

# Overcoming barriers in the transition from piped to alternative drainage systems

Ashley R M<sup>1</sup>., Cettner A<sup>1</sup>., Viklander M<sup>1</sup>., Walker L<sup>2</sup>., Sharp L<sup>3</sup>., Westling E<sup>3</sup>.

<sup>1</sup>LTU Lulea, Sweden

<sup>2</sup>Pennine Water Group, University of Sheffield, UK

<sup>3</sup>Pennine Water Group, University of Bradford, UK

## Introduction

Drainage and stormwater management are usually considered as secondary issues when developing urban areas. The layout of the properties, the road network and other aspects are organised first and drainage is 'easily dealt with' by laying convenient networks of pipes connecting foul water to sewers and stormwater either into a combined sewer or to some conveniently located water course or body (Butler & Davies, 2010). Unfortunately there are problems with this approach:

- Increased incidents of flooding in urban areas due to climate and other changes, such as more paved surfaces with increased runoff of rainfall, all overloading piped drainage systems;
- The recognition that stormwater discharges into water bodies causes both pollution due to the conveyed pollutants and also erosion and ecosystem damage;
- Burying the stormwater running off urban surfaces is a lost opportunity in that it makes no contribution to urban liveability via sustaining green areas nor does it provide opportunities for alternative water supplies for e.g. garden watering or toilet flushing;
- The construction of piped drainage systems requires significant use of energy, carbon emissions and in use, often continuing pumping and energy use;
- Buried piped systems with separate pipes for stormwater and sanitary flows often suffer from wrong connections of one into the other;
- Where the drained stormwater system connects into an existing main sewer system, this system may become overloaded in times of rainfall and if it is a combined sewer, discharge dilute foul sewage mixed with the stormwater via combined sewer outfalls into water bodies, causing significant ecological impacts and aesthetic problems due to smells and sewage derived solids.

There has been a growing recognition in many countries worldwide that stormwater should be managed using systems other than pipes and sewers because of some or all of the above problems (e.g. Chocat et al, 2007; Ashley et al, 2011). An emerging consensus is that alternative systems can achieve more safe (from flooding) urban surfaces by keeping water closer to its source, i.e where it lands and hence, the alternative system involves many more distributed (decentralised) components than the traditional system and these components may be multi-functional, i.e. provide environmental protection and visual amenity and other elements not just concerned with drainage (Ashley et al, 2011).

Much has been written about the need for and how best to bring about changes to the way in which urban stormwater is managed in developed countries and whether or not resistance to change is an institutional, professional or governance problem (e.g. van De Meene, 2010). Nevertheless in some

parts of the world particular external stresses or drivers such as drought and/or environmental protection have led to a change in the perspective on urban water from a problem to an opportunity (e.g. in Australia: Centre for water sensitive cities, 2011 and USA: USEPA, 2010). Such alternative systems have a variety of names and there is no global consensus on what they should collectively be termed. For example, in the USA and Australia stormwater is seen as a potential resource, not a threat, in providing 'green infrastructure' (GI) (e.g. Seattle Public Utilities, 2009) and alternative sources of water as part of a process known as Water Sensitive Urban Design (WSUD) (Wong, 2006) respectively. In many parts of these countries the development process is strongly aligned with this vision and planning and building processes seek to utilise non-piped drainage systems for stormwater management. In EU countries there is a much more mixed attitude amongst developers and the professionals responsible for planning how best to manage stormwater, despite there being a wealth of information, knowledge and evidence about the value of using alternative drainage systems. It may be considered that there are two competing stormwater drainage systems: one is traditional and the other is being asserted as a superior alternative and therefore the putative switch to the latter could be perceived as a potential transition. In practice some countries, regions and areas are further advanced along this transition than others.

This paper examines the stalled transition in England and Wales and the on-going but slow transition in Sweden from one dominant regime, that of piped stormwater drainage, to an alternative, which here is termed the stormwater utility niche (SUN) regime. This is considered in contrast with practice in USA and Australia. A recently developed theoretical model for understanding transitions (de Haan & Rotmans, 2011) is used: A multi-pattern approach describing sequences of patterns of change. The latter provide a definition of transitions: *"as a fundamental change in the structures, cultures and practices of a societal system, profoundly altering the way it functions."* The way in which stormwater has traditionally been managed is illustrated in Figure 1 using constellation' perspective. This is explained in the following sections.

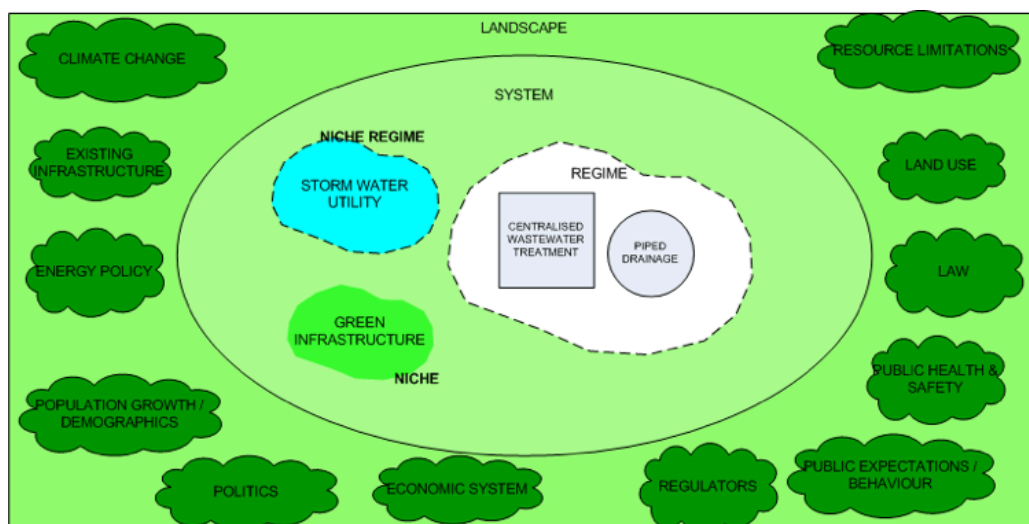


Figure 1 Urban drainage system illustrated in terms of a number of constellations

## Societal systems and transitions

Societal systems are complex adaptive systems that adapt to the prevailing environment and simultaneously to societal needs. The societal system is composite, built up from a number of

societal subsystems. In de Haan's (2010) theory, the societal subsystems are denoted as constellations which together compose the societal system as a whole (e.g. Figure 1). The dominant or most powerful constellation is the regime and this functions as the normal way in which societal needs are met within a particular domain.

Stormwater is usually disposed of via drains and sewers and hence centralised wastewater treatment is the dominant constellation providing for society's needs (Figure 1). The weaker constellations are deviants, novel, unorthodox or provide for particular and specific needs not fulfilled by the regime; these are niches. For example, rainwater harvesting is a non-dominant constellation that provides a particular societal need and that is not usual, certainly in the UK and Sweden, although common in Australia. Recently, however, even the English water companies have started to refer to rainwater harvesting in their forward thinking (e.g. Kelda Group, 2011) as part of integrated water management. Niche-regimes are constellations that challenge the dominant regime competitively. Source control urban drainage, known as SuDS in the UK, is a niche-regime in Australia as part of WSUD and is rapidly becoming the dominant regime in the USA. In the UK, this approach is verging on becoming a niche-regime but is not quite there yet. Whereas in Sweden, it is the dominant regime in some places (e.g. Malmö, Stahre, 2008) and there is mixed use of both regimes in many other areas (Cettner et al, undated).

When a dominant constellation becomes displaced by a new regime, there is a transition to a new functioning of the societal system, known as a regime shift (de Haan & Rotmans, 2011). Transitional change occurs in a series of phases of relatively slow, fast and slow dynamics, as a multi-phase concept. The process of transition is: niche > niche-regime > displaced/replaced regime. When this happens the changed regime is a new way of providing society's needs; not simply a gradual evolution to a better functioning of the original regime which is only an evolutionary transformation into a revised state that is not significantly different from the previous. An evolutionary change might be the shift from using combined to using separate sewers. In contrast, historically the transformation from pre-sewered cities to seweraged cities may be considered as a real transition to a new regime (Geels, 2006).

There are 3 stages in the application of the theoretical model of de Haan & Rotman (2011), understanding:

- conditions* under which a transition (from one dominant constellation to another) will occur – the drivers for this process
- patterns* of transitional change – social mechanisms that describe typical forms of transitional change
- pathway* of a transition – how it unfolds with time

The conditions are drivers for the patterns and a transitional path is a result of the patterns.

## **Drivers and conditions for change**

The conditions above may be considered as necessary to, but not necessarily sufficient in themselves for a societal change, these are further explored below.

Drivers of transitions are founded in societal need. If a function is not adequately fulfilled then there is a need for a change in constellation(s). This may be due to changing needs in society as much as a

failure of the regime to fulfil the needs. Urban drainage contributed enormously to public health, welfare and safety by the introduction of 'universal' sewerage in the developed world by the mid 20<sup>th</sup> Century, such that waterborne disease outbreaks became extremely rare. Expanding cities, increased sealing of surfaces, more and more roads, densification, growing individual wealth and expectations of safety and security from threats by citizens, however, had already begun to challenge the efficacy of the dominant regime as flooding was found not to be eliminated entirely.

The growing wish for environmental protection coupled with excessive water resource consumption meant that stormwater discharges had to be cleaned up and more water began to be passed downstream to treatment plants. This was further encouraged in Europe by the Urban Wastewater Treatment Directive (91/271/EEC). Ideas about sustainability<sup>1</sup>, had also drawn attention to the need to balance societal needs, environmental and economic considerations and in Europe. The Water Framework Directive (WFD) (2000/60/EC) attempts to point the way to do this, although it emphasises not at disproportionate cost. The subsequent introduction of what is known as the Floods Directive (2007/60/EC), enjoins the WFD and flood risk management into an integrated vision for 'natural' water management that challenges the efficacy of the sewer regime which is incapable of simultaneously delivering all of society's needs and expectations (Ashley & Brown, 2009).

Climate change further complicates this picture and society requires infrastructural systems that are flexible and adaptable in order to remain functional in the face of uncertain climate change threats with locally unpredictable consequences. Evidence illustrates that piped/sewered systems are much less flexible than alternative local, at source, decentralised and dispersed systems for stormwater management (Peters et al, 2011).

The niche-regime of stormwater utility in Figure 1, coupled with the niche constellation of open space and green infrastructure can provide the necessary flexibility and also a wide range of multi-functional benefits that piped drainage systems alone cannot. These constellations can, together, also provide all of the functioning that the incumbent piped system regime can deliver, although this requires the appropriate and definitive separation of storm and foul sewage in order to maintain the public health and welfare that was brought in with the original introduction of piped drainage systems in the 19<sup>th</sup> Century.

Where the regime is not in tune with the overall environment or landscape within which it is set, it is said to be suffering from *tension*. Clearly stormwater management systems are set within the landscape outlined above (Figure 1), and in their failure to provide the range of societal needs and expectations from these systems there are tensions between the use of sewers and their required functioning. There are two tensions: Structural and cultural. *Structural tension* relates to the physical infrastructure and associated economic, legal and formal aspects of the regime's relationship with the environment in which the regime is embedded. Whereas *cultural tension* may exist in the cognitive, discursive, normative and ideological relations between the regime and the surrounding environment.

Clearly debates about the relative merits of sewerage versus source control stormwater systems cover both types of tension. For example, construction and operation of sewers requires

---

<sup>1</sup> Sustainability is still a contested concept

considerable energy and carbon emissions, which is at variance with the current push to mitigate the effects of climate change by reducing emissions. Yet the discursive and ideological views of this are extremely limited by the way in which the constellation delivers the 'outputs'. In London, for example, the 'super-sewer' Tideway Tunnel is in process of being delivered – a 37km long 7.2m diameter tunnel to manage some 60 CSO discharges into the River Thames with no benefit in terms of flood risk reduction or in supplementing the water supplies in the City (Thames Water, 2010). This is going ahead despite exhortations to reduce carbon emissions and is in total disregard for developments in knowledge in more than a Century as it is simply replicating the Victorian approach of using large sewers for public protection, albeit in this case the main driver is river pollution. The primary reason for this is that there is a need to fulfil the requirements of the Urban Wastewater Directive (UWWTD) but also, because the regime player, Thames Water Services, is only empowered to construct sewers, not the alternatives being built elsewhere in the world in similar sized cities (*ibid*). An equivalent constellation image to Figure 1 could be constructed showing how the regime and constellation players and actors are inter-related and where the dominant regime sits in terms of power; with in this case, the private water companies having the power in England and Wales.

*Stress* is said to occur where the dominant regime's functioning is inconsistent or inadequate within itself; where the structure of delivery fails to match with the complementary internal culture. An example is where the constraining of discharges from CSOs forces more stormwater to be passed to treatment plants, in turn reducing the efficiency of operation of the plants, in turn requiring more energy and chemicals to be used. In England, the revolution in water service provision brought about by privatisation in 1989 has been credited with providing the essential services and infrastructure ever since and at lower cost than if privatisation had not occurred (House of Lords, 2006). Yet the indebtedness of these private companies is considerable (STW, 2010) and many of the former assets have been stripped; making the effectiveness and efficiency of the promoted private model questionable. In 2011, the economic regulator for the water industry is pushing for yet more 'competition' and fragmentation of the water industry which will further compromise the ability of the service providers to deliver the multi-value and multi-functionality that society now demands (Cave, 2008).

Niche innovations that challenge the dominant regime are said to exert *pressure* on the regime and source control systems for managing stormwater outside the sewer system potentially make many stormwater sewers redundant and simultaneously provide multiple benefits, including increased efficiency in sewage treatment. Pressure can often be considered therefore as competition. This example illustrates how the niche regime of stormwater utility can potentially make aspects of the sewer regime redundant or obsolete. There have been a number of initiatives in England and Wales to challenge the dominant sewer regime, although practice in Scotland has already shifted to prioritise stormwater utility approaches (e.g. SuDS working party, 2010). In Scotland the shift was in recognition of the need to manage the impact of stormwater on receiving water quality, whereas in England and Wales, the driver has been managing flooding.

In England the Flood & Water Management (FWM) Act 2010 is now being implemented and was developed mainly in response to the 2007 flooding. This Act places a lot of reliance on so-called

Sustainable drainage systems (SuDS)<sup>2</sup>; a key element of stormwater utility approaches. Nevertheless the precise way in which the Act is being commenced; in a process of co-creation between Government and those who will have to implement the Act in practice, may mean that the use of piped systems will still remain the norm in England. In this case, England will be out of step with both Scotland and Wales, with the latter having a ‘surface water management strategy’ (SWMS) designed to take stormwater out of the sewer networks of Wales. The SWMS has taken some ideas from initiatives such as those in Portland, Oregon (Foster et al, 2011) and calls for engagement, charging, legislative and technical initiatives that could help reduce surface water flow (DCWW, undated).

## Patterns

Transitions are continually occurring and occur in patterns. Such patterns are emergent phenomena (whole being more than the sum of the parts) (Ashley & Brown, 2009) and autonomous in relation to the processes that produce the patterns. De Haan & Rotmans (2011) suggest that there may be a limited number of ideal patterns which may be used to describe how one constellation can ‘rise to power’ and how the regime adapts. Two extremes may be considered: forced from outside the system and/or risen from within. Where the latter occurs, smaller internal constellations within the landscape gain power and compete for the regime, in a process called *empowerment*, essentially a bottom-up process. This may be applicable to describe the change from combined sewer systems to separate systems in the mid 20<sup>th</sup> Century. The example of the promotion of SuDS in the new Act in England is a top-down imposed pattern, were it to result in a displacement of the piped drainage regime, being an externally forced transitional pattern, known as *reconstellation*. Where the original piped drainage regime (which would remain for foul sewage) absorbs the change as it has in Scotland (by Scottish Water) this would be a process of regime *adaptation* which may in fact be a transformation rather than a true transition. The three elements of empowerment, reconstellation and adaptation may be used together to describe any transition in a concatenation of patterns acting on a societal system.

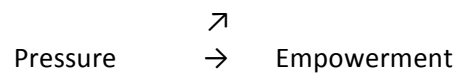
## Applying the constellation (or ‘3 pillars’ model) to urban drainage

Here the state of the system may be defined initially in terms of its’ composition – the regime, niches, niche regimes and the landscape; then in terms of the condition, including tensions, stress and pressures that may possibly drive change. It may then be possible to define the pattern that changed the system state (in an existing system that has changed this is possible by backcasting) from some former state. Sequential patterns together can be concatenated to develop a continuous pathway of transition. Conditions drive patterns (de Haan, 2010) as illustrated in Table 1.

Table 1 Certain conditions drive certain patterns of change

Condition		Pattern
Tension	→	Reconstellation
	↘	
	↗	
Stress	→	Adaptation
	↘	

<sup>2</sup> There is limited evidence that such systems are necessarily more or less sustainable than alternatives and in any case the context in which they are used is as important in defining whether or not they are more or less sustainable



For this paper the change from the dominant piped drainage regime to another more effective regime, that of stormwater utility in Europe is of interest. This change has not taken place and is in various states as illustrated in Table 2 for the countries being considered.

Table 2 The state of stormwater drainage regimes in example countries in Europe

Country	Stormwater drainage Regime	Attributes	Main reasons for prevailing regime
Scotland	Main driver is environmental protection. Preference for non-piped systems enshrined in regulations and supported by Government and institutional actors and no attempt at integrated water management only application of SuDS	Responsibilities defined in regulations. National pilot projects give widespread examples although good scientific and economic evidence is lacking. Nonetheless developers preferentially constructing systems to be adopted by Scottish Water.	Developers perceive non-piped systems to be more expensive and less attractive to property owners. Municipalities have limited resources to engage and encourage alternative systems.
England	Main driver is flood risk management. Default is to use piped drainage systems unless forced to do otherwise despite new Act. Sector dominated by large monopoly private water companies responsible for sewerage.	Planning stipulations rarely define the need to use stormwater utility systems. Little connection between liveability and linking stormwater and green infrastructure. Development land use and road layouts prioritised. Few pilot studies or scientific investigations. Little cost-benefit data. Some water companies now perceive there is a potential commercial advantage in promoting SuDS (e.g. Anglian Water, 2011)	As above. Densification and construction on brown field sites make application of non-piped systems difficult and perceptions about land-take and loss of revenue dominate developer's beliefs. Municipalities chronically resource limited. Interest mainly in flood risk management prevents multi-value benefits from being accounted for. There are niche interests amongst professionals and some authorities but no clarity (Walker et al, undated)
Wales	Main driver is flood risk management. Incumbent regime actor, Welsh Water has adopted a surface water management strategy (SWMS) to disconnect supported	Widespread awareness amongst virtually all of the main players of the SWMS and potential benefits. To effect a change all aspects of business need to be changed, not simply the aspirations to use non-piped systems.	General willingness to use alternatives but practicalities of delivery inhibiting pilot projects. Lack of credible UK examples. Interest mainly in flood risk management prevents multi-value benefits from being

	by Government although this is linked to a green space strategy (DCWW, undated)		accounted for and is inhibited by the economic regulator's (Ofwat) stance on this. Business model of Welsh water so far has inhibited the use of non-piped systems.
Sweden	Main driver is flood risk management usually combined with environmental protection. The norm is to use piped drainage systems but many municipalities support alternatives in regulations.	Municipalities are legislated to be responsible for urban planning, including stormwater management. The municipalities' Water divisions mission and responsibility is to provide citizens with water and sanitation services regulated in the Act on public water services. There is widespread awareness of stormwater alternatives amongst the main players. There are many national non-piped project examples over the last decades in cities and towns without any wider impact in smaller settlements.	Municipalities have varying engagement in promoting alternatives. Many municipal interests have to reach some consensus in the planning process (Cettner et al, undated). Water divisions' influence and commitment to alternatives in planning activities varies. Regulations in the Act of public water services inhibit alternative approaches in practice. This also applies to the powerful players as developers and contractors who often divert good intentioned municipalities to use traditional drainage.

Starting from the information about the state of the stormwater drainage regime in England given in Table 2, the stalled transition will be considered in relation to the potential pathways in Table 1, in Table 3.

Table 3 Potential pathways to transition of stormwater management in England

Pattern	Conditions for change	Characteristics	Evidence
Reconstellation	Tension	Top-down imposed change coupled with adverse functioning of the constellation in relation to its environment.	Water management is fragmented among: private water and sewerage companies, municipalities, highways, developers and individuals each with their own motives and beliefs. The FWM Act purports to address the need for change and promote this pathway. In practice provisions are being diluted by a single (peak) group – developers with a selfish and narrow vision and also several water companies. Water industry regulator is promoting pilot projects by water companies using non-piped systems for flood risk reduction but many companies are resisting this and the regulator is actively promoting piped drainage systems where it is 'too difficult' to promote the alternative.

	Stress	Top-down imposed change responding to internally adverse functioning of the constellation.	Also to some extent following the above, although perhaps the main stress driver is the regulator for the water companies, Ofwat, recognising that managing flooding using sewers is unaffordable.
Adaptation	Tension	Internally induced changes in response to adverse functioning of the constellation in relation to its environment	Some English water companies see business opportunities in services offered to operate non-piped systems. Some land use planners stipulating non-piped systems in strategic plans.
	Stress	Internally induced changes responding to internally adverse functioning of the constellation	Some English water companies see a change as being desirable due to multiple benefits to them: e.g. lower flows to treatment and cheaper ways of delivering sewer flood risk reduction.
	Pressure	Internally induced changes responding to adverse functioning with respect to another constellation	Some companies starting to recognise flow attenuation, water quality, energy and carbon benefits of non-piped systems in their climate change mitigation and adaptation plans, although no real action as yet.
Empowerment	Stress	Bottom-up constellation change responding to internally adverse functioning of the constellation	Certain developers, planners, municipalities and visionary consultants delivering non-piped drainage systems in recognition of limitations of existing regime and multiple benefits of alternatives
	Pressure	Bottom-up constellation change responding to adverse functioning with respect to another constellation	As above, and going further in terms of relating alternative systems to multi-benefits and energy in other constellations. Increasing awareness & acceptability in professionals & public for alternatives

Table 3 illustrates that there are a number of niche and supporting attempts to effect the transition from piped stormwater drainage systems to alternatives and hence stormwater utility systems can be seen to truly be definable as a niche-regime. However, so far this can be termed a failed transition, definable as a 'Lock-in' (Ashley & Brown, 2009), where the transition has influenced the regime but failed to displace it. The most notable example of the failure is the continued construction of the Thames Tideway Tunnel (Thames Water, 2010). Figure 2 illustrates the transition pathways for the dominant regime, together with the emergent pathway for the alternative non-piped constellation in English practices for stormwater management. As this is closely tied to foul (sanitary) sewage management, the pathway for the development of foul sewage management is also shown.

Figure 2 shows that concatenations of transition patterns have occurred in English stormwater management and that the de Haan model provides definable elements of the constituent patterns.

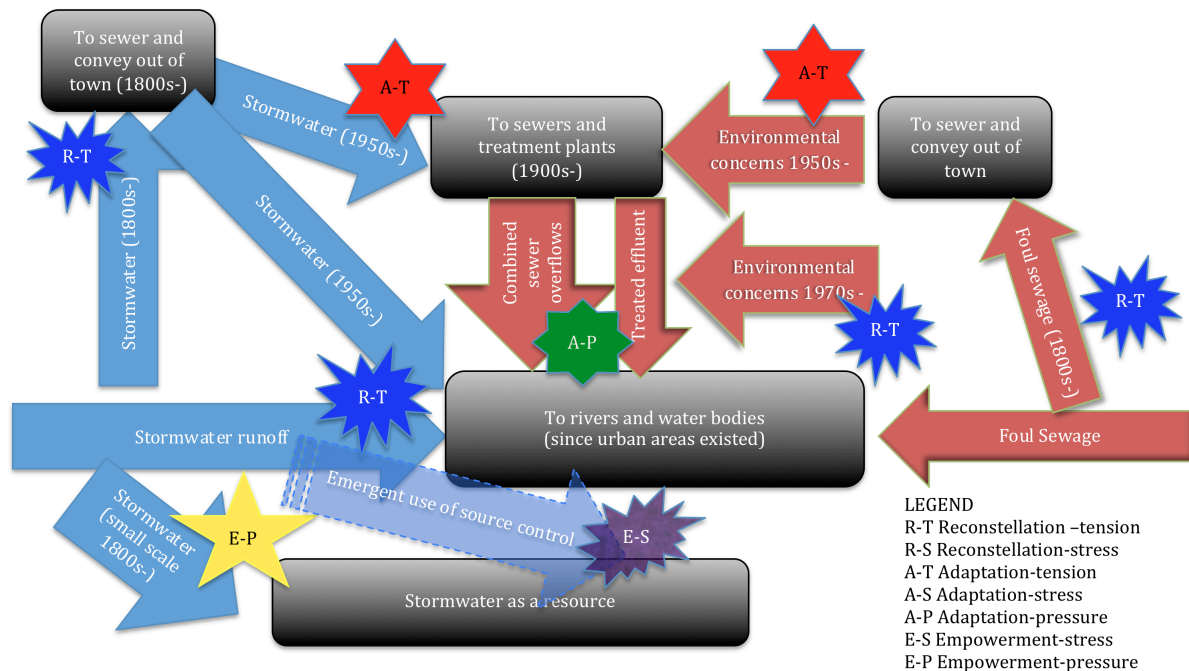


Figure 2 pathways to transitions in stormwater management in England

In Wales, there is much more of a consensus as regards the need to change the incumbent regime, following some 4 years of engagement with as wide a range of stakeholders as possible. Change is led by the private water company Dŵr Cymru Welsh Water (DCWW). This contrasts with a number of the equivalent water companies in England, who are amongst the biggest opponents to change there. In Wales, DCWW have a different business model to the rest of the UK, with no shareholders and have effectively ‘given themselves back to the people of Wales’ (Glas Cymru, 2011) as all profits are redistributed by DCWW back to the water charge payers annually. Table 4 shows how there is an on-going attempt to transition to stormwater utility from piped sewers in Wales.

Table 4 Potential pathways to transition of stormwater management in Wales

Pattern	Conditions for change	Characteristics	Evidence
Reconstellation	Tension	Top-down imposed change coupled with adverse functioning of the constellation in relation to its environment.	Water management is fragmented among: DCWW, municipalities, highways, developers and individuals each with their own motives and beliefs. The new FWMAct in England may also be adopted in Wales but the way in which it will be delivered is likely to be different, with greater commitment and compulsion for change from DCWW and the devolved Welsh Assembly Government (WAG). The WAG’s relationship with DCWW enables greater innovation in water service provision than in England, a closer working

			relationship with local authorities & a drive to consider Welsh interests in context. DCWW are still subject to Ofwat's regulation and in the 2009 price review Ofwat compelled DCWW to link their SWMS with reducing a number of properties at risk from sewer flooding. This clear target has skewed the on-going delivery of the SWMS with many more plans now aimed at using stormwater sewers rather than SuDS (DCWW, 2009).
	Stress	Top-down imposed change responding to internally adverse functioning of the constellation.	DCWW & WAG recognise the multi-value potential of alternative stormwater management, although the main stress driver as in England, is the regulator for the water companies, Ofwat, recognising that managing flooding using sewers is unaffordable. DCWW led the way in promoting the alternative approach (the SWMS) and this was taken up by the regulator.
Adaptation	Tension	Internally induced changes in response to adverse functioning of the constellation in relation to its environment	New SuDS pilot projects underwritten by DCWW are now being delivered in order to give other stakeholders (municipalities, developers etc.) confidence in the new approaches.
	Stress	Internally induced changes responding to internally adverse functioning of the constellation	DCWW has restructured following the 5 yearly price review. Partly in recognition of the previous business model's limitations for delivering a new regime it has fundamentally altered its functioning to bring more control over stormwater planning. In the former business model stormwater systems were delivered by term contractor-consultants who were disproportionately rewarded for 'digging large holes'. DCWW see a change as being desirable due to multiple benefits to the business and delivery of services to the people of Wales: e.g. lower flows to treatment and cheaper ways of delivering sewer flood risk reduction.
	Pressure	Internally induced changes responding to adverse functioning with respect to another constellation	DCWW recognise energy and carbon benefits of non-piped systems, although there is no real action links to these as yet. As yet the vision is not in terms of benefits for environmental management only for flooding.
Empowerment	Stress	Bottom-up constellation change responding to internally adverse functioning of the constellation	As in England certain developers, planners, municipalities and visionary consultants are delivering non-piped drainage systems in recognition of limitations of the existing regime and of the multiple benefits of alternative systems,
	Pressure	Bottom-up constellation change responding to adverse functioning with respect to another constellation	As above, and going further in terms of relating alternative systems to multi-benefits and energy in other constellations. Public engagement and the 'Greenspace Wales' campaign (of which SWMS is part) are helping to create public acceptability of the SWMS. Examples from the USA (notably Portland, Oregon) have been lauded by DCWW.

It is apparent that in Wales there is a very strong attempt to transition the ambient constellation to a new way of delivery of stormwater management and this is illustrated by the media interaction and the public and wider information systems and engagement (DCWW, undated). However, change has been slow due to the complex business structure used for delivery by DCWW up until 2010/2011 that has had to be reformed to align it better with the new aspirations. The previous business delivery relied on multiple term contractor/consultant teams who delivered assets with end targets that could be met using conventional sewered systems. Attempts to change the activities of these contractors were futile as their rewards were based on how many and how big the holes were that were used to construct the sewers. In the new model, most of the planning and design of new assets has been moved back in-house to DCWW, where the SWMS can be delivered. Nonetheless the edict from Ofwat to address a number of problems of properties with a sewer flooding risk within a short time period as part of the SWMS has meant that there has been a disproportionate focus on this aspect of stormwater management rather than the wider benefits. A traditional approach is now emerging whereby the use of 'we know they work' stormwater sewers rather than SuDS is becoming once again the norm.

This perhaps illustrates the need to change more than the obvious in a transition process – not simply to inform and exhort but to actually look at weak and ineffective business structures and narrow minded regulatory systems in terms of the needs for the wished for changed constellation.

In Sweden, pathfinding activities for managing stormwater using alternatives to piped drainage systems have been world leading (e.g. Stahre, 2008; Urban Water, 2009). Yet it is questionable as to whether or not a transition has actually taken place, or whether it is still aspirational on the part of a few visionaries. Table 5 provides an overview of the transition pathways in Swedish stormwater management.

Table 5 Potential pathways to transition of stormwater management in Sweden

Pattern	Conditions for change	Characteristics	Evidence
Reconstellation	Tension	Top-down imposed change coupled with adverse functioning of the constellation in relation to its environment.	A platform for change is the formal legislative act for the planning process which provides an opportunity to manage stormwater differently. The formal legislation for managing water does not actively encourage the use of non-piped systems.
	Stress	Top-down imposed change responding to internally adverse functioning of the constellation.	Strong local political support is a crucial driver in some municipalities to address alternative stormwater management. Some municipalities have adopted an 'environmental friendly' profile which facilitates the introduction of alternative solutions. Stormwater strategies have been developed and politically decided in many municipalities in order to support decisions about non-piped solutions.
Adaptation	Tension	Internally induced changes in response to adverse functioning of the constellation in relation to its environment	Experiences of flooding, increasing population, city expansion and densification. Existing water systems are not general seen as adequate for expansion for future needs. Many professional would rather use non-piped systems to supplement water supply options.

	Stress	Internally induced changes responding to internally adverse functioning of the constellation	Many Water divisions in the municipalities have an active part in the planning process; striving to deliver alternative systems. This is sometimes a result of the Water divisions' own initiative. If not fully aligned with the planning process, Water divisions struggle to achieve an adequate position to influence and control the plans for stormwater management.
	Pressure	Internally induced changes responding to adverse functioning with respect to another constellation	Some Water divisions see only limited possibilities to influence stormwater alternatives due to the lack of legal requirements. The water divisions' responsibility for alternatives is perceived as unclear with regard to the formal water act. Some Water divisions work is however, innovative and can create conditions in planning for alternative stormwater systems supported by other municipality departments.
Empowerment	Stress	Bottom-up constellation change responding to internally adverse functioning of the constellation	Water divisions sometimes take a clear stand and embrace stormwater solutions with or without pipes, in a planning context and in practical responsibility. This influential position has to be continuously striven for by the water division in order to be sustained. Competition with other players with an interest in stormwater can be challenging for the water division. Together with planners and other municipal departments, many develop ideas for using alternative drainage systems. However, these ideas are not always constructed as often powerful developers and contractors inhibit the process; preferring traditional piped systems.
	Pressure	Bottom-up constellation change responding to adverse functioning with respect to another constellation	Innovative municipalities and Water divisions have experienced growing interest in stormwater from the public. This is due to media publicity which in turn creates a certain pride amongst water professionals. Their efforts in delivering alternative solutions increasingly helps draw attention and focus on the aesthetic value of stormwater in the city environment.

Table 5 shows how Sweden is on a transition pathway, with mixed stormwater planning between the old piped regime and the new SUN. From early stage pilots that introduced non-piped solutions in demonstration projects, more trust is now put in the SUN niche-regime. Today there is a widespread attitude amongst professionals and others regarding the need to replace traditional piped solutions with alternatives. Nevertheless the diversity of local policies across Sweden's 290 municipalities that need to support the transition means that nationally the change process is slow. The regime has not been entirely displaced in municipalities and the use of traditional piped-system is functioning in parallel with the use of non-piped systems. In a number of cases the transition is being opposed in planning developments by powerful municipal actors (including developers and contractors) and by shortcomings in the water legislation that does not explicitly include any responsibility to operate and maintain stormwater alternatives by municipalities.

There is evidence of a potential pathway of change where planning takes fuller account of stormwater management and the Water divisions' gain power to influence the use of alternatives in a broader, integrated water management and multi-value sense. The change is being led by a small number of individual municipalities where the municipal support via e.g. policy leads to

reconstellation, motivating individual departments, including the Water division, to work together for innovative stormwater alternatives. The reconstellation, changes to local stormwater policies and being seen as a leading environmental municipality, raises empowerment, encourages a bottom-up change, becomes more visible in media and gains public attention appears to be a strong transition pathway to follow. This pathway further motivates the key actors involved to seek new ways to deliver stormwater alternatives and continue to develop a green infrastructure approach in the city landscape. Malmö is a good example of this, with the development of green initiatives coupled with a transition to non-piped drainage systems and a high national and international profile (Kruse, 2011).

### Lessons from the review and ideas to overcome the barriers to transition

It would appear that there is evidence from the de Haan model that supports the contention that the three countries examined are at different stages in the transition process from piped to alternative stormwater drainage systems as shown in Table 6.

Table 6 Summary of where each country is in the transition process

Country	Main conclusions regarding the transition process
England	There are very many and disparate players in water management in England. There is a stalled transition resulting from a change in Government in 2010 and a reinterpretation of the legislation alongside a desire to reduce regulation and support commercial enterprise (developers). Originally the new legislation was intended to produce an instantaneous transition through regulatory definition. There is some limited bottom up use of SUN systems instead of piped but more pilot applications and evidence is required.
Wales	Wales has a separate identity and ethos to England and follows English practice in water management only where it deems it appropriate or beneficial The new legislation from the UK Government may or may not be adopted in Wales and this will depend on whether or not the enactment will deliver the requirements to encourage/compel a change in practice Wales is committed to the SWMS in any case but has to provide many more examples of good practice and this will need to be underwritten by DCWW
Sweden	The primary players are the 290 municipalities with a varied approach to the use of non-piped drainage systems. There is no legislative compulsion to use alternative systems although many professionals and developers do use these. There are a number of world-leading pilots and examples of new practice in Sweden. Although by no means nationally adopted there does appear to be a slow transition across Sweden. Without compulsion through regulation or standards, this is to be expected.

What does this tell us about the transition processes and the way in which barriers to these may be overcome? Not surprisingly in this domain (water and drainage) the engagement and commitment of a wide range of stakeholders, players and actors are required to effect a transition. Tension, stress and pressure are probably each required for a transition to come about (i.e. a service to society needs to be delivered in a different way). The changes through Reconstellation, Adaptation and Empowerment each seem to be occurring in different phases and probably simultaneously in each of the cases examined (and are illustrated historically in Figure 2). Perhaps the main lesson from the overall review and application of the method is that where one main change pattern is stalled then an alternative may be more profitably exploited. For example, it is clear that in England the reconstellation pattern is stalled despite signs of tension and stress. There are still signs that

adaptation is taking place, not least due to perceived climate change needs and also signs that empowerment is occurring with a limited number of entrepreneurs 'getting on with it' as if there has already been a regime shift (e.g. Oxfordshire County Council, 2011). Most changes are due to pressure although in Wales, DCWW are responding to stress in the way they are changing their business model for stormwater management.

Widespread change seems to require pilot projects and experience of effectiveness to inculcate confidence. Policy changes also need to be influenced by sound science and evidence that is so strong as to be irrefutable by the 'Luddites'<sup>3</sup> resisting change.

## Summary & Conclusions

The application of the de Haan & Rotmans (2010) model for understanding transitions has provided a logical framework to help understand where the transition process from piped to alternative stormwater drainage systems is in England, Wales and Sweden. The definitions and components of the model have been shown to be applicable and useful and the conditions for change outlined in Table 1 are applicable within the context of changes in stormwater management practice. No attempt has been made here to define whether or not the model is sufficient in itself or whether additional perspectives are needed, nor to look in detail at concatenation and the steps in a change pathway other than as presented in Figure 2. What is clear, however, is that depictions of the constellations as in Figure 1 need to be made to define not only the physical-technical-environmental systems, but also the governance and institutional arrangements alongside this.

Three studies have been considered in this paper in relation to transition theories and particularly the 3-pillar approach (conditions, patterns, paths) proposed by de Haans (2010). The paper includes aspects from 3 themes for the conference. For example, Governance, power and politics has been particularly influential in attempting to force a transition in the UK with new legislation and responsibilities defined centrally in 2010, in a process of reconstellation. In an earlier parallel approach in the USA, the key article of legislation, the Clean Water Act 1972, actually resulted in a widespread failure in implementation until community and peak groups took up the cause; i.e. the origins for the transitions there lie in bottom-up action; an example of empowerment and pressure. In England and Wales most aspects of urban water management are delivered by private companies whereas in Sweden, some 290 municipalities have this role. Thus the role of firms and industry in transitions to new dominant constellations for urban water management is central to the former but less so in the latter; although private consultants and their advice, especially the legitimacy they give to alternative approaches is crucial in both cases.

The paper deals with a real and well recognised problem, one which leading practitioners, researchers and even policy makers are trying to tackle, that of transitioning to a better regime of water management. By evaluating a theoretical foundation that compares practices in a number of countries that are at different stages, potential opportunities can be identified for tackling the barriers that remain in the transition to a new (in fact no longer very new) and more sustainable way of handling urban drainage. This paper is the start of this process and is meant to provide a starting point for discussion.

---

<sup>3</sup> Named after the leader of the textile workers in the North of England who in the early 1800s resisted the introduction of machinery to replace hand working  
(<http://www.nationalarchives.gov.uk/education/politics/g3/>)

## References

- Anglian Water (2011). Towards Sustainable Water Stewardship. SuDS adoption manual. [www.anglianwater.co.uk/developers/sewer-connection/suds.apx](http://www.anglianwater.co.uk/developers/sewer-connection/suds.apx) accessed 25-03-11
- Ashley R M., Nowell R., Gersonius B., Walker L. (2011) Surface Water Management and Urban Green Infrastructure - A review of potential benefits and UK and international practices. An FWR Guide. FR/ April 2011. Foundation for Water Research. UK.
- Ashley R M., Brown R R (2009). Entrapped in common sense: why water management by current regimes is not sustainable and what we can do about it. Proc. 9th NESS: Knowledge, learning and action for sustainability, 10th-12th June 2009, London.
- Butler D., Davies J. (2011). Urban Drainage. 3<sup>rd</sup> Ed. Spon Press, London & New York. ISBN 978-0-415-45526-8.
- Cave M. (2008). Independent review: of competition and innovation in water markets. November. ISBN 978-1-84532-524-4. UK Crown copyright.
- Centre for Water Sensitive Cities (2010) Stormwater Management in a Water Sensitive City. Blueprint 2011. January.
- Cettner A. et al (undated) Professional experience of stormwater management and urban planning in Sweden. LTU Sweden.
- Chocat B., Ashley R M., Marsalek J., Matos M R., Rauch W., Schilling W., Urbonas B. (2007). Toward the sustainable management of urban storm-water. J. Indoor Built Environment. 2007;16;3;273-285. DOI: 10.1177/1420326X07078854.
- DCWW (2009) Dwr Cymru Welsh Water Periodic Review 2009 - Company's Final Business Plan Main Report April.
- DCWW (undated) Dwyr Cymru Welsh Water  
<http://www.dwrcymru.com/English/Company/Operations/surfacewater/index.asp>
- Accessed 10<sup>th</sup> June 2011
- Foster J., Lowe A., Winkelman S. (2011). The value of green infrastructure for urban climate adaptation. Center for Clean Air Policy. Washington DC. [www.ccap.org](http://www.ccap.org)
- Geels F. (2006). The hygienic transition from cesspools to sewer systems (1840-1930): The dynamics of regime transformation. Research Policy 35. 1069-1082.
- De Haan J (2010) Towards Transition Theory. PhD thesis Erasmus University Rotterdam. ISBN 978-90-8570-572-7
- de Haan J & Rotmans J (2011). Patterns in transitions: Understanding complex chains of change. Technological Forecasting & Social Change 78 (2011) 90–102
- Glas Cymru (2011) [http://www.dwrcymru.com/eng/company\\_information/glas\\_cymru/index.asp](http://www.dwrcymru.com/eng/company_information/glas_cymru/index.asp)  
Accessed 10-06-11

House of Lords (2006) Water management Volume 1: report. Science and Technology Committee 8th report of session 2005-6. HL Paper 191-I. The Stationery Office. ISBN 0 10 400871 7

Kelda Group (2011) Taking responsibility for the water environment for good. A contribution to the debate on the future of the water industry from Kelda, parent company of Yorkshire Water. Kelda Group Ltd Registered office address Western House, Halifax Road, Bradford, West Yorkshire, BD6 2SZ

Kruse A. (2011) The green space factor and green points. Town and Country Planning June : GRaBS Project – INTERREG IVC. Journal of the Town and Country Planning Association June Vol. 80 No. 6 p287-293. ISSN 0040-9960 (See also: <http://www.grabs-eu.org/>)

Oxfordshire County Council (2011) <http://www.oxfordshire.gov.uk/wps/portal/publicsite/> accessed 10-06-11

Peters C., Sieker H., Jin Z., Eckart J. (2011) Assessing future uncertainties associated with urban drainage using flexible systems – the COFAS method and tool. SWITCH deliverable 2.1.4. <http://www.switchurbanwater.eu/>

van de Meene S. (2010) Development of a Guiding Framework for Sustainable Urban Water Governance. PhD thesis Monash University, Melbourne, Australia

Seattle Public Utilities (2009) Stormwater Manual. Vol. 3. Directors rules for Seattle’s municipal code. November.

Severn Trent Water (2010) Changing Course: Delivering a sustainable future for the water industry in England and Wales. April.

Stahre P. (2008). Blue-Green fingerprints in the city of Malmö, Sweden. Pub. VA SYD. Downloadable from: [http://www.vasyd.se/en/water\\_sewer/stormwater/Pages/default.aspx](http://www.vasyd.se/en/water_sewer/stormwater/Pages/default.aspx) accessed 10-01-11

SuDS working party (2010) SuDS for Roads. Scots.

Thames Water (2010) Thames Tunnel Appendix E Potential Source Control and SUDS Applications - Annex 1: SUDS Evaluation for Example Areas. Available from: <http://www.thamestunnelconsultation.co.uk/consultation-documents.aspx> accessed 8th January 2011

Urban Water (2009) Hämtat från <http://www.mistra.org/download/18.1eeb372100d826222880001161/Urban+Water+%C3%85rsrapport+2002.pdf> 29 januari 2009.

USEPA (2010) Green Infrastructure municipal handbook. United States Environmental Protection Agency.

Walker L., Wright G., Digman C. et al (under review) Are UK Professionals Predisposed To Retrofit More Sustainable Surface Water Management Measures? Sub. CIWEM journal

Wong T H F (2006) Water Sensitive Urban Design – The journey thus far. Australian Journal of Water Resources Vol 10, No.3 p213-221 ISSN 1324-1583