 Banting et al, as above.

Various US cities: Cool roofs

Overview

- Risks of high temperatures are exacerbated in cities by the Urban Heat Island (UHI) effect
- Cool roofs have light-coloured coatings that reflect and emit heat, reducing the UHI
- Some US cities provide rebates for installing cool roofs
- Others have changed building codes and regulations to promote cool roofs

A cool roof or 'white roof' can reduce the temperature of a building's roof dramatically, and hence also reduce the Urban Heat Island effect. Cool roofs have a coating of light-coloured water sealant, which can last 10 to 20 years, depending on the quality of the coa-ting and the thickness applied. These white surfaces reflect and radiate a lot more heat than dark roof surfaces, and in the US they have been demonstrated to stay up to 40°C cooler[52]. By limiting the amount of absorbed solar energy, damage from ultraviolet radiation and daily temperature fluctuations – which cause repeated contraction and expansion – can be reduced. Both flat and sloping roofs can be made into cool roofs.

Cool roofs do not offer all the advantages of green roofs related to stormwater runoff, air quality and nature conservation, but they demand less investment. Furthermore, cool roofs are most effective on buildings with high roof-to-volume ratios, such as one or two storey buildings.

The Department of Energy's Lawrence Berkeley National Laboratory (LBNL) conducted an analysis to estimate potential energy and monetary savings resulting from the use of light-coloured roofs on residential and commercial buildings in 11 US metropolitan areas. The study estimates the reductions in peak power demand and annual cooling electricity use that would results from increasing the solar reflectance of roofs. Annual, city-wide results are shown in the Figures 40 - 41 below (in 1993 US dollars). Energy savings were calculated by comparing decreased summertime costs (from lower air conditioning demand) with any observed increases in wintertime heating expenditures. The results indicate that in most US climates, summertime air conditioning energy savings significantly exceed the winter penalty. For those who can not afford air conditioning in US cities, cool roofs offer a cheaper alternative to reducing overheating risks.

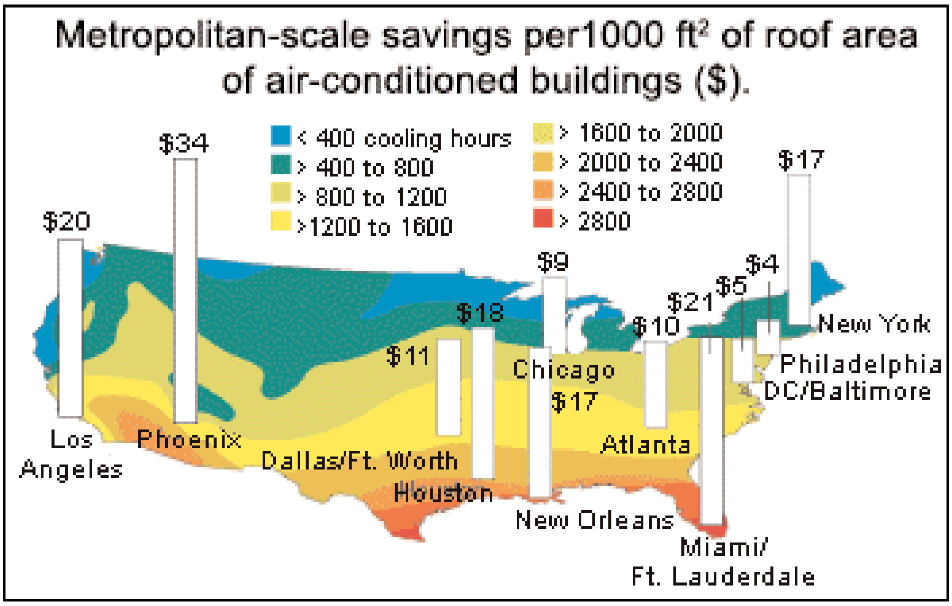

Figure 40: Savings ($) per 1,000 ft² of roof area of air conditioned buildings ($1 is approx. £0.60). (Source: US EPA, as above.)

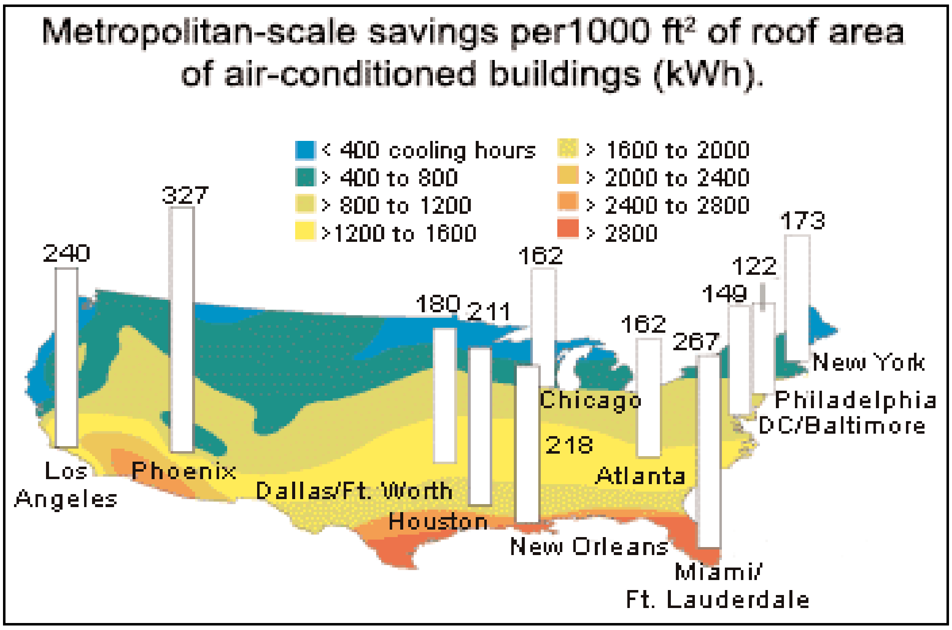

Figure 41: Savings (kWh) per 1,000 ft² of roof area of air conditioned buildings. (Source: US EPA, as above.)

Cool roofs in US cities and states[53]

California's Cool Savings Program provided rebates to building owners for installing roofing materials with high solar reflectance and thermal emittance. The highest rebate went to roofs on air conditioned buildings, while buildings with rooftop ducts and other non-residential buildings were eligible for slightly less. The programme aimed to reduce peak summer electricity demand and was administered by the California Energy Commission.

The City of Chicago's energy code requires that roof installations on most commercial, low-sloped air conditioned buildings have an initial solar reflectance greater than or equal to 25% to help reduce the Urban Heat Island effect.

Georgia instituted the "Georgia White Roof Amendment," which requires the use of additional insulation for roofing systems whose surfaces do not have test values of 75% or more for both solar reflectance and emittance. This regulation will serve as a model for changes in the building codes of other southern states because it addresses both energy conservation and environmental concerns.

New York's Office of Sustainable Design (a division of New York City's Department of Design and Construction) is promoting the use of cool roofs, and intends that all the buildings controlled by the City government should have cool roofs over the next 20 years[54]. This amounts to 10% of the roof area in New York. With the recent signing in New York of a new law mandating that all major city-funded construction and renovation projects meet energy conservation standards laid out by the US Green Building Council, New York's Office of Sustainable Design expects most projects to adopt the simpler white roof method, rather than opting for green roofs.

Footnotes

52 www.epa.gov/heatisland/strategies/coolroofs.html
53 www.epa.gov/heatisland/strategies/coolroofs.html
54 www.gothamgazette.com/article/environment/20051028/7/1635, October 2005

Tokyo: Managing the urban heat island[55]

Overview

- Temperatures in Tokyo have risen fast over the past century
- Tokyo Metropolitan Government has produced a Thermal Environment Map, to better understand the factors affecting the city's Urban Heat Island (UHI)
- Using the map, the government has designated areas of the city for measures to reduce the UHI, such as introducing greenery and creating ventilation paths for breezes

Context

Over the past century, the average temperature in small to medium cities in Japan has risen by about 1°C. In Tokyo, however, it has risen some 3°C. Tokyo Metropolitan Government (TMG) considers that global warming and Tokyo's growing urban heat island have contributed to these rising urban temperatures. TMG is developing policies and measures to alleviate this situation.

To better understand Tokyo's Urban Heat Island (UHI), TMG has produced a Thermal Environment Map, showing the atmospheric impact (thermal loading) from both man-made heat sources and ground surface conditions. This map was developed as follows:

- 17 regional factors (see Table below) have been grouped into five classes based on their thermal environment characteristics, and have been plotted onto a 500 m grid.

- The grid has been color-coded depending on the relative size of the thermal loading, for Type I (business cluster) and Type II (high-density residential) areas.

Regional factors affecting Tokyo's UHI

Class	Factor
Anthropogenic heat	Heat radiated from buildings
	Heat radiated from district cooling
	Heat radiated from automobiles
	Heat radiated from railways
	Heat radiated from businesses
	Anthropogenic heat (sensible heat)
	Anthropogenic heat (latent heat)
Ground surface covering	Water-area ratio
	Bare land and grassland-area ratio
	Vegetation-area ratio
	Asphalt-area ratio
	Buildings-area ratio
Shape of building	Average building width
	Average building height
	Sky view factor
Building use	Proportion of office floor space
	Proportion of residential floor space

The Thermal Environment Map enables TMG to understand the regional distribution of factors contributing to the UHI, and also the magnitude of their thermal loading on the atmosphere.

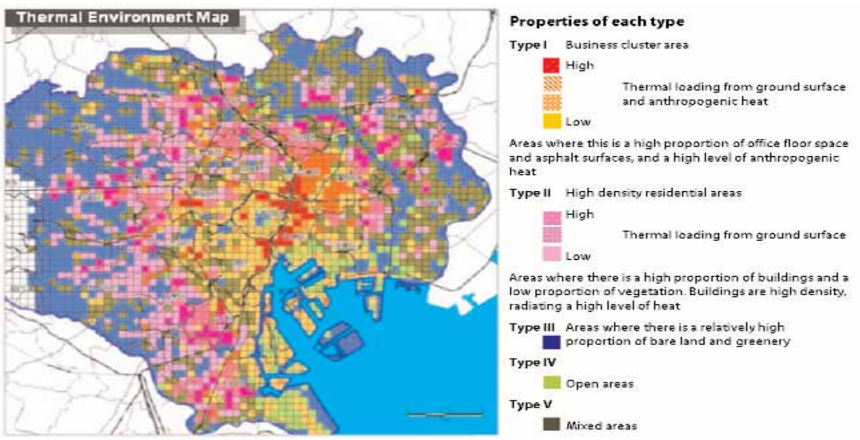

Figure 42: Tokyo's Thermal Environment Map. (Source: Tokyo Metropolitan Government Bureau of Environment and Bureau of Urban Development.)

Description of the strategy

Based on this map, the TMG has designated four specific areas in Tokyo for the implementation of measures against the UHI (see Box below). As part of Tokyo's future urban renewal, the "designated areas for the implementation of measures against the Heat Island Phenomenon" will be used to guide private sector redevelopment projects, as well as to focus efforts such as the introduction of greenery along walls, creating 'ventilation paths' to ensure breezes through the city, and planting lawns in school grounds.

The Designated Areas were also adopted in the national government's "model districts for measures against global warming and heat islands." TMG will continue to promote its measures in collaboration with the national government's measures.

In addition, TMG has set goals to expand the amount of green space in the city. To achieve these goals, TMG is formulating four policies:

- A policy to promote the development and improvement of city planned parks and green areas.
- A policy to promote the creation of 'environmental corridors' and a network of greenery.
- To build a green network, measures will be promoted to encourage private developers to form 'greenery development plans'.
- For privately-owned land (including corporate sports grounds and estate woodlands) a new system for privately-run parks will be introduced.

Designated Areas for the implementation of measures against the UHI in Tokyo

The Designated Areas were selected as follows:

- Based on the Thermal Environment Map, areas (such as business cluster areas and high-density residential areas) that have a large impact (thermal loading) on the atmosphere were identified.
- Focus was given to the Priority Redevelopment Areas for the Urban Renewal of Tokyo where environmentally-conscious private sector development is possible.
- Other areas were chosen where urban development should be systematically directed, incorporating preventative heat island measures.

Overview of the four Designated Areas

Central Tokyo Area (business cluster area measures), approximately 1,600 hectares
This is an area with both high day-time and night-time temperatures. The thermal loading from office buildings and asphalt is high, and there is a large amount of waste heat from buildings. This areas includes several Priority Redevelopment Areas for Urban Renewal.

Shinjuku Area (business cluster area), approximately 600 hectares
This is an area with both high day-time and night-time temperatures. The thermal loading from office buildings, housing and asphalt is high. It includes Priority Redevelopment Areas for Urban Renewal.

Osaki & Meguro Area (high-density residential area measures), approximately 1,100 hectares
This is an area where night-time temperatures remain high and many nights are humid. The thermal loading from the ground surface is high in high-density residential neighbourhoods. Again, this includes a Priority Redevelopment Area for Urban Renewal.

Areas Surrounding Shinagawa Station, approximately 600 hectares
This is an area where urban development should be systematically directed, incorporating preventative heat island measures.

Examples of initiatives to reduce the UHI in the Designated Areas include:

- Private sector re-vegetation projects, such as the redevelopment of Osaki Station West exit.
- Examining ways of securing wind or ventilation paths, mostly in areas where it is envisioned major development will be undertaken,so that breezes can pass through the city.
- Planting lawns in school grounds: For instance, Izumi Elementary School in Suginami-ku has planted turf inside the school grounds. The school hopes that the grass lawn will contribute to the well-being of the students and also help to tackle the problem of rising temperatures.
- Creating green roofs: For instance, vegetation has been planted on the rooftop of the Tokyo Metropolitan Assembly Building.
- Planting roadside trees: Planting trees along the roadside helps to shade the surrounding ground from the summer sun and cool the air.

Figure 43: Redevelopment of the Osaki Station West Exit A Zone including active introduction of greenery along walls. (Source: Tokyo Metropolitan Government Bureau of Environment and Bureau of Urban Development.)

Figure 44: The JR railway yard, an area for redevelopment, where 'wind paths' can be secured. (Source: Tokyo Metropolitan Government Bureau of Environment and Bureau of Urban Development.)

Figure 45: Izumi Elementary School has planted lawns. (Source: Tokyo Metropolitan Government Bureau of Environment and Bureau of Urban Development.)

Figure 46: Green roof on the Tokyo Metropolitan Assembly Building. (Source: Tokyo Metropolitan Government Bureau of Environment and Bureau of Urban Development.)

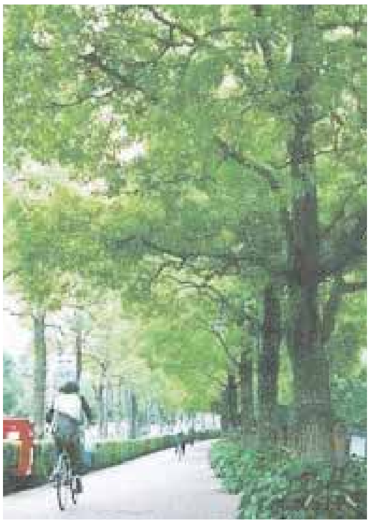

Figure 47: Roadside trees in Tokyo provide shade and cooling. (Source: Tokyo Metropolitan Government Bureau of Environment and Bureau of Urban Development.)

Footnotes

55 Tokyo Metropolitan Government Bureau of Environment and Bureau of Urban Development. 11 April 2005. See http://www.metro.tokyo.jp /ENGLISH/ADMINI/PRESS/2005/ftf56100.htm

Newark and Camden: The benefits of urban trees

Overview

- Newark and Camden both experience an Urban Heat Island (UHI) effect
- Research has shown that planting trees in urban areas is a viable and economically efficient way to reduce the UHI, as well as helping to remove pollutants from the air

Research has demonstrated the benefits of urban trees in and around the cities of Newark and Camden, New Jersey[56], using a computer programme called CityGreen, developed by the American Forestry Association[57]. At present, the UHI in Newark is estimated[58] to be on average about 3°C and for Camden, between 1.0 and 1.5°C. The study investigated three blocks in each city, and modelled the existing buildings and trees, as well as various scenarios for the present day and the year 2020 (see Figure 48).

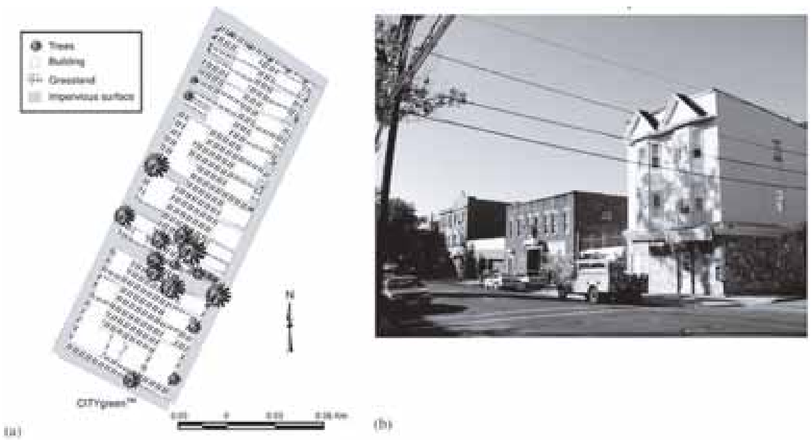

Figure 48: CityGreen base map and photograph of Sussex and Hecker block, Central Ward, Newark. (Source: Solecki et al, as above.)

Urban vegetation was shown to be a viable and economically efficient method to reduce cooling costs (air conditioning) (see Figure 49). The costs per tree start from as little as US$10 (£5.75) for small promotional programmes. The study showed that, to maximise air-conditioning-associated energy savings from urban vegetation planting, trees typically should be strategically placed in front of windows and to the east, west, and south sides of a house, to block both the morning and afternoon sun. Optimal tree planting locations will vary depending on latitude. Larger (mature) trees also tended to be more effective, as they provide a greater canopy cover and shade area.

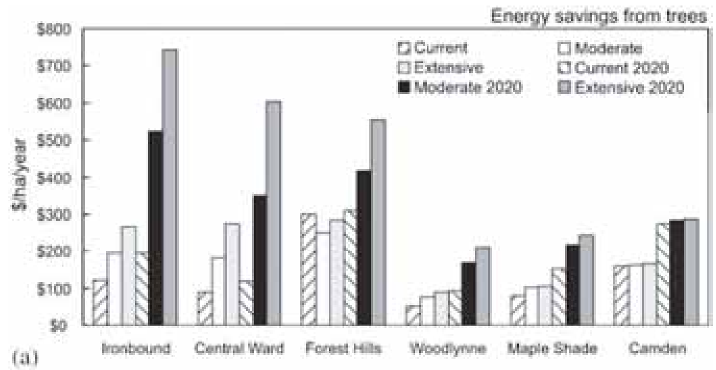

Figure 49: Energy savings (US$/ha/year) from trees in Newark (Ironbound, Central Ward, Forest Hills) and Camden (Woodlynne, Maple Shade, Camden). 'Current' refers to the existing configuration of trees in 2001; 'Moderate' includes additional immature trees adjacent to buildings; 'Extensive' includes the same trees as 'moderate' and also additional trees in any available open spaces on the site, including along streets. The data for the year 2020 show the effects of trees maturing/growing from 2001 - 2020, and of extra trees being planted over that time. Dollar values for 2020 are not adjusted for inflation. (Source: Solecki et al, as above.)

The analysis also showed that urban trees can lower health hazards associated with the UHI effect by removing pollutants from the air (see Figure 50). The amount attributed to pollutant removal is based on medical costs associated with increased pollutants and ozone production.

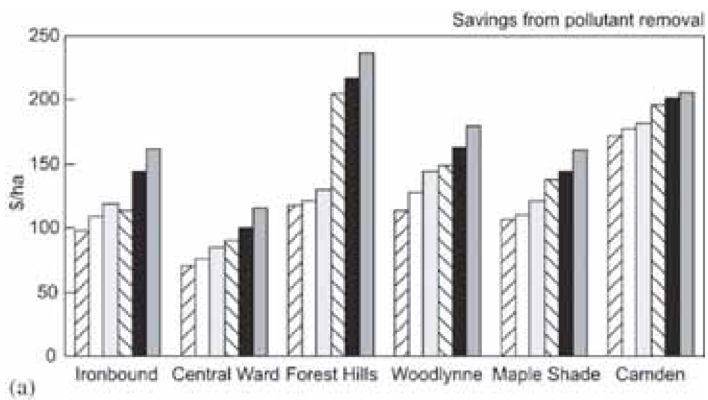

Figure 50: Savings, in terms of reduced medical costs, as a result of pollutants removal by trees (US$/ha/year) for Newark (Ironbound, Central Ward, Forest Hills) and Camden (Woodlynne, Maple Shade, Camden). (Source: Solecki et al, as above.)

The less affluent, inner-city neighbourhoods studied were found to be the ones where the hazard of the UHI is greatest. However, these neighbourhoods have less available open space for tree planting, and therefore lower maximum potential benefits. The study concludes that, as temperatures rise with climate change, these neighbourhoods may face greater consequences due to interactions between the UHI effect and global climate change.

The state of New Jersey has taken a first step in addressing these issues, in part as a response to the analyses put forward in this study. In 2003, the Governor of New Jersey created a state-wide urban forest, energy efficiency initiative called 'Cool Cities'. The programme includes joint operations by the State's Department of Environmental Protection and Board of Public Utilities and involves the planting of 100,000 trees in the cities of New Jersey. The program has already planted trees in Camden and Newark, and other cities including Paterson, and Trenton. The State plans to spend at least $10million (£5.8m) in the initial phase of operations[59].

Footnotes

56 Solecki, W.D, Rosenzweig, C., Parshall, L. Popec, G., Clark, M. Cox, J. Wiencke, M. 2005. Mitigation of the heat island effect in urban New Jersey. Environmental Hazards 6 (1) pp. 39 – 49.

57 American Forestry Association, 1996. CITYGreen software module for ArcView GIS v. 3.x, http://www.americanforest.org /productsandpubs/citygreen/citygreen5.php/.

58 Rosenzweig, C., Solecki, W.D., Parshall, L., Chopping, M., Pope, G., Goldberg, R. 2005. Characterizing the urban heat island in current and future climates in New Jersey. Environmental Hazards 6(1) pp. 51-62.

59 New Jersey Department of Community Affairs (NJ DCA). 2000. Affordable and environmentally friendly homes coming to seven New Jersey cities: state of New Jersey, Fannie Mae and PSE&G announce new urban housing initiative, http://www.state.nj.us/dca/news/2000/pr120700.htm

Philadelphia: Heat health warning system

Overview

- Heatwaves in Philadelphia in the 1990s caused heat-related deaths, leading to the establishment of the Philadelphia Heat Health Warning System (HHWS)
- The HHWS predicts the risk of dangerous heatwaves
- Health Department and other agencies then implement intervention activities including publishing warnings via the media, a 'buddy' system of visits to the elderly and a telephone 'Heatline'

Context and policy drivers

The Philadelphia Hot Weather–Health Watch/Warning System (PWWS) was developed in 1995, partly in response to heat waves in 1993 and 1994, to alert the city's population when weather conditions pose risks to health. It is the basis for more than 20 other heat–health watch warning systems being instituted in cities worldwide[60].

Description of the system

The PWWS has been designed as an early warning system to predict periods when there is a high risk of particular types of 'airmass' associated with heat-related mortality. The system forecasts airmass type for the current day and the coming 2 days during the summer season (15 May – 30 September). The system generates a health warning if the model forecasts four or more heat-related deaths. The local National Weather Service (NWS) office then decides whether or not to issue a warning to the Philadelphia Department of Health based on the PWWS forecasts, the heat index, and other information. For example, in 1995 the NWS issued a heat warning on 9 of the 15 days recommended by the PWWS.

An introduction to heat health warning systems

High temperatures cause increased deaths from heat stroke, cardiovascular, renal and respiratory diseases and metabolic disorders. While everyone is at risk, the most vulnerable groups are those over the age of 65, particularly those who are already ill, on certain medication or unfit. The death toll from heat waves was demonstrated in the 2003 heat-wave across Europe, which caused 27,000 to 40,000 excess deaths.

Heat health warning systems (HHWS) are acute responses during heat-wave events. They involve both meteorological and public health elements including:

- Sufficiently reliable heat-wave forecasts,
- Good links between meteorological and health agencies,
- Good understanding of the cause-effect relationships between the thermal environment and health,
- Effective communication and response measures to implement within the window of lead time provided by the warning, targeted at high risk groups,
- The community must be able to provide the required infrastructure.

To date, the effectiveness of HHWS as a whole or of specific health interventions have not been properly evaluated, although there is evidence that they have been effective during major events in Philadelphia.

Source: Menne, B. and Ebi, K.L. (Eds.) 2006. Climate change and adaptation strategies for human health. World Health Organization, Germany, pp. 409 – 426.

When a warning is issued, the Philadelphia Department of Health implements emergency precautions and mitigation procedures to reduce the mortality risk (see Box below)[61,62].

Intervention activities carried out in Philadelphia when the National Weather Service (NWS) issues a warning

The city of Philadelphia and other agencies and organisations institute a series of intervention activities when the NWS issues a warning:

- Television, radio stations and newspapers are asked to publicise the oppressive weather conditions, along with information on how to avoid heat-related illnesses.
- Promotion of a 'buddy' system: media announcements encourage friends, relatives, neighbours, and other volunteers to make daily visits to elderly people during hot weather. Buddies are asked to ensure that the most susceptible individuals have sufficient fluids, proper ventilation, and other amenities to cope with the weather.
- A 'Heatline' is operated in conjunction with the Philadelphia Corporation for the Aging to provide information and counselling to the general public on avoidance of heat stress. The Heatline telephone number is publicised by the media and by a large display seen over much of the centre of Philadelphia. Health Department nurses are available to speak with callers who are suffering medical problems. These nurses may make referrals to field teams who make home visits and directly evaluate situations.
- Home visits: Department of Public Health mobile field teams make home visits to persons requiring more attention than can be provided over the Heatline.
- The Department of Public Health contacts nursing homes and other facilities boarding people requiring extra care to inform them of the high-risk heat situation and to offer advice on the protection of residents. In addition, during warning periods, mobile field teams make inspection visits to these homes to ensure adequate hot weather care for residents.
- The local electricity company and water department halt all service suspensions during warning periods.
- The Fire Department Emergency Medical Service increases staffing during warnings in anticipation of increased service demand.
- The agency for homeless services activates increased daytime outreach activities to assist those on the streets.

- Centres for the elderly extend their hours of operation of air-conditioned facilities.

- Air-conditioned shelter capability: The Department of Public Health has the capability to move persons at high risk out of dangerous living situations to an air-conditioned (overnight) shelter facility.

Assessment of the effectiveness of the system

The Philadelphia heat health warning system was evaluated during its first summer in 1995[63]. This evaluation concluded that there was some evidence that the system was effective in reducing the number of deaths: The HHWS model for Philadelphia indicated that 100-200 deaths would occur during the hot summer of 1995 if no action was taken. However, only 72 heat-related deaths were recorded in the city that summer, 32 of which occurred during two identified heat-wave periods. As the summer of 1995 progressed, the model overestimated heat-related mortality more regularly and by a greater amount. This supports the suggestion that people were responding to the heat advisories and warnings and lives were being saved as a result. It should be noted, though, that certified heat deaths do not account for all excess mortality during heat waves, so the HHWS model will always project more deaths that are actually certified as heat-related.

Initially, some forecasters at the NWS felt that the PWWS called too many advisories and warnings and were concerned that the public might become less responsive to subsequent warnings. An early evaluation of the system indicated that, because of this policy, warnings were not called frequently enough and that heat-related deaths occurred on days when the system called for a warning and the forecasters did not issue one[64].

Most of the financial costs of the system are indirect. They include costs arising from actions taken by city employees as a normal part of their jobs and actions taken by volunteers. The direct costs of the 'Heatline' and additional emergency service crews were estimated to be about US$210,000 in total over the 1995-1998 period.

HWWS are very difficult to evaluate. Heat waves are rare events and they have different impacts in different populations. It is not possible to compare directly the impacts of heat waves in terms of numbers of deaths, either in different cities or in the same city over time[65].

Typically, a public health intervention is evaluated by estimating lives saved (premature deaths avoided) and other criteria such as acceptability or reduction of health inequalities. HHWS, with accompanying health interventions, are considered to be effective in reducing deaths during a heatwave[66]. To date, there is little published information on formal assessments of the effectiveness of the systems or of specific intervention measures.

Footnotes

60 Kalkstein, L. S., 2003. Description of our heat/health watch-warning systems: Their nature and extent, and required resources. Final Rep. to Stratus Consulting Company, 31 pp.

61 Ebi, K.L., Teisburg, T.J., Kalkstein, L.S., Robinson, L., and Weiher, R.F. Heat Watch/Warning Systems Save Lives: Estimated Costs and Benefits for Philadelphia 1995-1998. BAMS, August 2004, pp. 1067-1073.

62 Sheridan, S., and Kalkstein, L.S., Progress in heat watch-warning system technology. BAMS, December 2004, pp. 1931 – 1940.

63 Kalkstein et al, 1996 (as above).

64 Kalkstein, L. S., Jamason, P.F., Greene, J.S., Libby, J. and Robinson,L.1996. The Philadelphia Hot Weather-Health Watch/Warning System: Development and application, Summer 1995. BAMS, 77, pp. 1519–1528.

65 Kovats, R.S. and Ebi, K.L. 2006 (In press). Heatwaves and public health in Europe. European Journal of Public Health.

66 Kovats and Ebi, 2006 (as above).

Shanghai: Heat Health Warning System[67]

Overview

- Heatwaves in Shanghai cause deaths, particularly among elderly women
- Shanghai Heat Health Warning System predicts the risk of dangerous weather conditions
- Shanghai Municipal Health Bureau and other agencies implement intervention measures including media announcements, preparing hospitals and ensuring availability of water, power and air-conditioned facilities

Context and policy drivers

With the recognition that heat is a significant weather-related killer in many areas of the world, there has been a growing impetus to develop warning systems to predict when heat waves will occur and when human health might be adversely affected. This has led to an important collaboration between international organisations to construct heat warning systems for cities around the world. Several international agencies including the World Meteorological Organization, the World Health Organization, and the United Nations Environmental Programme have decided to promote several Showcase Projects dealing with the impact of extreme heat on human health.

As a result of its potentially dangerous climate, along with high-quality mortality and meteorological data, Shanghai, which has a population of over 17 million (in 2003), was selected in 2000 as the second city in the Showcase Project[68].

The Shanghai HHWS is based on the same principles as the system in Philadelphia, and was developed through collaboration between officials from Shanghai (the Shanghai Meteorological Institute and the Shanghai Municipal Center for Disease Control and Prevention) and academics at the University of Delaware in 2000.

Description of the system

Shanghai's previous warning system issued a heat warning when temperatures were predicted to exceed an arbitrary threshold of 35ºC. The new Shanghai Heat Health Warning System (HHWS) utilises a more sophisticated air mass approach, which takes into account numerous weather variables and other factors that have been shown to negatively affect human health. The HHWS identifies specific air mass types that have been shown to increase mortality levels in Shanghai, and provides warnings when these air masses are predicted, so the new system is based upon actual human responses to weather conditions.

To develop the system, a technique developed at the University of Delaware[69;70] was used to analyse the impact different weather types on Shanghai's inhabitants. By evaluating the number of deaths that occurred under different conditions, the air mass type associated with the highest levels of mortality for Shanghai was found. The 'moist tropical' air mass type, associated with the highest average temperature and humidity, proved most dangerous. It occurs, on average, on 12.5% of summer days in Shanghai. On these days, 35 – 63 so-called 'excess' deaths were observed, compared to the daily average of 222 (an increase of 16-28%). The elderly were found to be most vulnerable. Overall, more women died than men, because the elderly population has a higher proportion of women than men. Factors such as the social structures of the city and building styles played a significant role in mortality related to heat events[71].

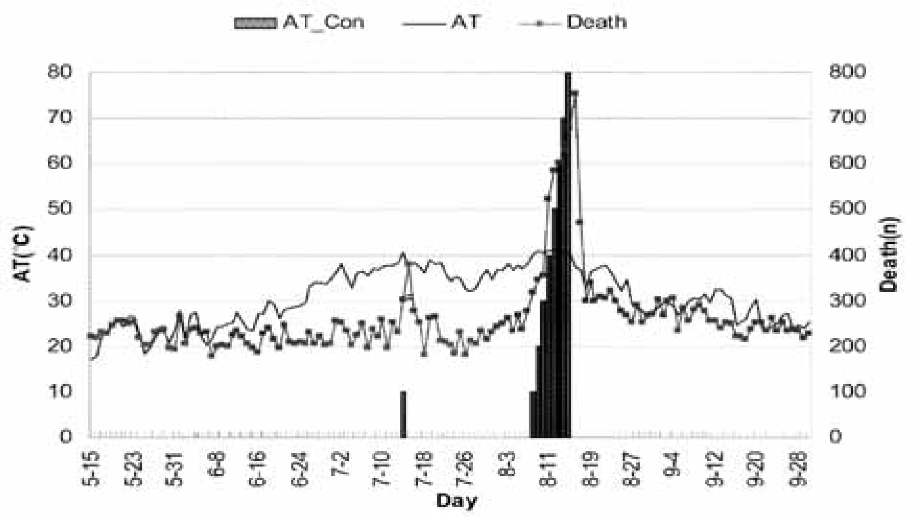

Figure 51: Apparent temperature (AT), consecutive days above 40°C (AT_Con) and numbers of deaths in Shanghai in the summer of 1998. (Source: Tan et al, 2004[72])

In the summer of 2001, Shanghai started to run the system experimentally, and it now operates every summer.

In the early summer, the health department cooperates with meteorological officials to promote heat and health education using mass media. Papers developed on heat/ health issues are distributed to other agencies and the press. The media are encouraged to provide coverage and education programmes on heat health risks.

A special educational programme targets risk groups, such as the elderly and people working in the hot environments. An official presentation to the community, which is reported to be effective in educating the general public in Shanghai, is organised. Leaflets or pamphlets are distributed to elderly people in downtown areas. These describe the adverse health effects of heat waves, and provide instructions for avoiding heat wave risks.

When an 'offensive' air mass is on its way, the HHWS predicts its arrival up to 48 hours in advance. The number of excess deaths is then predicted. Depending on this number, the Shanghai Meteorological Bureau issues one of three levels of warning, as follows:

- Level I warning: If 40–59 excess deaths are predicted,
- Level II warning: If 60–79 excess deaths are predicted,
- Level III warning: If 80 or more excess deaths are predicted.

A series of interventions, such as media announcements (TV, radio stations, newspaper), health education, preparation of hospitals and public services, and ensuring the availability of water and power and of air-conditioned facilities, are initiated by the Shanghai Municipal Health Bureau, along with other agencies[73]. The health department mobilises community health professionals, who implement heat/health intervention programmes. They pay visits to the elderly in the downtown area, especially to those with chronic diseases. Water and electricity supply, as well as cooling devices, are checked. Further education and advice about the prevention of adverse health effects is given.

Medical doctors who specialise in mental disorders, endocrine, nutritional and metabolic diseases are advised to pay attention to the severe adverse effects of some drugs used during a heat wave, and to give proper alternative treatment.

In Shanghai, air-conditioning is often the recommended measure to alleviate the health effects of a heat wave (though clearly this has implications for climate change mitigation). According to published statistics, 66.8% of households in the Shanghai urban area had air conditioning in 1998.

Assessment of the effectiveness of the system

To verify the predictive power of the system before it was put into operation, the weather data from the summer of 1999 was run through the model, and the numbers of deaths predicted by the model was compared to the deaths recorded. The summer was relatively cool but the system did detect several consecutive days of the dangerous airmass type in September. During this period, the system predicted 331 excess deaths, only slightly more than the 294 excess deaths actually recorded.

The September 1999 warm spell successfully illustrated how the system's predictive power can help city officials determine when the public should be alerted to help prevent heat-related mortality.

To date, the biggest challenges in implementing the system have proved to be difficulties in developing cross-agency collaborations, including:

- coordinating all urban agencies so that the system is utilised,
- developing appropriate implementation plans,
- developing adequate checks of the effectiveness of the system.

Footnotes

67 Tan, J. Kalkstein, L.S., Huang J., Lin, S., Yin H. and Shao, D. An operational heat/health warning system in Shanghai. 2004. Int. J. Biometeorol. 48, pp. 157–162.

68 World Meteorological Organization. April 2004. Proceedings of the meeting of experts to develop guidelines on heat/health warning systems. WCASP No. 63. Freiburg, Germany, 14-16 April 2004.

69 Kalkstein, L.S., Nichols, M.C., Barthel, C.D. 1996a. A new spatial synoptic classification: application to air mass analysis. Int. J. Climatol. 116, pp. 983–1004.

70 Kalkstein, L.S., Jamason, P.F., Greene, J.S., Libby, J. and Robinson, L. 1996b. The Philadelphia hot weather-health watch/warning system: development and application, Summer 1995. Bull. Am. Meteorol. Soc. 77 pp. 1519–1528.

71 World Meteorological Organization. April 2004 (as above).

72 Tan, J. Kalkstein, L.S., Huang J., Lin, S., Yin H. and Shao, D. An operational heat/health warning system in Shanghai. 2004. Int. JBiometeorol. 48, pp. 157–162.

73 Chunlin Shen, Shanghai Institute of Preventive Medicine, 2006, Pers. Comm.

Lisbon:
Heat health warning system[74]

Overview

- High temperatures in the 1980s and 1990s caused significant numbers of heat-related deaths in Lisbon
- Lisbon's ÍCARO surveillance system triggers intervention measures by the General Health Directorate and Civil Protection Service, including media announcements and a telephone advice line reinforced with nursing personnel

Context and policy drivers

On 15 June 1981, Lisbon was the hottest capital city in the world. Maximum temperatures reached 43°C, and some 1906 excess deaths occurred. Following this event, the Portuguese Observatório Nacional de Saúde (ONSA) together with the Vigilância Previsão e Informação - Instituto de Meteorologia, created a surveillance system called ÍCARO, which has been in operation since 1999. ÍCARO identifies heat waves with potential influence on mortality. It currently operates each year from 1 May to 30 September.

Description of the system

The ÍCARO Heat Health Warning System was originally based on a statistical model built using data for Lisbon's district area. Until recently, the ÍCARO Project defined a heat-wave when temperatures exceeded a threshold of 32°C for a minimum of 2 days. The system has recently been updated, using new statistical models that include data from the 2003 heat wave. The new system uses 'dynamic' thresholds for defining heat waves, rather than a fixed threshold temperature. It also takes account of the different effects of heat on mortality in different age groups.

The system calculates the 'ÍCARO Index' as follows:

(Number of expected deaths with the effect of heat / number of expected deaths without the effect of heat) –1

The 'number of expected deaths without the effect of heat' is the average summer mortality without heat-wave days[75]. An ÍCARO Index of 0 therefore means that heat has no effect on mortality and an ÍCARO Index of 1 that the mortality risk from heat is doubled.

The ÍCARO Index has five warning levels, based on the 95% confidence interval for Lisbon's mortality when no abnormal weather conditions occur (see table).

ÍCARO surveillance system warning levels[76;77]

ÍCARO index value	Effect on mortality
0	No effect – no warning
0 to 0.31	No statistically-significant effect on mortality
0.31 to 0.93	Possible effect on mortality
0.93 to 1.55	Heat-wave alert in analysis
Over 1.55	Heat-wave alert - serious consequences for health and mortality expected

The several warning levels imply different direct interactions among the various partners in the system (see Figure 50). The system is integrated with a number of health and meteorological institutions: the Portuguese National Institute of Health, the Portuguese Meteorological Institute, the Portuguese General Health Directorate and the Portuguese Civil Protection Service (see Figure 52)[78].

Higher levels of risk, which indicate heat-wave alerts, lead to greater interaction and systematic re-evaluation of observed temperature, predicted index values and weather conditions. If the ÍCARO Index reaches the third level, an announcement is made that a heat-wave may arrive within the next few days. This triggers intervention measures by the General Health Directorate and the Civil Protection Service, which communicates with five Regional Health Authorities and the Health Authorities Network. A free telephone number for heat advice is also activated, reinforced with nursing personnel.

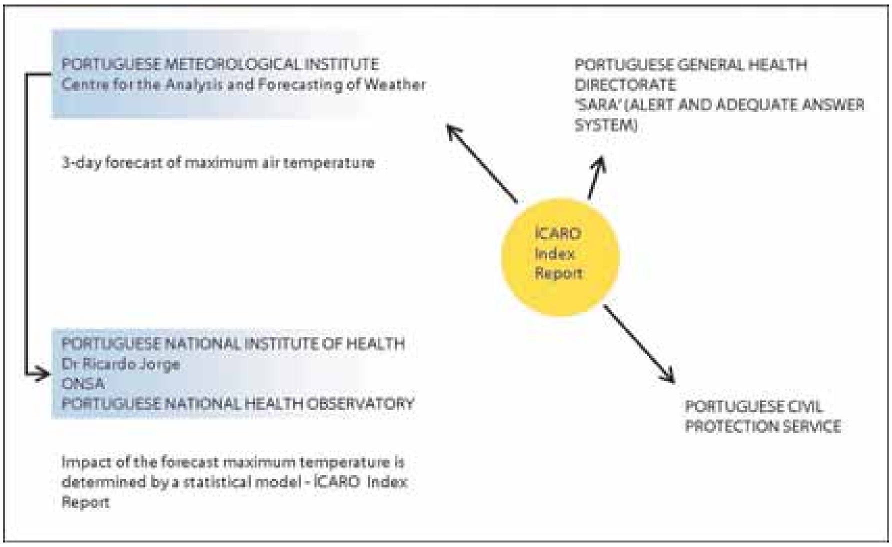

Figure 52: Flow chart of the Lisbon heat health surveillance system[79]

Assessment of the effectiveness of the system

The system was evaluated by comparing predicted and observed mortality for the summers of 1999 and 2000[80]. It was found that the system did a good job of predicting mortality for the first heat-wave in summer 1999, but was less accurate for the heat-waves that followed. Even when the threshold of 32ºC was not exceeded, relatively high mortality levels were observed, especially in early summer. This indicated that a temperature threshold that varies throughout the summer might be more suitable than using a fixed threshold of 32ºC, which is why the new system based on dynamic temperature thresholds has been developed.

Portugal was severely affected by the heat-wave of summer of 2003. From 27 July to 15 August, almost all Portuguese districts had weekly maximum temperatures above 32ºC and 13 of those districts had weekly mean maximum temperatures above 35ºC. The ÍCARO Surveillance System detected the heat-wave early, with a special warning issued on 30 July[81].

Overall, the ÍCARO Surveillance System performed well in 2003, and accurately predicted the effects that occurred: The predicted peaks of the ÍCARO index correlated well with observed temperature and mortality peaks. The official estimate of the excess mortality during the heat-wave (30 July to 15 August) is 1,953 deaths (all ages), with 1,742 deaths (40% excess) in the over 75-age group[82]. The free heat advice telephone number received 1,466 calls from members of the public. There is evidence that one woman who phoned the heat advice line was brought in for treatment and given a life-saving heart pacemaker[83].

A postal survey was conducted about the behaviour of the public in summers and in the summer of 2003 in particular, and how people responded to the heat-wave advice[84]. This revealed that:

- During the summer of 2003, 92.5% of the individuals who responded to the postal survey said they had read or heard advice about how to take care of themselves during the heat-wave.
  - The main information sources they used were television (95.2%), radio (56.3%), newspapers (49.3%), the internet (4.5%), family (22.8%), friends or acquaintances (17.3%) and health professional (11.5%).
  - The elderly (75+ years) and lower educated individuals showed lower levels of received information.
- During the extreme 2003 heat wave, those who read or heard the heat advice made more changes to their behaviour than those who did not.
  - Television warnings encouraged people to take baths and to wear light, loose clothing.
  - Newspaper warnings encouraged people to drink more liquids, as well as to open windows during the night, and to take care when walking or travelling.
  - Health professionals encouraged people to eat light meals, wear loose clothing, and to take care when walking or travelling.

Difficulties encountered in the summer of 2003 included that partners in the ÍCARO system had some problems in conveying warning messages to the population late in the heat stress period, when the media were more interested in reporting forest fires. It was concluded that passive systems, such as using the media to spread messages of interest during heat stress periods, are not reliable especially in a very long heat-wave. Therefore, active ways to convey information to the population need to be developed[85].

Footnotes

74 Koppe, C., Kovats, S., Jendritzky, G. and Menne, B. 2004. Heat waves: Risks and responses. WHO ,Europe. See http://www.wmo.ch/web/wcp/clips2001/html/HHWS_docs/E82629_1.pdf

75 Paixão, E. and Nogueira, P.J. 2002. Estudo da onda de calor de Julho de 1991 em Portugal: efeitos na mortalidade: relatório científico [A study of the July 1991 heat-wave in Portugal: effects on mortality – scientific report]. Lisbon, Observatório Nacional de Saúde.

76 Nogueira, P.J. et al. 1999.Um sistema de vigilância e alerta de ondas de calor com efeitos na mortalidade: o índice Ícaro [A heat-wave surveillance and warning system based on the effects on mortality: the ÍCARO index]. Revista Nacional de Saúde Pública, volume temático 1, pp. 79–84.

77 Kirsh, W., Menne, B. and Bertollini, R. (Eds.) 2005. Extreme weather events and public health responses. Springer-Verlag, Berlin, Heidelberg.

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79 Nogueira, P. and Paixão, E. 2003. Evaluation of the Lisbon heat health warning system. cCASHh Workshop on Vulnerability to Thermal Stresses, 5–7 May, Freiburg, Germany.

80 Nogueira, P. and Paixão, E. 2003 (as above).

81 World Health Organization. 2004. Extreme weather and climate events and public health responses. Report on a WHO meeting Bratislava, Slovakia 09–10 February 2004. See http://www.euro.who.int/document/E83004.pdf

82 Botelho, J., Catarino, J., Carreira, M., Calado, R., Nogueira, P., Paixão, E. and Falcão, J. (April 2004). Onda de calor de Agosto de 2003: os seus efeitos sobre a mortalidade da população portuguesa, Direcção Geral da Saúde & Instituto Nacional de Saúde Dr. Ricardo Jorge, Lisboa. See www.onsa.pt/conteu/onda_2003_relatorio.pdf

83 Nogueira, P. Pers. Comm.

84 Paixão, E. Nogueira, P. and Falcão, J. (2005). Comportamentos das familias portuguesas em epocas de calor e durante a onda de calor de Agosto de 2003. Estudo na amostra ECOS. Observatório Nacional de Saúde, Lisboa. See www.onsa.pt/conteu/relatorio_ecos_onda-calor-2003_onsa.pdf

85 World Health Organization. 2004 (as above).

Melbourne: Efficient use of water resources

Overview

- Melbourne has always had to cope with drought problems
- Policies have been developed to promote efficient water use, including Drought Response Plans and Permanent Water Saving Rules backed up by penalties
- Variable water tariffs are used so that low water use is cheap, with much higher tariffs for excessive use
- Rebates are available for water saving devices like rainwater tanks

Context and policy drivers

Melbourne, throughout its history and growth, has always had to live with climate variability. Drought is seen as a natural part of the highly variable climate, but it can be managed.

Melbourne Water manages Melbourne's water supply catchments, removes and treats most of Melbourne's sewage, and manages its rivers, creeks and major drainage systems. Melbourne Water is owned by the Victorian government and manages the water resources that are distributed by the metropolitan retail water companies. Melbourne's metropolitan water retailers are City West Water, South East Water and Yarra Valley Water.

Since the 1960s, water restrictions have been introduced in dry years because of low inflow into reservoirs and storage levels. Following the drought of 1972-73, work began to formalise water restrictions in Melbourne. At the end of 1975 the first set of water restrictions were put in place. More severe restrictions were put in place following the drought of 1982-83, which affected most of eastern Australia. The restrictions meant that people in even-numbered properties were allowed to use hand-held hoses between 7pm and 9pm on Wednesdays, Fridays and Sundays and those in odd-numbered properties on Tuesdays, Thursdays and Saturdays. Bucket watering was allowed from 7pm to 9pm on nights when hosing was not allowed. Since that drought, water authorities in Victoria (Melbourne’s state) have worked to plan for drought and simplify restrictions.

Melbourne's population is growing, which has increased demands on potable mains water. Commitments to return water flows to waterways for environmental benefit have placed further demands on water availability. This increased water demand, combined with changing climatic patterns, has meant that Melbourne's water supply reliability has diminished[86].

Description of the policies

At current consumption rates Melbourne may reach its water supply limits within 15 years. Integrated water management solutions are necessary to ensure secure and reliable water supply. Local, State and Federal Governments have made commitments to sustainable water management. The Victorian Government's White Paper, 'Securing Our Water Future Together 2004', outlines an holistic approach for urban water management. The Victorian Government's urban planning policy for Melbourne, 'Melbourne 2030', is committed to water sensitive urban design. The Melbourne 2030 policy recognises storm water quality as important to the health of Victoria's waterways. 'Total Watermark 2004' establishes the City of Melbourne's policy for integrated water management, committing the city to water conservation and quality targets.

These policies are being implemented in Melbourne to conserve and use water wisely. Specific policy implementation actions include Drought Response Plans, Permanent Water Saving Rules, water tariffs, the Water Smart Gardens and Homes Rebate Scheme and also Water Sensitive Urban Design (WSUD) guidelines. These are outlined and discussed below.

Drought Response Plans

In 1995, drought response plans were completed for the newly formed metropolitan retail water companies (City West Water, South East Water and Yarra Valley Water). The drought response plans include a four-stage water restriction regime.

Staged water restrictions (i.e. Stages 1 – 4) are activated when water storage fall below specified levels or 'trigger points', generally as a result of drought. These are temporary restrictions designed to achieve significant water savings (the higher the restriction level, the higher the savings required) over a short period of time.

The 'trigger points' that dictate when the next stage will be introduced varies month by month. As an example, for a 'Stage 2' restriction to be introduced in January, the storage levels would need to drop to 45% (figure from South East Water)[87]. The storage or 'trigger' levels are expressed as a percentage of total system storage amount, which is monitored by Melbourne Water.

The Drought Response Plans sets out the exact circumstances for introducing and lifting staged water restrictions.

Permanent Water Saving Rules

Permanent Water Saving Rules have now been implemented in Melbourne. These rules are a long-term water conservation initiative that will help ensure the sustainability of Melbourne's water supplies. They are permanent rules that will remain in place unless staged water restrictions are required as part of the Drought Response Plan (discussed above). The Permanent Water Saving Rules were first introduced in March 2005 to reduce water wastage and promote water efficient outdoor use.

Permanent Water Saving Rules target discretionary outdoor water use by residential customers (not business customers). Outdoor water use accounts for around 25% of all household water consumption. Overall, it is estimated that savings of around 2-3% of average annual water consumption will be achieved by implementing Permanent Water Saving Rules. All three of the water companies that operate in Melbourne have applied the Permanent Water Saving Rules, as required by the State Government.

South East Water[88] has outlined the 5 key rules:

1. Use manual water systems only between 8pm – 10 am. Manual watering systems (that you turn on or off by hand) can only be used to water gardens between these times, any day of the week. Also applies to public gardens and recreational areas.

2. Use automatic watering systems only between 10pm –10am. Time restrictions and also a rain or soil moisture sensor must be fitted to all new systems installed from 1 Sept 2005. Also applies to public gardens and recreational areas.

3. Fit hoses with a trigger nozzle. Must be fitted and used to wash cars or water gardens at any time.

4. No hosing paved areas. Hosing down driveways, paths, concrete, timber decking is not permitted. This does not apply in the case of an accident, fire, health hazard or other specific circumstances.

5. Apply to fill a new pool. Submit plan for approval by water retailer. Applies to pool capacity of 2,000 litres or more[89].

There are some exemptions within the rules, which are specific to certain circumstances or businesses. Some examples include: new gardens and lawns where watering systems can be used for the first 28 days after installation; sporting grounds and recreational areas may use watering systems where watering is necessary to avoid permanent damage to the surface and to avoid injury or damage to players. Various other miscellaneous exemptions are also cited[90]. To gain exemption, an exemptions application form needs to be completed and submitted to the relevant water company for approval.

Melbourne's three water retailers have the ability to take legal action against a person found breaching any of the Permanent Water Saving Rules. If a person is served with a warning notice and still breaches the rules, they may be prosecuted for non-compliance. The following penalties apply for non-compliance:

- First offence – Aus$1,000 (£412)
- Subsequent offence – Aus$2,000 (£824)
- A continuing offence incurs an additional penalty of Aus$200 (£82) per day (up to a maximum of £2,000 (£824))
- The water retailers also have the power to restrict water supply to anyone found guilty of breaching the rules.

Enforcement of the rules is undertaken through public involvement. The water retailers rely on the public to report any suspected breach of the rules. Where necessary, patrols are also conducted.

Melburnians have embraced the Permanent Water Saving Rules over the past year and understand that they have been introduced to help secure water supplies for the next 50 years.

Water Tariffs

The Victorian Government's introduction of step tariffs to reward water conservation (with safeguards to protect vulnerable community members through a Government-funded Utility Relief Grants Scheme) is designed to help the community understand more about the need to save water and to send signals about water consumption and its impact on water bills.

The prices for each step tariff for residential customers vary slightly for each water company but are approximately:

- Step 1 (0-440 litres per day): $0.78 (£0.32) per kilolitre
- Step 2 (441-880 litres per day): $0.92 (£0.38) per kilolitre
- Step 3 (881+ litres per day): $1.36 (£0.56) per kilolitre.

This stepped approach means that low water use is rewarded as it is cheap, and there are increasing costs involved in using more water. The objective of this pricing reform was to reduce overall demand by 5% in the short-term. The effectiveness of this reform will not be fully understood until the completion of the 2005/06 summer[91].

Figure 53: Brochures advertising the Water Smart Gardens and Homes Rebate Scheme. (Source: Government of Victoria[93].)

Water Smart Gardens and Homes Rebate Scheme

The Water Smart Gardens and Homes Rebate Scheme provides residential customers with a rebate off their water bill for purchasing water-saving devices and services, thereby reducing their water consumption. The scheme offers a range of 'inside' and 'outside' the home products[92]. The scheme encourages people to use water more wisely by making water saving products more affordable. It also helps save money on water bills for years to come. The brochure from the scheme is shown on the left.

Rebates for water-saving devices and services

Product	Rebate (Aus$)(£)
Greywater permanent tank system	$500 (£206)
Rainwater tank (600 litre min.)	$150 (£62)
Rainwater tank to toilet system (600 litre min.)	$150 (£62)
High pressure cleaning device	$30 (£12)
Dual-flush toilet	$50 (£21)
Water-efficient shower rose	$10 (£4)
Water conservation audit	$30 (£12)
A basket of garden products (this includes items such as flow control valves, garden tap timer, trigger nozzles etc.)	$30 (£12)

The Water Smart Gardens and Homes Rebate Scheme will run over 4 years until mid 2007. Since the launch of the scheme in January 2003 there has been an overwhelming response to take part and help save water. Over 100,000 rebates have been approved, helping Victorians save over 900 megalitres of drinking water a year.

Water Sensitive Urban Design

Water-sensitive urban design is the integration of urban planning and development with the management, protection and conservation of the water cycle as a whole. It includes simple treatment measures that collect, reuse and treat rainfall that falls onto the street.

The City of Melbourne local government has developed the Water Sensitive Urban Design Guidelines (WSUD)[94]. The WSUD guidelines detail how residents and businesses can use the principles of water sensitive urban design to achieve the water saving and water quality targets established by Total Watermark 2004[95]. Total Watermark 2004 is Melbourne's twenty-year strategy for managing water in the City of Melbourne. The strategy sets innovative policies and actions for managing the total water cycle including water consumption, stormwater, wastewater and groundwater. Some of the policies and actions are outlined in the following table.

Melbourne water conservation policies and actions[96]

Action	Description	Partners and potential partners	Timeframe
Green Star	Green Star commercial building rating tool proposed for insertion into the Melbourne Planning Scheme with benchmarks for efficient water consumption. The planning system has a role to play by requiring developers to design buildings in accordance with environmental design principles.	Green Building Council of Australia	2004
Rainwater Harvesting Guidelines	Implementation guidelines for staff to encourage effective installation of rainwater harvesting schemes in residential, commercial and industrial premises.		2004
GreenSaver	Retrofitting program for water and energy efficiency in homes.	Green Plumbers, City West Water, Commonwealth Scientific and Research Organization (CSIRO), Australian Research Centre for Water in Society (ARCWIS)	2004/05
CH2	Leading water saving design and technology in new Council administration building.		2004/06
Sustainability Street	Community development program for neighbourhoods to undertake their own initiatives in water, energy, and waste reductions. Initial groups in North Melbourne and Kensington.	City West Water, Environs Vox Bandicoot.	2004/06
Royal Park Wetlands	Stormwater harvesting project whereby a wetlands and water recycling facility is designed to cut drinking-quality watering needs by 80% for Royal Park.	Melbourne Water	2004/06
Queen Victoria Markets	Harvest rainwater for use in the markets and nearby properties. Education program for vendors. Water audit and implementation of identified water savings.	Environmental Protection Authority (EPA), City West Water, Victorian Government	2004/06
Common Ground Fountain	Proposed construction of new water feature with an educational water conservation focus at Birrarung Marr. Water will be recirculated.	City West Water	2004/06
Council Buildings	In-house education and promotion of water smart practices. Retrofit water efficient showers in all buildings. Retrofit dual flush toilets in all buildings. Landscaping for sustainable water outcomes, eg childcare centres. Reduction in water pressure.		2004/06
Toilets	More efficient internal cleaning. Trial waterless toilet. Retrofit dual flush toilets. Feasibility study? of rainwater harvesting and greywater re-use for toilet flushing.		2004/06
Reduce Water Consumption in Parks and Gardens	Minimise water consumption by plants in new and upgraded plantations and on median strips. Drought-tolerant turf species sown where appropriate. Products such as wetting agents will be used to control the release of soil moisture. Site plants in clusters that have a similar water requirement. Use signage to educate about water efficiency. Run training courses to improve water efficiency. Develop water conservation plans for Sports grounds. Contracts to reflect water conservation and stormwater management. Install water-recirculating systems in the fountains (not recycling water) in accordance with City of Melbourne's Fountain Strategy. Some installation of water recycling systems and the proposed use of treated water from water mining projects.	City West Water, South East Water	2004/07
Irrigation in Parks and Gardens	Adopt water efficient irrigation practices such as the installation of moisture-sensitive and drip systems. A Water Management Plan will be developed to outline irrigation schedules subject to horticultural needs, infiltration depth and water delivery rates. A Water Conservation Measures Response Plan will detail irrigation during times of water restrictions.		2004/07

The key principles in the guidelines for Water Sensitive Urban Design are:

- demand management – reducing the demand for water in homes and businesses,
- 'Fit for Purpose' water use – using appropriate quality water for relevant purposes,
- the use of alternative urban water sources through rainwater harvesting, stormwater collection, greywater reuse and blackwater reuse, and
- applying stormwater best practice environmental management.

The Water Sensitive Urban Design Guidelines are incorporated in policy, planning, public safety, maintenance, flood protection, and design of urban areas. It is a requirement that the WSUD Guidelines are considered for all civic projects undertaken by the City of Melbourne. It is intended that WSUD will be a mandatory consideration for private projects by the end of 2006.

Fact sheets are also available on rainwater tanks, porous paving, rain gardens and site layout and landscaping.

Melbourne Water has implemented new drainage standards to reduce the impacts of stormwater run-off on receiving environments in line with the Urban Design Guidelines. This is to minimise the impact of urban development and storm water run-off on rivers, creeks and bays[97]. A range of techniques are used by Melbourne Water include swales, wetlands, rainwater tanks, greywater re-use, rain gardens, green roofs etc.

Communicating with the public on saving water

There are enormous public awareness initiatives associated with the water savings schemes the State of Victoria. These have been by numerous media routes including television adverts, radio announcements, poster campaigns, competitions, school engagement and even community interaction events. Some of these activities are outlined below.

Figure 54: Poster campaigns back up new initiatives as shown in this 'Permanent Water Saving Rules' poster. Simple slogans get the key messages over in this '5 reasons' poster. The poster is backed by the State Governor of Victoria. (Source: Government of Victoria.)

Water – Learn It! Live It!
A water conservation and education program for Victorian schools.
This comprehensive programme for both primary and secondary schools shows how schools can actively implement water conservation and water education across the curriculum, with the aim of reducing water consumption and improving water management across the school community. This scheme is promoted by Melbourne Water.

To encourage the uptake of this programme, there are a wide range of resources and incentives available to the schools. This includes information on how to get the schools involved in the first place, opportunities for excursions and tours around water sites, and an achievement programme with awards.

The ethos behind this programme is that the government believes that schools can play a vital role in encouraging life-long learning and behavioural change. Participating in a range of activities helps people understand the role of water in their lives and sustainability issues. The programme website states that, 'Schools can become leaders – and part of the solution – in conserving our water resources to achieve the target of sustainability through education and awareness'[98].

Interactive Community Events
Excerpt from the promotion for interactive community events[99]:

'Water Saving is Easy'
'Everyone has a role to play in conserving our water. It's easy to use water more wisely and without making major lifestyle changes. Even the small things make a big difference.

To learn simple, immediate and effective ways to save water inside the home and garden, while saving on your water bill, visit the Our Water Our Future "Water Saving Is Easy" interactive stand at a community event in your area over summer.

With practical, hands-on demonstrations, our friendly presenters will show you just how easy it is to take action and conserve water. Learn how to:

- detect a leak
- install a water efficient AAA rated shower rose
- install water efficient flow control aerators for your taps
- install a flow control valve in your shower fixture
- change the washer in a dripping tap (homeowners and occupiers)
- install a drip irrigation system for your garden
- set an automatic and manual garden timer.'

Footnotes

86 City of Melbourne's WSUD Guidelines Water Sensitive Urban Design Guidelines. See www.melbourne.vic.gov.au/rsrc/PDFs/Water/WSUDGuidelines.rtf
87 www.southeastwater.com.au/sewl/index.asp?link_id=1.833
88 www.citywestwater.com.au/iis?command=get_info_page&id=45790
89 www.ourwater.vic.gov.au /ourwater/dsenowof.nsf/childdocs/ -2FF15FA0F54B80B4CA256FB6001FFD31?open
90 www.ourwater.vic.gov.au /CA256F310024B628/0 /EA065B7DDC09AC43CA256FB80014C140 /$File/PWSR-general+Exemptions_Fact+Sheet.pdf
91 www.watersmart.vic.gov.au/Default.asp?bhcp=1
92 www.ourwater.vic.gov.au/ourwater/dsenowof.nsf/LinkView /434B228903A69B76CA256F54001D7DB67791A 5F203C894104A2567CB00031088
93 www.ourwater.vic.gov.au/ourwater/dsenowof.nsf/obj/Home+and+Gard en+Rebates+Downloads/$file/rebate_brochure.pdf?open
94 City of Melbourne's WSUD Guidelines Water Sensitive Urban Design Guidelines. See www.melbourne.vic.gov.au /rsrc/PDFs/Water/WSUDGuidelines.rtf
95 www.melbourne.vic.gov.au/info.cfm?top=120&pg=2652
96 www.melbourne.vic.gov.au/rsrc/PDFs/Water/TotalWatermark1.pdf
97 www.melbournewater.com.au/content/publications/fact_sheets/draina ge/water_sensitive_urban_design.asp?bhcp=1
98 www.ourwater.vic.gov.au/ourwater/dsenowof.nsf/childdocs/- B07350F512F36FECCA256F4900833054- 5F3674FA83D4FFA5CA256F4E00006DFB?open
99 www.ourwater.vic.gov.au/ourwater/dsenowof.nsf/childdocs/- 11EB031D2CB4FB54CA2570EC001F6062?open

Gold Coast Waterfuture strategy[100]

Overview

- The population of the Gold Coast is expected to double by 2050, putting pressure on water resources
- The Gold Coast's Waterfuture strategy provides a range of measures aimed at ensuring sufficient water until 2056
- The strategy includes water from dams as the main water source, as well as new initiatives on: desalination, recycled water, rainwater tanks, water leakage and pressure management, and water conservation measures

Context

Australia's Gold Coast has world-class beaches and heritage-listed national parks. The desirability of the Gold Coast has made it one of the fastest growing regions in Australia, with a population expected to more than double by 2056. This presents challenges in providing water services for the future.

Traditional water supply strategies have relied heavily on water from dams. However changing climate and rainfall patterns have made these sources less reliable and recent droughts have prompted a long term water resource strategy to be created by Gold Coast City Council, termed 'Waterfuture'.

Description of the strategy

The new Gold Coast Waterfuture (GCWF) Strategy was completed in December 2005. It consists of a diverse range of initiatives, as shown in the chart below, which aim to secure 466 megalitres of water per day by 2056. The total cost of the GCWF Strategy is estimated to be approximately Aus$5.8 billion (£2.4 billion) over the next 50 years.

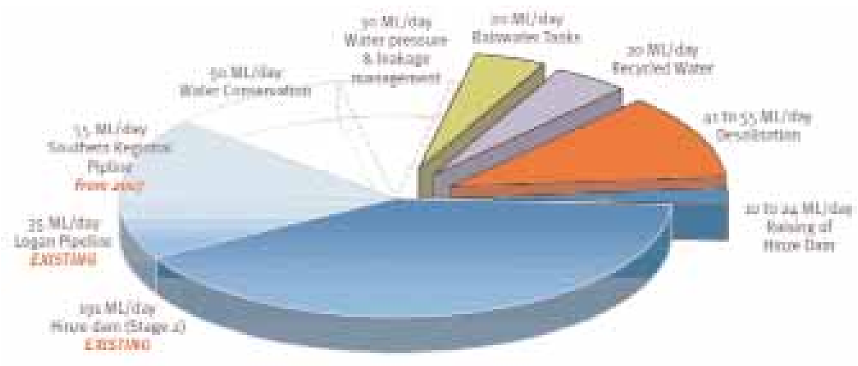

Figure 55: Components of the Gold Coast Waterfuture strategy

The main traditional source of water for the Gold Coast is the Hinze dam, which was constructed in 1976 and raised to its current height in 1985. The Wivenhoe Dam also supplies the city via the Logan Pipeline. In December 2004, the council resolved to raise Hinze Dam for flood management and water supply purposes. It is expected that the dam will be raised between 1.3 to 11.3 m to increase the dam yield by 10 to 24 ML per day, as shown in the chart.

A range of new water-resource management initiatives are also included in the strategy including:

- desalination,
- recycled water,
- rainwater tanks,
- water leakage and pressure management, and
- water conservation measures.

These are briefly described below. There are a number of other water sources that are being further investigated, which could be implemented to supplement the GCWF Strategy. These include:

- greywater reuse,
- groundwater,
- stormwater harvesting,
- indirect potable reuse of highly treated wastewater.

Desalination

The preferred GCWF Strategy is based on developing a seawater desalination capacity of between 41 to 55 ML per day commencing in 2031. The implementation of desalination later in the GCWF Strategy allows time for improvements in desalination technology and costs, which could result in increased power efficiency and reductions in cost.

However, if the regional water shortage continues and dam levels do not significantly increase, the council is considering bringing forward desalination as an emergency bulk water source for the City.

If progressed, the desalination plant would be operational by the end of 2007. Gold Coast Council will make its decision on whether or not to progress with desalination in May 2006, pending the impact of the current wet season on regional dam catchments.

Recycled water

Currently around 20% of the Gold Coast's wastewater is recycled. The recycled water is used for:

- irrigating agricultural crops,
- irrigating parks, gardens, golf courses and other open spaces,
- development sites for dust suppression and landscaping. The use of potable (drinking) water is banned on building sites with exceptions by absolute necessity.

Recycled water users must pay to be connected to the recycled water mains or use a registered recycled water carrier. There are nine recycled water collection points for the recycled water carriers on the Gold Coast and the number of carriers is constantly increasing.

The Gold Coast Waterfuture Strategy aims to improve and enhance use of recycled water. Very high quality recycled water (Class A+) will be supplied from wastewater treatment plants in the future. A pressurised pipe network, similar to the drinking water system, will distribute recycled water to each household for toilet flushing, garden watering and external maintenance. Recycled water will also be provided to commercial, industrial and community facilities for similar non-drinking uses, as well as irrigating open spaces such as parks. The preferred GCWF Strategy is based on recycled water being implemented on a significant scale, replacing the use of approximately 20 ML of drinking water per day.

Rainwater tanks policy

In an effort to reduce demand for drinking water, the council is supporting and encouraging the installation of rainwater tanks on both new and existing homes across the city. Introducing rainwater tanks into residential homes can save up to 75,000 litres of water per year (this saving is an average taking into account both dry and wet years).

Rainwater tanks are now mandatory on all new houses built on the Gold Coast. Detached dwellings are required to fit a tank with a capacity of 5,000 litres, and semi-detached dwellings, flats etc, must install 3,000 litre tanks. The tanks are used to collect water from roofs for toilet flushing, gardening and supplying the washing machine cold water tap. They also provide a secondary function of reducing stormwater runoff. Rainwater tanks installed in an area supplied by town water will be fitted with a continuous back up water supply to ensure that during low rainfall periods there is water available to the plumbing fixtures.

The cost of purchasing and installing a rainwater tank system under this policy is currently estimated to be between Aus$3,400 (£1,400) to Aus$4,600 (£1,900).

Existing households are also encouraged to install rainwater tanks, though it is not mandatory for them to so do. For customers who voluntarily install a tank, rebates apply as per the Home Watersaver Rebate Service (see below). The rebate scheme also covers the installation of water saving appliances and flow regulators.

Figure 56: A household rainwater tank (Source: Gold Coast Water and Gold Coast City Council, www.goldcoast.qld.gov.au/t_gcw.asp?PID=4913)

Water leakage and pressure management

High water pressure in the water supply system increases water wastage due to leaks and breaks in pipelines. It also increases water use in homes and businesses. The preferred GCWF Strategy has adopted the target of reducing drinking water use by 30 ML per day by 2056 through water leakage and pressure management. The initiative is designed to reduce the water pressure in the Gold Coast's water supply distribution system by upgrading the current system. This reduction in water pressure will minimise the amount of water lost due to leakages from pipe joins and fittings, as well as reducing the amount of water consumed across the city.

Gold Coast Water conducted a trial of pressure and leakage management in one part of the city in 2003/04. Over a six-month period, steps were taken to detect and repair leaks and progressively reduce network pressures in an area containing almost 47 km of water mains, servicing 3,310 connections. During this time, average daily water consumption in the trial area reduced by approximately 22% – equivalent to 89.15 ML a year. There was also a 75% decrease in water service breaks, and a 71% reduction in water main bursts.

Following this successful trial, the pilot programme was expanded to take in other areas of the city. The pressure control is delivering similar results, with water savings expected to equal about 168 ML a year.

With the success of these trials, the leakage and pressure programme will be rolled out across the city. In May 2005, the Federal Government committed funding to assist Gold Coast Water in implementing this city-wide initiative with $3.15m (£1.3m) in assistance. The programme is being implemented progressively between July 2005 and 2007.

Water conservation
Gold Coast Water has a range of awareness, education and training programmes to promote water conservation (see section below), as well as a Gold Coast Home Watersaver Rebate Scheme. These are similar to equivalent initiatives in Melbourne (see the Melbourne case study for further details).

Gold Coast Water has also recently started the Home Watersaver Service which involves a licensed plumber visiting homes and installing water efficient devices. The scheme promotes cost-saving incentives to encourage successful adoption in the local community.

The State Government has recently introduced changes to building regulations on all new home plans approved from 1 March 2006, which must include:

- AAA-rated (or 3 star) shower roses,
- dual-flush toilets, and
- water pressure-limiting devices to restrict water in areas with high water pressure.

Regional-level drought contingency planning measures[101]
At a regional level in South East Queensland, a drought contingency plan is in place. This involves using trigger levels to reduce water consumption. Three levels have been agreed upon by SEQWater and its local government partners, implemented as follows:

- Level 1 (when combined regional water capacity falls to 40%): Voluntary call on residents to monitor their home water use and find ways to cut consumption.
- Level 2 (when capacity falls to 35%): Ban on sprinklers.
- Level 3 (when capacity is only 30%): Ban on sprinklers and outdoor hosing.

This approach to trigger levels bears many similarities to Melbourne (see the Melbourne case study for further details). As of October 2005, Gold Coast City is at level 2.

Awareness and education programmes

The Watersaver Education Programme is a city-wide scheme to improve the awareness and adoption of water efficiency in both homes and businesses. All forms of print and digital media are employed to convey the programme's message. The programme's components include:

- A Community Education component, made up of a variety of community-based activities including public fora, community events and shows, the development of Watersaver resources such as the Garden Watersaver guide, and general promotional opportunities for the Watersaver message. The intention is to raise awareness of the Watersaver message throughout the community, and to identify the water saving activities that can easily be undertaken by water users on the Gold Coast.

- The GreenPlumbers Watersaver Industry Training scheme is a national scheme to train trades-people in water conservation and environmental aspects of their work.

- The Garden Watersaver Industry Training Programme is designed to give members of the nursery, landscaping and irrigation industries the knowledge, skills and materials to be able to educate residents about water efficiency.

- The Schools Education Programme teaches students of all years to value and conserve water as part of their curriculum.

Footnotes

100 www.goldcoast.qld.gov.au/t_gcw.asp?PID=5141

101 www.waterforever.com.au/home/inner.asp?ID=61&pnav=59&onav=59

Germany and Belgium: Train depot rainwater harvesting system[102]

Overview

- To manage water resources, Germany has installed rainwater harvesting systems in industrial facilities, office buildings and residential areas
- Flanders in Belgium has introduced an obligation to install combined rainwater harvesting and attenuation systems in new buildings

Context

Germany is the leader in the field of rainwater harvesting, and has installed systems in industrial facilities, commercial office buildings, residential areas, airports, schools, prisons, etc. Other countries have followed suit, for example, Flanders in Belgium has now introduced an obligation to install combined rainwater harvesting and attenuation systems in new buildings[103].

Description of the systems

Rainwater harvesting captures and diverts rainwater. Typically, rainwater is collected from rooftops and is diverted into barrels or large storage tanks. The amount of rainwater collected from a rooftop can be significant. A 93 m^2 (1,000 square feet) roof can catch 568 litres of water from a rainfall of just 6 mm.

A soakaway is sometimes used in conjunction with rainwater harvesting, rather than a storage tank. This is a low lying area filled with stones, shingle or gravel to allow water to drain away.

A rainwater harvesting system has been installed at a train maintenance depot owned by Hohenzollerische Landesbahn (HLZ) in Germany. The rainwater is collected from the depot roof and is stored in underground tanks for future use. It can then be redistributed for cleaning trains and flushing toilets in the depot building. This system also captures and recycles the water once it has been used to clean the trains. One gantry wash plant can wash 6-10 vehicles per day, and automatically washing each vehicle uses approximately 350 litres of water. The roof area required to supply enough water is approximately 900m^2 together with a storage tank volume of 30m^3.

In Belgium, a large rainwater harvesting system has been installed at a train maintenance depot. It includes flow rate metering and water level-independent water extraction from four separate 480m^3 storage tanks, as shown in the diagram below.

Figure 57: Rainwater harvesting system used at Belgian train maintenance depot (Source: Aquality Trading and Consulting Ltd.)

Figure 58: Internal and external views of the train maintenance depot owned by Hohenzollerische Landesbahn (HLZ), Germany (Source: Aquality Trading and Consulting Ltd.)

Footnotes

102 Lutz Johnen, Aquality Trading & Consulting Ltd, Pers. Comm.
103 Lutz Johnen, Aquality Trading & Consulting Ltd, Pers. Comm.

New York City Climate Change Task Force[104]*

Overview

- There are uncertainties about how climate change will affect New York's water supply and wastewater treatment systems
- The New York Climate Change Task Force supports institutional decision-making on climate change for these systems

Context and policy drivers

The New York City (NYC) Water Supply System consists of watersheds up to 120 miles north of NYC, as well as delivery systems, and wastewater treatment plants, which discharge to the surrounding harbours and coastal estuaries.

New York City's Department of Environmental Protection is responsible for this Water Supply System. In regard to this responsibility, the New York City Department of Environmental Protection has established a Climate Change Task Force to support institutional decision-making in light of climate change, because of uncertainties about how climate change will affect New York City's water supply and wastewater treatment systems. These concerns were heightened by Hurricane Katrina.

The Task Force is addressing a range of climate risks that have impacts on the City's water supply and wastewater treatment systems including:

- sea level rise,
- higher temperatures,
- an increase in extreme weather events, and
- changing precipitation patterns.

*Case study written by Cynthia Rosenzweig, David Major, and Melissa tults, of Goddard Institute for Space Studies at Columbia Earth Institute, and Kate Demong of the New York City Department of Environmental Protection, USA, 2006.

The Commissioner of New York City's Department of Environmental Protection (NYCDEP) decided to implement the Task Force, which is a collaboration between NYCDEP and the Center for Climate Systems Research at Columbia University. Membership of the Task Force is agency-wide. Representatives from eight of NYCDEP's main bureaus are engaged in identification, evaluation, development of adaptations, and report writing. Climate change informational workshops are held for other agency staff. The response so far has been positive.

Figure 59: Treatment tanks overflowing at a Bronx Water Pollution Control Plant during March 2001 storm. Unusually high tidal elevations blocked discharge of treated sewage into the East River and caused back-up. (Source: New York City Department of Environmental Protection).

Figure 60: New York City Water Supply System. (Source: New York City Department of Environmental Protection).

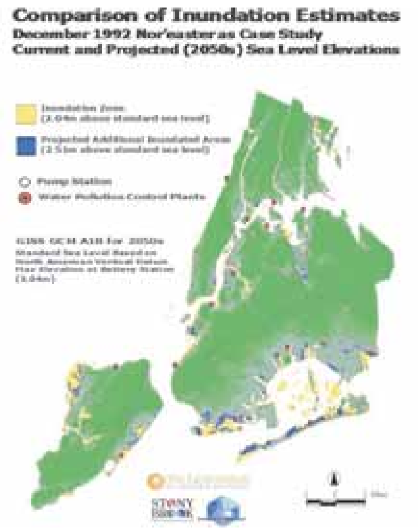

Figure 61: Inundation of New York in December 1992 storm surge compared to a projected inundation in the 2050s taking account of mean sea level rise due to climate change (Source: New York City Department of Environmental Protection).

Description of the Climate Change Task Force

The Task Force evaluates adaptation and mitigation options for both current and new infrastructure design and investment, policy planning, and operations management. It is examining adaptation options ranging from the near-term through the medium and long-term. Planning is guided by climate change scenarios, with a focus on the 2020s, 2050s, and 2080s.

An adaptation framework was created and possible adaptation strategies have been identified and assessed under a set of climate scenarios (based on the Intergovernmental Panel on Climate Change (IPCC) Global Climate Model simulations to be presented in the forthcoming IPPC Fourth Assessment Report).

Specific examples of possible adaptation measures being investigated by the Task Force include but are not limited to:

- Creating climate change scenarios for use both intra-and inter-agency,
- Evaluating and updating rainfall intensity-duration-frequency curves that can be used for the design of sewer system elements to incorporate future climate change,
- Developing strategies for the sewer system to deal with potential back-surges due to sea level rise,
- Incorporating climate change into design considerations for water pollution control plant facility rehabilitation and/or upgrade, and
- Analysing changes in dominant vegetation types in the watershed, and sediment and nutrient loads in reservoirs to support water supply management.

The various adaptation options being investigated have substantial variation in terms of cost. Detailed cost-benefit analyses are in the planning stage.

Setting up the Task Force involved overcoming institutional and bureaucratic issues, as well as successfully communicating climate science to decision-makers.

Both adaptation and mitigation of climate change are priorities within the Task Force and the NYCDEP. Currently, adaptation is the Task Force's primary focus, but planning for a greenhouse gas management plan for the agency is also underway.

Assessment of the effectiveness of the Task Force

The focus of the CCTF is on municipal stakeholders. The work that the Task Force has undertaken and shared to date has proven extremely beneficial. From educational outreach to collaboration building, the Task Force informs others within the agency and in other NYC agencies about the need for proactive planning for climate change. The success of the Task Force will be measured by the implementation of identified adaptation efforts into NYCDEP operations. Success will also be measured if the efforts lead to a city-wide Climate Change Consortium to support adaptation.

In the second half of 2006, the NYCDEP Climate Change Task Force will release its report on adaptation and mitigation responses to climate change.

Footnotes

104 Case study written by Cynthia Rosenzweig, David Major, and Melissa Stults, of Goddard Institute for Space Studies at Columbia Earth Institute, and Kate Demong of the New York City Department of Environmental Protection, USA, 2006.

Annex A

What is the London Climate Change Partnership?

The aim of the London Climate Change Partnership is to help ensure that London is prepared for its changing climate. It is chaired by Gerry Acher and supported by the Greater London Authority. It comprises key stakeholders from London governance and business.

The Impacts of Climate Change on London

The LCCP was formed in 2001 when it commissioned a study into the impacts of climate change on London from a consortium of consultants led by Entec UK. The report *London's Warming* was launched by the Mayor Ken Livingstone and Michael Meacher, the then Environment Minister, on 24 October 2002.

London can expect weather that is slightly drier overall, but with more rain in winter. We expect the weather to be warmer on average, and with more frequent extremes, such as hot dry summers. In addition, the sea level is expected to rise, more in the South East than elsewhere in the UK.

The Study looked at a broad range of impacts across issues such as flooding, water resources, health, the built environment, transport and other infrastructure, business, tourism, biodiversity, lifestyles.

Transport

The LCCP commissioned research on the impacts of climate change on London's transport systems. The report was launched in September 2005.

Development

The LCCP has been working with the South East Climate Change Partnership and the East of England Sustainable Development Round Table on a checklist for development. This argues for the principle that:

developments should be designed for the climate throughout their lifetime, not just the climate when they are built.

It provides guidance on issues such as water re-use and efficiency, reducing flood risk, avoiding overheating and minimising damage from subsidence and heave. A draft checklist was launched at the Sustainable Communities Summit in February 2005 in Manchester and the consultation period closed at the end of April. The final checklist was launched at the Thames Gateway Forum in November 2005.

Chair

Gerry Acher CBE LVO was appointed Chair of the London Climate Change Partnership in 2005. Until December 2001 Gerry Acher was a member of the board of KPMG and the Senior Partner of its London office. Between 1999 and 2004 he was a member of the Government's Advisory Committee for Business and the Environment. He is a member of the President's Committee of London First.

Membership

The London Climate Change Partnership is led by the Greater London Authority. Partners include:

- Government Office for London,
- Environment Agency,
- Thames Water Utilities Ltd,
- Association of British Insurers,
- acclimatise,
- Corporation of London,
- Association of London Government,
- London Sustainability Exchange,
- London Development Agency,
- London Climate Change Agency,
- London Resilience,
- Transport for London,
- Thames Gateway London Partnership,
- Housing Corporation,
- Regional Public Health Group – London,
- UK Climate Impacts Programme.

Publications

London's warming: the impacts of climate change on London Summary Report, London Climate Change Partnership, 2002

London's warming: the impacts of climate change on London Technical Report, London Climate Change Partnership, 2002

The impacts of climate change on London's transport systems, Greater London Authority, 2005

Adapting to climate change: a checklist for development, Greater London Authority, 2005

Further information

Reports are available to download from www.london.gov.uk/climatechangepartnership

For further information, contact Climatechangepartnership@london.gov.uk

July 2006

Acknowledgements

Acclimatise are indebted to the following people who have contributed to the study.

Gerry Acher, Chair, London Climate Change Partnership, UK

Gotelind Alber, Climate Alliance, Germany

Harry Archibald, Alberta Environment, Canada

Richard Ashley, Department of Civil and Structural Engineering, University of Sheffield, UK

David Baker, Transport for London, UK

Richard Barton, London Underground Ltd, UK

Phil Bedient, Civil and Environmental Engineering, Rice University, USA

John Blanksby, Department of Civil and Structural Engineering, University of Sheffield, UK

Sheridan Blunt, City of Melbourne, Australia

Penny Bramwell, Government Office for London, UK

Clare Brennan, Greater London Authority, UK

Stephan Brenneisen, Institute of Geography, University of Basel, Switzerland

Virginia Burkett, US Geological Survey, USA

Sebastian Catovsky, HM Treasury, UK

Matthew Chell, Greater London Authority, UK

Shen Chunlin, Shanghai Institute of Preventive Medicine, China

Stewart Cohen, Institute for Resources, Environment & Sustainability, University of British Columbia, Canada

Keith Colquhoun, Thames Water Ltd, UK

Andrew Comrie, Department of Geography and Regional Development, University of Arizona, USA

Wim Dauwe, Flemish Waterways Authority, W&Z, Antwerp, Belgium

Andrew Deacon, Department for Environment, Food and Rural Affairs, UK

Kate Demong, New York City Department of Environmental Protection, USA

Rachael Dempsey, CSIRO, Australia

John Dora, Network Rail, UK

Andrew Eagles, The housing corporation

James Farrell, Greater London Authority, UK

Jenny Fraser, British Columbia Ministry of Environment, Canada

Dusty Gedge, Livingroofs.org, UK

Marc Gillet, Observatoire National sur les Effets du Réchauffement Climatique, France

Oliver Grant, Environment Agency, UK

Simo Haanpaa, Centre for Urban and Regional Research, Helsinki University of Technology, Finland

Jacquelyn Harman, UK Climate Impacts Programme, University of Oxford, UK

Madeleen Helmer, Red Cross, Netherlands

Kevin Hennessy, CSIRO, Australia

Nannerl Herriot, Regional Public Health Group – London, UK

Tetsuya Ikeda, JICA Japan-China Technical Cooperation, China

Lutz Johnen, Aquality, UK

Andre Jol, European Environment Agency, Denmark

Catherine Jones, Transport for London, UK

Wynne Jones, Transport for London, UK

Sari Kovats, London School of Hygiene and Tropical Medicine, UK

Paul Kirshen, Civil and Environmental Engineering Department, Tufts University, USA

Klaus Koenig, Professional Association for Water Recycling and Rainwater Utilization, Germany

Andreas Kress, Climate Alliance, Germany

Diana Liverman, Environmental Change Institute, University of Oxford, UK

Will Lochhead, Government Office for London, UK

David Major, The Earth Institute, Columbia University, USA

Edmund Maurer, Municipal board of Linz, Austria

Gerry Metcalf, UK Climate Impacts Programme, University of Oxford, UK

Glenn McGregor, Department of Geography King's College London, UK

Jane Milne, Association of British Insurers, UK

Jelle van Minnen, Netherlands Environmental Assessment Agency, Netherlands

Philip Mote, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, USA

Alex Nickson, Greater London Authority, UK

Niels Nijmeijer, Water Board Riverland, Netherlands

Paulo Nogueira, National Institute of Health, Portugal

Jennifer Penney, Clean Air Partnership, Canada

Benjamin Preston, CSIRO, Australia

Jill Rankin, Hampshire County Council, UK

Tim Reeder, Environment Agency, UK

Shirley Rodrigues, Greater London Authority, UK

Per Rosenqvist, Swedish Commission, Sweden

Cynthia Rosenzweig, NASA and the Earth Institute, Columbia University, USA

Jennifer Salmond, Division of Environmental Health and Risk Management, University of Birmingham, UK

Rob Shaw, Town and Country Planning Association, UK

Michel de Smet, Flemish Waterways Authority, W&Z, Antwerp, Belgium

Amy Snover, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, USA

Maryke van Staden, Local Government for Sustainability, Germany

Roger Street, UK Climate Impacts Programme, University of Oxford, UK

Melissa Stults, The Earth Institute, Columbia University, USA

Tracy Tackett, Seattle Public Utilities, USA

Jianguo Tan, Shanghai Urban Environmental Meteorology Research Center, China

John Taylor, Seattle Public Utilities, USA

Andrew Tucker, Thames Gateway London Partnership, UK

Richard Ubbens, City of Toronto, Canada

Jack Vokral, New York City Department of Environmental Protection, USA

James Voogt, Department of Geography, University of Western Ontario, Canada

David Vowles, London Resilience/Greater London Authority, UK

Ger de Vrieze, Water Board Riverland, Netherlands

Keith Ward, Seattle Public Utilities, USA

Jane Welsh, City of Toronto, Canada

Chris West, UK Climate Impacts Programme, University of Oxford, UK

Eva Wong, US Environmental Protection Agency, USA

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