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OPPORTUNITIES AND BARRIERS TO SUSTAINABILITY INNOVATION ADOPTION IN A UK WATER AND SEWERAGE COMPANY

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Opportunities and barriers to sustainability innovation adoption in a UK water and sewerage company

Supervisor: Dr. Brian McIntosh

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If something is sustainable, it can carry on indefinitely….

Abstract

Over the last twenty years, the concepts of sustainability and sustainable development have assumed political importance around the world, and have been largely embraced by governments and prominent international institutions. These concepts have been a means of tackling the challenges of population growth and environmental change.

For the UK water sector, these concepts now represent a multitude of challenges. The confluence of climate change and population growth is reducing access to, and the availability of, water resources. The financial costs of inputs such as energy, chemicals, materials and cost of process by-products such as greenhouse gases, carbon, and waste services continue to rise. Government regulators are demanding an improvement in the quality of services, increasingly stringent conditions for emissions to water, air or land, catchment-specific management of the water environment, and the adoption of long-term planning horizons. The UK government has expectations that the water sector will play a role in the delivery of its targets for reducing energy consumption and carbon emissions. Society demands that WaSCs engage in high-level stakeholder consultations and employ long-term visions to guide their decision-making. Finally, WaSCs are increasingly expected to demonstrate and respond to local and global concerns (under the rubric of corporate responsibility) to further justify their value to society.

Building the sustainability paradigm in practice within a WaSC requires innovation in not only technologies, structure and processes, but also behaviour, culture, knowledge and skills. These organisational changes can be recognised as sustainability innovations if, when employed, they further the WaSC's management or understanding of sustainability principles. The desired benefits of sustainability innovation adoption are to improve the resilience of water and sewerage services and / or reduce the burden of these services on the natural systems on which they are reliant.

The aim of this research was to identify the factors that influenced the innovation development process and the adoption of sustainability innovations for a specific UK WaSC. The objective of the study was to generate an understanding of these factors in order that the findings could be used to inform future sustainability innovation initiatives and improve sustainability innovation adoption. The research findings, although undertaken within a specific department of a specific UK WaSC, are also of value to other stakeholders within the water sector concerned with understanding and improving the pace of adoption of sustainability innovations.

Through a process of embedded research at a WaSC, this research identified a range of potential sustainability innovations that might be viable against a range of critical criteria identified by employees at the WaSC. The research then recorded the sustainability narratives of WaSC employees during the innovation process for three sustainability innovations selected against these criteria. This qualitative data was subject to thematic content analysis, axial coding, and conceptual mapping.

The research revealed that the adoption of the sustainability innovations was dependant on innovations in terms of their contribution to the financial goals of the organisation, their perceived or real impact on the service provision, and the changes to risk position for the WaSC. These factors will vary in value through time, as restructuring and contract renewal events can inhibit or enable innovation opportunities. Innovation adoption was also influenced by the compatibility of the suggested innovation with the properties of the WaSC, expressed as policies, objectives, strategies, roles, responsibilities, resources and culture, which in their current form are failing to address principles of sustainability evenly.

The findings suggest a skewed selection and uptake of sustainability innovation, which favours a set of innovation opportunities limited by: WaSC policy and goals, existing roles responsibilities and expertise, the innovation cost advantages and the perceived risks to services associated with the innovation. Under these circumstances, the outlook for radical improvements to the sustainability performance of a WaSC through the adoption of sustainability innovations is bleak. This study suggests that the pace of sustainability change generated through sustainability innovations in UK WaSCs will probably proceed incrementally and favour those innovations clearly supported by existing WaSC policies and drivers.

Keywords: innovation, sustainability, asset-management, Indicators, decision-making, wastewater systems, barriers, opportunities, influence, adoption, water utilities, asset delivery

Dedication

I dedicate this thesis to my fiancée -Danielle Colclough, to my family, and to those that have supported me (professionally and otherwise) through this research.

Acknowledgements

I would like to thank the following people for their help and support at various points within this research, and within my life. I must start with Verusca Calabria, who first said to me in a pub in Brighton, you could go back to university; you are not stupid 'Babooo' go for it, and with that a new direction did begin.

Following this, I would like to acknowledge through my trials and loneliness in this research, the friends who listened when I had not much to say but just wanted someone to talk to and to laugh with, these moments made life much more pleasurable. My family I will thank, for at any opportunity including this one it is worth being grateful for the support and love we share among us. To my new family Dani, Marlow and Malachi, I am thankful for the love and times I have shared with you all through the three years together, and I am also thankful for the years still to come.

Breaking with tradition, I will thank my supervisor Brian McIntosh, whom beyond the call of duty, or with a strong sense of duty, from the far reaches of the globe has supported me through this PhD.

Finally, thanks to those people whom have helped by reading and reviewing my writing, supporting me in my battle with grammar, meaning, and clarity.

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List of Abbreviations

AIM	Adoption Influence Model
AM	Asset Management
ASP	Activated Sludge Plant
BM	Batch Manager (in Capital Delivery Unit)
BOD	Biochemical Oxygen Demand
CIBSE	Chartered Institute of Building Service Engineers
CDU	Capital Delivery Unit
CO_2	Carbon dioxide
CBA	Cost Benefit Analysis
CBO	Community Based Organisation
CFC	Chlorofluorocarbon
COD	Chemical Oxygen Demand
CSR	Corporate Social Responsibility
DEFRA	Department for Environment Food and Rural Affairs
DWI	Drinking Water Inspectorate
EA	Environmental Agency
EEA	European Environment Agency
EGSB	Expanded Granular Sludge Bed
EPO	Engineering Partner Organisations
EPR	Extended Producer Responsibility
EIA	Environmental Impact Assessment
EMS	Environmental Management System
EU	European Union
E&W	England & Wales
FD	Funding Directive
FFF	Forum For the Future
GDP	Gross Domestic Product
GHG	Green House Gas

GRI	Global Reporting Initiative
HDPE	High-density Polyethylene
HSAF	Hybrid Submerged Aerated Filter
HVAC	Heating Ventilation and Air Conditioning
HYBACS	Hybrid Bacillus Activated Sludge
IFAS	Integrated Fixed Film Activated Sludge
IOA	Input Output Analysis
IPCC	Intergovernmental Panel on Climate Change
ISD	Information System Development (methodology)
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCC	Life-Cycle Costing
LCM	Life-Cycle Management
MBBR	Moving Bed Bio Reactor
MBR	Membrane Bio Reactor
MCA	Multi-Criteria Analysis
MEFA	Material and Energy Flow Analysis
MFA	Material Flow Analysis
MIPS	Material Intensity per Unit Service
$N0_2$	Nitrogen dioxide
NGO	Non-Governmental Organization
NH_3	Ammonia
OC	Organisational Change
OEDC	Organisation for Economic Co-operation and Development
OFWAT	Water Service Regulation Authority
OI	Organisational Innovation
P	Phosphorus
PVC	Polyvinyl Chloride
R&D	Research and Development

RFM	Reporting and Finance Manager (in Capital Delivery Unit)
ROAME	Rationale, Objectives, Appraisal, Monitoring, Evaluation
SAM	Strategic Asset Management
SCA	Sustainable Competitive Advantage
SCADA	Supervisory Control and Data Acquisition
SD	Sustainable Development
SFA	Substance Flow Analysis
SI	Sustainability Indicators
SM	Stream Manager (in CDU)
SOP	Standard Operating Procedure
SPI	Sustainable Process Index
SSSI	Site of Special Scientific Interest
SWARD	Sustainable Water Industry Asset Resource Decisions
TF	Trickle Filters
TSS	Total Suspended Solids
UASB	Up flow Anaerobic Sludge Blanket Digestion
UK	United Kingdom
UN	United Nations
UNCSD	United Nations Commission on Sustainable Development
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UWS	Urban Water Systems
WaSC	Water and Sewerage Company
WCED	World Commission on Environment and Development
WRM	Water Resource Management
WSP	Waste Stabilisation Pond
WWF	World Wildlife Fund
WWSP	Water and Wastewater Service Provider
WWTP	Waste Water Treatment plant

Glossary of Terms

Absorptive capacity: the availability to an organisation, of relevant skills, knowledge and resources to recognise and exploit innovation opportunities (Zahra and George 2002)

Adaptive Capacity: the facility of an organisation to adopt innovation and change (Staber and Sydow 2002)

Administrative (innovation): a type of innovation that is used by the organisation to indirectly support the basic work activities of the organisation (e.g. management tools) (Damanpour 1991).

Business model: a type of innovation that changes to how an organisation creates and delivers services to its members and/or customers.

Compatibility: the degree to which an innovation is perceived as being consistent with existing values, past experiences and the needs of the receiver (Rogers 2003).

Complexity (innovation): the degree to which an innovation is perceived as difficult to understand and use (Rogers 2003).

Complexity (organisation): the number of technological and organisational interdependencies (Tidd 2001).

Discrepancy: 'is the belief that a change is needed; that there is significant gap between the current state of the organization and what it should be' (Armenakis and Harris 2009, p. 129)

Externality: is the cost or benefit of an action that is not transmitted through the price of the transaction, and is incurred by a party that did not agree to the action.

Formalization: the emphasis within a organisation on the following of rules and procedures (Damanpour 1991).

Intra- organisation: within an organisation

Inter-organisation: between two or more organisations

Mechanistic: the degree to which an organisation has clear, well-defined, centralized, vertical hierarchies of command, authority, and control, resulting in rigidly defined jobs, technologies, and processes.

Observability: the degree to which the results of an innovation are visible to other (Rogers 2003).

Organicity: the ease with which an organisation can modify and adapt organisational routines and behaviours in response to external drivers (Tushman and O'Reilly Iii 1996)

Performance gap: is an awareness of a performance gap between the performance of the organisation and the desired performance (Rogers 2003).

Process: a type of innovation that mediate between the inputs and outputs of the organisation, defined as tools, devices and knowledge of through-put technologies (Gopalakrishnan and Damanpour 1997)

Product (innovation): a type of innovation that directly relate to changes to the outputs of the organisation, for example, a new product or service package (Gopalakrishnan and Damanpour 1997).

Relational capital: the stock of relations an organisation can maintain with other organisations (Capello 2002).

Relative advantage: the degree to which an innovation is perceived as better than the idea it supersedes (Rogers 2003).

Socio-technical system: an approach to conceptualising an organisation that recognises that within a organisation people and technologies are separate but relational systems.

Specialization: represents different specialisms found in an organisation, it is measured by the number of occupational roles or types in an organisation (Damanpour 1991)

Technical (innovation): a type of innovation that are the technologies with which an organisation delivers its product or services (Damanpour 1991).

Trialability: the degree to which an innovation may be experimented on within a limited basis (Rogers 2003).

Uncertainty (innovation): the degree to which the risks associated with an innovation are understood and managed Complexity (Rogers 2003).

Uncertainty (organisation): is the rate and predictability of technological and market changes (Tidd 2001).

1 Introduction

This chapter briefly introduces the research project. It presents a justification for such a study and refers to the planned beneficiaries of the research and the body of knowledge to which this research will contribute. The aims and objectives of the research are then presented, along with a report on how a strategic partnership between the university and the Water and Sewerage Company (WaSC) shaped the research approach. This is followed by an examination of the limitations of the research, and a presentation of the structure of the thesis, in order to navigate the reader through the work undertaken. The latter sections give an account of the roles and responsibilities of the WaSC to its stakeholders and the structure and roles within the WaSC under study, with specific focus on the business processes of capital planning and delivery. Finally this chapter, introduces the reader to the subject of sustainability, the different value positions that may be adopted regarding sustainability and their implication, the way sustainability is interpreted by UK water regulators generally, and it discusses the means of incorporating sustainability into a WaSC.

1.1 The Research Project Explained

Like any organisation, a WaSC has both direct and indirect impacts on the three pillars of sustainability, environmental, economic and social. However, unlike many industries, the business of the WaSC is in direct and immediate relation to the environmental services of the hydrological cycles within the geography of operation. These provide the water resources from which the WaSC draws influent for potable water, and for the deposits of (treated) effluent. The survival and health of our communities is dependant (in part) on an appropriate allocation of these resources for domestic, agricultural, industrial or environmental purposes (Cosgrove and Rijsberman 2000).

The way in which resources are allocated or employed has the facility to sustain or degrade them. Sustaining resources ensures that the services will continue. Degrade them, and the service quality or quantity becomes increasingly difficult to maintain. This is as true for the degradation of natural resources as it is for human and financial resources. For this reason, sustainability is of prime importance regionally, nationally and internationally, and consequently the UK water sector has its role to play in understanding and adopting sustainability.

Sustainability has altered planning horizons; the Environment Agency has now adopted a long term (25 year visions) (EA 2001). In 2007 the Water Services Regulation Authority (Ofwat) demanded that the water and sewerage companies prepared strategic direction statements that would set out a 25 year vision and aspirations for the WaSC to encourage longer term planning horizons (better suited to sustainability). It has also changed the roles and responsibilities of WaSC and regulators, when in 2003 the Water Act mandated that the authority (Ofwat) *'contribute to the achievement of sustainable development*' (UK 2003, p.40). The UK Government Department for Food and Rural Affairs (DEFRA) in its document 'Directing the Flow' (2002) suggested that sustainable development should be applied as a '*framework for water policy'*, and concluded in relation to sustainable development '*The principles of sustainable development apply very heavily in the case of water and set the framework for decision-making'*(DEFRA 2002, p.19).

In recognition of this sea change, the water sector voluntarily began to develop a set of sustainability indicators to report against: in 2001 four water utilities publicly reported and this had risen to 23 in 2010 (UK 2011). Recently DEFRA's document 'Future Water' (2008) sets out a vision of a sustainable water sector. In this document, it positions sustainable development as a '*strategic framework for the water industry which incentivises innovation, sustainability, demands long term planning and ensures short-term efficiency savings to reduce customers' bills*.' This document also more clearly suggests that Ofwat take a stronger role in its responsibilities to sustainable development, to which Ofwat responded with its strategy document 'Delivering Sustainable Water Strategy' (2010). Within this context of unclear sustainability visions, responsibilities and principles, there have been changes in the sustainability performance in the water sector. Despite many years of reporting, the sustainability indicators for 2010 suggest a negative trend for energy consumption, waste generation, and water demand, while for other indicators there is evidence of a positive trend of reduced environmental impact (chemical use, GHG in wastewater treatment, SSI sites).

It seems all parties agree that innovation is inseparable from meeting the challenge of sustainability. In Ofwat's strategy document 'Delivering Sustainable Water' (2010), innovation is identified as a solution to mitigating the effects of climate change, worldwide water scarcity, adapting to climate change, complying with stringent environmental standards and meeting rising consumer expectations. In 'Future Water'(2008) innovation is again identified as a solution to the challenge, and the all parliamentary group sector report (2008) identified innovation as playing a vital role in enabling UK WaSC to meet the challenges of sustainability. In Water UK's document 'Sustainable Water, State of the Water Sector Report' (2008; 2008), Water UK (2008) describes the process of transition towards sustainability as raising awareness of sustainability amongst employees, customers and key decision makers, the development of innovation towards more sustainable solutions, and the support and performance of the supply chain. The statements above suggest that innovations are the means by which a WaSC progresses to more sustainable behaviours.

However investment in R&D has fallen from £45 million pounds in the late 1990s to £18 million by 2008 (CST 2009) suggesting that there are declining resources available for innovation in the sector. Of innovation and the water sector Thomas and Ford said the *'UK water industry does have diverse and unexploited inventiveness'* which represents *'a significant potential to increase its innovation intensity'* (2007, p.3). This dissonance between innovation need and innovation performance of the sector has led some authors to refer to it as a crisis (Thomas and Ford 2005). The Council for Science and Technology, *'see an urgent need for step-changes in the application of technology to address both climate change effects and enable further improvements to the efficiency of operations within the water sector to be made'* (2009, p.3). Both authors accuse the water sector of incrementalism that is failing to meet the radical departures required of it.

A few reports address directly innovation in the UK water sector: Martin Cave in 2009 wrote an 'Independent Review of Competition and Innovation in Water Markets', (2009), and the report identifies barriers to R&D and innovation within the UK Water sector. The UKWIR report, 'Barriers to Innovation in the Water Sector' (Thomas and Ford 2006), reviewed ten innovation cases and found that innovation adoption in was inhibited by the risk averse nature of strategies and purchasing policies of UK WaSCs. Not focused on the UK water sector but the Australians, Brown and Farrelly (2009) identified a typology of barriers to innovation in WaSCs and identified where these barriers impacted across an institutional capacity assessment framework which spanned from human resources, intra organisational capacity, inter organisational capacity to, finally, external rules and incentives. The Cave Review (2009) focuses its analysis and recommendations to the institutional structures which Brown and Farley would refer to as 'external rules and incentives'; the UKWIR (2006) report reflects evenly across the institutional assessment scales.

This research contributes to this dialogue on innovation in the water sector, uniquely; this research presents data captured throughout the innovation process stages using narratives generated during the innovation development process. With this data, the research reveals the topics of sustainability narratives and analyses that reveal how innovation does occur and what influences innovation adoption. This research does this with a specific focus on the process for innovations that have as an objective to improve the sustainability performance or management. This research thereby identifies how progress towards sustainability for WaSCs through innovation occurs and what influences this process.

1.1.1 The need for the study

A growing number of WaSCs in the UK are beginning to turn the rhetoric of sustainability, identifying sustainable solutions, and putting these into action (UK 2008). However, the industry economic regulator, Ofwat, have been slow to define its position on sustainability, only in 2010 outlining its sustainability strategy (Ofwat 2010). This has left WaSCs in England and Wales with the challenge of identifying appropriate sustainability values and corresponding indicators/measures and identifying means to improve their sustainability performance. Whilst trying to achieve these, the WaSCs must also interact with a broad set of stakeholders including customers, unions, community based organisations (CBOs), non-governmental organisations (NGOs), city councils etc., as well as maintaining a high standard of service, which is regulated by Ofwat, the Drinking Water Inspectorate (DWI), and the Environment Agency (EA). European Union (EU) directives further influence WaSCs[1]. All of these directives will be significant contributing factors to the way in which WaSCs operate. The UK government's existing policies and its interpretation of EU policy present both a challenge and an opportunity to WaSCs. These policies are laid out in a variety of DEFRA documents (DEFRA 2002; DEFRA 2007; DEFRA 2008).

To define and implement sustainability is in itself a challenging process (Beck and Speers 2006). From the variegated interpretations of sustainability, an organisation must determine appropriate sustainability values and/or principles it can subscribe to,

[1]: EU Water FD- Catchments plan to drive water quality status improvements (6yr cycle 2020); EU Waste FD – Waste; prevention, reuse, recycling, recovery, disposal. (2020); EU Extended producer responsibility - Packaging to Product - Producer Take Back Initiatives; EU Emission Trading Scheme – centrally allocated- No Free allocation- increasing to nitrous oxide and peruflurocarbons; EU Chemical Safety Standards – 2018 objective to drive replacement of harmful and toxic chemicals.

effectively integrating these principles into practice within a WaSC requires innovation in technologies, structure and processes, behaviour and culture, and knowledge and skills. These organisational changes can be recognised as sustainability innovations (SI) if, when employed, they further the WaSC's management or understanding of sustainability principles. The literature on institutional/organisational change, tool adoption and organisational innovation, suggests a plethora of variables that can influence such an undertaking. For example, Venkatesh and Davis suggest that management comprehension and experience can affect the adoption of a technological innovation (Venkatesh, Morris et al. 2003; Venkatesh and Bala 2008). In addition the UK water industry is a highly regulated environment, which Legge suggests may constrain an organisation's facility to manage a transition towards a more sustainable behaviour (Legge 2000). The capacity for WaSCs to interpret sustainability and manifest it into a stronger sustainability practice will be subject to both intra-organisational and environmental constraints. To help keep abreast of these challenges, the UK water industry is involved in the production of literature, through collaborative research with bodies such as UK Water Industry Research (UKWIR)[2] or Water UK[3]. Despite this there is limited material discussing key questions that may concern the water utility sector and sustainability. A clear consensus has yet to be determined on any of the following:

- What does sustainability mean to the UK WaSC?
- What role do sustainability innovations play in the delivery of a sustainable UK water sector?
- How are WaSCs incorporating sustainability innovations?
- What determines the adoption outcomes for sustainability innovations?
- Will adoption of sustainability innovations result in improved sustainability for a WaSC?
- What are the most sustainable technologies applicable to UK WaSCs?

[2] Provides a framework for the procurement of common research programme for UK water operators
[3] Representative body of the UK water industry to engage with government, regulators, stakeholder organisations and the public

The obvious lack of the kinds of information that can be used to guide and improve sustainability innovation adoption in the sector may impede the development of a more sustainable water industry. Therefore, this research makes a valuable contribution to the literature on sustainability innovation and adoption in organisations (specifically in the UK water sector). A number of sustainability innovations have been developed by the water sector, imported from other utility sectors, and developed by academic institutions to assist WaSCs in developing more sustainable practices. These range from new economic evaluation tools such as triple bottom line reporting (Kenway, Howe et al. 2007), to scenario based planning tools (Alegre, Jeffrey et al. 2004; Ashley, Booker et al. 2004), new decision criteria (Foxon, McIlkenny et al. 2002) or new technologies. The uptake and generation of innovation in the UK WASCs is considered very poor (Thomas and Ford 2005; Brown, Sharp et al. 2006; Cave 2009).

In response to the sustainability challenge, a WaSC invited Cranfield University to embark on a sustainability-driven research project. The project would assist the WaSC in the identification, development and piloting of sustainability innovations. The research would capitalise on this opportunity and record factors that influence the innovation adoption process and outcomes, thereby generating a valuable body of knowledge. This knowledge could then be applied to the water utility sector in general, to improve the adoption likelihood of future sustainability innovations.

Within the field of organisational change (OC) and the innovation literature, there already exists a significant body of literature on factors that influence use or adoption of tools, technologies and business process innovations (Davis 1989; Venkatesh and Davis 2000). However, very little research has been developed that focuses on the WaSCs and the UK water industry, less still with a specific focus on the delivery of innovations that are intended to aid an organisation in meeting a set of sustainability-generated criteria. Prior to this study, it was unclear what factors influenced the selection and uptake of sustainability innovations in the UK water sector, and to what extent the influencing factors were constant through the stages of innovation.

By engaging on a longitudinal study, which mapped the innovation journey, the research has contributed to a richer understanding of the factors that influence the innovation process and adoption outcomes within the UK water sector. The research project contributes directly to a body of knowledge on sustainability innovation in the UK water sector. This knowledge will enable future selection of an appropriate innovation and may positively influence the design development and adaptation of sustainability innovations. A further justification for this study is that it helped to identify activities and undertakings that can influence the adoption of sustainability innovations.

The research information will be valuable to those connected to the water sector and those interested in influencing the adoption of sustainability innovations. These could include WaSC managers and those in the industry at large, to help anticipate and identify likely sources of constraint for sustainability innovation initiatives. The research findings will, likewise, enable government regulators (Ofwat, Environment Agency, DWI and DEFRA) and utility stakeholders (consumer groups, environmental groups, utility management and directors and investors) to coordinate efforts to minimise barriers and maximise opportunities, when incorporating sustainability appraisal innovations into WaSC. This study will also be of interest to any persons involved in the management of future, sustainability-change initiatives.

Presented below is the basic lay out of the thesis, the section following describes the research aims, the research scope, and introduces the reader to the research context.

Structure of the thesis

Figure 1 presents the structure of the thesis, outlines the chapters, their content and their function within the research project.

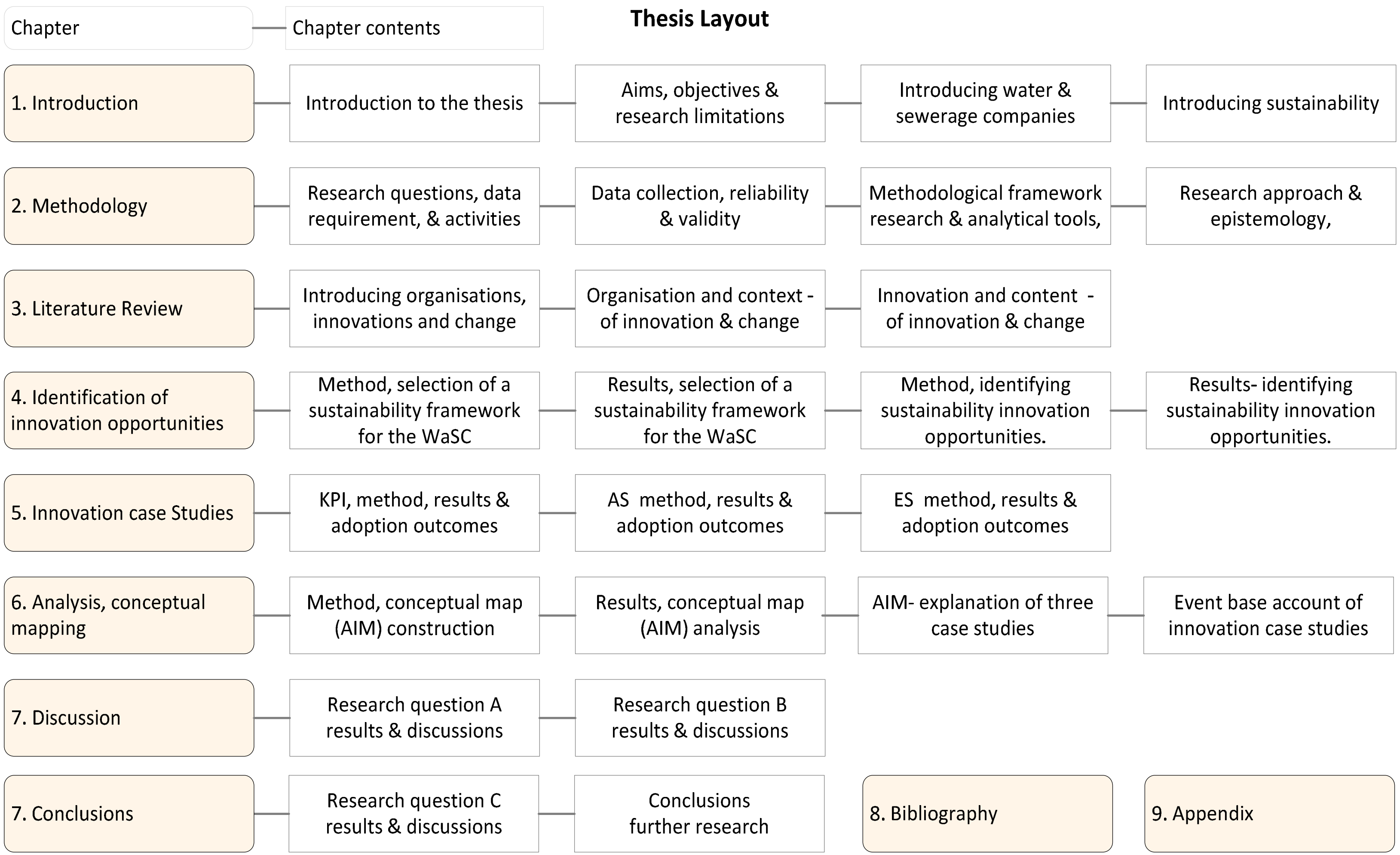

Figure 1 Structure of thesis

Chapter 1. Introduction

The function of the introductory chapter is to lay out the aims and objectives of the research project and equip the reader with the necessary understanding of the research area. The scope of the project is also summarised. This chapter enables both an understanding of the research agenda and a familiarity of the project landscape.

Chapter 2. Methodology: A description of research methods and epistemology

This chapter specifies the data that is required to answer our research questions, describes the methodological framework adopted as well as the research tools and analytical tools that enabled the research to meet the data requirements. A detailed description of the research process and the epistemological and ontological foundations of this research follow this explanation

Chapter 3. Literature Review

This chapter presents a literature review in order to identify key information both for the research development and delivery and the interpretation of results. The literature review centres on the relationship between organisation and the antecedents and determinants of organisational change and innovation. The information garnered in this literature review is subsequently used in the development of methodology and the analysis of results.

Chapter 4. Identification of innovation opportunities

The chapter reveals the methodological activities applied to identify and/or generate sustainability innovation opportunities within the WaSC. The chapter presents firstly the method and results undertaken to identify a sustainability framework suitable to appraise the sustainability of a UK WaSC, and subsequently the methods and the results of activities undertaken to generate and or identify opportunities for sustainability innovation within the WaSC.

Chapter 5. Development and proposal of innovations (three case studies)

This chapter introduces the reader to the three sustainability innovation case studies developed and proposed to the WaSC. For each innovation case study the methodology employed in the development of the innovating is presented, followed by the resultant innovation and the WaSC adoption decision concerning the innovation.

Chapter 6. Analysis: conceptual mapping

This chapter presents the methodology and results of the qualitative analysis applied to the sustainability narratives of WaSC employees recorded during the research. The research employed conceptual mapping of innovation adoption influences supported by a thematic and axial coding using the qualitative software tool Nvivo.

Chapter 7. Discussion

This chapter synthesises and discusses the principal research the findings in the light of the literature, and presents a response to research questions A and B.

Chapter 8. Conclusions

This chapter presents the conclusions and the response to research question C. It then discusses the limitations of the research, as well as its value to the field of innovation within the water sector.

Writing style

During the writing of this thesis, it became necessary to both develop terms and adopt terms from the literature to help categorise the research findings. When these terms are used in the text of this thesis, they will be *italicised* to discriminate the nouns from their common meaning. Similarly, throughout this thesis, quotations from the research transcripts have been used to add texture to the report. Quotations from the qualitative data produced in this research are presented *"italicised"*, blue, indented and with speech marks, while citations from the literature are '*italicised*' with inverted commas.

1.2 Aim and Objectives of the Study

In light of the discussion presented above, the aim of this study is to:

- Facilitate the selection, development and proposal of sustainability innovations, in order to evaluate innovations with respect to the factors that influence the innovation process and adoption outcomes.
- To capitalise on these activities and to generate knowledge of the opportunities and barriers which enable or inhibit one specific WaSC's transition towards more sustainable practices across the organisation.

This study explores the following research questions:

Table 1 Research questions of this study

Research Questions
A. How has a specific UK WaSC incorporated sustainability innovations?
B. What factors influence a WaSCs selection and uptake of sustainability innovations?
C. What changes would assist the WaSC in improving its potential to adopt sustainability innovations?

This research focuses on understanding the potential for incorporating sustainability innovations into UK WaSCs. This process of incorporation typically requires a WaSC to embed sustainability goals or decision-making criteria into the fabric of the organisation. These changes are innovations and may take the form of a modification of business processes, strategic goals or objectives, technology and IT systems, data capture and reporting or changes to the roles and responsibilities. For the purposes of this research, a sustainability innovation is any alteration to the WaSC that furthers its understanding or management of sustainability principles.

The existing research in the area has been largely limited to identifying potential tools or new technologies, evaluating the efficacy of those tools, or identifying regulatory barriers to the adoption of sustainability improving innovations. By contrast, this research identifies factors that influence the adoption process and outcomes of sustainability innovations, with a specific focus on the changes available to the WaSC.

The researcher and the WaSC agreed three deliverables (Figure 2 below), which aimed to inform practice and thereby, improve the means by which UK WaSCs adopt sustainability innovations. These deliverables were negotiated throughout the project with the WaSC project sponsors.

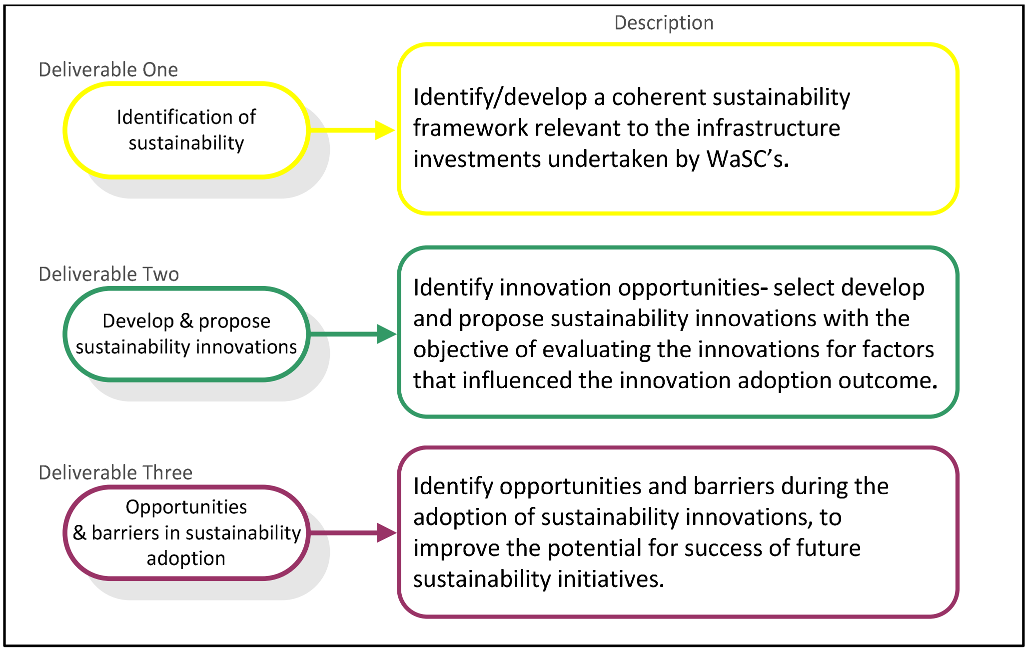

Figure 2 Project deliverables (Cranfield University to the WaSC)

Deliverable number one was the identification of sustainability. The research identified a need to formulate a comprehensive and coherent understanding of sustainability for the business. Prior to this there was no clear statement from either the WaSC, or the sector in general, that identified their sustainability values or criteria. It was also acknowledged that a clear understanding of sustainability was necessary in order to engage the business in the development of sustainability innovations. This measure was to ensure clarity as to the objectives of the innovations.

Deliverable two would use an established innovation development framework to facilitate a series of workshops, focus groups and interviews, which would identify, develop and propose sustainability innovations for adoption by the WaSC.

Finally, deliverable three was the analysis of the first two deliverables; a process designed to enhance the WaSC's understanding of the opportunities and barriers that exist during the adoption of sustainability innovations. This deliverable would present key findings, which would improve the potential for success of future sustainability initiatives.

The success of the research project was implicitly dependent upon the cooperation and motivation of the WaSC (research partner). The following section briefly describes how working within a strategic partnership differs from traditional scholarship.

1.2.1 Working within a strategic partnership

Collaborative research (between academics and industry), which aims to generate useful, organisational, knowledge is referred to as 'engaged scholarship' (Van de Ven 2007). Engaged scholarship has additional demands that may not always be met by traditional scholarship. These are described by Furco (2002) in Table 1 below.

Furco's distinctions suggest that engaged scholarship must be socially motivated and influenced, with a practical application to the beneficiaries of the research ('research beneficiary community'). For the purposes of this research the 'research beneficiary communities' are the employees of the WaSC and the WaSC sector in general. To proceed with this engaged form of scholarship, the research project is required to balance the requirements of three parties: Cranfield University, the researcher and the WaSC. These multiple needs do not automatically align. The researcher's motivation is to generate new knowledge that is intellectually and methodologically rigorous enough to merit a PhD, while the WaSC is primarily concerned with the generation of useful knowledge, which is methodologically rigorous or compelling enough to warrant engagement. However, this research project meets the motivations of both the researcher and the recipient community. The research design and findings are described in subsequent chapters. The following section is a statement on the limitations of the research with specific regard to the potential application of the research findings. The section then briefly describes how the research outputs are defined by the research context and engagement with the WaSC.

Table 1 Traditional scholarship + *(engaged scholarship)*

- Breaks new ground in the discipline (***and has a direct application to broader public issues)***
- Answers significant questions in the discipline, (***which have relevance to public or community issues***)
- Is reviewed and validated by qualified peers in the discipline (***and members of the community***)
- Is based on solid theoretical (**and practical bases**)
- Applies appropriate investigative methods
- Is disseminated to appropriate audiences
- Makes significant advances in knowledge and understanding of the discipline (***and public social issues)***
- *(**Applies the knowledge to address social issues in the local community**)*

(Adapted from Furco 2002, p10)

1.2.2 The research scope

The researcher acknowledges that the findings of this research may be applicable only to a limited extent outside of the WaSC. The innovations identified and developed in this project are only a small example of the multiple sustainability innovations potentially available. Thus, caution is advised when applying the findings of this research to alternative innovations. However, it is also assumed that many of the challenges identified during this research may reflect opportunities and barriers familiar to many organisations and many sustainability innovations.

The outputs from this research project are limited by three primary factors: skills, time and resources. These factors have played a role in the development of the project throughout and may be divided into two forms: fixed factors and variable factors. One of the fixed factors is the time allocated to the research, which is limited by grant availability and the abilities and interests of the researcher. Variable factors include the WaSC management 'buy in' and operating environmental factors, both of which can have significant impact on the resources at the disposal of the research project. The allocation of resources to the project has also influenced the availability of the WaSC workforce to the project, thereby affecting the depth (data quality) and quantity (sample size) of data available. The levels of technical support made available to the project also influenced the selection of sustainability innovations that the researcher was able to assist in development and/or piloting at the WaSC.

The following sections introduce the reader to requisite knowledge about the business of water and sewerage services in the UK, including the features of the organisation's processes for the delivery of infrastructure assets specific to the WaSC that is the subject of this research. The following sections also introduce the reader to the subject of sustainability in order to establish a frame of reference on sustainabilty and the relative influence of the research project towards achieving improved sustainability for the WaSC.

1.3 UK Water and Sewerage Companies

1.3.1 A WaSC as an infrastructure business

At their simplest, WaSCs can be described as a set of infrastructure assets used to provide water and sewerage services. For the water services, a WaSC will extract water resources, treat the water to a standard where it is potable and then distribute that water for domestic & commercial clients. For the sewerage services, the WaSC collects fouled water from domestic and commercial clients and treats the fouled water to a suitable water quality standard, and then returns the water to the natural environment. For these services, the WaSCs exact a fee (see Figure 3 below).

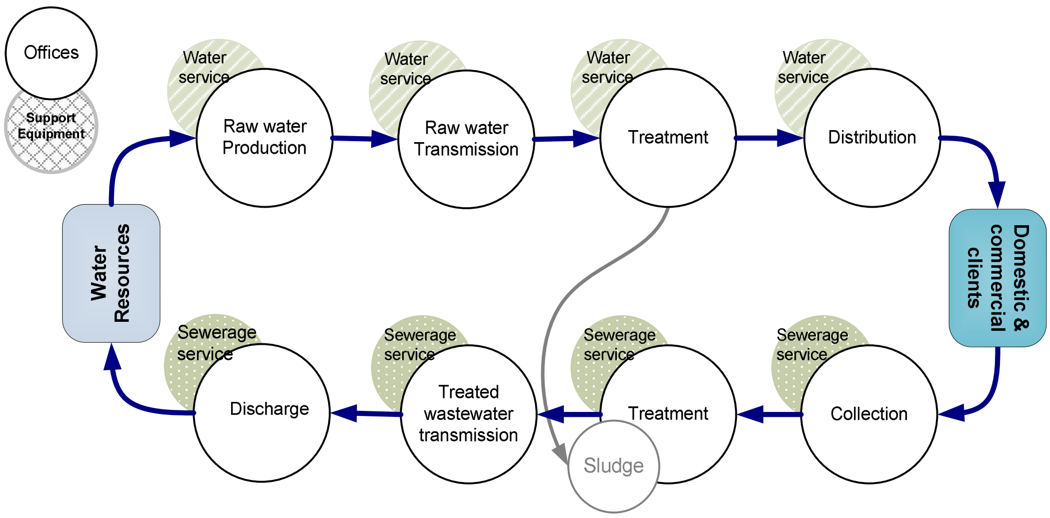

Figure 3 Schematic representation of the WaSC services provision and key infrastructure

However, the diagram belies a plethora of complexity. For example, sources of water resources are typically multiple and complex (both a variety of groundwater and surface water sources will be exploited) and many of the surface water resources will also play a role in the maintenance of sensitive environmental resources, such as a wildlife habitat. The distribution, transmission and collection involve a network for water and sewerage services, which will use thousands of pumps, drains, screens and pipes and fittings throughout a large geographical area. The treatment assets may also vary, significantly, in terms of the treatment process technologies employed, water storage, and inlet and outlet technologies. Furthermore, there is the management of and the technologies employed for the disposal or exploitation of the service by-products, sludge and screenings material produced during sewerage service collection and treatment, and to a lesser extent raw water production and treatment. Finally, WaSC offices are required to manage the service and equipment used to maintain the infrastructure. As Heather and Bridgeman note '*The water industry has developed over a long period of time into a large and complicated network of assets*' (2007, p.132). These infrastructure assets may therefore range, in age, from new to in excess, of 100 years old (for civil structures, or up to 20 years old for electromechanical (EM) technologies).

Infrastructure assets that fulfil the above functional role extend throughout the region in which the WaSC operates. These assets meet the demands of domestic and commercial clients and required water quality consent at the time of design and construction.

For the WaSC, within which the research takes place, these infrastructure assets treat over a billion litres of drinking water per day and a billion litres of sewerage water are treated and returned to the natural environment every day. For the target WaSC over 700 water and sewerage treatment sites spread throughout the region treat the water and sewerage and there are more than 120 reservoirs and a piped infrastructure of over 40,000 miles. To maintain a viable service the business needs to efficiently operate, maintain and when necessary, replace and renew this infrastructure. The following section describes the context or environment within which the WaSC must perform.

1.3.2 The WaSC environment

The WaSC, as a business, has three immediate distinct organisational environments that it must manage: the resource environment, the local asset environment and the client environment (see Figure 4 below).

The resource environment is the catchment geography, from which the WaSC abstracts water and to which it returns water. The quantity and quality of water abstracted and returned to the catchment must be carefully managed in order to maintain the vitality and health of the catchments on which the WaSC is dependent. The local asset environment can be understood as how the WaSC manages the impacts arising from the operation and maintenance of a large set of infrastructure assets, and how the WaSC seeks to manage the impacts of this and service to the communities, which they serve. Finally, there is the client service environment, which incorporates the activities that are a direct interface between the WaSC and its clients. This includes all aspects of negotiating and fulfilling the contract of service between the WaSC and its clients and vice versa.

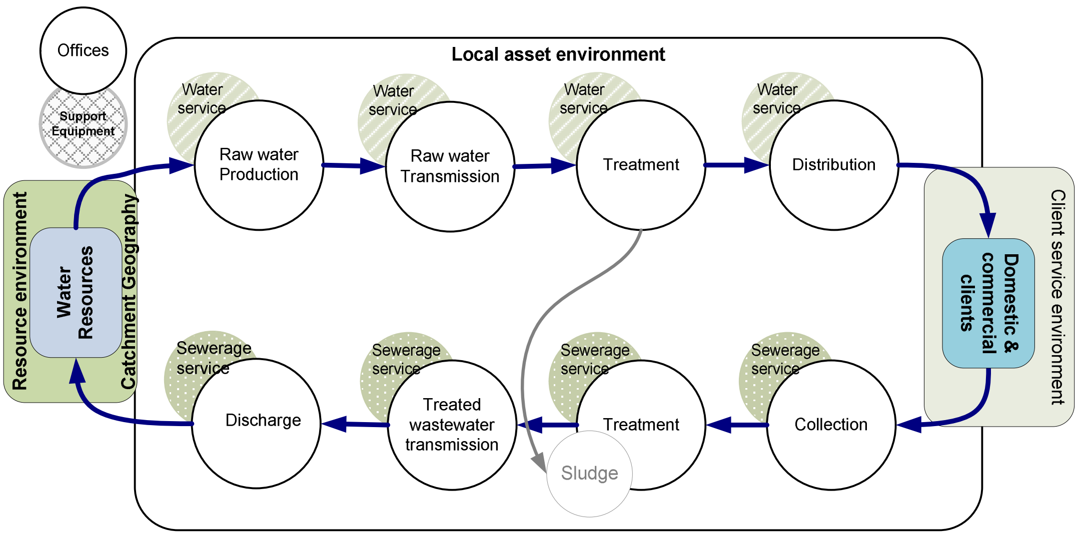

Figure 4 Schematic representation of the main management environments for WaSC's infrastructure and water and sewerage service provision.

In addition to these immediate three environments, which all WaSC inevitably must manage regardless of geography or nationality, a fourth environment can be defined. That fourth environment is that of the WaSC to the global environment; this fourth management environment will be discussed late in the chapter. In amongst or as a part of these three main environments are the regulators; the following section positions these regulators in relation to their role to the WaSC.

1.3.3 England & Wales WaSC regulators

England and Wales has a privatized water sector, which has been divided into ten regional zones; ten key Water and Sewerage Companies manage the majority of water and sewerage service provided. To ensure the WaSC do not abuse their monopoly position they are subject to rigorous regulation. There are three regulatory bodies that a UK WaSC is accountable to: the Environment Agency (EA), the Drinking Water Inspectorate (DWI) and Ofwat (see Figure 5 below).

The EA is the UK national environmental protection agency; it is the legal authority that monitors and enforces the environmental performance of the WaSC. The EA sets and determines the limits to abstraction of water from environment and quality of water returned to the environment. Failure to adhere to these environmental performance requirements results in financial penalties, imposed by the regulators, Ofwat and or enforced by the courts. Ofwat is the regulator charged with ensuring the customers (domestic and commercial clients) of the WaSC are not overcharged and receive good value for money. Ofwat financially regulates the business by reviewing, sanctioning and monitoring the standards of service to clients (serviceability targets), the consumer price a WaSC is allowed to charge, and the investment to be undertaken over a five-year period on the asset infrastructure referred to as an Asset Management Period (AMP).

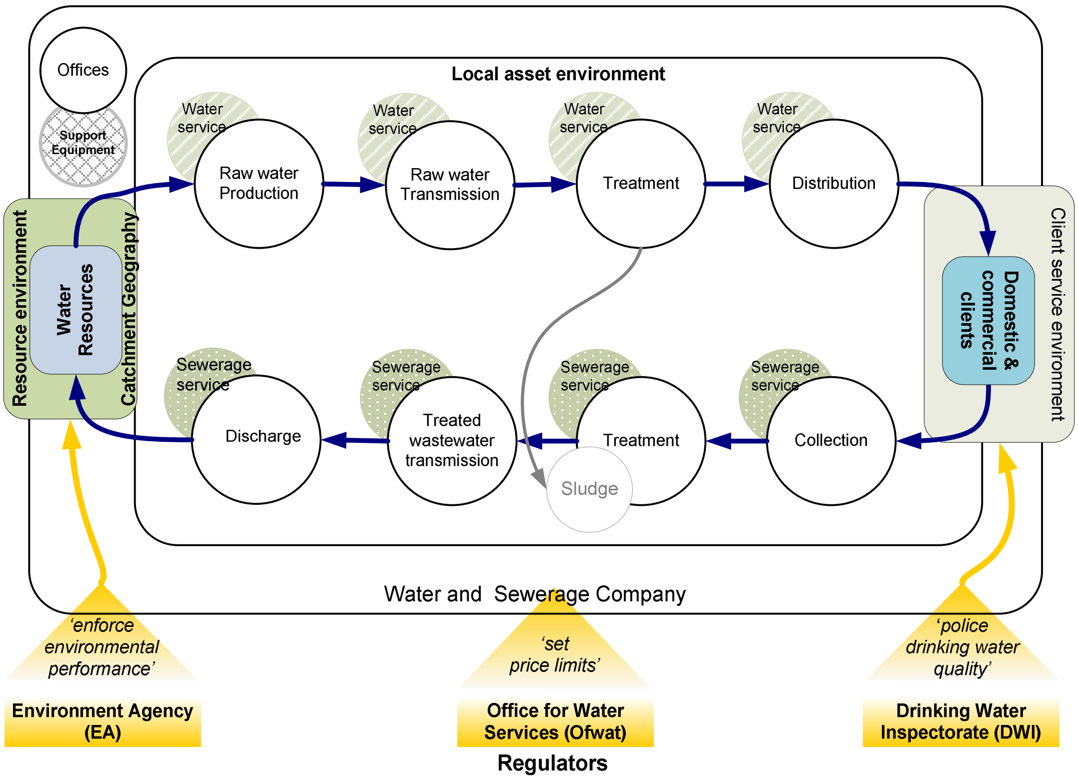

Figure 5 Schematic representation of the principal regulators for WaSCs of England and Wales and the WaSC's infrastructure and service environments.

Ofwat also creates the financial incentives for the WaSC and can administer financial penalties to a WaSC that fails to meet the sanctioned behaviour. Finally, the DWI is responsible for defining the potable water quality targets, monitoring and enforcing the potable water targets through penalties administered through the courts or Ofwat. In addition to the regulators, a WaSC is subject to the interests of many stakeholders. The following section briefly introduces the various stakeholders in the WaSC.

1.3.4 UK WaSC stakeholders

A UK WaSC has many stakeholders with which it must interact. The three external environments: resource, local asset infrastructure and the client service, provide the WaSC with a large set of stakeholders whose concerns and needs must be managed in some manner by the WaSC. A WaSC stakeholder may be an individual or an organised group of individuals; they may belong to the client base, to the local community to the WaSC and its operations, or can consist of national, regional, or international interests. They are motivated by both long-term and / or immediate factors from local to global impacts, generated as a result of the WaSC's activities.

Furthermore, the WaSC must manage its regulatory stakeholder environment. These are the regulators: EA, Ofwat and DWI and their authorities (local, national & international), and their internal stakeholders, the employees and employee groups within the WaSC, and the shareholders and board of directors of the WaSC. The following section describes the structure and roles and responsibilities adopted by the WaSC to manage this infrastructure intensive multi-stakeholder business.

1.3.5 Managing a UK WaSC

The modern WaSC has more to concern itself with than just a source of water to be shared in an equitable fashion. A modern WaSC has a complicated network of distribution and treatment processes to service and maintain (See Figure 6 below), a complex, natural network of ground and surface waters, protected by a variety of regulating bodies, and potentially polluted by numerous sources. The WaSC operates in a dynamic environment, and is potentially vulnerable to changes in the activities and values of its stakeholders and the resource environment. To understand how the WaSC business under research is delivered, the main business roles have been identified and grouped by direct support activities and indirect support activities.

Direct support activities are the activities without which the infrastructure assets would fail to operate and the WaSC would be incapable of rendering water and sewerage services to its clients.

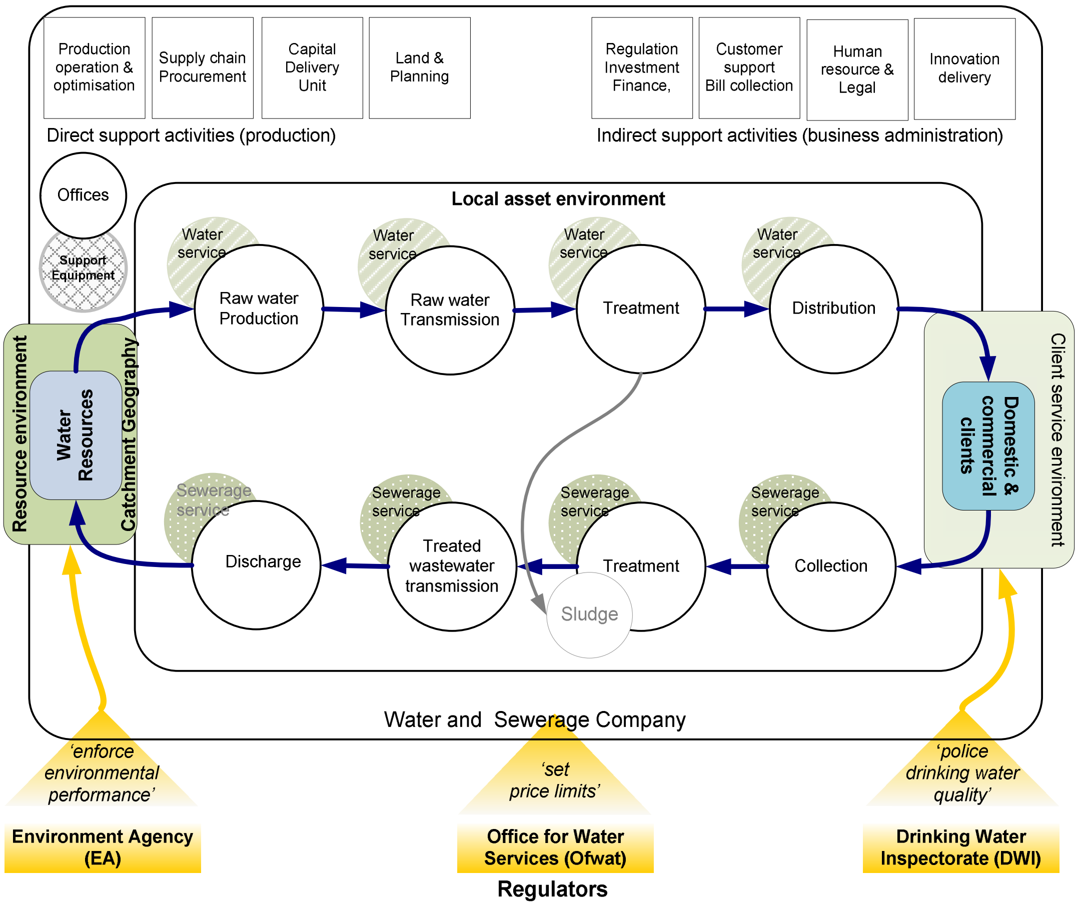

Figure 6 Schematic representation of the key business departments for the WaSC and its infrastructure and regulatory environment

The direct (infrastructure) support activities in the WaSC under research are as follows:

- Production, which is responsible for the operation of the asset infrastructure and optimizing the performance of assets duties, which here also includes elements of inspection and recording of infrastructure condition and events or the data capture, laboratory testing and modelling of data for optimization or risk, an initial identification or prognosis.
- Supply Chain and Procurement department is responsible for establishing purchasing relationships with the market place for products or services that the WaSC requires in operation or maintenance, repair or replacement of its assets.
- Capital Delivery Unit (CDU) is responsible for the delivery of infrastructure solutions to business risks, typically through the replacement of built assets. CDU

liaise with partner organisations selected for their skills in design and construction of the solution infrastructure, and commission new assets for delivery from these partner organisations.

- Land and planning department liaise with landowners for access and compensation, in order that CDU are able to build new infrastructure or gain access to existing infrastructure. Land and planning may also identify and liquidate land assets that are surplus to existing requirements.

Indirect support activities are the WaSC administrative activities that are vital to efficient running of a business. The indirect (business) support activities in the WaSC under research are as follows:

- Regulation, which monitors and influences incoming regulation, to ensure the business meets and will continue to meet its regulatory requirements. A key aspect of this business function is the reporting and liaising with the WaSC regulators.
- Investment is the strategic planning of asset investment, reviewing the infrastructure and predicting and identifying where in the asset-base investment should take place.
- The function of the WaSC's Finance departments is the management of income and expense throughout the business, and the disbursement of finance.
- Customer Liaison department provides the direct interface between the WaSC and its clients, it manages customer complaints and is also a source for targeted marketing of client and their WaSC related behaviours. A further function of the Customer Liaison is the collection of service fees from domestic and commercial clients.
- Human Resource is the department responsible for recruiting, and training of employees of the WaSC; these services are offered across the business.

- The Legal Department is responsible for the writing, negotiating and advising on legal contacts across the business and for asserting the legal position of the business.
- Finally, 'Innovation Delivery' is the department responsible for undertaking research, development or introduction and piloting of innovations to the WaSC.

Figures 3 to 6 illustrate that the WaSC is an infrastructure intensive business with numerous asset functions, which are often subject to different environmental contexts and therefore constraints, opportunities, stakeholders and regulators. To run this infrastructure business multiple functions are required, some of which are administrative functions, others directly ensure the continued supply of water and sewerage services to the required water quality limits. To maintain service the business needs to manage the maintenance and replacement of its infrastructure assets.

This research focused specifically on innovations that would improve the performance or understanding of sustainability for the department CDU in a WaSC. The CDU is responsible for the replacement or renewal of asset infrastructure. This area of focus was selected by workshop and consultation with the WaSC. Members of the WaSC who participated in the research felt strongly that at the point of renewal and / or replacement of infrastructure assets, opportunities to change the overall sustainability performance should be available. By focussing on sustainability innovations which may benefit CDU, the research was not able to address sustainability innovations for the operational side of the WaSC.

The operational sustainability impacts are significant for the water and sewerage sector. For example, in England and Wales, WaSCs not only use over nine thousand gigawatt hours per year of energy, they also produce five million tons of GHG per year as a by-product and lose three thousand nine hundred megalitres of water per day through leakage. Moreover, the industry has so far failed to curb a growth trend in domestic water demand (WATERUK 2012).

The operational side of the WaSC is clearly a compelling target for both sustainability innovations and sustainability performance improvements. There are a number of possible operational improvements which might be implemented. For example, one option is to improve sustainability performance by optimising the existing infrastructure using tools such as ISO 24500 (Cabrera Jr, Ellison et al. 2009). Another option is to intervene in a catchment or watershed to influence land use and manage or influence agricultural behaviour. This can improve sustainability performance by reducing influent loads and quality (Naiman 1992). Two further possible operational improvements are to implement demand-management activities in order to reduce operational load (Butler and Memon 2006) and to employ Strategic Asset Management Systems (SAMS), which allow a WaSC to improve its understanding of the status of its asset base to facilitate the selection of optimal investment targets (Marlow and Burn 2009). Finally, specific environmental management systems - such as ISO 14000 (MacDonald 2005) - may be used specifically to help an organisation recognise and reduce its environmental impact.

All of these operational improvements have the capacity to alter the sustainability performance of the WaSC. However, Thomas and Ford (2005) recommend a more drastic course of action. In order to achieve the radical changes in sustainability performance that they believe are necessary, a WaSC must discard existing models and technologies and re-conceptualise how it delivers water and sewerage services. From this perspective, while innovation in both infrastructure and operation is necessary, radical leaps in sustainability performance cannot be based on legacy technologies, but on the innovations that supersede them.

It is at the point of the renewal or replacement of infrastructure that the WaSC employees also believed there was an opportunity to alter the infrastructure system and therefore alter the sustainability performance of the system. As a result of this logic, the research focused its efforts on the introduction of a sustainability innovation within the CDU. The following sections describe the role and place of the CDU within the WaSC in more detail.

1.3.6 The WaSC and its investment planning process

The WaSC analysed in this research project is owned by a holding group that specialises in water and sewerage supply. It owns a number of WaSCs based in the UK and a small number overseas. The majority shareholder of this holding group at the time of the research was a large bank.

The WaSC is responsible for the delivery of services in a large region of England. It treats over one and a quarter billion litres of water for drinking and a billion litres of wastewater per day, servicing over two million homes. In order to achieve this, the WaSC has a distribution network of over sixty thousand miles and hundreds of reservoirs and water and wastewater treatment works.

To maintain and improve its level of service, the WaSC must regularly renew or replace a proportion of the infrastructure assets upon which it is reliant. The regulator Ofwat enforces this process by sanctioning the WaSCs investment plan. It is the responsibility of the WaSC's investment planning team to select the infrastructure investment targets for the investment plan from this extensive asset base. This process is described below.

The investment planning team must propose to the regulator the type of investment (what risks will be resolved) and the estimated cost of that investment for a regulation-enforced and monitored 'asset investment planning period' (AMP) of five years. To develop this investment plan, the investment planning team uses a combination of service risk, risk models, cost benefit analysis (CBA), and consultations.

A service risk is where the infrastructure is unable to deliver the required or desired level of service. Risk is estimated using a simple risk matrix, which maps the severity of the impact against the probability of the impact event taking place. For the WaSC, infrastructure risk can take many forms. For example: a frequently failing part of the infrastructure which must be fixed or replaced, a change in demands on an asset (increase in population or change in population behaviour) which means the asset is no longer able to perform the required service, or a change in the performance of the asset in achieving a regulatory target. Risk models are also used to anticipate the requirement for asset renewal or replacement. They are constructed from a combination of predicted asset life and real asset life, the latter calibrated using data entered by asset managers as they become aware of changes in the asset's state.

CBA is used to prioritise asset investment risks by calculating and comparing the benefits and costs of a project. Different investment projects may then be compared and those projects that are most cost beneficial to the organisation can be identified. In addition to risk model inputs, the CBA enables specific positive goals or outputs to influence the investment prioritisation in order to generate the desired outcomes. For example, there may be additional strategic investments that are guided by the strategic asset vision of the WaSC, or specific cost beneficial environmental goals that are incorporated into the CBA. The output of the CBA is an initial capital investment plan.

Once an initial capital investment plan is in place, it is assessed by asset managers, who compare the modelled infrastructure risks with their experience and understanding of the asset base investment need. At this point asset managers may identify additional investment targets (i.e. of higher priority or concern) to those indicated by the proposed investment plans, and the proposed investment plan is revised accordingly.

Having been assessed by the asset managers, the revised investment plan is then sanctioned or returned for revision by the board of directors. Once the board of directors is satisfied with the investment plan it is proposed to the regulators Ofwat, which evaluates whether the investment plan is good value for the customer (i.e. if the investment is justified and the estimated value of the investment is not inflated).

Once the regulator sanctions the investment plan, the CDU is responsible for the delivery of the capital investment plan. How the department CDU interacts with other parts of the business and with other organisations in carrying out these duties is described in the following section.

1.3.7 The WaSC and its infrastructure delivery process

This section describes the management structures and the business process steps used to manage the design, construction and commissioning of new infrastructure assets for the delivery of the capital investment plan of the WaSC (See Figure 7 below). It does so in order to introduce the existing business processes within which the researcher, along with members of the CDU, developed proposals and the pilot project for sustainability innovations.

The CDU is the business unit within the WaSC whose primary responsibility is the mitigation of risks through investment in asset infrastructure. The CDU manage asset infrastructure investment from site investigations and risk analysis through to designing and constructing solutions. The CDU of the WaSC under investigation in this study planned an investment portfolio of £1.9 billion over the AMP 2010-2015.

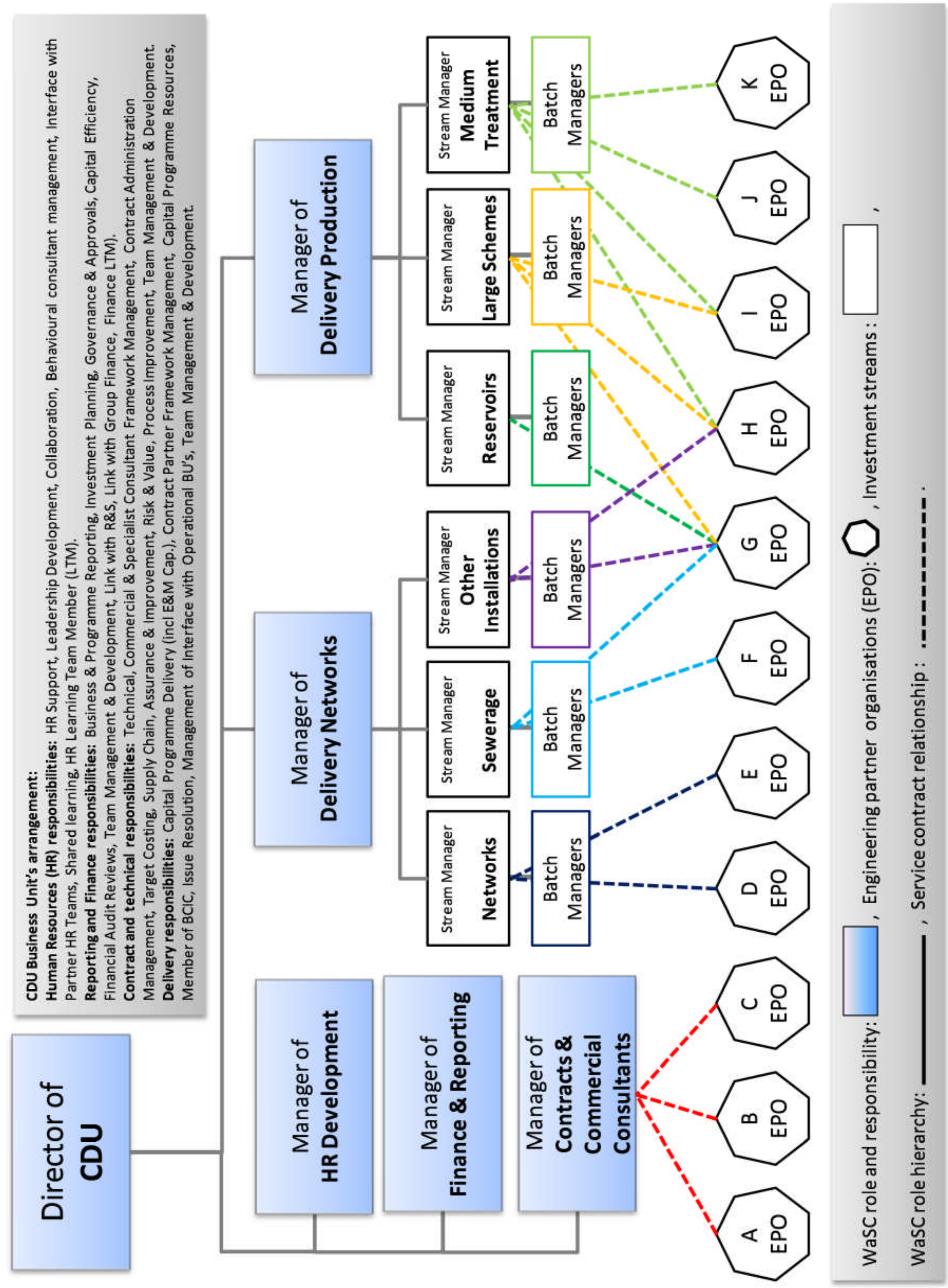

Figure 7 Organogram of the WaSC capital delivery unit and engineering partner relationships

Five teams support the CDU in its delivery of the capital investment plan: Human Resources, Reporting and Finance, Commercial and Contract, and Delivery, which is sub-divided into two teams; (delivery) Production and (delivery) Networks. The two delivery teams are responsible for the delivery of the capital investment plan. Human Resources supports the CDU with the necessary learning and development tools for the members of each team. Reporting and Finance are responsible for the internal and external monitoring, management and reporting of team finances and reporting interests. The Commercial and Contract department is responsible for commissioning EPOs for specialist support on the technical and commercial needs of the department.

The CDU's delivery of the capital investment plan is divided into six areas, which are referred to as 'investment streams'. Five of these streams relate directly to asset infrastructure types. The stream 'Reservoirs' are reservoir-related assets, 'Networks' and 'Sewerage' typically relate to pipe infrastructure for the transmission of potable water and sewage respectively, 'Medium Treatment' is the infrastructure used to change the chemical or physical properties of sewage, sludge or water for drinking and 'Other Installations' are assets such as pumping stations and those related to telemetry. The sixth stream, 'Large Schemes', differs from the other streams as it is determined by project cost and can refer to any project that resolves a risk at a cost of greater than ten million pounds.

Each CDU stream has a Stream Manager (SM) who is responsible for the delivery of a stream of solutions to risks. To achieve this, each stream has a team of Batch Managers (BMs), who are responsible for managing the resolution of a number of business risks. BMs liaise with Engineering Partner Organisations (EPO), which have been selected for their skills in design and ability to construct a solution infrastructure, and from whom they commission new assets for delivery. All asset streams, except 'Reservoirs', have more than one EPO to which it can allocate the infrastructure delivery projects.

The process of selecting and delivering new asset infrastructure has been developed by the WaSC to reduce the cost of its investment in asset infrastructure. This is the capital cost of infrastructure or ‘capex’ and comprises all the costs associated with the design, building and commissioning of asset infrastructure. The ‘capital cost’ is different to the operational costs, which encompasses all the (post-commissioning) costs of running, maintaining, and repairing the asset throughout its life. The regulator, Ofwat, has devised a reward system for UK WaSCs whereby efficient capital construction is rewarded. Under Ofwat’s reward system, the WaSC can keep as profit the difference between the planned capital costs and any reduction in real capital costs of investment in asset infrastructure. This is termed ‘capital efficiencies’ and is a mechanism for generating profit from the WaSC business in the UK. Monitored and checked by the regulator, capital efficiency cannot be realised by changing the capital infrastructure itself, only by the efficiency with which the infrastructure is constructed and commissioned. These capital efficiencies can either be shared with shareholders, or reinvested in the business in any manner chosen by the WaSC. The WaSC under consideration here has embedded this driver in the contractual arrangements its partner organisations such that the capital efficiencies realised are shared between the WaSC and the EPO.

The steps developed to enable the EPO to realise efficiencies in the delivery of built infrastructure are depicted in Figure 8 below. The WaSC has grouped infrastructure risks together (called a batch), so that rather than giving the EPO one infrastructure problem at a time, which is the traditional approach, the EPO receives a batch of risks. This is so the EPO has the opportunity to optimise its deployment of resources and thereby maximise efficiency in delivery by saving time and cost.

A batch may also be brought together as this presents an opportunity to further improve the opportunity for efficiencies. For example, a batch may contain regionally close risks to limit the travel time and expenditure of the EPO partner. Or the batch may contain multiples of similar/ and or identical risks so that the EPO partner can create a team that will become increasing efficient as it becomes increasingly familiar with the work tasks required and optimises itself.

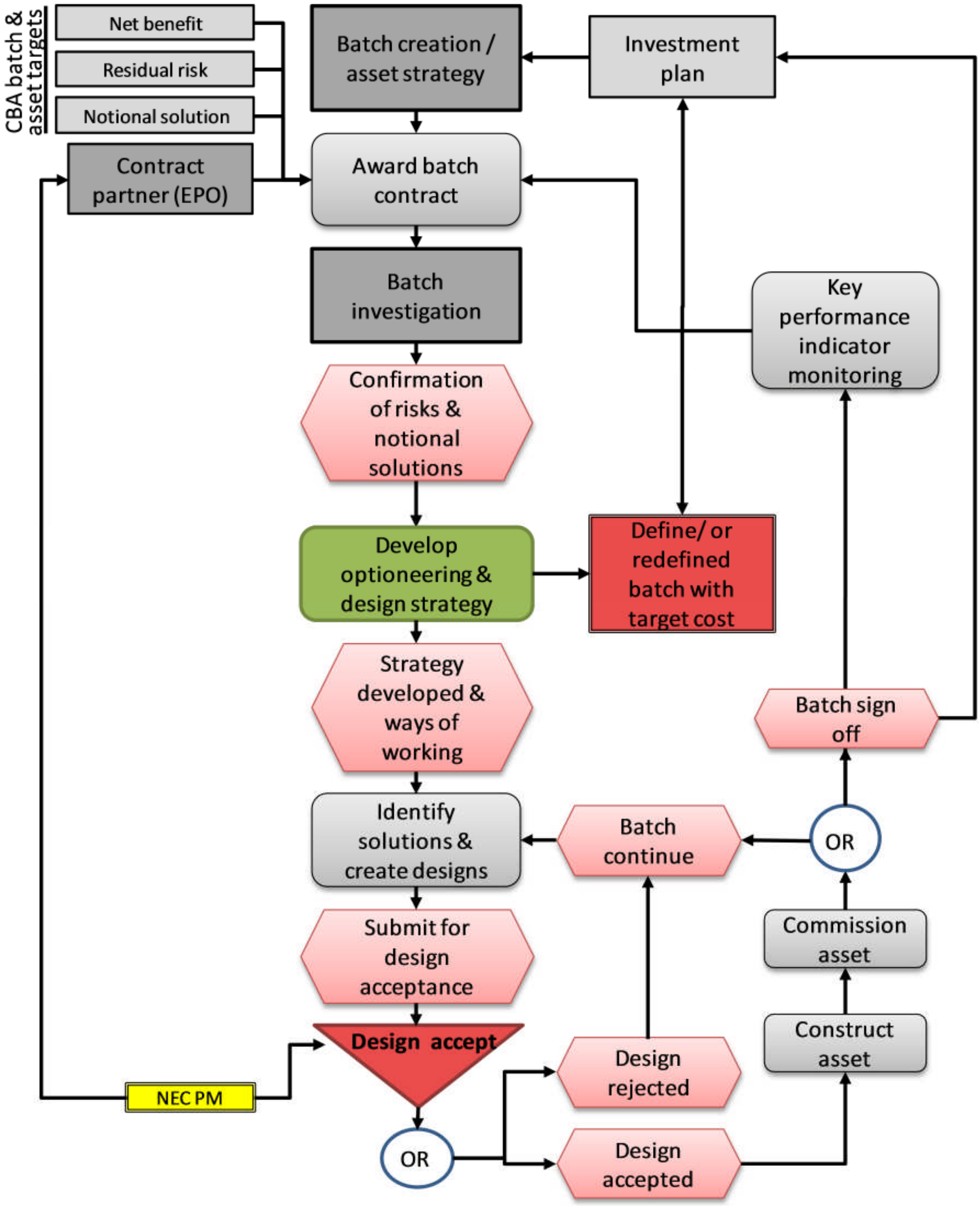

Figure 8 Flow chart of the WaSC asset infrastructure procurement process

The process developed by the WaSC for CDU is described as follows. A batch of infrastructure risks are identified by the WaSC and grouped together. Each infrastructure risk has a notional solution attached to it; the notional solution is the infrastructure solution used to resolve the service risk. Notional solutions are identified through the 'Asset Standards' contractual documents that stipulate the type and specification of infrastructure that must be used, or the technology employed typically in the previous AMP. Each notional solution will have an associated capital cost for its design and construction, (modelled from investment experience of the WaSC) and a whole life cost.

The batch is then delivered to the EPO, with a batch target delivery cost. The target delivery cost is based on the sum of the notional solution capital costs but with a reduction based on cost efficiency commitments made by the EPO during the EPO selection process. The EPO then performs a batch investigation; the batch investigation is used to verify or contest the risk and notional solution proposition and ensures that the scope of the problem defined by the WaSC is correct. Any alterations identified by the EPO are now used to amend/negotiate the batch contents accordingly. At this point, the scope and the contents of the batch are fixed and the EPO can then proceed to deliver asset infrastructure solutions that resolve the identified risk.

The EPO will then undertake a detailed design of the infrastructure solution to the risk; proposed infrastructure solutions must conform to the guidance in the Asset Standards and the Engineering specification[4], (unless a dispensation is agreed). In addition to this, each proposed solution must be equal to or less than the WLC of the notional solution, not the capital costs. Once the proposed solution is accepted, the EPO will construct and commission the agreed infrastructure.

[4] Engineering specifications are contractual documents that stipulate the type and specification of material employed their quality and construction methods that must be used in the construction of specified assets.

The above process and the outputs are monitored continually using Key Performance Indicators (KPI), by a body called Asset Improvement (AI) and the members of the CDU. These KPI monitor the performance of the EPO in the delivery of infrastructure solutions to the WaSC and identify both practices/processes and solutions that should be replicated and mitigate and discourage negative practices, processes and solutions. They are also used to compare EPO behaviours and motivate competition between EPO within the stream for batches.

The above description outlines the process of the CDU business unit; it was within this business unit that this research identified and proposed sustainability innovations to the WaSC. The business unit CDU is identified as it is the business unit in which new infrastructure solutions are designed and constructed and therefore represented the frontline in transitioning the WaSC to infrastructure solutions that are more sustainable. The following section introduces the reader to the subject of sustainability, its variegated interpretations and how sustainability can be and is manifest within a WaSC.

1.4 Understanding Sustainability

To understand what sustainability means and how it might be applied to WaSC decision processes it is necessary first to comprehend the underlying concepts, principles and various interpretations that can be taken. This will be done by briefly reviewing the roots of sustainability and identifying the prevalent concerns that influenced the sustainability dialogue, and how the developing world agenda was subsumed into this sustainability dialogue. Various positions which can be taken towards sustainability are then described, and their implication for sustainability adoption in WaSC. Finally, the chapter presents the UK regulatory position on sustainability.

1.4.1 The roots of sustainability

The sustainability principle concerns are initiated by trends that began in the industrial revolution and continue to this day, concerns that human populations tend to over-exploit and pollute (and thereby degrade) local and global resources. The following section identifies the key facets in comprehending these sustainability concerns.

The age of Reason and Enlightenment paved the way for the Industrial Revolution, a revolution that changed man's relationship to nature for the following 200 years. This revolution featured the mechanisation of agriculture, industry and transport, the international trading of commodities, the migration of labour markets from agriculture to industries and across the world and rapid growth in urbanization (Hobsbawm 1987). The demographic and consumptive impacts of the Industrial Revolution have since fuelled a rich dialogue that questions the ability of the earth to provide sufficient food or wealth for an ever more abundant population. In the 1960s the work of Kenneth Boulding at the Massachusetts Institute of Technology (MIT) brought to the fore the concept of *Limits to Growth.* Numerous economists and agronomists had previously argued that increases in population would overrun the potential for equivalent economic or agronomic growth. The MIT study concluded that the world would face severe shortages of food and non-renewable resources by the middle of a 21st-century (Meadows, Randers et al. 2005). Importantly these reflections are no longer centred just on the capacity of the planet to provide sufficient food, but importantly for WaSCs, these fears now encompassed all the Earth's services including food, water, energy, and the absorption of waste. It was a major challenge to the consumptive behaviours of western countries and associatively for the WaSC within them[5].

In the same period, concerns arose around the impact of emissions generated by the activities of industrialized societies on human health. The book Silent Spring (Carson 1962) argued that the prevalent technologies of the 40s and 50s resulted in unforeseen and unintended consequences and that the technological *quick fix* approach that continued to prevail, would lead to seriously damaging consequences, and advocated a principle now referred to as the precautionary principle. The precautionary principle as suggested by Carson, is acting cautiously on the assumption that our knowledge of the effects of our actions is always exceeded by our ignorance. It thereby rules out all practices except those that are indefinitely sustainable and advocates that as much of nature should be preserved intact. Atmospheric nuclear testing had been demonstrated to spread radioactive materials across the world. A myriad of other invisible health threats had been generated, many of these synthetic chemicals, which were later to be identified as carcinogens, teratogens, mutagens, and immune and endocrine system disrupters. Thousands of examples of synthetic chemicals exist that were later found to have unintended consequences, either for human or ecosystem health. Most famous of all (and discussed in Carson's book) was DDT (dichlorodiphenyltrichloroethane), which, developed as an insecticide, was later discovered to have the potential to cause premature birth, lower male fertility and increase the risk of breast cancer for pre-puberty exposed girls (Clapp, Jacobs et al. 2008). In addition to the localized human health concern there were impacts to the local environment identified in bird populations (Connell 1999).

[5] A MFA analysis of Germany 1989 suggested that water accounted for 95% of material through put.

The field of atmospheric pollution measurement was not properly established until the 1960s. As understanding of the field grew, so the impacts of human activities on the atmosphere were recognised. By the 1970s the discoveries within the field had regionalized concerns over pollutants and their impacts. Firstly in 1972 the UN conference on the Human Environment in Stockholm focused on regional pollution issues such as acid rain, and practices in the disposal of hazardous waste (Edwards 2005). In the late 1970s, pollutant and emission concerns would be globalised with concerns over ozone depleting CFCs, which would later be subsumed into a broader set of atmospheric pollutants largely referred to as Green House Gases (GHGs - carbon dioxide, methane, nitrous oxide, ozone and CFCs). The identification of these atmospheric pollution sources globalised the system boundaries of pollution and had a significant impact on the understanding of sustainability of human activities and the public perception of pollutants in particular (Seinfeld and Pandis 2006). In particular, GHGs significantly alter the balance of gases in the atmosphere and stratosphere, resulting in the green house effect which subsequently is linked to climate change. Climate change now seems inevitable, and the likelihood is that climate change will alter the world's hydrological cycle. In particular, climate change is expected to result in:

- Increases in the frequency and severity of both droughts and floods;
- Changes in traditional precipitation and runoff patterns;
- Degradation of water quality by changing water temperatures, flows, runoff rates and timing;
- Threats to coastal aquifers from rising sea levels, with potential implications for coastal populations reliant on groundwater resources (IPCC 2007)

Parallel to emerging evidence about the impact of emissions on human health, and on global atmospheric conditions, ecologists developed theories about the maintenance of functioning ecosystems. One of the early pioneers, Aldo Leopold (1887-1948), unsatisfied with popularist principles of conservation of his time, focused on developing an understanding of ecosystem health. His view of ecosystems, where complex interactions between biota maintains balance is now broadly supported by the scientific community, although it should be noted that recent work has emphasised the dynamic nature of this balance and the potential for ecosystems to suddenly and irreversibly change under different pressures and perturbations (Gunderson and Holling 2002). Scientists following Leopold's view (conservation biologists) have argued that the preservation of biodiversity is integral to maintaining strong ecosystem health. In doing so, they link human (societal) health to that of ecosystems functions and to the multitude of biota that comprise that ecosystem.

Concerns about biodiversity, ecosystem functions, pollution, resource consumption and climate change now lie firmly at the root and core of environmental sustainability, and are clearly related to the activities of WaSCs. However, the notion of sustainability developed beyond these core concerns are a consequence of debate about relationships between poverty and environmental degradation. It is this topic that is now discussed, referring to the now famous Brundtland definition of sustainable development, which:

> '*meets the need of the present without compromising the ability of future generations to meet their own needs'* (WCED 1987, p.16).

The additional term 'development' emerged as a direct response to concerns about meeting growth needs of low-income countries, while mitigating environmental degradation and has since significantly modified the meaning of sustainability for developed countries. It was argued that the model of development advocated and used by high income countries had resulted in significant negative environmental impacts and that it had also largely failed to raise the quality of life for the world's poor[6]. The report argued that poverty and environmental degradation are interdependent, that poverty could not be overcome in a world of ecological decline and that rehabilitation of the environment would not occur in a world of deprivation. It went on to suggest that

[6] The rich countries of the world account for approximately ¼ of the world population and consume ¾ of all energy and materials produced, and as a result of this are accountable for most of the worlds pollution.

poverty in itself is a cause of environmental degradation and that the poor by necessity are often forced to destroy their immediate environment in order to survive.

The term ‘sustainable development’ helped frame the relationship between people, resources, environment and development. This now recognizes that sustainable development must be socially sanctioned. Sustainability is not just a concept about the environment and how it should be treated, but also recognizes a social contract to support socially agreed means and ends to achieve sustainable development. Unfortunately, the term ‘development’ is a word readily substituted for economic growth. Thereby the legitimate addition of the term ‘development’ to the growing sustainability concerns has resulted in a generic term that is often used to support economic goals often regardless of environmental costs. It is now commonly criticized for being too vague and open to political moulding (Shearman 1990; Bell and Morse 1999; Jabareen 2004; Gibson 2005) or as Robinson states, it is “woolly” and easily embraced in rhetoric (Robinson 2004).

The concerns outlined above have become the arguments for sustainability, which incorporate both direct environmental concerns and those of society towards its own developmental needs. These concerns shape the means by which a society seeks its social goals and sanctions the use of its environmental resources. These decisions are influenced by social values regarding humanity, the natural world, and technology. The relationship between these three elements is examined in the following section.

1.4.2 Positions regarding environmental sustainability

The diversity of environmental stakeholders is huge today, with environmental lobby groups, commercial and governmental organisations and the public positioned across a spectrum of positions, from radicals to conservatives. Table 2 below explores some of the positions regarding sustainability that may be taken, using four worldviews: extreme cornucopian, accommodating, communalist and that of the deep ecologist.

Table 2 Environmental spectrum (adapted from Pearce & Turner (1990, p.14)

	Techno-centric		Eco-centric	
	'Extreme' Cornucopian	**Accommodating**	**Communalist**	**Deep Ecology**
Ethical position	Anthropocentric; Instrumental value in nature	Wider notion of stewardship for nature; intergenerational equity considered	Extension of ethical responsibilities to non humans; strongly communitarian	Acceptance of bioethics
Economic goal	Maximise economic growth ethic in material value	Long term sustainable growth	Equitable share of economic benefits	Resources allocated to enhance and improve natural capital
Resource use	Resource exploitative, growth orientated position	Resource conservationist; managerial	Resource preservationist	Extreme preservationist
Economic evaluation	All forms of capital can be substituted with no regard to form of capital.	Natural resource management rules: Renewable natural capital to be substituted according to rule sustainable yield.	Pre-emptive macro environmental constraints on economic growth based on natural and social capital limits	Minimum form of natural capital can be substituted in economic evaluation, de-industrialisation
Innovation and ecosystem impacts	Unfettered innovation	Precautionary principle (misused) Innovation inhibited by scientific proof of harm	Precautionary measures taken despite proof of harm not yet established	Burden of proof of non-harm on innovation proponent

The cornucopian and accommodating worldviews may be considered techno-centric in that they are likely to place a high value on technology, using it as a reference in decision-making. The communalist or the deep ecologists are eco-centric, place a high value on natural systems with decision-making referenced to these natural systems.

These positions in relation to sustainability may have a profound impact on how the WaSC acts. To a problem such as high sediment loads in reservoirs, a techno-centric is more likely to find technology based solutions, such as hydro suction technologies or slotted pipe sediment sluice. An eco-centric approach is likely to utilise preservationist strategies, such as land management schemes that include reforestation of reservoir basins to reduce sediment in runoff.

Under each worldview, the table describes the goal, the corresponding use and management of resources, the rules associated with the evaluation of the economic cost and benefits, the corresponding ethical position between man and nature, and the principles to mediate innovation in pursuit of goals.

The table, from left to right, demonstrates positions of increasing concern for environmental sustainability. These different worldviews can be held by individuals, organisations or institutions. Table 2 is used to serve as an indicator of logical corresponding positions; however, it is just as likely that conflicting positions are held simultaneously and positions on each of these will dependent on the context. The text below describes how the differences stated in Table 2 may impact the behaviour or arrangement of the WaSC.

The 'Ethical position' illustrated in Table 2 describes differing positions regarding the value of nature. For example, the cornucopian ethical position is that nature is at man's disposal and holds a purely instrumental value. This is opposed to positions to the right that credit nature with an intrinsic value, its instrumental value being largely the life supporting functions of its ecosystems.

Different economic goals for a WaSC may result in different management or ownership models. An economic goal that seeks to maximise growth (measured by financial profit) is well-suited to the shareholder ownership model prevalent in WaSCs in England and Wales where WaSCs are administered by shareholder owned businesses. In this model, it is incumbent on these WaSCs to meet the needs of their shareholders to see a good return on their investment - i.e. a return that is rapid, regular and large. The WaSC therefore arranges itself (through management goals, structures and policies) to achieve the goal of economic growth most effectively. However, an alternative economic goal for long-term sustainable infrastructure might seek different investment strategies that do not provide immediate shareholder dividends. Such an economic goal may be better suited to a different form of ownership, one that is orientated towards the long-term viability of the WaSC.

'Resource Use' describes the implications of the ethical position in terms of approach to natural resource use, from exploitation of resources to conservation of resources, the protection of resources to secure a viable future, and preservationist resource strategies; nature should be protected at all costs to secure ecosystem health. For WaSCs, the former indicates that man's responsibility to his natural environment is limited to extracting instrumental value and the latter suggests that a WaSC is best served by a functioning ecosystem, and its activities should include guardianship and protection of the resource, regardless of potential economic instrumental value. A WaSC position on the exploitation of resources is critical to the behaviour of the WaSC and most acutely recognizable in the field of water resource management (WRM). If a WaSC is to take the cornucopian worldview it would legitimately justify unsustainable abstraction of groundwater (beyond sustainable yield) to serve a growing population (benefits for social and economic capital), as this 'weak sustainability' position permits total substitution of capitals. However, a WaSC that assumes a resource preservationist approach (strong sustainability position) to increasing water demand (social capital) would more likely lead to demand management strategies, or increases in uptake of water recycling solutions (limiting net impact on natural capital). The strong sustainability position assumes that some natural capital (ecological assets) such as the ozone layer, or biological diversity, must not be allowed to decline. These ecological assets form 'critical natural capital' and human survival depends on them and should therefore be non-substitutable. A deep ecologist's position on the resource use may look to significantly reduce the impact of the WaSC on natural resources. This may include a significant departure from the recognized centralized treatment and distribution system in order to reduce natural resources, or a greater concentration on the development of passive systems.

Finally, as a sector the relationship between risk and innovation may be managed differently according to value position held by the WaSC or the regulatory body. An example of this is the Water Framework Directive (WFD), the EU water legislation that is based on the precautionary principle of a communal approach where 'precautionary measures are taken even if proof of harm not fully established'. This directive targets water quality to mitigate environmental damage, increasingly demanding improved water quality over time, to ensure that in this complex system there is a reduced likelihood of permanent degradation. An alternative approach may be to allow pollution of surface water bodies until scientific proof of cause and effect is established. Alternatively a sustainable threshold applied to water quality may either enable significantly more release of pollutants into water bodies, assuming that the ecosystem is robust and will not be permanently degraded, or sites may be identified as in Sites of Specific Scientific Interest (SSSI) and put aside to maintain a limited amount of high quality fresh water ecosystems[7].

The sustainability positions adopted by a WaSC and its sector will be evident in the sustainability innovations, and in business structures and processes. The above demonstrates that multiple value positions may be held in the field of sustainability, and the degree to which a WaSC is cornucopian or follows a deep ecologists perspective may alter through the WaSC and from individual to individual or can alter between the

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[7] It has often been suggested that sustainable threshold, certainly in terms of ecosystems is so complex to model that it is difficult to ascertain where that threshold should be (Haberl et al. (2004).

different regulatory bodies within the sector. Certainly, the stakeholder environment will be as varied as the positions in Table 2. The following section introduces the UK government and water sector position on sustainability by briefly reviewing important policy statements and the sustainability related innovations with which the WaSC must engage.

1.4.3 How sustainability is reflected in EU and UK water regulation

UK WaSCs are subject to multiple influences in the generation of sustainability positions. These influences include Ofwat, the EA, the UK Government Department for Environment Food and Rural Affairs (DEFRA) and the EU, of which the UK is a member state. Each of these bodies has statements and authoritative controls which indicate their stance on sustainability and which, in turn, influences a WaSC's position on sustainability.

The UK water sector also includes sector bodies such as UKWIR, which commissions research on behalf of UK WaSCs, and Water UK, a representative body which liaises between the UK water industry, the government, regulators, stakeholder organisations and the public. The following section discusses statements made by the European Union (EU) and the UK government and its departments on sustainability and the water sector in order to introduce the reader to the institutional influences shaping a WaSCs position on sustainability.

As demonstrated by numerous failed attempts to agree strategies for climate change mitigation, reaching internationally agreed strategies or binding targets in the field of environmental protection and development will always prove difficult. While this raises important questions about the ability of international regulations to assist nations seek a sustainable society, the EU, of which the UK is a member state, has effectively driven regulation to protect or improve the environment through its membership. The EU, (which has adopted the precautionary principle which is close to a deep ecology position), has been passing legislation on water and the environment since the 1970s. Of direct consequence to WaSCs is the target for surface and ground water quality set by the Water Framework Directive (WFD). The Directive commits all member states to have water bodies of good quality by 2015. In addition to the WFD there are many EU targets laid down in the *Sixth Environmental Action Program*. The sixth environmental action program tackles all environmental hazards and strategies, from waste and recycling to energy and climate change. Many of these have affiliated targets for reduction or phasing out of the use of some hazardous chemicals, and the re-wilding of the environment.

Each member state is allowed a limited degree of freedom in their interpretation and application of the directives within the WFD. The UK Government's sustainability strategy of May 1999 was developed based on the Brundtland definition and aims to '*ensure a better quality of life for everyone now and for future generations to come*'(DETR (1999), p.8 cited in Foxon, McIlkenny et al. 2002). Four key objectives are proposed as the means of achieving this:

- *'Social progress which recognises the needs of everyone*
- *Effective protection of the environment*
- *Prudent use of natural resources*
- *Maintenance of high and stable levels of economic growth and employment'(DETR 1999)*

These statements, and the activities of the UK government, are equally broad and so often fail to direct research and development effectively towards improving sustainability , i.e. towards more sustainable systems of production and consumption, or towards more appropriate systems of understanding what the impacts of human production and consumption are on the natural environment. A further look into UK Government sustainability rhetoric finds that it employs a version of 'the precautionary principle', which suggets that sound scientific evidence should guide government policy actions. This is somewhat different from the guidlines provided by the EU, according to which governments are obliged to take policy actions where there is a suspected risk of environmental harm, despite a lack of scientific certainty. However, the position of the UK seems to be moving. Referring to the 'precautionary principle', the forthcoming UK Government Water Sector Report (WSR) suggests that a '*lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation'*.

The principle of sustainable development within the Water Sector Report (WSR) (as yet unpublished) is to be based on a composite of two previous DEFRA reports, Directing the Flow (DEFRA 2002) and Future Water (DEFRA 2008). These are a set of operating expectations advocating social progress, protection of the environment, prudent use of natural resources, adoption of waste hierarchy, economic growth, long-term strategic planning, sound use of scientific knowledge, transparency, information and participation, and working in partnerships and adoption of the polluter pays principle. This principle advocates; that those responsible for environmental degradation are responsible for paying for its remediation. The processes for achieving sustainability advocated in the WSR include assessing suppliers' environmental performance, and carbon impact (or footprint) comparisons, using life cycle assessment and environmental impact assessment. It also maximises the adoption of sustainable options, use of sustainability criteria in decision making and working together to influence design and implementation of legislation and guidance in order to facilitate practical change towards sustainability.

The Department for Environment Food and Rural Affairs (DEFRA) is responsible for policy covering environmental protection, food production and standards, agriculture, fisheries and rural communities in Britain. Its strategic priorities are currently as follows: climate change and energy, sustainable consumption and production, protecting the countryside and natural resource protection, sustainable rural communities, a sustainable farming and food sector including animal health and welfare. In setting out its vision for the challenges for water in the future, DEFRA concentrates heavily on aspects of water security, infrastructure, and pollution, and does not set many sustainability targets, except for SSSI condition improvement, Ofwat leakage and delivery targets, a reduction in domestic and industrial water consumption, and a reduction in CO_2 by 2020 (DEFRA 2008). There is acknowledgement of a vision of the status of water by 2030 although it does not suggest environmental principles, which underpin such a vision. The focus on SSSI above all others may indicate a preference for weak sustainability rather than a precautionary principle applied across a broader spectrum of environmental issues.

The Environment Agency is responsible for abstraction licenses and monitoring of the status of both water bodies and land. Its most recent relevant document, Hidden Infrastructure (2007), does little to help guide the modern WaSC in sustainability terms, arguing that the future will require extra infrastructure capacity along with demand management measures to cope with anticipated population growth, particularly in the south east of England.

Ofwat is the economic regulator authority for all UK WaSCs. Its take on sustainability has been criticized, which it acknowledged itself. Ofwat does not seem to have elected to follow the precautionary principle, and in fact it could be suggested it is taking the opposite approach, having argued '*the need for sound evidence to support our understanding of causal relationships when considering actions to protect or improve the environment*' (Ofwat 2006, p.9). In 2007, however they invited the WaSCs to embark on long terms strategic planning by preparing 25 year Strategic Direction Statements to help explain long-term investment processes and to assist the move away from short term 5 year planning to a more sustainable industry. Water UK has advocated its members (UK WaSCs) to report on 36 sustainability indicators, which include social, service, environmental, and economic metrics. Again, they give an indication of what sustainability concerns are for the WaSC but submission is voluntary, although most WaSC support submission. Results from all water companies are combined annually, to be used for identifying sector sustainability trends, and not as a comparison of WaSC sustainability performance or to help benchmarking sustainability performance.

Together these sector statements and activities seem to assist in framing what factors are relevant to the sustainability of a WaSC, but fall short of defining what is sustainability for the WaSC and therefore it is difficult to see what might be a reasonable expectation for waste reductions or be considered a prudent sustainable resource position for the industry. Some advocate tools or practices by which sustainability will be better understood, but it is up to the individual WaSCs or the WaSC sector at large to determine how sustainability should be pursued and incorporated. The WaSC has the option therefore of taking a proactive or reactive stance to this environment.

The section following this describes the methodology applied in this research.

2 METHODOLOGY: Research Methods and Epistemology

The purpose of this chapter is to introduce the research methods and activities undertaken that ensure the validity of the data produced in the delivery of this research project. Firstly, the chapter reviews the research questions and introduces the data required to respond to each research question. The chapter proceeds to present the research phases developed to capture and analyse the data so that the rationale for each research phase, its relationship to the research questions, and the methodological and analytical tools employed are understood. Finally, the chapter describes the measures taken to ensure the validity and reliability of the data.

2.1 Answering Research Questions

The aim of this research was to understand the opportunities and obstacles that exist to a WaSC's transition towards more sustainable practices through the adoption of sustainability innovations that were focused on processes and methods for evaluating asset design options. A sustainability innovation is any organisational change that increases the set of sustainability related principles applied in any given organisational process. For example, sustainability related principles can be incorporated into an organisation's tools, methods, processes, policies, goals, strategies or the roles and responsibilities of employees. An innovation may have a quantifiable impact on the sustainability performance of an organisation by specifying new processes or materials, or more efficient operating practices. An innovation may also contribute to generating organisational knowledge and understanding on principles related to sustainability principles through a post-construction appraisal of asset impact.

This research hypothesises that the factors that influence sustainability innovation adoption are evident in the narratives employed by potential adopting groups during the development and evaluation of sustainability innovations. Analysis of these narratives therefore effectively identifies the key factors that influence sustainability innovation adoption. This study mapped these factors for a specific department within a WaSC. These adoption influencing factors were used to inform the WaSC of ways it could improve the uptake of future sustainability innovation initiatives. This study was seen as essential because innovation adoption is recognised as a key mechanism by which UK WaSCs are expected to manage current and future areas of concern which occur under the rubric of sustainability.

A business unit within a specific UK WaSC was identified as a target for the development and proposal of sustainability innovations. This unit, Capital Delivery Unit (CDU), was responsible for the design, construction and delivery of new infrastructure assets. The opportunities and barriers to the WaSC's adoption of a sustainability innovation became evident during the process of innovation development, when evaluating the innovation proposal, and when monitoring the eventual adoption outcomes. Three research questions explored the issues faced by the UK WaSC as they attempted to adopt sustainability innovations.

A- *How has a specific WaSC incorporated sustainability innovations?*
B- *What factors influence the selection and uptake of sustainability innovations?*
C- *What changes would assist the WaSC in improving its potential to adopt sustainability innovations?*

Each of the research questions seeks to explore different aspects of the WaSC and its adoption of sustainability innovations. Thus, each question has different data capture requirements. For example:

Research question A: '*How has a specific WaSC incorporated sustainability innovations?*' is a form of enquiry that seeks a process explanation of outcomes (Poole and van de Ven 2004) and may also be referred to as a 'process' mode of enquiry. This mode of enquiry seeks to theorise cause and effect through an analysis of a sequence of events over time. A process model of research makes the following assertions: entities (i.e. people, groups, organisations, machines and other material artefacts) participate in events (i.e. units of social process; what happens to entities and what they do) and, as a result of these events, the entities may change. In process studies the temporal sequence of events is critical, as is the duration of the events (the temporal period of an event) and the event duration (the length of time an event has a causal effect on the phenomena under investigation). All prior events and causations may have a bearing on an outcome. Therefore, immediate and distal factors may need to be included when undertaking a process study (Van de Ven 2007).

Research question B: '*What factors influence the selection and uptake of sustainability innovations?'* is a 'what' question commonly referred to as a 'variance approach'(Poole and van de Ven 2004). The variance approach attempts to explain change in terms of independent and dependent variables. Rogers (2003) reflects on variance approaches, suggesting that they are yet to distinguish a set of organisational characteristics that determines an organisation's innovativeness. Mahdi (2003) notes that product innovation models are unable to reliably explain findings across sectors, as participants in innovation are not '*hyper-rational, homogenous and non choice-restricted actors*' (Mahdi 2003, p.1) rather they will typically be irrational, hetrogenous, and choice restricted and the properties of these difference s will be influenced by context.

Previously, authors such as Tornatzky and Klein (1982), and Wolfe (1994) argued that the determinants and processes in organisation innovation adoption are also subject to context specificity, and that the field would benefit from a context-specific understanding. These earlier views are supported by Damanpour (2009), who concludes that a service organisations capacity for introducing and integrating sets of innovation types over time is individual and unique. Thus, innovation adoption characteristics are unique to organisations and types of organisations. In light of these insights, future research on innovation may benefit from a focus on the factors that govern innovation adoption within a specific context, rather than attempting to produce generally applicable analyses. Throughout a sector, where organisations may share unique but similar characteristics, such organisations may also share innovation adoption.

When taken together, the process and variance approaches (research questions A and B respectively) are complementary to understanding organisations and their relationship to innovations, in particular where context-specific characteristics, such as understanding cultural cognitive frameworks for action, come together with temporal dimensions, such as a shared event history. While a variance study contributes to an understanding of the different mechanisms (content and context) that influence an outcome, typically in terms of dependent and independent variables, a process study captures and explores the narrative of how the variance mechanisms interrelate through time to drive an outcome.

Research question C: '*What changes would assist the WaSC in improving its potential to adopt sustainability innovations?'* is neither specifically variance nor process. In fact, it is the synthesis of the findings of both questions A and B on the adoption of sustainability innovations into useful knowledge. Research question C challenges the researcher to develop the understanding developed throughout the course of the research project, and to synthesise the data into a form that can improve practices for the WaSC.

The three research questions combine to ensure that process data generated from research question A, and variance data generated from research question B, are identified and then combined and synthesised according to the terms of research question C. This combination provides a practical format with which the WaSC can improve understanding and/or practice.

2.1.1 Research method

The research adopted a 'mixed methods' approach. 'Mixed methods' employs both qualitative data and quantitative data capture and analysis, and allows different methodological, ontological and epistemological assumptions for different phases of the research (Blaikie 2007).

There are a number of advantages to adopting a 'mixed methods' approach. The qualitative data ensures the results are rooted in a social reality and are able to convey a richness of detail (Denzin and Lincoln 2005). Qualitative data can tolerate contradiction and also enable the researcher to identify ambiguity (Denscombe 2003), which is important as this research is seeking a context-specific understanding of innovation. It is important that the research method nuance the data with context-specific detail, including when and where ambiguity and contradiction exist. Quantitative data reduces the likelihood of researchers being misled by false impressions and provides analytical opportunities to identify relationships in the data (Eisenhardt and Graebner 2007). By adopting the mixed methods approach, quantitative data can be used to support the building of a model that explains adoption in the context of the WaSC (Jick 1979). In the current research, quantitative data was used to help the researcher qualify qualitative data themes. Quantitative data was to be used to assess the sustainability performance of some assets; however, this part of the research project was never concluded and therefore has not contributed to the research findings in this thesis. The following section describes in more detail the data required to respond to the research question.

Data requirements to respond to the research questions

Table 3 below, describes the key data required to respond to the three research questions. The subsequent sections within this chapter present the research activities that meet these data requirements. In order to respond to research question 'A', data on the adoption of sustainability innovations in the WaSC and that of the WaSC's history of similar innovation adoption events (i), must be collected. This data can be used to generate a synchronic and or diachronic account of sustainability innovations in the WaSC. Diachronic data shows the relationship between phenomena evolving over time, while synchronic data shows the relationship at single point in time (Ruspini 2002).

Diachronic data provides a process understanding of sustainability innovation and change for the WaSC while synchronic data tell us about the conditions. These data were used to express how an event takes place, or enables the identification of patterns of events through time, which influence events and outcomes. The synchronic and diachronic data analysis is distinct from time series data, which will typically take data at intervals, defined by time intervals or an event occurrence.

Table 3 Research question's data requirements

Research Questions	Data required to answer research question
A. How has a specific UK WaSC incorporated sustainability appraisal innovations?	i. Diachronic and synchronic data on the sustainability innovation adoption process and the WaSC sustainability change history.
B. What factors influence a WaSCs selection and uptake of sustainability appraisal innovations?	ii. The WaSC's endogenous & exogenous characteristics that influence the selection/adoption decision for proposed sustainability innovations. iii. The innovation characteristics that influence the selection/adoption decisions for sustainability innovations.
C. What changes would assist the WaSC in maximizing its potential to incorporate sustainability into practice?	iv. Existing factors that influenced sustainability innovation adoption in capital delivery. v. Alterations that would improve adoption of sustainability innovations. vi. All of all of the above data.

Research question B required the capture of data on (ii) characteristics endogenous and exogenous to the WaSC, which influence the adoption of sustainability innovation, for example, internally available resources, or 'slack resources' (Damanpour 1991), are an endogenous characteristic of the innovation context. An exogenous characteristic would be the availability of resources (Crossan and Apaydin 2010) such as ferric sulphate, which is commonly used as a coagulant in water treatment. Question B also required data on the characteristics of the sustainability innovations that influence the adoption (iii), for example, the size of the innovation (Garcia and Calantone 2002).

In order to respond to research question C, it was first necessary to understand existing factors that influenced sustainability innovation adoption in capital delivery (iv). This could then be used to identify innovations to the WaSC to improve adoption of sustainability innovations (v). Finally, all the above data (vi) would be used for analysis and synthesis in response to research question C. Together, research questions A, B and C have been developed to generate data that can inform the development of future sustainability innovation initiatives for parties wanting to plan, undertake or encourage sustainability innovation in a WaSC. This was achieved by generating knowledge on: the different modes of sustainability innovation that have been incorporated into the WaSC, the conditions that inhibit or facilitate the adoption of sustainability innovations, and the conditions that inhibit or facilitate the innovation process.

The following section presents core actions undertaken in this research project. It does so by dividing the research into six phases and identifying the principal activities (including the adopted design methodology) undertaken within each research phase and the relationship of these activities to the research questions, their data requirements and the project deliverables.

2.1.2 Research phases, activities and data requirement

This section presents core actions undertaken in this research project (see

Figure 9 below). The section outlines the methods employed through the different phases of the research project. For each phase, the following is presented: the principal activities undertaken, the analysis employed, the resulting decision outcomes, and how these correspond to the data requirement for each research question and the agreed project deliverables. Below are the six research phases that supported the generation of the data that was required to respond to the research questions:

Phase 1. **Preparation & literature review** established the research approach and familiarised the researcher with the research topic.

Phase 2. **Selecting a sustainability framework** identified a robust interpretation of sustainability that was relevant to the activities of the WaSC. This was important, as a sound interpretation of sustainability was the reference point from which the rest of the study could be evaluated.

Phase 3. **Appraising sustainability practices** applied to the sustainability framework identified in research phase two in order to appraise sustainability of existing practices. This revealed obstacles to, and opportunities for, sustainability, and contributed to meeting the data requirements (*i), (iv) and (v)*.

Phase 4. **Innovation development** identified and developed innovations to improve the sustainability performance of the new asset infrastructure, and generated data requirements (*i)* to (*v)*.

Phase 5. **Piloting & proposing sustainability innovations** proposed and piloted the innovations developed in the previous phase in the WaSC, contributing to the data requirements of (*i)* to (*v)* on the proposed innovations.

Phase 6. **Analysis & thesis synthesis** of the data collected in previous research phases, contributing to the final data requirement (*vi)*.

The detail of each research phase is presented below in Figure 9, which presents a useful graphic that should be used together with the remainder of this section.

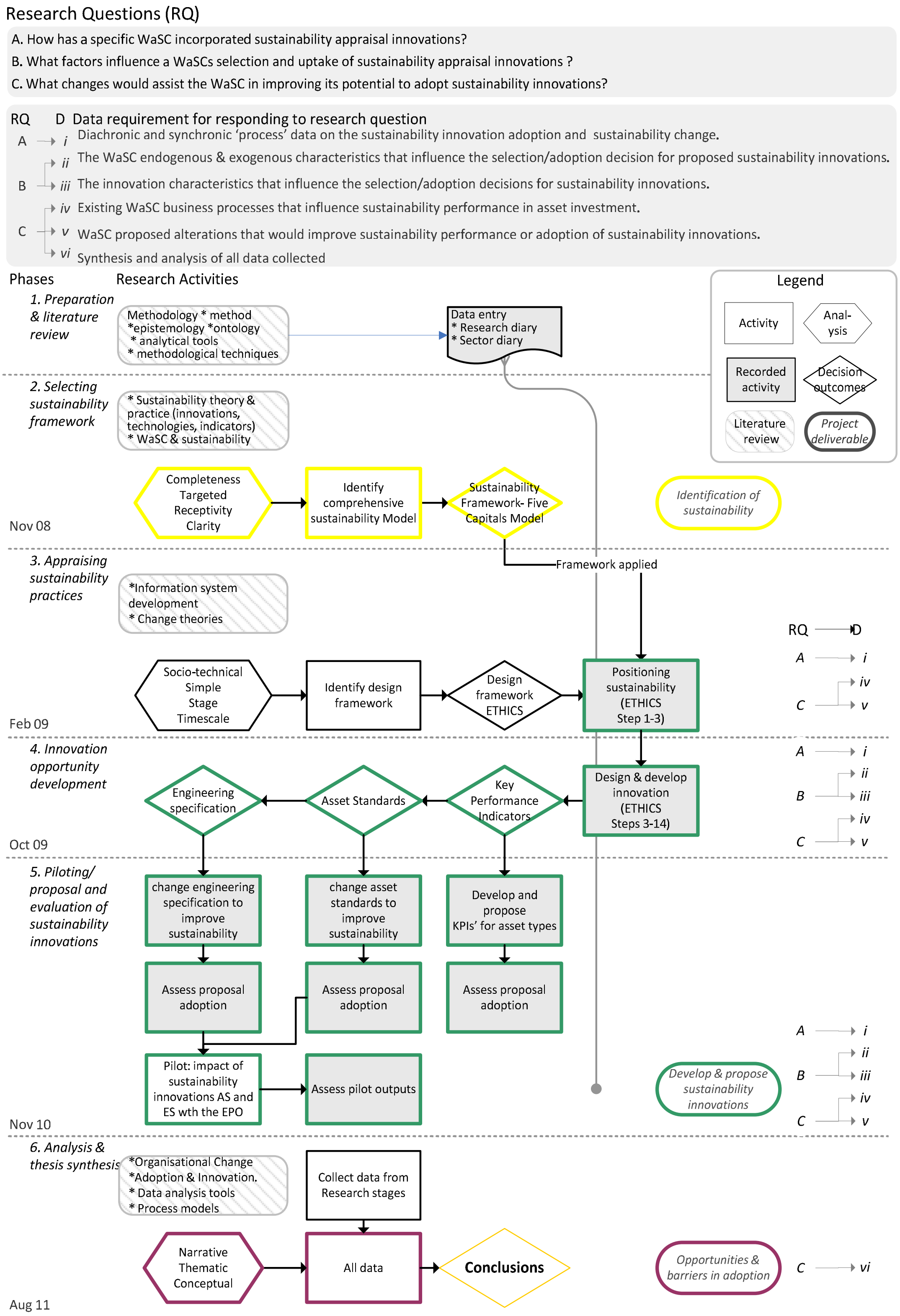


Figure 9 Summary of the research project activities (data collection , analysis) the required project outputs (research questions, data requirement, and the project deliverables) and project phases.

Research phase 1: Preparation and literature review

The research preparation and literature review was a desk-based review of required material to undertake research on, and analysis of, results from an investigation into sustainability innovations and WaSCs. The desk-based review can be grouped into the following three themes:

1. Theme one ensured that the research presented was based on a sound comprehension of the mechanisms with which to generate knowledge, and assisted in the selection of a methodology, method, epistemology, ontology and the identification of corresponding analytical tools and methodological techniques to ensure the quality and validity of the data produced.

2. Theme two was focused on developing an understanding of the theoretical and practical aspects of sustainability. Theoretical aspects included an exploration of how the main ideas and principles related to sustainability are currently defined in the literature (see page 37). The practical aspects are the real activities or events advocated to incorporate sustainability into WaSCs or organisations in general, such as the economic or decision support tools, indicators, technologies and strategic concepts that have enabled a WaSC to incorporate sustainability. Theme two also included an analysis of the literature on UK and EU WaSC's regulatory environments in order to assess how the industry is regulated, and the implications of this for a UK WaSC's sustainability. The understanding generated from this part of the literature review is presented in the introduction to this thesis (see pp. 18- 37).

3. The third theme focused on the organisational change and innovation literature. The objective was to become familiar with the extent to which changes within organisations are mitigated by the process of change itself (research into Information Systems Development [ISD] and process research studies), the impacts of change (research into organisational change) and factors that mediate the effects

of those impacts (research into organisation adoption and innovation factors). This final theme helped identify literature that informs the discussion, analysis and conclusions of the thesis.

Theme three is presented in the literature review. To ensure that the research project remained current, the second and third research themes spanned the entire length of the research project. Two data gathering activities also span the length of the research project: data entry within the researcher's diary and a sector diary. The data collected in both diaries can be used to verify data and to help build theory. The function of the researcher's diary is described on page 83. The sector diary allowed the researcher to stay informed of the principal administrative and operational concerns for UK WaSCs. This activity was not concerned with single or idiosyncratic pollution incidences; rather, it examined sector-wide trends, concerns and expectations by regularly monitoring the sector websites of key stakeholders (Ofwat, Water UK, and UKWIR) for news, reports and articles that referred to incoming regulatory changes, or environmental and operational concerns that related to sustainability.

Research phase 2: Selecting a sustainability framework

This phase identified a sustainability framework that would be applied in subsequent phases of the research project. The purpose of this was to ensure that the researcher and the organisation (the WaSC) had a shared understanding of sustainability in order to: evaluate current practices across the WaSC, identify areas where sustainability management could be improved, and develop potential innovations that would influence the sustainability performance of the WaSC. Identifying a sustainability framework enabled the WaSC to apply it to future sustainability initiatives. Two research activities were undertaken to identify a suitable sustainability framework:

1. A literature search was carried out to identify a number of possible sustainability frameworks.

2. Four criteria were used to assess the frameworks, these were *completeness*, *orientate*, *receptivity* and *simplicity*. *Completeness*, ensured that the selected framework was representative of the subject area, while *orientate* and *simplicity* ensured the clarity of interpretation of the framework and *receptivity* ensured that the framework was attractive enough to be adopted.

Detail on the methodological activities undertaken, a justification of these activities and the results obtained, are presented on pages 117 to 132. The sustainability framework that was selected was the nested 'Five Capitals Model', developed by *Forum for the Future* (Porritt 2007). This framework was selected because it scored highest on completeness of coverage, and was favourable in the three additional adoption criteria.

Research phase 3: Appraise sustainability practices

This phase was concerned with a preliminary engagement with the WaSC using the sustainability framework identified in research phase 2. This phase established a shared comprehension of sustainability between the researcher and WaSC, and initiated the collection of the data requirement (*iv)*. To increase the potential for innovation adoption, the Information System Design (ISD) framework was adopted as the research's innovation design framework. The design framework guided the process for sustainability innovation and ensured that a coherent approach to design development and delivery of innovation was employed.

To identify the design framework, different ISD methodologies were evaluated against the following criteria:

- Firstly, in framing the organisation as a 'socio-technical' entity, the methodology focuses on both the technological and human systems and pays attention to the relationships between them.
- Secondly, that the approach was 'simple', meaning further training or education (such as computer programming) to apply the methodology was not required.

- Thirdly, that the methodology could be applied to the relevant ‘phases’ of innovation development. For this research, these were: problem identification, innovation development and, potentially, innovation piloting and evaluation.
- Finally, that the ISD methodology could be implemented within the ‘timescale’ allocated to the activity by the researcher.

The design framework selected was Enid Mumford’s ‘Effective Technical and Human Implementation of Computer-based Systems’ (ETHICS). ETHICS is an Operational Research (OR), or Information Systems Development (ISD), methodology, which sets out fifteen steps providing a framework or method for defining the problem environment and developing workable solutions (see Box 1 below).

This research adopts the same conceptual assumptions as ETHICS: that the most successful information system development is sensitive to the employees’ needs and that the generation of acceptable solutions is more easily achieved through participation. The employee-fit with the innovation proposal is managed by encouraging participation in the design of new systems and internal resistance to change is made explicit and can be managed, thereby creating greater buy-in to the change objectives and the proposed system solution. For the purposes of this research, ETHICS was employed to guide a series of workshops and focus groups with the objective of developing and identifying ways of changing the processes through which new assets are designed and constructed.

Box 1 ETHICS information system development method

Name: Effective Technical and Human Implementation of Computer-based Systems'
Developed by: Enid Mumford (1983)

Central tenets of ETHICS:

Organisation is: socio-technical System
Design fit: achieved through participation of the user group (user focus ISD)
Approach: flexibility in application of methodology is recognised as necessary

Method steps of ETHICS:

1. Why Change?
2. System Boundaries
3. Description of the existing system
4. Definition of key objectives
5. Definition of key tasks
6. Definition of information needs
7. Diagnosis of efficiency needs
8. Diagnosis of job satisfaction needs
9. Future analysis
10. Specifying weighting efficiency and job satisfaction needs and objectives
11. Organisational diagram of new system
12. Technical options
13. Preparation of detailed work design
14. Implementation
15. Evaluation

Participant groups and roles:

- **Steering Group (SG) –** consists of managers and support employees necessary to facilitate the project. The SG is responsible for facilitating the project, advising and guiding the direction and sanctioning managerial support for the procedure.
- **Design Group (DG) -** consists of selected or elected personnel who represent a spectrum of roles within the system under investigation and at the boundaries of the system. They play an active role in the development of the new IS and are responsible for assisting the research by gathering relevant information.
- **User Group (UG) –** consists of all people directly impacted by changes to the socio-technical system and a number that sit on the system boundaries. They are consulted on the demands of the socio technical system.

Forms of participation and enquiry:

- Consultative – using the SG to establish initial dialogue and project direction.
- Representative – the DG sets strategic planning objectives and then devises tools and tactics for achieving them.
- Consensus - enabling the impacted staff to play a role in the design of a new work system through consensus.

The overall objective of the research exercise is to move the WaSC closer towards improving its sustainability performance. The sustainability framework identified in research activity two was incorporated into the development methodology to identify the state of existing practices within the WaSC and the subsequent innovation development requirements and activities needed to achieve these sustainability objectives.

The ETHICS methodology lays out 15 steps for the redesign of socio-technical systems. For research phase 3, the first three steps of the ETHICS methodology were applied as follows:

1. *Why Change?* - Generate consensus on the need for change and understanding the objectives of change. – *Using the five capitals framework for sustainability
2. *System Boundaries* – Identify the boundaries of the system and where it interfaces with other systems.
3. *Description of the existing system*- Create a shared description of the existing system under examination.

These three steps were carried out in a series of workshops and focus groups with the organisation (for a detailed account, including results, see pp. 135 to 160). For an explanation of the data sources that were used see page 75, and for the sampling strategies employed see page 77.

The first step, 'why change', characterised by arguments for a proactive approach to sustainability, which encouraged participants to take a proactive sustainability position and helped motivate participation in the research. The participants were introduced to the 'five capitals model', which was identified in research phase two, and the research project aims. The five capitals model was used to establish a shared understanding of sustainability, so that participants could critically evaluate the WaSC's current practices and later evaluate sustainability innovation options. The sustainability arguments are utilised to engender a desire to be more proactive in progress towards the incorporation of sustainability, through the adoption of sustainability innovations. All subsequent workshops, focus groups or interviews began with this first step in detail with new participants and as a memorandum for repeat participants.

The second and third steps were used to help the researcher build an understanding of the WaSC (structures, processes, roles, responsibilities, boundaries, goals and policies, stakeholders etc.) and to assess factors that influence the sustainability performance of the asset infrastructure utilised for service delivery. The sustainability framework was used to assess the existing WaSC for points where the sustainability was previously influenced, is presently influenced, or where there is an unexploited possibility for influence. The system boundaries were also identified at this stage. The immediate aim of the research project was to change the sustainability performance of the infrastructure asset investment by the WaSC. The system here refers to the WaSC's established decision-making system for the selection of infrastructure assets. Thus, the boundaries of the 'system' must be understood and all the factors that influenced these infrastructure investment decisions constitute the boundaries of this system.

Together, the ETHICS steps 1-3 established an understanding of the tools and processes already used by the business to manage sustainability and to make an appraisal of current practice. The activities undertaken produced data for research requirements (*i), (iv)* and (*v*). This data was carried through to the following research phase (the full results and a more detailed account of the ETHICS steps are available in the results section, pp. 135 to 160).

Research phase 4: Develop innovations to improve the sustainability practices

This research phase was concerned with identifying and developing sustainability innovations in collaboration with the WaSC employees. Where possible, the research phase continued to apply the ETHICS steps as a framework for the development of the innovation in order to ensure that innovation opportunities identified were developed in a coherent fashion. The following nine ETHICS steps were employed to guide a series of focus groups within the organisation aimed at identifying and developing sustainability innovations. For an understanding of sources of data and a justification of the means for data collection, see pages 75 to 77, for the results of all ETHICS steps see results section pages 135 to 160.

4. *Definition of key objectives* - question activities that lie within the design boundaries and development objectives.
5. *Definition of key tasks* – describe the principal tasks necessary to achieve the objectives.
6. *Definition of information needs* – re-examine target activity.
7. *Diagnosis of efficiency needs* - to expose variance in the existing system.
8. *Diagnosis of job satisfaction needs* - to ensure broad participation in the design process by revealing the needs and fit of activities to the user group.
9. *Future analysis* - ensure the system is sufficiently flexible in order to accommodate possible future scenarios.
10. *Specifying* - job satisfaction needs and objectives
11. *Organisational diagram of new system* - development of alternative system developments that can help the WaSC better meet the objectives identified in step
12. *Technical options* - identification of technical support and infrastructure that can assist in the development of new system solutions.

The activities undertaken (guided by the above ETHICS steps) contributed to data requirement (*i*) to (*v*) see Table 3. They were undertaken in small focus groups and workshops (a core set of participants was maintained throughout the process to ensure that there was a coherence of design and development). The focus groups were digitally recorded and the findings were summarised and shared with the focus group for comment and modification.

Research phase 4 identified a number of sustainability innovation opportunities (see results section, pp. 135 to 160). Three opportunities for sustainability innovations were selected for development into a proposal to the WaSC in research phase 5:

> *Key Performance Indicators* are sets of evaluative measures associated with the design, construction and commissioning of new infrastructure by engineering partners. They are used by the WaSC post-design and construction of the infrastructure asset in order to assess the engineering partners on the quality of their delivery. The KPI influence partners by signalling key business concerns and are used elsewhere in the business to identify and share best practice.
>
> *Asset Standards* is an appendix to the partner contract. The document stipulates the infrastructure options available to the contracted engineering partners to resolve the infrastructure risk and the design specifications and critical design features of that infrastructure. The engineering partners are thereby contractually obliged to adhere to the asset standards unless they have been given special dispensation, which must be agreed formally by the WaSC employee responsible for the asset standard and by a panel of senior WaSC directors.
>
> *Engineering Specification* is an appendix to the partner contract. The document stipulates suitable materials for any given function and context, and handling and construction methods associated with stipulated materials. The engineering partners are contractually obliged to adhere to the engineering specification unless they have been given special dispensation, which must be agreed by a panel of senior WaSC directors.

The key performance indicators (KPI), Asset Standards (AS), and Engineering Specifications (ES) were identified for development into sustainability innovations to be proposed to the WaSC for adoption in research phase 5.

Research phase 5: Piloting & proposing sustainability innovations

The piloting and proposal phase for the three innovation opportunities identified in research phase four utilised the final three steps of ETHICS as a guidance tool:

13. *Preparation of detailed work design* - specify the system to be piloted.
14. *Implementation* - pilot the new system.
15. *Evaluation*

For each of the sustainability innovation opportunities the activities (research steps) carried out were different:

The KPI project involved designing a series of focus groups and interviews to identify ten 'win win' sustainability KPIs that could be applied to the different investment streams within CDU. These were then proposed to the WaSC business and interviews were held with three key decision-makers, to ascertain the adoption outcome for each sustainability KPI and the reasons for the adoption outcomes. For a detailed account of the research activities and results see pages 160 to 176, KPI Results.

The AS and ES project was an investigation into engendering sustainability through the existing contractual tools: asset standards and engineering specifications. The same three activities were undertaken for both AS and ES sustainability innovations development:

1. First, expert advice was collected from within the sector: academics, engineer partners, and also some employees within the WaSC, were consulted by short

questionnaire on wastewater treatment processes that could be identified to improve sustainability performance (for asset standards) and the materials that could be specified to improve sustainability performance (in the engineering specifications).

2. Secondly, the findings from this consultation were collated, summarised and presented in a manageable form.

3. Finally, the proposed changes (sustainability innovations) to the asset standards and to the engineering specification were then proposed to the WaSC in focus groups and one-on-one interviews with the employees responsible for AS and ES. This activity captured the reactions of the decision makers to the proposed sustainability innovations, the adoption outcomes, and the reasons for the adoption outcomes. This contributed to data requirements (*i)* to (*v)*. For a detailed account of the research activities and results see page 176.

Waste water treatment was selected as the focal area for this research because it provided the opportunity to follow an investment decision from inception through to construction. Water treatment and distribution assets were excluded from the focus of this study, as it would not be possible to follow investment decisions so far along the CDU process. This factor limited the research opportunities for data gathering and, consequently, the available research directions.

Research phase 6: Analysis and synthesis

The final research phase was concerned with generating conclusions and theory on the adoption influences on sustainability innovations for a UK WaSC. To achieve this, a number of analytical tools were adopted and applied to the data. Analytical tools are ways of thinking about data, systems, techniques or procedures that can be applied to the raw data to assist in its analysis, and to make comparisons or ask questions of the data.

Research phase six applied the following analytical tools to analyse the data:

- Narrative analysis, which enabled the researcher to identify stories that framed activities and positions concerning sustainability and sustainability innovations.
- Thematic content analysis, which enabled the narratives to be grouped by themes that emerged from the narratives.
- Axial coding, which disaggregated themes into components and helped identify new commonalities that could establish new themes.
- Conceptual mapping, which is an iterative process of building, evaluating and modifying concepts and their relationship to one another.

The analytical tools enabled the researcher to analyse and gain a better understanding of the data. The above tools are all appropriate for working with the contextual data generated by the project. The researcher selected these tools to generate information to respond to the research questions and meet the data requirements. The analytical processes were applied sequentially, with the objective of meeting the identified data requirements (*i*)-(*v*): sustainability in general, sustainability innovations proposed by the research and historic sustainability innovations within the WaSC. A more detailed account of the analytical tools employed is presented below.

Narrative analysis

The Oxford English Dictionary (OED) describes a narrative as '*an account of a series of events, facts etc., given in order and with the establishing of connections between them'(2005).* Narratives are not solely historical accounts of the social world but are also commonly used by people as templates for planning and enacting activities (Czarniawska-Joerges 1997) and in making sense of the world (Weick 1995). Thus, Pentland (1999) suggests that within organisations, a commonly accepted narrative may not only represent a historical account of events, but is also like ‘ruts in the road’ (1999, p.712), which are followed and re-enacted frequently. In this light, the study of narratives becomes an important tool for process analysis within organisations. Van de Ven (1995) supports this position, claiming that the selective retention of a narrative is identified as a core construct that can be used to explain surface patterns in process theory. The following analytical tools were applied to the narratives employed by the WaSC employees as they relayed their accounts of sustainability. It is through a close analysis of these accounts, that a better understanding of the core factors that influence sustainability innovation adoption can be gained. The following analytical tools were applied to the WaSC sustainably narratives.

Thematic content analysis

Firstly, a form of ‘Content Analysis’, called thematic content analysis was applied. Carol Grbich (2007) describes content analysis as the ‘*systematic coding and categorising approach which you can use unobtrusively to explore large amounts of textual information*’(2007, p.112). A form of content analysis was selected for this research project primarily because it is a textual form of analysis suitable for analysing the large volumes of transcript data (which were digitally recorded and transcribed) arising from each interview, workshop and focus group. Thematic content analysis is a subset of content analysis whereby the content is analysed to identify themes arising from the transcripts (Given 2008). A pure approach to content analysis would be concerned with the type of language used. However, thematic analysis identifies patterns without concern for the language used. In thematic content analysis, data items (individual units of data) are allocated to themes or grouped inductively. The grouping of data units generates data sets (themes) that are induced from the data corpus to manageable themes. The same data unit may be coded to multiple themes or data sets. One way in which the research made an appraisal of the relative importance of the themes was by a simple process of counting the number of data units coded under each theme.

Axial Coding

Secondly, a form of coding referred to as 'Axial Coding' (Corbin, Strauss et al. 2008) was applied to the data sets that had been identified. Axial coding enables the themes, or data sets, to be revisited in order to elaborate on the different dimensions of a theme. For example, a theme such as 'regulation' may have positive or negative associations to sustainability, a specific regulatory event, or an aspect of the regulatory regime in the business may be repeatedly referred to. Axial coding allowed the researcher to explore and understand all these different functions or relationships to the term regulation. The process of axial coding enabled the researcher to cultivate a more profound understanding of the data, and assisted in identifying new themes and relationships within the narratives.

Because the data-gathering activities were based on open-ended questions and semi-structured interviews, the axial coding was, inevitably, a form of inductive post-coding, as the researcher was unable to predict the responses. The computer software Nvivo (2011) was employed to facilitate thematic and content analysis and axial coding. A number of computer programs, such as Nvivo, TEXTPACK, Verbstat and Statpac, are available to assist in the coding and management of qualitative data required in content analysis (Bryman 2008). All of these will, typically, enable or automate the coding of text, the process by which verbal text is converted into variables for analysis (Lewis-Beck, Bryman et al. 2004). At its simplest, this coding of texts facilitates a statistical exploration of the frequency of a word, term or coded data set, in relation to others. Nvivo was selected because it is designed specifically to assist qualitative researchers in the storing and management of large amounts of qualitative data and code and in the analysis of that data. It was also the software package readily available to Cranfield University.

By using Nvivo as a tool for the thematic analysis and axial coding of WaSC employees' narratives, the researcher was able to identify many implicit factors or phenomena (objects, events, people, institutions, organisations, activities, strategies) which explained the WaSC's relationship to sustainability and sustainability innovations. These factors were either endogenous or exogenous to the WaSC. The Nvivo software helped reveal relationships between these factors, for example, data units coded to the theme 'regulator' were commonly coded with, or near, data units coded as 'strategy of capital cost reduction'. Once the axial coding had taken place, (the researcher was effectively immersed in the data) and the process of axial coding seemed to be resulting in diminishing returns, i.e. all options for coding had been exploited, the researcher approached the narrative data with a third analytical tool.

Conceptual map

The third analytical tool employed was the development and testing of a conceptual map. The objective of this research was to understand and develop theory on the incorporation of sustainability innovations in a WaSC; the conceptual map is the synthesis of that understanding. The thematic content analysis was used to build an understanding of the principal themes under which data units could be coded. Applying axial coding to themes enabled the researcher to begin to develop a conceptual map (Lewis-Beck, Bryman et al. 2004; Flick, Kvale et al. 2007; Corbin, Strauss et al. 2008). The event based visual maps enabled the researcher to see longitudinal patterns in innovation adoption, and thereby establish explanations for certain events (Poole 2004), as well as the conditions under which those events occurred. This understanding was also employed in the development of the conceptual map.

Building the conceptual map was an iterative process of building, evaluating and modifying concepts and their relationships. To evaluate, verify and modify the conceptual map, the researcher employed the qualitative software Nvivo to code and investigate the transcript data. The process used all available material: raw data, synthesised data and data such as the research diary, to inform the conceptual map development. In order to ascertain if the map could be used to explain the transcript, and vice versa, it was tested by returning directly to the raw data (the WaSC employees' transcripts associated with sustainability innovation). This process was repeated until the researcher was satisfied that the conceptual map explained those narratives in the raw data that are concerned with innovation adoption.

The result of these processes was the development of an understanding of the factors and processes that influenced sustainability innovation within the UK WaSC. The resultant adoption influence map (AIM) describes the factors that influence sustainability innovation adoption for the WaSC (see p. 205 for details and description).

The following section pays close attention to the data collection techniques, the sources of data, and the activities undertaken to ensure data validity. It then describes the ontological and epistemological assumptions of this research.

2.2 Reliability and Validity of the Data

The following section describes activities employed to ensure that the data was not biased by the methodology (to ensure subjectivity) and to ensure the validity and reliability of the data produced. Firstly, the section reflects on the data sources (research participants), the sampling strategy employed, the principles for eliciting fair and honest responses and identifying the specific concerns that arise when eliciting information in groups. The researcher's role, in generating bias and the activities undertaken to mitigate this effect, was also considered. Finally, the principal methodological process of triangulation was applied to the findings in order to verify the research data.

2.2.1 Data collection and sources

This section introduces the data sources and associated collection activities (see Table 4, below), and identifies the principle sources that contribute to the research findings.

Multiple data sources were exploited in the course of this research project, including data collected from sources both internal and external to the WaSC. However, not all data was used in the synthesis of these research findings; only the data resulting from the interviews, focus groups and workshops, the researcher's diary notes and memos (shaded in grey in Table 4 below). Thus, the research is primarily concerned with the reliability and validity of this data.

Table 4 Data type, source and collection activity

<table>
<tr><td>Data type</td><td>Quantitative</td><td colspan="5">Qualitative</td></tr>
<tr><td rowspan="3">Data source</td><td colspan="3">The WaSC</td><td colspan="3">External</td></tr>
<tr><td colspan="2">Employees</td><td rowspan="2">Engineering Partners Organisation</td><td rowspan="2">Academics</td><td rowspan="2">Researcher</td><td rowspan="2">The WaSC sector</td></tr>
<tr><td>Cost modelling team</td><td>Cross section of employees</td></tr>
<tr><td>Data Collection Activity (Format)</td><td>Computer cost modelling (Excel)</td><td>Interviews, focus groups & workshops (Word)</td><td colspan="2">Emailed, questionnaire (Excel)</td><td>Notes memos & diaries (Word)</td><td>Website scanning (Word)</td></tr>
<tr><td colspan="7">Dark grey data was used in the synthesis of these findings</td></tr>
</table>

The qualitative data from workshops, focus groups and interviews from the WaSC was the principal data (supported by the researcher's diary) used to engender an understanding of how the WaSC has reacted to sustainability challenges and changes. The data collection activities were all digitally audio recorded and later transcribed and analysed. Eleven different one-to-one interviews were conducted, each lasting between forty and sixty minutes, and twelve different focus groups/workshops, lasting between thirty minutes and three hours. These activities produced over twenty-two hours of digital audio recording for transcription. The data produced from these activities was used in the development of the research project theory. In order to ensure the reliability of these activities, the selection of the participants from which the data is received must be understood. This is referred to as the sampling strategy and is outlined below.

2.2.2 Research sample

This section describes and justifies the research sampling approach. It briefly describes the key terms used in sampling and then proceeds to describe and justify the sampling strategies employed in this study.

The process of selecting a specific set of data sources from a larger population is referred to as sampling (Silverman 2005). Initially, a relevant population for study is identified (a sampling frame may be added to ensure only relevant samples are used). Samples are the data sources used for studying the research population. The ratio between the number of samples taken and the population is the sample size (Lewis-Beck, Bryman et al. 2004). A sampling strategy is the methodological process for selecting the samples from within the sample population and different research activities are suited to different sampling strategies.

There is a wide range of possible sampling strategies: non-probability, purposive, quota, random, snowball, stratified, theoretical and convenience (Given 2008). Predominantly, the researcher used participative groups or interviews as a means of capturing data. The strategy adopted for identifying samples (participants) in this process is referred to as purposive sampling (Given 2008). In purposive sampling the procedures employed are themselves strategic choices made to optimise the achievement of the research objectives. For example, some steps of the methodological framework ETHICS required a continuity of participants so that a number of participative groups were able to develop a proposal for innovation over the course of the process. Inevitably, this requirement for continuity had an impact on the sample diversity during these data collection periods. Staff turnover had an impact on sampling demands such as creating a reliable or consistent group of participants, and ensuring a sample was representative (when necessary). Participant attendance was typically subject to competing work pressures and significant period of transitions where job roles are unclear or unallocated. This research employed two additional sampling strategies, convenience (predicated on the accessibility of participants) and snowballing, which uses contacts already established to help identify subsequent participants. The convenience strategy used people that were amenable to participation and identified other organisation initiatives with which to combine. In contrast, the snowballing sampling strategy focused on leveraging existing contacts to encourage the participation of other organisational members. For a detailed account of the position and role of participants in different phases of data collection, see Table 5 below.

For the ETHICS design framework, participants were divided into three groups: Steering Group (SG), Design Group (DG), and User Group (UG). The participants' relationships to these groups are presented in Table 5. The SG consisted of the researcher, Aaron Tanner, the Cranfield University project supervisor, Brian McIntosh, and employees of the WaSC that had established an interest in supporting the research project.

The DG members were identified by SG members and were revised as the SG deemed, or when the DG identified relevant targets. The DG consists of personnel selected by the SG or elected by members of the DG and are representative of core-users and those at the boundaries of the WaSC department CDU, which was the target of the sustainability innovations. The relationship between the DG, the SG and the UG (CDU) are presented in Table 5. Table 5 demonstrates that the research project was able to collect data from multiple disciplines within the business. Larger workshops at the beginning of the research were profitable for producing information from across the business on sustainability. Later, the project was also able to hold workshops/focus groups with a core of relevant participants in the development of the sustainability innovation.

Table 5 Data collection activities, formats, the participants, and the duration of research activities.

KEY	
one to one activity	△
group activity	▲
consulatation activity	⇨
Steering group member	*SG*
Design group member	*DG*

Research group	Tier	articipant Role	Research phase	phase 3			phase 4						phase 5					
			Innovation process stage	*Agenda setting pt 1*			*Agenda setting pt 2*			*Matching, KPI Developmen*			AS & ES Developmen t			*Adoption Decision*		
			Research Activities: Project direction	ETHICS step 1	ETHICS step 1	ETHICS step 1, 2	SG review of findings	ETHICS step 3	ETHICS Steps 3-14	KPI - focus group A	KPI - focus group B	stream prioirties	AS Consultation	ES Consultation	WaSC costing	AS & ES focus group	AS and ES interviews	KPI adoption interview
		No. Participants	11	6	6	14	3	24	6	4	5	6	11	2	1	5	2	3
		No. Sessions	1	1	1	1	1	1	3	1	1	6	na			1	2	3
		Duration (min)	180	60	60	90	50	120	420	90	120	360				120	90	180
	1	CDU- area manager (Other)						▲										
	2	CDU- SM (other)										△						
SG	1	CDU- Reporting and finance manager				▲		▲										△
	2	CDU- SM (large)										△						
	2	CDU- SM (reservoirs)										△						
	3	CDU- BM- (reservoirs)									▲							
	2	CDU- SM (medium)										△						
	3	CDU- BM- (medium)									▲							
DG	3	CDU- BM (medium)		▲	▲	▲		▲	▲									
	2	CDU- SM (networks)										△						
	3	CDU- BM- (networks)									▲							
DG	3	CDU - BM (networks)		▲	▲	▲		▲	▲									
	3	CDU- BM- (large)									▲							
	3	CDU- BM, (large)								▲								
	3	CDU- BM, (large)								▲								
	3	CDU- BM, (large)								▲								
DG	3	CDU- BM (medium treatment)		▲	▲	▲		▲										
	3	CDU- BM (networks treatment)						▲										
	3	CDU- Private 2 Public Implementation manager	▲															
	4	CDU- communications advisor						▲										
	2	Production- Strategic asset management engineer											⇨					
DG	2	Production- Strategic asset management engineer		▲	▲	▲		▲	▲				⇨			▲		
	2	Production- risk and capital planner							▲									
	1	Production- Risk and programme manager						▲										
	2	Production- operator	▲															
DG	2	Production- operator optimiser		▲	▲	▲		▲	▲									
	2	Production - control and planning manager						▲										
	1	Production- programme manager				▲		▲										
	2	Production- management acountant						▲										
	2	Production- programme analyst						▲										
	2	Production- asset manager				▲		▲										
	2	Production- energy optimisation	▲															
	2	Production- Energy Programme Manager	▲															
	1	Production- Asset optimisation manager											⇨			▲	△	
	1	RIU- Regulator reporting manager										△						
	2	RIU- business process improvement analyst						▲										
DG	2	RIU- business process improvement analyst		▲	▲	▲		▲	▲									
	2	RIU- reporting	▲				▲											
SG	2	RIU- environment CRC manager					▲											△
	3	RIU- environment lead advisor					▲											
SG	3	RIU- environment, lead advisor	▲															
	3	RIU- Investment Planning & Value Manager	▲															
SG	2	RIU- regulation strategy manager	▲															
	2	RIU- Investment strategy manager				▲		▲										
	2	RIU-Commercial contracts assistance						▲										
	1	RIU- cost modelling manager													⇨	▲		
	3	RIU- solution costing modelling engineer						▲										
	2	RIU- business analyst				▲		▲										
	3	RIU- investment planner						▲	▲									
	2	Customer- customer experience manager	▲															
	1	Supply chain- fleet, procurement manager	▲															
	2	Supply chain- Large schemes specialist				▲		▲										
	2	Supply Chain- Materials engineer														▲	△	
SG	3	Innovation delivery- lead advisor	▲															
	2	IT- senior IT professional				▲		▲										
Externals																		
		EPO- (a)- technical consultant																△
DG		EPO- (a)- technical consultant											⇨			▲		
		EPO- (a)- technical consultant											⇨					
		EPO- (a)- technical consultant											⇨	⇨				
		EPO- (b)- technical consultant											⇨	⇨				
		EPO- (b)- technical consultant											⇨					
		Academic consultant (a)											⇨					
		Academic consultant (a)											⇨					
		Academic consultant (b)											⇨					
		Academic consultant (c)											⇨					

It could be argued that small samples are limited in their practical value for generalisation. However, in qualitative studies such as this, the research goal is to achieve a contextually specific and in-depth understanding of the phenomena of sustainability change. According to Morgan, such research is in fact ‘well suited to small sample sizes’(Given 2008).

As discussed above, the research was able to collect data from multiple participants, however, the quality of the data provided from participants is not guaranteed. In order to ensure that participants were willing to contribute to building valid data, it was important that the data elicited was truthful, and therefore a number of activities were undertaken to encourage open and honest dialogue with and between participants.

In each session, the researcher explicitly stated his desire to elicit truthful responses from participants and sought to create an environment that was conducive to truthful responses by requesting that each participant sign a consent form (See Annex A). The participant consent was more than a reassurance of confidentiality; it also informed participants of the researcher’s ethical research commitment and the explicit obligation of the researcher to the participant to protect the interests of the participants (Silverman 2005). Furthermore, all data collection activities took place in a private room and, before undertaking the data gathering activity, the researcher read the following statement to the participants to remind them that the research consent form and it tenets still applied:

> *As part of my research obligation I have responsibility for the safe and secure use of the data I collect and to ensure that no harm comes to the participants or organisations as a result of my research activities.*
>
> *To achieve this I have asked all participants to sign the research consent form and act accordingly.*
>
> *The ethical consent form is concerned with data and participant protection:*
>
> - *My obligation not to do anything with the data received that could negatively impact the company or the subjects of the research.*

- *My obligation to protect the identity and source of the research unless prior consent is achieved.*
- *Your rights as a participant to withdraw participation or information recorded at any time.*
- *My obligation to ensure that data is securely stored.*

To ensure an open and honest dialogue and the legitimacy of the data received

- *Your obligation not to share information divulged during this research in a manner that would negatively impact fellow participants or the organisations they work for.*

Having established the conditions for eliciting a truthful response, the researcher could then engage in data gathering.

Where possible, all questions asked of the participants were open-ended; a format that permitted the free flow of ideas, concepts and responses (Oppenheim 2000) while remaining guided by the research agenda. According to Robson (2001), a semi-structured and open question format for interaction can help to generate a broader understanding and discussion of the subject matter, as well as enable participants to engage more fully in the discussion.

This research data was dependent on establishing an honest free-flowing dialogue. To facilitate this, the researcher generated a safe and secure environment in which data interviews, focus groups and workshops were undertaken and research questions were open-ended where possible. However, while such conditions generated valid data for one-to-one interviews, much of the data collection was with groups of participants. While participative groups have been recognised as intense and rapid forms of knowledge sharing and generation (Alasuutari, Bickman et al. 2009), a number of weaknesses in group participation have been identified by Robson (2001). These weaknesses are presented below, along with the activities undertaken by the researcher to mitigate their impact:

- **Ensuring participation in discussion**: there is a danger that some participants may appropriate the group by steering and dominating the group discussion. As a result, less forthcoming members of the group may not feel confident to share their opinions. To mitigate this, the facilitator worked to ensure that all participants were encouraged to voice their opinions and felt comfortable doing so. During the workshop, the facilitator actively sought the participation of all members of the group; inviting comments and responses to statements as equally as possible (Oppenheim 2000).

- **Ensuring representative discussions**: both the facilitator and participants may, intentionally or unintentionally, steer the subject of debate and thereby bias findings to fit their agenda. Judging when a topic or direction of enquiry has been exhausted, or is not suitable for discussion, is complex and highly subjective. The interviewer managed this problem by applying standard time limitations to each research question or meeting objective. Additional time was allocated to review and continue a line of enquiry, which was determined by the participant groups.

- **Ensuring outputs and findings are representative**: findings from the workshops were written up and circulated to participants (often in the form of draft meeting notes). This allowed participants to challenge or develop the notes and summaries developed by the researcher from the activities. Adaptations were then assimilated into the final version of the meeting notes. Additionally, to encourage openness, the facilitator asked all participants to read and sign a research consent form, which clearly indicated the responsibilities of the researcher to protect the interests and confidentiality of the participants and organisations concerned.

Further to the activities undertaken by the researcher to ensure the reliability and validity of research data in groups, it was also necessary for the researcher to examine their own impact on the research findings; this is referred to as *researcher bias*. The following section discusses possible sources of researcher bias and methods to monitor and mitigate its effects.

2.2.3 Managing researcher bias

This section discusses the methods employed to manage the researcher's bias and methods to ensure the validity of the results obtained. In qualitative research, researcher bias resides in the potential for either an explicit or an implicit partiality to compromise the research findings. Activities that may be subject to bias range from the selection of the research question to the methodologies employed for the data collection and interpretation activities. Thus, careful measures should be taken to prevent researcher bias from pervading the research. The previous sections of this chapter have identified methodologies in bias management when working in participative groups and in the sampling strategies. This section is concerned with reflexivity and managing researcher bias as well as with additional activities undertaken to ensure the validity of results.

This research is a form of applied research. It was therefore impossible for the researcher to perform a piece of 'value free research'(Lewis-Beck, Bryman et al. 2004), which assumes the research is free of human values. In contrast, this research assumes a reflexive stance as advocated by feminist researchers (Given 2008). In this form of reflexivity, the researcher can hold a value position (Given 2008) and, moreover, their experience, skills and background play a role in the framing and development of the research. In reference to reflexivity, David Silverman (2005) suggests that the attitudes and disposition of the researcher can impact the data received in two principal ways: their influence over the respondents during data capture and their influence in the interpretation of the data.

It is therefore important to monitor the impact of the researcher as far as possible to limit its effect on the validity of data. The principal activities that were undertaken to manage the validity and reliability of the data are described below. These were reflexive behaviours such as, reviewing and confirming understanding, maintaining a reflexive dialogue through diaries, developing the sensitivity of the researcher to the data and, finally, triangulating results.

The Researcher’s notes and memos

The researcher’s notes and memos, which were kept during the research project, were used as a source of data to help understand the process of change in two ways; firstly, to explore how the researcher influenced change, and secondly, to identify organisational factors that influenced the efficacy of the project. A researcher embedded within an organisation with a remit to generate sustainability innovation simultaneously holds two distinct but integrated roles: researcher and change agent/facilitator (Enid 2001). These roles require different skills and approaches to the work undertaken. Reflexivity is one activity that can be undertaken to aid the researcher in accounting for their influence on the outcomes of the research undertaken (McNiff, Lomax et al. 2003). Reflexivity is an ongoing appraisal by the researcher of the values he/she brings to the research (analysis of subjectivity), and the impact that the researcher’s skills or character traits may have on the activities undertaken or the participation of individuals. In order to do this, the researcher kept a diary for reflection. At the end of each data gathering activity, the researcher asked himself the following questions:

a) Have all objectives been met? Identify weaknesses.
b) Points of interest and or concern about workshop proceedings.
c) Did all participants participate?
d) Do you have any participant or participation concerns?
e) Are there any practical issues with the interactions?
f) What was the researcher’s performance (e.g. position, disposition, sensitivities)?

This process of self-reflection had to be maintained throughout the research, as well as in the analysis and dissemination of results. Keeping a researcher's diary, meeting notes and memos, enabled the researcher to review the diary and use it to assess how the project results were affected by the performance, skills and attitudes of the researcher and in relation to the participants and potential participants with whom the research was carried out. The researcher's diary was also used to record key events for the WaSC sector, which were identified by regularly scanning the main pages and headlines of three sector-specific websites. By scanning these sites, the researcher was able to recognise the prevalent concerns of the sector, which were then identified or confirmed in participatory groups. The following three websites were used:

- Water UK, (www.water.org.uk),
- Ofwat (www.ofwat.gov.uk)
- UKWIR (www.ukwir.org/site/web/content/home).

Alongside the methodological requirements outlined in the preceding pages, a method was needed for verifying the data generated. The method adopted was triangulation, and the following section presents how triangulation was used in this research project to verify data and findings.

2.2.4 Triangulation of results

In order to test the validity of the data produced, the data was triangulated. Evidence from multiple sources, including data from different participants of the research and, where possible, across research distinct activities, was utilised to triangulate the data (Lewis-Beck, Bryman et al. 2004; Silverman 2005; Given 2008). Non-verbal sources of data were also reviewed; this included the organisation's work-flow-charts, policy and strategy documents and sector reports and statements. Small triangulation activities included the informal triangulation of data during or after the participative groups and interviews because results were discussed and reviewed with the steering group. Results were also triangulated through the regular reporting of findings with members of the steering group, who contested or corroborated the results.

The following section is concerned with describing the overall research approach and epistemology.

2.3 Discussing the Research Approach, and Epistemology

This section identifies and describes the research strategy employed, and the ontological and epistemological assumptions adopted for this research project.

This qualitative research project investigated the underlying mechanisms that explain observations. As such, it follows Durkheim (1858- 1917), who advocated an inductive strategy for such social sciences enquiries. In an inductive strategy, data collection is undertaken without prejudice of theory to their relative importance and without reference to individual manifestations (Blaikie 2007). These data points are ‘social facts’, which are analysed and compared without reference to a hypothesis. Thus, generalisations are inductively drawn as to the relation between patterns observed in ‘social facts’ (Blaikie 2007). The current research first gathered data without selecting or determining its relative importance. These facts were classified in an attempt to discover underlying mechanisms to explain observations.

As the research project adopted a ‘mixed methods’ approach, which utilised qualitative data (used to explore the organisation and its obstacles to the adoption of sustainability processes) and quantitative data (used to identify the cost performance), the project holds two different ontological positions in relation to these two data types/functions. For qualitative data, the ontological premise of the ‘idealist’ is adopted; here a social reality exists only as shared interpretations of that social reality as manifested by the social actors (Blaikie 2007). Implicit in the qualitative research is the understanding that group and individual perceptions of reality have an impact upon the experience of reality. Thus, the logic of this enquiry shares these assumptions. For quantitative data, the ontological assumptions adopted are ‘Realist’. A realist perspective is predicated on the idea of a world independent of the observer that is real and measurable (Blaikie 2007). However, the quantitative data did not contribute materially to the research conclusions or findings.

The epistemological method (how to make things known) of this study is *Process Narrative*. The epistemology of a process narrative suggests that by describing the mechanisms and processes through which entities interact we are able to understand how change occurs (Van De Ven and Johnson 2006).

3 LITERATURE REVIEW: Organisations and Innovation

As outlined in chapter one, this study responds to a need to understand the influences on sustainability innovation adoption for a UK WaSC. The study operates under the assumption that improved sustainability performance (sustainability change) is achieved through the adoption of sustainability innovations by a water and sewerage company (organisation). This chapter will review the existing literature on innovation and organisations in order to inform the current study. The organisational innovation (OI) literature will later be compared with the findings of this research study, which considers the influences on the adoption of sustainability innovations that were developed and proposed by the researcher in the context of a UK WaSC capital delivery unit. In order to gain a better understanding of innovation adoption within a WaSC, this chapter will review the literature on the following:

- Section one develops a conceptual understanding of organisations and organisational change.
- Section two describes and defines innovation and the role innovation plays within organisations and organisational change.
- Section three describes the characteristics of the innovation context that have been proven to influence innovation adoption
- Section four presents the characteristics of the innovation which have been proven to influence innovation adoption.

3.1 Organisations

This section develops a conceptual understanding of organisations by exploring and developing debates about how an organisation may be defined and understood. The purpose of this section is to familiarise the reader with different theories on what constitutes an organisation, and to characterise and position the current research in relation to the existing research.

The difficulties in defining an organisation are well expressed by March and Simon: *'We are dealing with empirical phenomena, and the world has an uncomfortable way of not permitting itself to be fitted into clean classifications'* (1958, p. 20). Firstly, there is disagreement over whether or not an organisation is an object or an activity; an organisation may be conceptualised as either a process of organising (a verb) or as an entity with structure (a noun). This distinction can be traced back to the philosophies of Democritus and Heraclitus, who had fundamentally different visions of the nature of reality. Democritus believed that reality consists of materials or substances that change only in their position over time and space. Heraclitus did not believe in the stable reality of enduring things, but rather that all things are in a process of activity and change (Van De Ven and Poole 1995). When considered in the context of researching an organisation, a Heraclitic outlook perceives the 'organising system' as an entity which is in a constant process of change and within which change is an innate quality. This is an important ontological distinction. On the one hand, the view of a social world of things in which processes represent changes in their material constitution, and on the other, a world of processes where in the things are reifications of things (Van de Ven and Poole 2005).

These distinctions ascribe different ontological properties to social reality: an organisation conceptualised as a noun, suggests that the attributes of the organisation have a single meaning over time. When the organisation is conceptualised as a verb, the organisation is perceived as, or is an act of, reification of a set of processes that maintain the organisation, thus the constituent '*entities, attributes, events may change in meaning over time*'(Van de Ven, Angle et al. 2000, p.36). When associating the organisation conceptualised as a verb with Heraclitus, social reality is employed in a constant process of maintaining the existence of the organisation, where explanations of causations incorporate both immediate and distal factors.

Momentarily setting aside these disagreements over the fundamental constitution of an organisation (as either an object or an activity), researchers in organisational theory have been able to build consensus that enable organisational studies to distinguish organisations from their environment. Bedeian (1984) noted that consensus within the study of organisations suggests that organisations develop as instruments for attaining specific goals, and they are likely to emerge in situations where people recognise a common or complementary advantage that can be best served through collective as opposed to individual action.

According to Bedeian (1984), organisations are emergent 'goal orientated structures', which can be partially controlled, and which constrain as well as enable the activities of individuals. Scott and Davis (2007) outline six elements of which all organisations are comprised, the first of which is the physical, technical, cultural and social environment in which it participates and to which it must adapt. The environment is described as all things external to, but which have an influence upon, an organisation as it seeks to achieve its goals and strategies. Goals and strategies are the second of Scott and Davis's elements, and consist of the objectives that the organisation is in pursuit of, and the strategies put in place to achieve them. In order to carry out its strategies for goal realisation, an organisation must carry out activities or 'work tasks' and employ technologies (these are the third and fourth of Scott and Davis' (2007) elements). Finally, Scott and Davis (2007) suggest that organisations consist of formal and informal organisation. Formal organisation is a more or less explicit and codified expression of how a 'work task' should be undertaken, while informal organisation is the implicit, emergent characteristics of values, norms, culture, social networks, politics etc.

Scott and Davis's conception of formal and informal organisational structures has been criticised as dualistic because it separates people from the formal and informal forms of organisation. Anthony Giddens (1979) presents a social theory of '*structuration'*, which is predicated on the understanding that the social patterns (formally) depicted in organisational charts are only patterns of behaviour that individuals choose to enact and re-enact continuously, reminding us that these social patterns of both formal and informal organisations only exist when people choose to reproduce them.

In an attempt to systematise the wide range of organisational theories, Richard Scott offers three discrete definitions of an organisation; the rational system perspective, the natural system perspective and the open system perspective:

- The rational system perspective describes organisations as '*collectivities orientated to the pursuit of relatively specified goals and exhibiting relatively formalized structures.*'
- The natural system perspective describes organisations as '*collectivities whose participants share a common interest in the survival of the system and who engage in collective activities, informally structured, to secure this end.*'
- The open system perspective describes organisations as '*coalitions of shifting interest groups that develop goals by negotiations; the structure of the coalition, its activities, and its outcomes are strongly influenced by environmental factors*' (Scott and Davis 2007, p.29, p.30, p.31)

These distinct conceptualisations describe three different ways in which goals are formulated within organisations and the degree of formality of structure employed in the pursuit of goal attainment. The rational system has a high degree of formality and the goals are well defined in relation to other types of collectivities in the environment. The natural system suggests that the organisation is subject to contrasting and possibility conflicting interests, which play out though consensus, conflict, coercion or dominance. The open system places emphasis on the way in which an organisation's environment shapes and influences its behaviour and goal formation. The different ways of conceptualising organisations may result in a different focus. For example, an open system understanding of an organisation lends itself to macro- and intra- organisational influences on the organisation, while from the natural systems perspective the climate of inter-departmental conflict, and the informal organisation would be the focus. The rational system perspective would look at the formal structure and goals.

Bedeian's (1984) definition of organisation for organisations has been adapted by Daft (1995) in his book *Understanding the Theory and Design of Organisations*. He suggests that all organisations are:

i) social institutions (entities) composed of sets of persons with well established patterns of interaction,
ii) developed to achieve specific goals, thereby requiring order and cooperation,
iii) consciously coordinated and deliberately structured and
iv) are social instruments possessing relatively identifiable boundaries and existing on a relatively permanent basis.

Perhaps a more concise definition of organisation, which touches on elements of all three perspectives of organisation systems, is Richard Hall's:

> *'An organization is a collectivity with a relatively identifiable boundary, a normative order (rules), ranks of authority (hierarchy), communication system, and membership coordinating systems (procedures); this collectivity exists, on a relatively continuous basis in an environment, and engages in activities that are usually related to a set of goals; the activities have outcomes for organisational members, the organisation itself and for society'. (Hall 1987, p.40)*

Hall introduces a series of organisational mechanisms into the debate around the definition of an organisation: boundaries, norms, authority, communication and coordination. Although Hall's definition of organisations uses the language of formal organisations, suggesting a definition that lends itself to the rational system, he also makes specific reference to outcomes of an organisation, or impacts for people and society (Jaffee 2001). Thus, he emphasises that organisations both influence, and are influenced by, their environment.

This research aims to identify adoption influences on sustainability innovations. The literature developed thus far in the field has largely been from an open system perspective, looking predominantly at the organisational environment to explain and trends in sustainability innovation adoption (Thomas and Ford 2005; Thomas and Ford 2006; Thomas and Ford 2007; APPWG 2008; Cave 2009; Cave 2010). This research concentrates on the challenges presented by the formalised system of the WaSC (closer to the rational system perspective), in order to identify the barriers and opportunities for innovation that can be immediately or rapidly remedied because they are part of a rational system and therefore subject predominantly to the authority of the organisation.

The purpose of this research is to generate change in the UK WaSC, which will improve its sustainability performance, however, at the very least; the research aims to improve the WaSC's management of principles associated with sustainability. The research works under the assumption that some form of change is necessary to the organisation. In order to contextualise the research activities and results, the following section identifies and reviews forms of change within the existing organisation literature.

3.2 Organisations and Change

This section examines the existing definitions of change, the types of change that can occur and the attributes of change within an organisation. Firstly, the principal types of change are introduced, then the three ways in which change may be categorised are demonstrated. These categories are: rate of occurrence, change from existing practice and changes characterised by the process by which they came about. These characterisations are used to contextualise the current research and to provide material for critical discussion of its results.

Organisational change can be described as '*a difference in form, quality and/or state over time in an organisational entity*' (Poole and van de Ven 2004, p.xi). An entity may range from something small, such as one person's thought or behaviour, to something large, such as a change in an organisational sector. Thus, change is any difference observed between two points in time.

In order to say anything meaningful about change, it is important to be able to discern the type of changes that can occur. There are very few categorisations of 'types of change' where the criterion is change itself. However, one example is described by Zmud (1978) in his paper on the measurement of change. Zmud (1978) presents Alpha, Beta and Gamma change as three different types of observable change:

- Gamma change is where the subject alters their understanding or conceptualising of an issue,
- Beta change is where a subject alters the relative importance of a criterion, and
- Alpha change is where change has occurred but cannot be recognised as either Gamma or Beta. The narrative in Table 6 below illustrates this.

As illustrated below, Zmud (1978) identifies three kinds of observable change. Zmud's (1978) categorisation of change is distinctive because it is directly concerned with a description of what type of change manifested is in the observed criterion. Most attempts to distinguish between different types of change generally do so by describing either attributes of change, such as its form, function or content, or the impact of change; the contextual impact, rather than the change itself.

Table 6 Three types of observable change: Alpha Beta and Gamma change

	Job description/event	Type of change
Background: At four equidistant points in time (T1, T2, T3 and T4) WaSC job descriptions are monitored for changes to cost and carbon considerations.		
T1	-building wastewater treatment assets that work -as cheaply as possible	
Event	*innovation that promotes the importance of low carbon construction*	Gamma Change (T1- T2) The subject's job role conception has restructured to include the carbon criterion.
T2	-building wastewater treatment assets that work -as cheap as possible -where possible adopting low carbon construction materials	
Event	*A rise in the cost of energy which is predicted to continue*	Beta Change (T2-T3) The relative importance of elements of cost criterion has been recalibrated from lowest capex to lowest whole life cost.
T3	-building wastewater treatment assets that work -for the lowest whole life cost -where possible adopting low carbon construction materials	
Event	*The WaSC CEO new policy is launched 'Energy Negative'*	Alpha Change (T3-T4) the concept 'energy generation' that is not a criteria for measurement is identified as a change (neither Gamma nor Beta)
T4	-building wastewater treatment assets that work, -That maximise our energy generation capacity -for the lowest whole life cost -where possible adopting low carbon construction materials	

When taken together, the type, attributes and context of change create a rich picture of how change operates within an organisation. The characterisation of the contextual impact of change typically indicates the level of change (individual, group, department, whole organisation etc), and a dimension of magnitude, for example, the tempo of the change. Change characterised by ‘tempo’ is concerned with the distribution and intensity of change events over time in the organisation.

Table 7 below, considers the contextual tempo of change, described in contrast to the pace and units of change typical to the organisation. The different tempos of change are: episodic change, which refers to a single rapid change event followed by long periods of stability; organisational change, which may also be continuous and brief and rapid accelerated change. Where accelerated periods of change occur within a context of a relatively stable but continuous change, this is referred to as ‘punctuated equilibrium’.

Table 7 Descriptions of change episodes determined by rate, duration and unit of change (Todnem 2005)

Change category	**Unit of Change**	**Pace description**
Discontinuous change	The whole business	Single rapid change event followed by long periods of consolidation
Episodic- intermittent		
Continuous change	The whole business	Business change fundamentally and continuously
Bumpy Continuous Change	The whole business	The rate of business change will alter between long intense and calm periods
Incremental change	One or more parts of the business (< the whole business)	Steady rate, multiple but independent change objectives identified and executed separately.
Evolving		
Bumpy Incremental change		Accelerated periods of change in a context of relatively mild steady state of change.
Punctuated Equilibrium		

As an organisation or department may be subject to multiple change events (or periods of consolidation) over a given period of time, or at one single time, the table above can also be usefully applied to describe the landscape of organisational change activities within which the ‘focus’ change event takes place.

Table 8 below characterises change by the degree of change from existing practices. Again, one of the units of change is the level at which the change occurs (i.e. from individual to whole organisation change), and the unit of characterisation is the radical-ness, which is the degree of departure from existing practice.

Table 8 Scales of organisational change

Change Category	Unit of operation	Description
Fine Tuning	Team or department or division/ organisation unit.	Ongoing process to align strategy, process people and structure.
Convergent		
Transactional		
Incremental adjustment	The whole organisation	Distinct (not radical) modification to management processes and organisational strategies.
Evolutionary		
Modular transformation	One or several major departments/ division /organisation units.	Distinct/radical changes to management processes and organisational strategies
Corporate transformation	The whole organisation	Radical changes to management processes and organisational strategies.
Revolutionary		

An extreme radical change to an organisation can be easily recognised, as it will typically render existing knowledge in the organisation redundant. This means that the change renders redundant core competencies, such as skills, and knowledge expertise built up by the organisation. The change thus requires the organisation to disregard previous modes of operation and to invest in the development of new core competencies. At the opposite end of the scale, a small change event would make only minimal change within established knowledge and protocols.

Change can also be characterised by the factors that produce it. A simple example of this is planned change in contrast to unplanned change. Unplanned changes are events that are not purposefully conceived, and whose impact is not predefined. Planned change, by contrast, is deliberately conceived to improve the organisation and is implemented by knowledgeable actors.

Planned change can be separated into four types in terms of the rules that govern the planned change event. Firstly, '*planned change management'*, is a predefined change activity, while *'emergent'* is a change that occurs as a result of devolved responsibilities and is an open-ended process. The third and fourth manners of change are, '*contingency'* and '*choice'*, which represent both categories of change and distinct organisational theories about the way change takes place. However, they differ in their conception of how an organisation relates to its context. With '*contingency*' change, the change process and outcome are determined by situational and structural variables, and cannot be influenced by managers and organisations (Donaldson 1995; Clegg, Hardy et al. 1996). Conversely, with '*choice*' change, the organisation exerts an influence on its environment, has the ability to shape its environment and determines the change processes and outcomes (Child 1972).

Van de Ven and Poole (1995) offer another way in which organisation and change can be characterised, which they refer to as the '*generative mechanism*' (or motor) of the change process. The *generative mechanism*, or motor, is a set of change process theories that seek to explain how and why change takes place in social or biological entities. Van de Ven and Poole (1995) describes four distinct *generative mechanisms* for change: *Life cycle, Evolutionary*, *Dialectic*, and *Teleological*. '*Each refer to a different sequence of change events that are driven by different conceptual motors and operate at different organisational levels*' (Van De Ven and Poole 1995, p.510). *Life cycle* is when a change takes place due to a predefined program of sequential periods: 1. start up, 2. grow, 3. harvest, 4. terminate; an institutional, natural or logical program prefigures the stages. An *Evolutionary* model of change repeats the sequential periods: 1. variation, 2. selection, 3. retention; change occurs as populations compete for scarce resources and environmental selection results in change. *Dialectic* refers to change that occurs as a result of conflict and confrontation between opposing interests or forces. Its event sequence is theorised as: 1. thesis meets antithesis, 2. conflict, 3. synthesis. Finally, *Teleology* change comes about through goal formulation and purposeful enactment. The event sequence is: 1. dissatisfaction, 2. search interact, 3. goal formulation, 4. implement goals (Poole 2004). Organisations are complex systems made from multiple entities and which interact with multiple systems. As a result of this complexity, multiple motors for change may be acting on a single change event.

In an attempt to both describe and manage the organisational change, many authors have developed organisational models. These models are graphic depictions that help us to map what change has occurred (content and context), and how (the process).They also help predict which part of the organisation will need to change in response to innovations or change events. According to Burke (2011), the role of an organisational model is to:

i) Help categorize; as organisational change has multiple data points, these need to be compartmentalised into relevant and manageable groups.
ii) Enhance our understanding; the model should enable the user to identify problems/opportunities.
iii) Help to interpret data about the organisation to enable the user to isolate problems and/or opportunities during change.
iv) Provide a common short hand to rapidly convey meaning in order to help facilitate change activities.
v) Guide action for change by helping to prioritise problems and solutions when undertaking organisational change.

There are multiple organisational models for understanding organisational change. For example, the concentric circles model Mintzberg and Westley (1992); the Business Process Change Model (Kettinger, Teng et al. 1997); the punctuated socio-technical change model (Lyytinen and Newman 2008) and the Burke and Litwin Causal Model of organisational change (Burke and Litwin 1992; 2011). All of the aforementioned models have been advocated for use in understanding organisational change. Many of them build on Harold Leavitt's (1965) Multivariate Systems Model, which is presented below. The Leavitt model consists of four primary components: task (the system objectives and goals), people (the actors that carry out the goal), technology (the tools utilised in pursuit of the task), and structure (the workflow, communication channels, and decision-making authority). These four attributes comprise a multivariate system, in which an alteration to any one component requires alteration to the others. This system is presented here as a simple illustration of how change in one part of an organisation must be accommodated by other parts of the organisation. Leavitt's social-technical model presupposes an open system, with the result that environmental boundaries can also be classified by the same four constructs: task, actors, technology and structure. In a Socio-technical system such as Leavitt's, when the four components are in equilibrium across the system components and its environment, the system can be said to have stable relationships with which to carry out its tasks. In this state, the task performance will not deteriorate. The system can be identified as unstable when any of the four components are not aligned with each other, or the components are misaligned between system and environment.

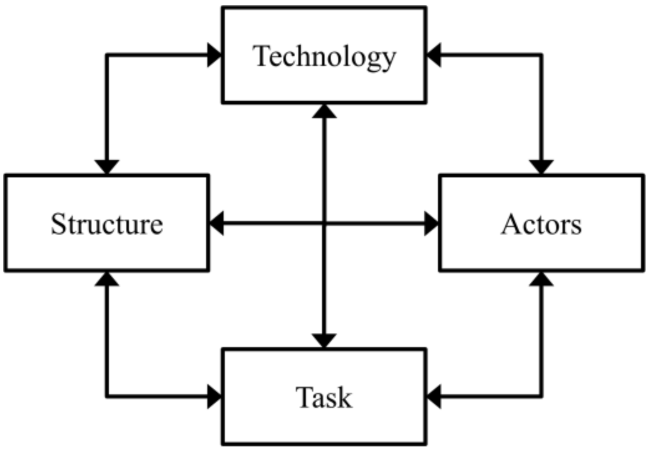


Figure 10 Organizational system model (adapted Leavitt's (1965)

In this model, a structural misalignment can be referred to as a *gap*. These gaps may be due to a pivotal event, either internal or external to the organisation, or because of a gradual change in behaviour. Responses to gaps may take the form of the adaptation of the system components, or deep system change whereby the system rewrites deep structural rules or tasks.

A key facet of organisational change is innovation, because innovation is the activity undertaken to address the *gaps*. For this reason, Poole and Van de Ven describe innovation as a '*wellspring of economic and social progress*' and a '*partner of change'* (2004, p.xi). The subject of organisation and innovation, examines how organisations react to, or generate, innovations or 'vice versa'; how innovations interact with organisations. Innovation plays a vital role in organisations and, if they are to survive, all organisations must be capable of making adjustments to their components in order to accommodate change (Hodge and Anthony 1988).

Describing innovation is a challenge as innovations manifest in so many different forms. This is best illustrated by Rogers' definition of innovation: '*innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption*' (Rogers 2003, p.12), Daft and Becker (1978) Daft (1995) and Damanpour (1996) all refer to organisational innovation as, the creation or adoption of an idea or behaviour new to the organisation. Definitions of innovation identify newness to the organisation as its principal feature. However, newness is only defined in relation to the context in which it occurs (Zaltman, Duncan et al. 1973; Rogers 2003), thus 'as long as the idea is perceived as new by the people involved it is an innovation'(van de Ven 1986). A simple typology of innovation in organisations would be process innovation, product innovation or business model innovation. Process innovations are those innovations that mediate between the inputs and outputs of the organisation, defined as tools, devices and knowledge of through-put technologies (Gopalakrishnan and Damanpour 1997). Product innovations directly relate to changes to the outputs of the organisation, for example, a new product or service package (Gopalakrishnan and Damanpour 1997). Business model innovations are changes to how an organisation creates and delivers services to its members and/or customers. The 'type' of innovation may be administrative or technical. Administrative innovations are used by the organisation to indirectly support the basic work activities of the organisation (e.g. management tools) (Damanpour 1991). Technical are all innovations that are used directly to produce the organisations' products or services (Damanpour 1991). For this research project, the aim is to facilitate sustainability-focused change to the WaSC by embedding sustainability-focused innovations within the organisation. The following sections synthesise the existing literature in order to identify the key findings on innovation and organisations. The antecedents and determinants of innovation and change in organisations are presented below.

3.3 Antecedents and Determinants of Innovation and Change in Organisations

This section reviews the literature on the determinants for innovation and change in organisations, and explores the factors that influence the adoption of sustainability innovations. The section first examines the dominant themes that arise; it then explores these themes to identify the core determinant of innovation and change.

A large amount of literature has been produced on organisational innovation (Wolfe 1994; Crossan and Apaydin 2010). This literature draws on a variety of academic disciplines, just some of these are: sociology, psychology, economics, anthropology, political science, information and communication technology, organisation and management and behavioural sciences (Greenhalgh, Robert et al. 2004).

From the Meta analyses and reviews of innovation literature, different authors have identified multiple ways that the literature may be systematised. However, the prevalent thematic divisions of organisational change are content, context, and process, which have been identified by multiple authors (Zaltman, Duncan et al. 1973; Damanpour 1991; Wolfe 1994; Armenakis and Bedeian 1999; Poole and van de Ven 2004; Crossan and Apaydin 2010). Armenakis describes content as issues that focus on the substance of organisational change, context as the forces and conditions acting on an organisation's external and internal environment and process as issues that address actions undertaken during the enactment of organisational change. Pettigrew (1987) makes the same thematic groupings for the strategic directions of change, but adds to the theme 'content' the qualities of the objective's purpose and goal. Wolfe (1994) argues that the innovation stage is an aspect of context that is often overlooked in innovation studies. He suggests that failing to take proper account of the innovation stage in research design '*contributes to inconsistent and, at times, contradictory research results because the direction of the influence of some determinants on innovation is dependent upon the stage being considered*' (Wolfe 1994, p. 414). In the same paper, Wolfe lists 17 innovation attributes or content determinants. Armenakis (1999) also discusses a fourth thematic grouping common to change efforts from the organisation and innovation (OI) literature: outcomes. Outcomes are the legacy of the innovation initiative, for example, improvements to the organisation's efficiency in profitability, changes to market share, or change in attitudes such as innovation cynicism or company loyalty. A key variable in OI studies is the level of analysis, which is commonly identified as a distinct thematic group. The level of analysis refers to the research subject group. Common levels of analysis are the individual, group, business unit, department, intra-department, organisation, sector or institutions. OI literature must identify the organisational level under analysis (Damanpour 1991; Wolfe 1994; Anderson, de Drew et al. 2004; Camison-zomoza, Lapiedra-alcamÃ- et al. 2004; Hage and Meeus 2006).

Mary Crossnan's (2010) multi-dimensional framework for organisational innovation diverges slightly from the content, context and process formulation outlined above. Her framework divides and subsumes process into two themes: 'determinants of innovation', which is similar to context, and 'dimensions of innovations', which is similar to content. This division of process thus divides attributes of process between content and context. In order to do this, Crossnan defines process as '*a category of concepts of* *organizational actions, such as rates of communications, work flows, decision making techniques, or methods for strategy creation' (2010, p.1173)*. This is in contrast to Armenakis' *(1999, p.293)* definition of process as '*undertaken during the enactment of organisational change*'. or '*process theory',* which is the underlying logic that explains a causal relationship between independent and dependent variables (Poole 2004).

This literature review will apply a simple content characteristic/context distinction whereby the innovation process is also understood to be a characteristic of the innovation. This distinction is a simple way to divide the findings and is logical because the division is simple and clear. The innovation context relates to environmental qualities that may influence innovation uptake. Innovation characteristics are the properties that are associated with the innovation, including the innovation process.

3.4 Context of Innovation and Change

Context broadly refers to the organisational environment, which can be divided into the internal environment (internal context) of the organisation and the environment external to the organisation (external context). In the book *Innovations and Organisations,* Zaltman et al. (1973) describe the internal environment as physical and social factors within the boundaries of the organisation, or a specific decision unit that is taken directly into consideration in the decision-making behaviour of the individuals in that system. While the external environment, consists of those relevant physical and social factors outside the boundaries of the organisation or specific decision unit that are taken directly into consideration in the decision-making behaviour of the individuals in that system.

Figure 11 (below) presents a synthesis of different ways in which the innovation context can be characterised as well as determinants that have been proven to influence the adoption of innovation in organisations. The figure depicts the range of determinants and variables (separated by level of analysis) which together generate combinative effects on innovation in organisations.

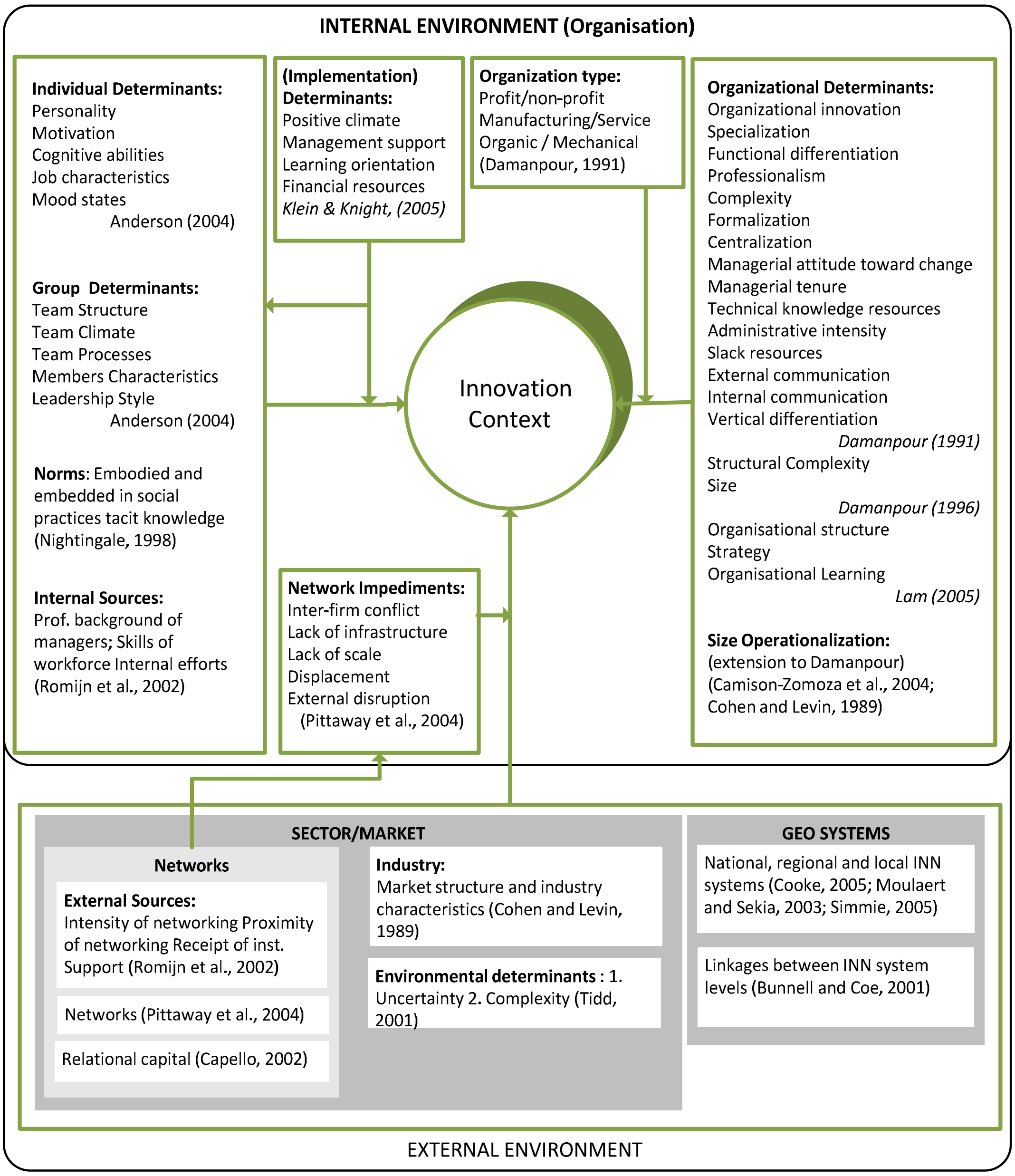


Figure 11 Schematic of the determinants of organisational innovation in existing research (adapted from Crossan (2004)

Within the internal environment, the lowest level of analysis is the individual and, typically, is a participant in a work group. The individual and the work group have been identified as key promoters and inhibitors of innovation (Zaltman, Duncan et al. 1973;

van de Ven 1986; Anderson, de Drew et al. 2004). Anderson reviewed individual level determinants from the literature between 1997 and 2002 and found twenty-four different features, which he categorised under the five subject headings he describes as key determinants of the individual. These are: personality, motivation, cognitive ability, job characteristics and mood states. From a group level analysis he identified nineteen different features of a work group, categorised into five classes of group determinants: leadership, membership, climate, process characteristics and structure (Anderson, de Drew et al. 2004).

These individual and group determinants surrounding innovation are influenced by normative constructs and learnt, tacit knowledge (Nightingale 1998). Thus, the problem, the innovation process and the solution are all socially constructed and are therefore subject to the sociological and political factors that determine those that participate in the innovation development and the decision. Similarly, individual and group determinants are influenced by the history, specific skills and knowledge network of those involved (Romijn and Albu 2002).

At the level of organisation, the organisation type may be distinguished by its structure, its output (i.e. service or manufacture, and profit or not for profit organisations) (Damanpour 1991), and its size (Cohen and Levinthal 1990; Camison-zomoza, Lapiedra-alcamÃ- et al. 2004). An organisation therein has some 18 moderators for innovation identified under organisational determinants. However, this is a simplification, as these are categories of determinants demonstrated to have influenced innovation adoption in organisations. It is not an exhaustive account of all the innovation and organisation literature. For example, ‘perceptions of culture’ is a category from Anderson’s review (2004) constructed from three separate facets of organisational culture (Support for experimentation, tolerance of risk failure, and risk taking norms), which all have been demonstrated to influence innovation in organisations. The aforementioned are attributes of an organisation that may be more or less fixed.

In Figure 11, the 'Implementation Determinants', Klein and Knight, (2005) present a model for key determinants during innovation implementation which consists of: managerial support, financial resources, learning orientation and positive climate. These organisational factors influence organisational innovation; they are factors which may have the potential to be influenced by or through the innovation process. These determinants are defined by the relationship between the innovation and the organisation and therefore are a key management area for innovation development and delivery.

Turning now to the external environment within which the organisation resides, Tidd (2001) demonstrates that both *environmental uncertainty* (the rate of technological and market changes) and *complexity* (the number of technological and organisational interdependencies) influence organisational innovation. Networking with regional science bases and parties with complementary capabilities positively influences organisational innovation (Romijn and Albu 2002). Pittaway et al. (2004) found that, among numerous other benefits, high levels of networking increased innovation diffusion. Capello (2002) states that 'relational capital' (the stock of relations an organisation can maintain with other organisations) influences organisational innovation, but concedes that it also depends on sectoral and spatial characteristics. Additionally, variations in sectors/industries will influence the likely organisational relationship to innovations in general (Schmalensee, Willig et al.; Fagerberg, Mowery et al. 2005). This last point is supported by territorial models (Moulaert and Sekia 2003), which seek to explain innovation growth in sectors, or on a national, regional or local scale (Cooke, Gomez Uranga et al. 1997; Simmie 2005).

It has been demonstrated that the 'Innovation Context' is multivalent and multifaceted. It is clear that influences on innovation processes do not simply concern the immediate impact on individuals, but must also look at the organisation, its existing structure, patterns of work, mental modes of authority and innovation recipients.

Innovation content, as described above, is primarily the attributes and dimensions of the innovation. It is suggested that an innovation's characteristics may have an impact on its effectiveness, or on an organisation's capacity to assimilate it. Thus, the characteristics of an innovation may also be classified as potential determinants of innovation. The following section reflects on innovation content and the innovation attributes that have been proven to influence innovation within organisations.

3.5 Characteristics of Innovation

Where possible, innovation attributes should be identified and logged. It is generally felt that understanding the combined effects of attributes (and content) will enable innovation researchers to better predict innovation and adoption behaviours (Damanpour, Walker et al. 2009). Figure 12, below, presents an overview of the innovation characteristics: determinants, types and variables of content, which are identified by Gopalakrishnan & Damanpour (1997), Crossan & Apaydin (2010) and the behavioural and adoption theorists Venkatesh, Morris et al. (2003).

The attributes assigned to an innovation can be dichotomous, as in *product* or *administrative*, or they might imply a range, radical-ness, for example. Garcia (2002) critically reviews the terminology of innovativeness and proposes a scale of thirty-one different classifications for innovativeness. Gopalakrishna & Damanpour (1997) presents a review of innovation research from the fields of economics, organisational sociology and technology management, and identifies five dimensions of innovation:

1. Level - the innovation target group
2. Type - the innovation characteristics
3. Stage - innovation development stage (idea conception – infusion)
4. Timing - the innovation diffusion stage (pioneer – laggard)
5. Magnitude - extent of innovativeness and pervasiveness through target level

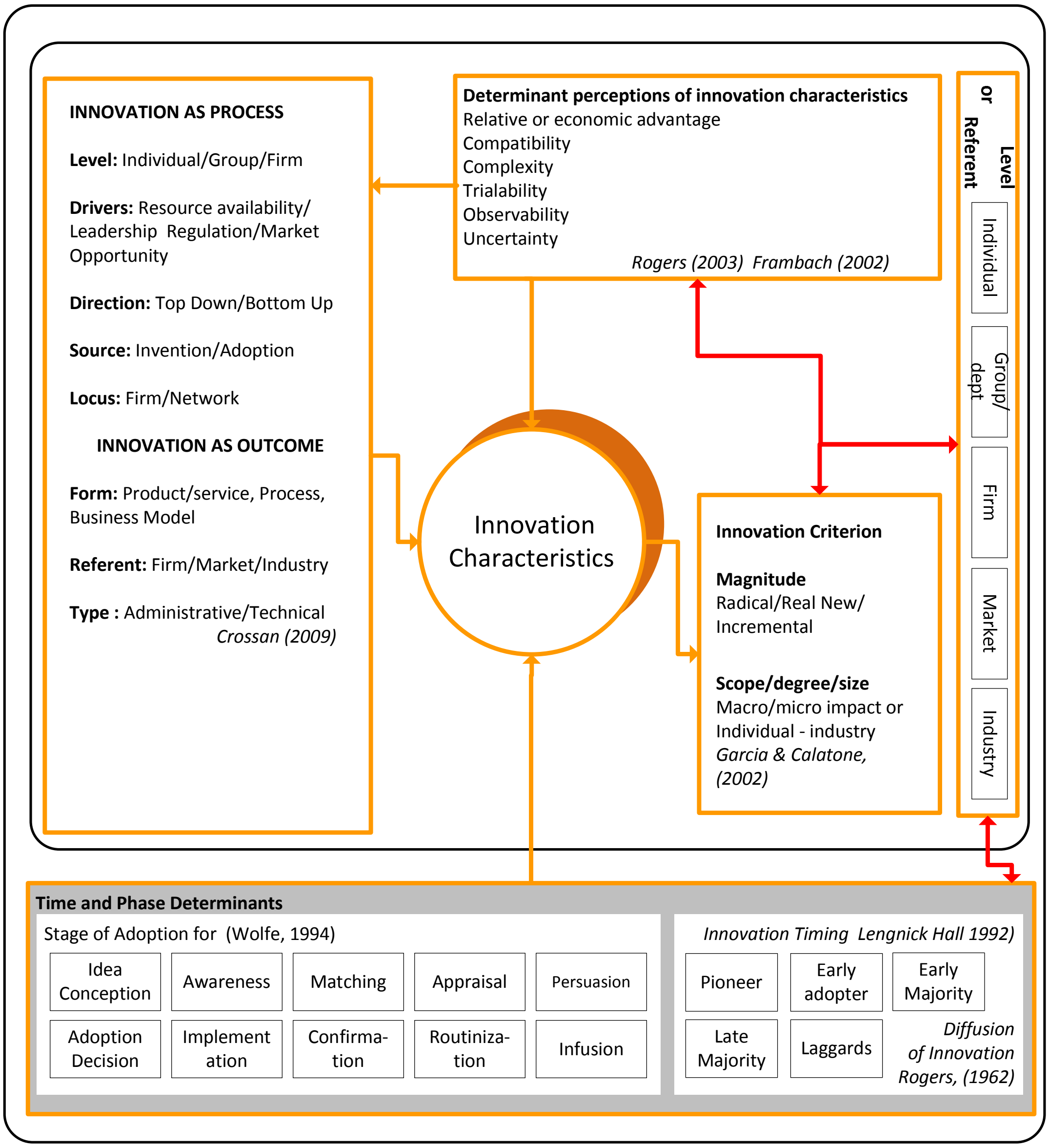


Figure 12 Schematic characterising dimensions of innovation from existing literature (adapted from Crossan, 2004)

Figure 12, above, presents innovation process and outcomes, both of which are dimensions of innovations. Innovation process is the dimension of the innovation that describes 'how' the innovation takes place. For example, the drivers for an innovation may be internal (available skills) or external (regulatory requirement), the source of the innovation may be an internal generation of an idea (ideation) or external adoption. Similarly, the innovation might be developed through top-down management, or from a bottom-up direction. The innovation process may also be characterised by the level of the organisation that is active in its development or adoption. Finally, the innovation process may be described by the innovation locus, which may be the firm or the sector network. These are all what Crossan (2010) terms dimensions of the innovation process and should not be confused with the process study, which seeks to describe how things happen through underlying logic and mechanisms. Innovation as an outcome answers 'what?' or 'what kind?' questions, and becomes a description of the 'form' the innovation has taken (e.g. a process, product or business model innovation).

The innovation criteria in Figure 12, above, are the means of evaluating the relative impact of the innovation on the adopting organisation. Magnitude is the degree of change it induces. Magnitude can range from the radical, which may produce fundamental change in the organisation of an institution, to the incremental; a marginal departure from existing practices (Gopalakrishnan and Damanpour 1997). Scope is the number of people affected by the magnitude of change. This can be expressed in scales from number of people, to organisational departments, or the sector-wide impact (Garcia and Calantone 2002).

The innovation dimension 'referent' or 'level' captures the necessary contextualisation of the innovation criterion, and the 'time and phase determinants' of innovations. The 'referent' or 'level' dimension establishes a benchmark from which the innovation is measured. For example, a radical innovation can only be understood in relationship to the organisation or sector, whereas an incremental innovation occurring within the organisation may be new to the organisation, but not the sector.

A number of perceptions of innovation characteristics have also been proven to influence the adoption of innovation. Frambach (2002) identifies these as: '*relative advantage*', '*compatibility*', '*complexity*', '*trialability*', '*observability*' and '*uncertainty*' . These terms are defined in Table 9, below.

Table 9 Determinant perceptions for innovation adoption (Rogers 2003)

Relative advantage	Is the degree to which an innovation is perceived as better than the idea it supersedes
Compatibility	Is the degree to which an innovation is perceived as being consistent with existing values, past experiences and the needs of the receiver
Complexity	Is the degree to which an innovation is perceived as difficult to understand and use
Trial-ability	Is the degree to which an innovation may be experimented on within a limited basis
Observability	Is the degree to which the results of an innovation are visible to other
Uncertainty	Is the degree to which the risks associated with an innovation are understood and managed

A further complication to the generation or comprehension of perceptions of innovations of adopting units is that innovation perceptions are subject to a socially conditioned representation. Burton et al. (1997) conducted research which indicated that a group or network may generate an 'organising vision' about the utility, function and purpose of an innovation which influences the functions utilised by the adopting organisation. Thus, early attempts to describe the functional role an innovation might play in an organisation can be undermined by the 'organising vision'.

Perhaps the model that most explicitly depicts the role played by the perceptions of the adopter or the adoption decision-making unit on adoption is the Technology Acceptance Model (TAM). First developed by Davis (1989) to help understand and predict the adoption of new information technology (IT innovations) within organisations, TAM suggests that the combination of perceptions surrounding the 'Ease of Use' and 'Usefulness' of a technology innovation would determine a behavioural intention that preceded the use behaviour. TAM is now in its third iteration and has been informed by multiple technology and behavioural models including: the theory of reasoned action (TRA) (Fishbein and Ajzen 1975), the TAM, the motivational model (MM) (Davis 1993) 1992, the theory of planned behaviour (Ajzen 1991), the model of personal computer

(PC) utilization (Thompson and Higgins 1991), the innovation diffusion theory (Rogers 2003), the social cognitive theory (Bandura 1986) and the unified theory of acceptance and use of technology (UTAUT) (Venkatesh, Morris et al. 2003). Figure 13, below, depicts the theoretical framework for TAM.[3]

The TAM framework further illustrates that user perceptions are an important variable to be managed in innovation situations. Moreover, the user perceptions on technological innovations are influenced by: individual differences, (such as: personality and demographics), the socialised environment (which demonstrates the role of normative behaviours and subjective norms in attitude and perception formulation), the system characteristics (which are attributes and features of the technological innovations that guide the formulation of perceptions); and the facilitating conditions (which consist of organisational support that facilitates adoption behaviours and pro adoption perceptions).

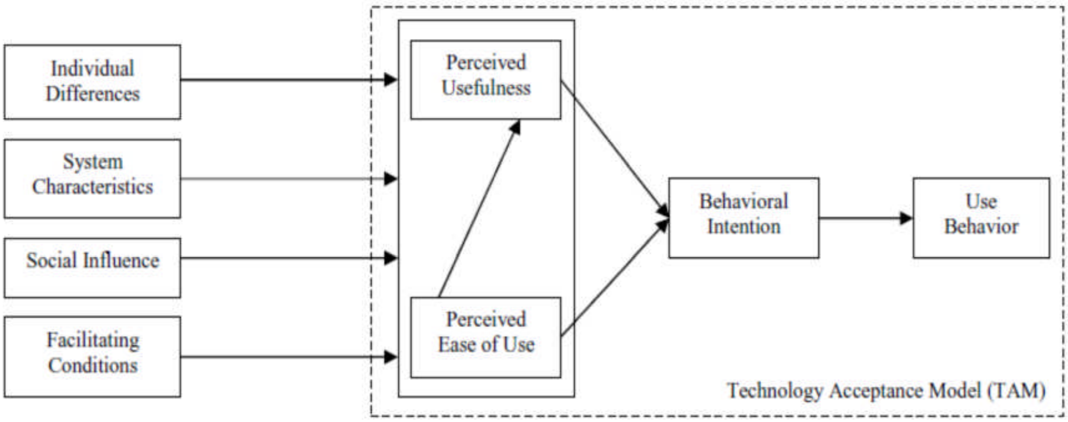


Figure 13 Theoretical framework of the 'technology acceptance model' (Venkatesh and Bala 2008, p. 276)

The above theoretical framework, and the multiple iterations of TAM, suggests that innovation impact is mediated by the attributes of an organisation, the organisational context and their relationship to the innovation (Venkatesh and Davis 1996; Venkatesh and Bala 2008). The 'Relative advantage' of an innovation (Davis 1989; Moore and Benbasat 1991; Karahanna, Straub et al. 1999; Plouffe, Vandenbosch et al. 2001), the *complexity* and the difficulty the subject has in understanding/using the innovation (Thompson and Higgins 1991; Thompson, Higgins et al. 1994), and the *compatibility* with the existing values/past experiences and needs of the user (Moore and Benbasat 1991), are all perceived in relation to the existing system and/or alternative practices. The most recent contribution to the discussion comes from Armenakis and Harris (2009), who summarise over 30 years experience of studying and working in organisation change. They argue that the most important '*sign post[s]*' for adoption are the recipients' motives to support adoption:

- discrepancy: a belief that there is a significant need for change
- appropriateness: that the change proposed is correct to address the discrepancy
- efficacy: the belief in the capacity of the recipient and organisation to implement the change
- principle: that there is suitable buy-in from leadership
- valence: the belief that the change is beneficial to the recipient

Finally, the box labelled 'time and phase determinants' in Figure 11 demonstrates that all factors may be contingent on the stage of adoption. A number of authors have presented innovation by distinguishing the phases for the adoption and diffusion of innovation, or a description of the change process (Zaltman, Duncan et al. 1973; Cooper and Zmud 1990; Rogers 2003). One of the earliest, which is perhaps over simplified, is the 'unfreeze – change – freeze' model developed by Lewin (Lewin (1951, 1958) cited in Seo, Putnam et al. 2004). It is generally accepted that not all innovation content and contextual factors will impact innovation adoption evenly throughout the adoption stages (Wolfe 1994; Gopalakrishnan and Damanpour 1997; Michael 2001; Armenakis and Harris 2009; Damanpour, Walker et al. 2009). It is therefore useful to distinguish the innovation by stages. Wolfe (1994) attempts to consolidate the work of seven different authors and presents a ten-stage innovation process model. For the purposes of this research, Wolfe's innovation stages are pertinent up to the adoption decision stage.

Table 10, below, presents in more detail how different authors have divided these stages in the innovation adoption process.

Finally, in terms of innovation stages or phases, diffusion of an innovation through a populous may also influence the factors that influence the innovation adoption. Rogers (2003) presents a diffusion model divided into stages of diffusion which is determined by the adopting unit position through time of a total adopting population. The 'pioneers' are the earliest 2.5%, while laggards are the last 16% of the adopting population.

This research studies innovation stages one to five; from idea generation to decision over adoption or rejection. Table 10, below, presents in more detail how a number of different authors divide and interpret.

Table 10 Comparison of four descriptions of the early Innovation adoption stages

Author	*1*	*2*	*3*	*4*	*5*	*6*
Wolfe (1994)	Idea conception	Awareness	Matching	Appraisal	Persuasion	Decision: adopt /reject
Rogers (2003)	Performance gap	Agenda setting	Matching			
Verloop and Wissema (2004)	Idea generation	Preliminary investigation	Detailed investigation	Concept development	System Development	
Tidd et al (2005)		Search	Selection			

The stage models present the following pattern:

- Stage one: a decision making unit (DMU), which can be one person or many, becomes aware of an innovation or the possibility of an innovation. While Rogers (2003) first phase identifies the prioritising of need which is an awareness of a performance gap between the performance of the organisation and the desired performance, Armenakis and Harris (2009) refer to this same state as discrepancy.
- Stage two: Rogers (2003) suggests for 'agenda setting' the organisation should search their environment for potential innovations. Tidd et al. (2005) refer to this

as an active process of searching and scanning. The awareness of an innovation may create a performance gap or discrepancy, as well as becoming the solution to the condition.

- Stage three: the movement from a condition of multiple innovation solutions to refining and identifying the preferred innovation. Tidd et al. (2005) refer to this as selection and suggest the process requires building a strategic framework to assess innovation, to understand the business case, and to generate the necessary coalitions to ensure that the innovation is a strategically strong decision for the organisation. Wolfe simply states that '*a problem or opportunity is matched to the innovation*'(1994, p.411).
- Stage four: the costs and benefits of the innovation are appraised. This appears to be the same as the strategic evaluation referred to by Tidd et al. (2005).
- Stage five: is, according to Wolfe (1994), a process where support and opposition to the innovation attempt is voiced, which influences the adoption decision.

While Wolfe (1994), Verloop and Wiseman (2004) do not describe the content of the stages in detail, Verloop presents a model where each stage has a gate which must be passed through in order to proceed to the next. It serves to remind us that at any point in the innovation process a decision may be made over the innovation conditions (motivations and/or incentives) necessary for the WaSC to engage further resources in the development and proposal of the innovation. Rogers (2003) and Mintzberg (1979) note that an adoption decision can be revisited and altered at future points in time.

For this research, the identification of a performance gap is particularly pertinent because the research does not prescribe the adoption of specific innovations, but relies only on the perception of a performance gap between sustainability practices and the WaSC's current practices. Thus, the first task of the researcher, acting as the 'Change Agent', is to '*develop a need for change*' (Rogers 2003, p.369) or generate the perception of a performance gap.

Figure 11 and Figure 12 are a synthesis that maps out the fields of influence for innovation in organisations; it is by no means exhaustive. However, the purpose of this literature review is to develop a framework around which the results, discussion and conclusions can be understood, and to understand to what extent the results of this research into sustainability innovation adoption in the UK WaSC is comparable to those within the innovation adoption literature.

4 INNOVATION OPPORTUNITY IDENTIFICATION

This section presents the results and the methodological activities undertaken by the researcher in order to identify sustainability innovation opportunities. Firstly, the section presents the processes by which a set of sustainability principles is selected in order to appraise the sustainability performance of the WaSC. The second part of this section presents the means by which sustainability innovation (SI) opportunities are identified.

4.1 *Identifying a Set of Sustainability Principles*

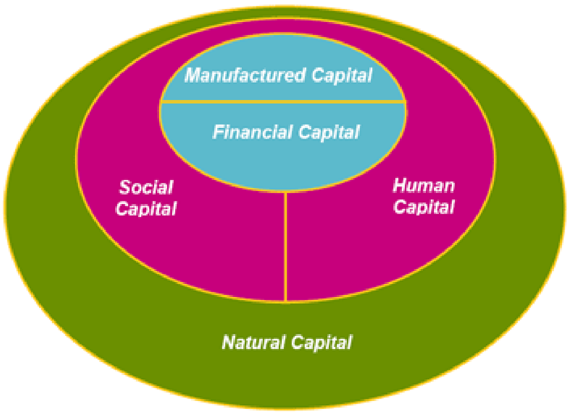
To develop sustainability innovations with a WaSC it is first necessary to generate or identify a set of sustainability principles. The set of sustainability principles are used to facilitate an understanding of the concept addressed by the principles. The selected set of sustainability principles need to meet the following research demands:

- That it presents the WaSC with an understanding of sustainability that is comprehensive in its coverage of the subject area.
- That it is comprehensible and easy for the WaSC to interpret.
- That it can be readily associated with good working practice.

The Five Capitals model, which was developed by Forum for the Future (Porritt, 2007), was the set of sustainability principles that was selected. The Five Capitals model was chosen because it is comprehensive in its coverage of the subject, simple to understand. Moreover, the model is directive – and thus identifies preferred sustainability end states – and it is relevant to the needs and expectations of the WaSC. The Five Capitals model defines five capital stocks and describes a number of principles to guide the management of these stocks (see Table 11 below).

As an organisation is reliant on these five capital stocks, the model proposes that a sustainable organisation should seek to maintain and, where possible, enhance these stocks rather than deplete or degrade them. Below is a description of the methodological strategies employed in the selection of the sustainability principles (set), a description of the framework (Five Capitals model) and a discussion of the strengths and weaknesses of the principles as well as the influence that this process may have on the subsequent innovation adoption process.

Table 11 Five Capitals Model



Natural Capital - the natural resources (energy and matter) and processes (direct and indirect) needed by organisations to produce their products and deliver their services.

Human Capital - incorporates the health, knowledge, skills, intellectual outputs, motivation and capacity for relationships of the individual.

Social Capital - any value added to the activities and economic outputs of an organisation by human relationships, partnerships and co-operation.

Manufactured Capital - material goods and infrastructure owned, leased or controlled by an organisation that contributes to production or service provision.

Financial Capital - assets of an organisation that exist in a form of currency that can be owned or traded, including (but not limited to) shares, bonds and banknotes.

4.1.1 Method

Three methodological activities were undertaken in order to select a relevant sustainability framework to apply during the research with the WaSC. These activities ensured that a coherent, relevant and comprehensive understanding of sustainability would form the conceptual basis for the research and its interaction with the WaSC. The following three activities were undertaken:

1. The dimensions of sustainability around which consensus exists were identified.
2. Sustainability principles (sets) were then assessed according to their coverage of sustainability dimensions and a series of additional adoption concerns.
3. Finally, a sustainability principle (set) was selected for adoption and adapted for use with the WaSC.

In order to identify the principles of sustainability around which consensus exists, the research followed the chronology of the sustainability literature, defining the boundaries of the subject area and identifying the core dimensions of these discourses (key topics of interest) and their elements (issues and concerns related to these topics).

The body of sustainability literature from which the consensus was extracted was identified by consulting three databases: Scopus, Web of Knowledge (ISI) and Cranfield University library catalogue. The search terms, Title: "sustainability science" OR "sustainability Model*" OR "sustainability theory*" OR "sustainability indicators" OR “sustainable development” were used in the subject areas: Environmental Science, Business, Management and Accounting and Economics, Econometrics and Finance. The research was informed by the 50 most cited references between the years 1999-2009. The topic areas (groups and subgroups) around which consensus exists were used to construct a detailed understanding of the principles that constitute sustainability.[8]

[8] The elements around which consensus exists are important as it is assumed by the researcher that this dialogue is informed and refined through a scientific research process of observation, which generates theory that is tested through empirical study.

To build a comprehension understanding of the consensus on sustainability from the literature reviewed, the researcher first identified principles of sustainability and grouped them together by assigning a principle to one of the pillars from the 'Three Pillars' model: Environment, Economic and Social (Gibson 2006). Where principles from the literature could not logically be accommodated by one of the initial principal groups, the remaining principles were used to identify and generate further principal groups. This process created a description of principles of sustainability and built a framework with which existing sets of sustainability principle sets could be assessed.

In order to assess sustainability principles (sets) for completeness of coverage, and to evaluate them in relation to concerns around adoption, the following methodological activities were undertaken.

Readily available sets of sustainability principles ('off the peg' sets) were identified using the findings from the previous literature search and analysis. The 'off the peg' sets were then compared with the researcher's own consensus-constructed set of sustainability principles. If the sustainability principle was clearly described it was marked as managed by the researcher, using an (●). This was a simple means to evaluate the extent to which the adoption of the sustainability principle (set) would result in the appraisal of the dimensions of sustainability. It is thereby a simple indicator of how comprehensively the sustainability principle (set) covered the subject area.

This was termed 'completeness of coverage'. Completeness is relevant as it indicates how well the sustainability principle (set) covers the subject area.

During informal discussions with members of the project steering group, concerns arose over how to reduce the barriers to the proposed sustainability principles (sets). As a result, a set of qualities with which to assess sustainability frameworks was identified.

To improve the likelihood that participants would adopt and engage with these principles, the following qualities were added to the assessment framework:

- *Simplicity* - proposed principles should not require users to undertake multiple steps to understand or identify their impact.
- *Orientate* - principles should clearly illustrate the desired direction in which the dimension of sustainability should be moving.
- *Relevance* - the source of the sustainability principles (sets) should be respected by the user group, as relevant institutional supporters or adopters (public sector or similar organisations) are associated with, or have endorsed, these principles.

The researcher employed a simple key to evaluate the sustainability principles (sets) against these qualities. The referent for the evaluation was the group of sustainability principles (sets). If a sustainability principle (set) was evaluated by the researcher to have a strong quality in relation to the group of sustainability principles (sets) then it was marked with a plus sign (+); if it was not, then it was marked with a minus sign (-).

The project steering group agreed to adapt and simplify the language of the 'principles' (or rules) where necessary in order to ensure that the identified framework could be easily interpreted when applied to, and discussed within, the business. In order to guarantee that the proposed framework and principles would be easily understood by the research participants, the researcher and steering group identified sector-relevant examples which demonstrate the effective management of a sustainability principle as advocated by the selected sustainability principle (set).

4.1.2 Results

1. Identify the elements of sustainability around which consensus exists

The research identified six groups around which sustainability principles were arranged: environmental, economic, social, management decision making, and rules governing production systems and their design. See Annex B in the Appendix for the chronology of sustainability theory, and Annex C for the sets of sustainability indicators identified as a result of this research. The groups and their topics are described below.

Environment is concerned with the impact of human activity on the natural world:

- **Natural capital stock** refers to sustainability principles that govern the exploitation of different natural resources. The principles suggest that both biotic and abiotic natural resources are essential elements in supporting ecosystem services and sustaining life. Consumption of finite resources should be minimised or terminated, and renewable resources should not exceed the sustainable yield.
- **Pollution/emissions** principles are concerned with the release of substances into the natural environment. The principles advocate minimising the adverse human and environmental health effects of releases of gases, liquids or solids into bodies of water, the atmosphere, or to the ground by reducing the number of release events so that the concentration does not exceed the concentration found naturally at the point of diffusion.
- **Waste reduction** principles advocate for the efficient use of resources with the aim of minimising pollution. Waste products and waste in production must be minimised with a target of zero. Waste may be anything material or other, unused or unproductive, which is released from a system. This system may be considered a waste stream. The literature suggests that waste should be reduced through reuse and recycling and through synergistic waste to production cycles.
- **Energy reduction** is the recognition that the global sources of energy are, overwhelmingly, fossil fuel based or nuclear and that this causes either significant releases of pollutant/emissions, or the production of highly toxic waste that may have local and/or global impacts. The sustainability principles that relate to energy are concerned with minimising energy use from fossil fuel sources and transitioning to clean energy sources.

- **Biodiversity protection** is concerned with the maintenance of all life forms, or the fecundity of living organisms. It suggests that all forms of life have intrinsic value and are instrumental to ecosystems. To maximise the resilience of ecosystems, the principles associated with biodiversity protect and preserve biodiversity from depletion through human activity.
- **Habitat protection** principles are concerned with the preservation of habitats and are closely linked to biodiversity. Different types of habitat must be preserved in order to maintain their function as ecosystem providers both for their inhabitants and within a larger ecosystem balance. To maximise the resilience of ecosystems and allow humanity to benefit from them, the habitats of flora and fauna should be protected and preserved from depletion by human activity. Where possible, opportunities are exploited to replenish and naturalise habitats previously lost to human development.

Economic encompasses rules for assigning, calculating and evaluating costs and benefits in decision-making:

- **Growth/ viability** ensures that the growth of the surrounding economy does not diminish the ability of the organisation to maintain standards of service, for example, its ability to offer a standard of living that would attract and maintain employees, or to ensure the maintenance and/or replacement of assets.
- **Economic equity** is the sharing of the economic benefits and burdens generated by service provision.
- **Economic valuation** is concerned with the proper valuation of social or environmental costs and benefits. Traditionally, this is focused on incorporating costs and benefits that refer to factors external to economic decision making.

Social is concerned with principles of fairness within or between communities. The main principles identified were:

- **Standard of living**, which ensures that a reasonable quality of life is encouraged through adequate access to health care, leisure time, safe working and living environment, cultural resources, protection of human rights, an adequate living wage, and freedom from discrimination.
- **Participatory justice** is the right for people to participate in decisions that have an impact on them, either directly or indirectly.
- **Intergenerational equity** refers to the fairness in allocation of resources between current and future generations, as well as the quality of those resources.
- **Intra-generational equity** is fairness in the allocation of resources between competing interests at the present time.
- **Corruption and governance** refers to the fact that operating in a corrupt system with poor governance undermines all efforts towards sustainable behaviours such as fairness and equity, participation or transparency.

Social (global) conditions required for cooperative action are peace, security and poverty alleviation:

- **Poverty alleviation** *(Global Agenda)* implies that poverty drives the unsustainable use of resources and increases population growth.
- **Peace and security** *(Global Agenda)* enables sustainable development.

Decision-making refers to the constructs to be incorporated into decision making to maximise the potential to improved sustainability performance as a long-term outcome:

- **Future vision** refers to the activity of identifying future goals or a vision of sustainability, which would help to plan a transition to a sustainable future adequately.
- **Long-term thinking** requires that planning horizons assess the long-term impacts of decisions and account for potential contextual changes through the planning horizon.

- **Integrative management** advocates integrating systems of management to ensure that dimensions of sustainability be considered together in a framework for sustainable development.
- **Systems thinking** is a holistic approach to problem solving. This approach views 'problems' as part of the overall system and maintains awareness of micro/macro scales and cross disciplinary/sector relationships.

Production systems are principles which advocate the governance of anything produced by humans:

- **Flexibility and adaptability** ensures that a system can be altered should the future context require change.
- **Robust and durable** describes the need to improve the overall durability of a system by ensuring that any component of the system maintains working order under a diverse set of conditions.
- **Eco Form** promotes sustainability in the design of products and services by accounting for the impact of their entire life cycles through a number of factors: specification, using lower-impact materials, improving energy efficiency, managing quality and durability, and planning for reuse and recycling during the design stages. Eco form also advocates a process described as 'bio mimicry', in which the design of products seeks to replicate natural processes. Through these means, the inputs, outputs and by-products of the design object are less likely to have an adverse environmental impact. It is advocated that production systems seek to replace ownership for service agreements, to help drive the generation of sustainable production systems.

There are a number of principles identified within the reviewed literature and theory on sustainability that could be not be placed in any of the groups above. Thus, these domains do not represent an exhaustive list of the nuances from the literature on sustainability. The objective was to develop a set of subject criteria with which to evaluate sustainability frameworks and the researcher believes that the groups outlined above represent the sustainability issues and principles that are most commonly discussed in the literature.

Eleven sustainability principles (sets) are identified in the literature and evaluated using the evaluation framework (see Table 12). The Five Capitals was the sustainability principles (set) selected to integrate into the sustainability innovation adoption process. It was selected because it scored positively for all three 'framework adoption qualities': simplicity, orientated and relevance, and because it was able to explain many of the principles.

The Five Capitals advocates that a sustainable organisation should seek to maintain and, where possible, enhance the five forms of capital assets upon which it depends, rather than deplete or degrade them. Its associated model also presents capitals nested within each other (as indicated in Table 11, which illustrates the dependencies between the capitals). The model then describes a number of principles for the treatment of each of the five capitals, and it is these principles that were evaluated and were adapted and adopted within the research project.

The evaluative framework identified the Five Capitals as most comprehensive in its coverage of the sustainability groups. However, within the sustainability group of 'decision making', neither the sub category 'integrative management' nor 'systems thinking' was explicitly identified as the strategic tool for planning transitions to improved sustainability performance. In addition, Five Capitals failed to consider a global or transnational scale.

Principles for 'participatory justice', 'poverty alleviation' or 'promotion of peace' - all of which can be associated with a broader global and social agenda - are not explicitly referred to in the Five Capitals principles set.

Table 12 Evaluation framework of sustainability principle sets developed by a systematic review of the literature

Key	
explicate principle	●
demonstrative of adoption factor	+
undemonstrative of adoption factor	-

		Evaluated sustainability principle (sets)										
Groups	Sustainability sub groups	FFF Five capitals (FFF 2011)	Royal Academy of Engineers (RAeng 2005)	TNS principles (TNS 2011)	Natural logic (Logic 2010)	Bellagio Principles (Bellagio 2011)	Hanover Principles (Hanover 2000)	The Earth Charter (Charter 2000)	EU Declaration (EU 2005)	One Planet Living (WWF 2008)	UK Gov (DEFRA 2002)	Global Compact (UN 2004)
Environment	Natural capital stock	●	●	●	●			●	●	●	●	
	Pollution/emissions	●	●	●	●				●			
	Waste reduction	●	●	●	●		●			●		
	Energy reduction	●	●	●			●			●		
	Biodiversity protection	●		●	●			●	●			
	Habitat protection	●	●	●	●				●	●		
Economic	Growth/viability	●		●	●		●	●	●		●	
	Economic equity	●		●	●					●		
	Economic Valuation	●										
Social	Standard of living	●	●	●	●	●	●	●	●	●	●	●
	Participatory justice		●			●		●				
	Intergenerational equity	●	●	●		●	●		●		●	
	Intra-generational equity	●	●	●		●		●	●			
	Corruption & governance	●			●	●			●			●
(Global)	Poverty alleviation					●		●		●		
	Peace and security							●				
Decision making	Future vision	●	●	●		●						
	Long-term thinking	●	●	●	●	●	●					
	Integrative management				●	●						
	Systems thinking					●	●					
Production systems	Flexibility & adaptability		●									
	Robust & durable		●				●					
	Eco Form	●					●					●
Frame work adoption qualities	Simplicity	+	-	-	+	-	-	+	+	+	+	+
	Orientate	+	-	-	+	-	-	+	-	+	-	-
	Relevance	+	+	+	-	-	-	+	+	-	+	+

It is likely that the principal target audience for this model are UK industries, in which case, the unit of analysis is the sustainable local and/or national (rather than global) society. Additionally, this model was highly rated by the researcher for *receptivity*, largely because the same sustainability principles (set) had previously been adopted by Water UK to identify the industry sustainability indicators. The subsequent activities enhanced the sustainability principle set, already highly marked for simplicity.

To guarantee that the proposed framework could be comprehensive across the WaSC, the researcher, together with the steering group, adapted the ‘principles’ (or rules), simplified the language and disaggregated compound statements into succinct statements of intent (where necessary). The adapted principles are presented in Table 13 below.

Overall, the adaptations, which resulted from dialogue with the members of the steering group, centred on making large statements smaller. The purpose was to make it as easy as possible for the employees of the WaSC to relate the principles to their activities. More significantly, during the process some of the principles were diluted. Members of the SG justified this reduction in the force of the principles by arguing that WaSC employees would not believe that the WaSC leaders and policy would ever adopt the principle thus causing the process to stall and make it impossible to ensure the participants’ faith in the process.

In the field of human capital and social capital the principles were also simplified and disaggregated, however, here there was no loss of emphasis or meaning. The dilution can be seen in the Natural Capital section, where the word ‘eliminate’ was substituted for ‘reduce’ in NC.2 and NC.5 (see Table 13 below).

For Infrastructure Capital, the sustainability assessment framework highlighted two areas: adaptability and flexibility, and robust and durability, which are explicitly covered in the Forum for the Future, Five Capitals principles. As a result, the researcher and the

SG agreed on the development of two additional principles, IC.1 and IC.2, to ensure the sustainability principle (set) was a good reflection of sustainability concerns.

Finally, 'Financial Capital' was also altered so that a few principles migrated to other capitals (SC.8 was previously under Financial Capital). Similarly, a number of principles were not maintained in the adaptation process: 'Value intangible assets such as brand and reputation' and 'Ensure the wealth created is fairly distributed'. The latter was rejected as it was believed by the SG to be open to ridicule, and suggested a conservative interpretation would already be covered in SC.4. The valuation of intangible assets such as brand and reputation was assumed to be an aspect of prudent financial management.

The result of the search for a set of sustainability principles suitable for incorporation into the WaSC to assist in its understanding and adoption of sustainability suggested that the Five Capitals model was the best candidate from those evaluated. The model was then adapted to ensure the WaSC would easily understand and use the principles (set) to evaluate their practices.

Table 13 The sustainability principles (of the five capitals model) resulting from adaptation by the WaSC SG

Natural Capital	
NC.1	Protect/improve habitat, biodiversity and ecosystem functions.
NC.2	Reduce emissions of substances to a concentration that can easily be assimilated by natural systems: a. chemical concentrations and nutrient loads; b. GHG , ozone depleting substance; etc
NC.3	Reduce dependency on materials that are naturally scarce.
NC.4	Reduce use of virgin materials and resources.
NC.5	Reduce dependency on, and accumulation of, manmade substances that may prove harmful to ecosystem or human health and substitute all with substances that can be easily assimilated and broken down by natural systems.
NC.6	Use renewable resources only from well-managed and restorative eco-systems.
NC.7	Reduction/elimination of waste.
NC.8	Increase/full recycling of resources.
NC.9	Reduce/eliminate dependency on fossil fuels (thereby increasing use of renewable energy resources).
NC.10	Reduce energy demand.
Human Capital	
HC.1	Ensure adequate Health and Safety standards are met.
HC.2	Respect human rights throughout their operations and geographical regions.
HC.3	Respect human values and their different cultural contexts.
HC.4	Give employees (where possible) access to training and education.
HC.5	Educate and promote higher standards of health and support mental wellbeing.
HC.6	Provide a reasonable living wage and fair remuneration for employees and business partners.
HC.7	Allow for and enhance recreation time and support individuals' active involvement in society.
HC.8	Ensure supply chain partners apply the same principles to fulfilling employee needs.
HC.9	Create opportunities for varied and satisfying work.
Social Capital	
SC.1	Source materials ethically and treat suppliers, customers and citizens fairly.
SC.2	Reduce emissions of persistent compounds that are harmful to ecosystems or human health.
SC.3	Respect and comply with local, national and international law.
SC.4	Provide a supportive family-friendly labour policy.
SC.5	Prompt and full payment of taxes and support of social infrastructure.
SC.6	Minimise the negative social impact of products and services or maximise the positive.

SC.7	Support the development of the community in which the organisation operates, including economic opportunities.
SC.8	Assess the wider economic impact on society of the organisation's activities, products and services e.g. in creating wealth in the communities in which the organisation operates.
SC.9	Encourage and engage in transparent consultation and communication with relevant internal and external stakeholders.
SC.10	Fulfil commitments made with suppliers, customers/citizens and regulators.
SC.11	Effective Communication throughout the organisation , reflecting shared values and objectives.

Infrastructure Capital

IC.1	Ensure that systems, processes and infrastructure performance are maintained under a robust set of future-operating scenarios.
IC.2	Seek to maximise the flexibility and adaptability of infrastructure to respond to a diverse set of future-operating scenarios.
IC.3	Develop infrastructure that facilitates ease of maintenance: a. Design for disassembly ; b. Modular designs (to minimise potential negative operational and maintenance expenditure).
IC.4	Seek to reduce or eliminate waste and emissions in production systems.
IC.5	Where appropriate replace products for service contracts.
IC.6	Optimisation of infrastructure/technologies and processes in a way that uses resources most efficiently.
IC.7	Optimise the recycling of resources.
IC.8	Identify and utilise synergistic production systems where one organisation's waste streams are another's resources.
IC.9	Seek improvements and innovation in the design of product systems (eco-efficiency and eco-innovation).
IC.10	Apply sustainable construction techniques when looking at new infrastructure.

Financial Capital

FC.1	Employ prudent financial management.
FC.2	Efficient use of financial resources (reducing and minimising costs).
FC.3	Management of financial risk (over both short and long term).
FC.4	Internalise environmental and social costs and assign an economic value to them.
FC.5	Effective total costs under a robust set of future scenarios *e.g. : a. Unit running costs; b. Unit capital costs; c. Remediation costs of infrastructure; d. Internal manpower costs; e. External services costs ratio; f. Imported (raw and treated) water costs ratio; g. Energy costs ratio h. etc.*
FC.6	Effective management of financial risk exposure.
FC.7	Timely fulfilment of contracts.

4.1.3 Discussion

The process of identifying a comprehensive set of sustainability principles revealed a number of sustainability innovation considerations. Defining or identifying principles of sustainability is a necessary first step in the incorporation of innovations related to sustainability within an organisation. Such principles frame an organisation's subsequent activities to determine what is, and what is not, sustainable behaviour, and thus act as a guide to practice. The first challenge is to understand exactly what sustainability is (Jabareen 2004; Robinson 2004; Vos 2007) and to then refine this understanding so it can be applied to a particular area of specialism, as did Cruickshank (2004), Fenner (2006) and Marlow (2011). This research found that there was a great diversity in the sustainability sets; both in terms of how comprehensively they cover the subject and how instructive they are to the user.

When adopting a set of sustainability principles, the WaSC faces the question of whether or not to modify the principles. Adaptation may take many forms, such as removing or adding principles, and diminishing or increasing their relativism, value or severity. The risks of such adaptation are that the principles cease to be meaningful, that they fail to relate to sustainability and, if applied, would never achieve sustainability. Cashman (2007) argues that the interpretation of sustainability upheld by the various water stakeholders in the UK has resulted in a 'watering down' of the meaning of sustainability. The current research corroborates Cashman's (2007) assertions. Sustainability maxims, such as 'zero waste' became 'reductions in waste' in response to the perception that sustainability maxims were too great a leap in ambition or practice to be considered serious for adoption by the WaSC.

The watering down, adaptation or removal of sustainability principles may lead to a number of negative consequences for the delivery of sustainability. The risk is that the

WaSC may prefer and/or select the principles and goals to which the organisation already subscribes, recognises and understands. This behaviour may result in:

i) An organisation that is undertaking unsustainable practices but does not recognise them as such.
ii) An organisation that is undertaking unsustainable practices and deliberately obfuscating the fact.
iii) An organisation that is undertaking unsustainable practices and is pretending they are sustainable practices (green washing).

Van Marrewijk (2003) and Baumgartner (2010) present scales of corporate sustainability positions, which are framed by the sustainability principles they subscribe to and the institutional arrangements pursued and developed in order to deliver the sustainability ambitions. Lower positions on the scale, or low to intermediate positions of sustainability adoption, can create an environment in which a range of unsustainable behaviours are hidden, or opportunities to move towards more sustainable practices go unrecognised. A simplified example of this is, in seeking sustainable water environments, the WaSC may begin to elevate the discharge consent levels for BOD, N and P (either voluntarily or forced). If the WaSC, or its regulators, select a piecemeal approach to sustainability then the implications of those actions may result in the higher consumption of energy or higher emissions of $C0_{2,}$ $N0_2$ or CH_4. To ensure that a piecemeal approach does not occur, some researchers and organisations have developed holistic decision-making tools (Foxon, McIlkenny et al. 2002; Ashley, Booker et al. 2004; Maheepala, Evans et al. 2006; Ashley, Blackwood et al. 2008).

To set the platform from which a holistic account of sustainability was available from the outset, this project identified a comprehensive set of sustainability principles. The selection of the sustainability principles (set) maps the problem domain; it influences the selection of sustainability innovations by allowing the WaSC to identify a performance gap between its current practices and more sustainable ones, and then orientates the selection of innovations towards the performance gap. Thus, the failure of the WaSC to select a comprehensive sustainability agenda inhibits the adoption of sustainability innovations by limiting the identification of sustainability innovations. The impact of change to the organisational 'task or goals' on the technology, the roles and responsibilities of actors, and the organisational structure is effectively conveyed by Leavitt's (1965) organizational system model which was later devloped by Lyytinen (2008). What is clear is that the more the new sustainability ambitions require a deviation from the existing task, the more disturbance throughout the model. Thus, radical changes to the task are likely to produce radical changes in the technology structure and actors.

The identification of sustainability innovations is therefore limited to those innovations that can be identified as a result of the performance gap (or difference in task) between current practices and those which are implied in the sustainability principles. The terms 'discrepancy' (Armenakis and Harris 2009) or 'Performance Gap' (Rogers 2003) highlight the role that newly embedded sustainability principles have on the generation of innovations.

From here on in, this project operates under the assumption that the WaSC is better adapted to achieving improved sustainability performance if the principles identified in Table 13 are managed within the organisation and/or by the environment in which the organisation operates. The organisation's policies, processes, structure and resources are the means by which it manages its operations and its principles of sustainability. A sustainability innovation is any organisational change that increases the set of sustainability principles applied in any given organisational process. The following section describes the method and results of employing the ETHICS steps to identify the performance gap between current practices and more sustainable ones, and to identify sustainability innovation opportunities.

4.2 Identifying Sustainability Innovation Opportunities

This section describes the methods and results of the project's identification of sustainability innovations for the WaSC. In order to identify and develop opportunities for sustainability innovations, the researcher was embedded within the WaSC for a duration of thirty months. The information system development (ISD) ETHICS was adopted to guide the identification and development of sustainability innovations within the WaSC. The ensuing pages present, firstly, the activities undertaken in order to identify sustainability innovations, and secondly, the results obtained for each activity.

4.2.1 Method

In order to create conditions conducive to the identification of multiple sustainability innovation opportunities the researcher was embedded within the WaSC. From this position, the researcher generated a consensus on the need for change within the WaSC and then, in collaboration with the WaSC employees, he identified the structures and processes required to appraise and manage sustainability, as well as opportunities for sustainability innovations. These activities were undertaken, using the methodological framework ETHICS, and each activity incorporated some of the ETHICS fifteen steps. This section presents the level and type of WaSC participation, the data collection methodology, the methodological activities applied (their objectives) and the results obtained for each activity.

Embedding the researcher in the WaSC

In order to identify and develop sustainability innovation opportunities in the WaSC, the researcher adopted an embedded research position. This position enabled the researcher and the organisation to establish a relationship and both parties could readily access information from each other through formal and informal channels. The researcher engaged with the organisation using a series of workshops and focus groups guided by the methodological framework ETHICS. These are separated into two activities, ‘why change’ and ‘identifying innovation opportunities’ and are presented below.

At the outset of the project, the researcher conducted a workshop at the WaSC with the aim of identifying or generating consensus on change objectives and the research target**.** This activity helped identify the overall project direction.

The overall project direction was established to ensure the project was responding to a need identified by the WaSC, rather than one assumed by the researcher or the steering group. To achieve this, the research engaged eleven WaSC employees (selected by the project steering group) for three hours. The exercise combined reflection on the Five Capitals principles, with a technique referred to as ‘backcasting’ (Dreborg 1996) with the aim of generating an overall understanding of sustainability as well as what constitutes a sustainable WaSC. The exercise captured statements by the participants associated with how a sustainable future might look and statements on principles of sustainability. The researcher, together with the group, then developed a list of possible project directions for the sustainability research project. Each participant was allowed three votes on the proposed research directions. The researcher and the SG then selected a research direction from the top five nominated directions. By way of preparation, the researcher undertook a two-day training course on the WaSC in the field identified as the proposed research direction.

Why Change?

Once the basic direction and target area within the WaSC was established, the researcher embarked on the ETHICS ISD guided activities. According to the ETHICS methodology, the ‘why change?’ question should generate dialogue about both existing problems within the organisation and opportunities for improvement and change. In addition, the researcher assumed the role of a change agent in order to motivate the DG to try to improve the incorporation of sustainability in the WaSC.

The DG was identified by the SG and consisted of WaSC employees responsible for, or familiar with, the delivery of capital schemes. These WaSC employees were employed consistently in many of the workshops, focus groups and interviews for much of the research. The ‘why change?’ exercise was undertaken across four separate group sessions and sixteen WaSC employees took part (including members of the DG). Over three and a half hours of digital recording was captured and transcribed.

The ‘why change?’ activities operated as follows; firstly, the researcher introduced the participants to the research project and its aims (qualified by the previous project direction activities). The researcher then presented the benefits for the WaSC of taking a proactive approach to sustainability, and the risks associated with taking a reactive approach to sustainability (the laggard position). Each participant was given a handout with the project aims, the workshop objectives, the five capitals principles and questions regarding the WaSC management of the five capitals principles. To generate a dialogue, the researcher read aloud the sustainability principles with the participants and asked the group to respond to the following questions:

Prompting Questions:

a) Currently, how effective is the WaSC at promoting the goals advocated in these sustainability principles?
b) What factors restrict our ability to aim for a really sustainable WaSC?
c) What factors contribute to this?
d) What needs to change, tasks activities, understanding, strategy to enable us to aim for this?

As the discussion unfolded, points made by participants were written on flip charts and the digital audio recordings were used to capture the comments and responses in detail.

At the end of each workshop, the researcher reviewed the data captured and the findings were emailed to the participants for comments and feedback. This was then incorporated into each subsequent session.

In order to identify the structure and processes utilized to appraise and manage sustainability and the opportunities for sustainability innovations, the research activity was guided by ETHICS steps two (system boundaries) and three (a description of the existing system).

ETHICS step two is called 'system boundaries' and it was used to clarify where the DG's responsibilities began and ended. The 'system boundaries' of the research project stipulated the time frame within which the research project must be carried out and, additionally, that any innovation identified by the project may be piloted by the WaSC, but would not necessarily be commissioned. The WaSC's 'system boundaries' referred to the system for the delivery of capital infrastructure by partner organisations.

ETHICS step three is called 'a description of the existing system'; it ensures that all members of the DG understand how the present system works.

To develop a description of the existing system, including an appraisal of sustainability, the researcher made use of a pre-existing process: 'describing and refining the new capital delivery system for the subsequent AMP period to match the contract strategy'. This existing process was running to introduce the user group to a new contract and capital delivery strategy; it enabled the user group to feedback and, to a limited extent, influence the new process. Capitalising on this pre-existing change process allowed the researcher to engage the DG both alone and within a larger group context, totalling sixteen participants for a period of two hours over two sessions. For these sessions, participants reviewed the new capital delivery process charts to identify where sustainability leverage was possible.

A number of questions were used to prompt the participants:

a) Where are the key points of leverage within this process map to help the WaSC achieve the sustainability goals?
b) How has this been managed so far?
c) What is missing from current activities that would help to achieve this goal in a more comprehensive manner?
d) How should the task objective be reframed to incorporate this?
e) Do you have any reaction to potential opportunities lost or gained with this reframing? Can you explain your reaction?

The views of participants were captured on post-it notes and by digital audio recording. The process used organisational process diagrams to prompt the participants. To help identify leverage points the participants developed and adopted the following objective:

> *"Maximise the sustainability performance of the infrastructure assets designed and built in capital delivery"*

Selecting and developing opportunities for sustainability innovations into proposals

Having identified some key potential leverage points to explore, the researcher, together with the DG, exploited the points to help develop a needs requirement to incorporate sustainability innovations. The needs requirement was guided by the ETHICS methodology. Firstly, the DG identified the key tasks (ETHICS step four) and information requirements (ETHICS step five) for embedding sustainability in the WaSC's decision-making processes. Subsequently, ETHICS steps six ('diagnosis of efficiency need') and ten ('organisational design of the new system') were applied to develop a more comprehensive vision of potential for sustainability change within the WaSC.[9] The needs

[9] ETHICS steps seven, eight and nine are concerned with mechanisms for eliciting a detailed understanding of the user preferences in new system designs. It was apparent that the research opportunity identifying sustainability innovations could not exploit the level of detail expected to perform these steps as no specific innovation opportunity had been commissioned by the WaSC. The project instead relied on the DG to articulate their preferences as users/designers of the system.

requirement was explored using a gap analysis. For the gap analysis exploration, a detailed set of capital delivery process maps were marked with the previously identified leverage points. These were placed on the wall and participants were asked to describe the key tasks required for each leverage point to achieve the sustainability objective and its information needs. The following questions prompted the enquiry:

a) What tasks must be carried out if the objectives are to be achieved?
b) What is the primary role and purpose of these tasks?
c) What are the critical success factors for achieving these tasks?
d) Do we need to arrange these tasks in a form of hierarchy? If so, what kind of hierarchy and why?
e) Does the existing task meet the full need? If not, how do we adapt this?
f) Do you have any reaction to potential opportunities lost or gained with this reframing?
    - Can you explain your reaction?
g) What information needs are there to fulfil these tasks?
h) Who requires this information and when?
i) What relevant information do we already collect?

Key tasks were reviewed one by one and information requirements added to the tasks and placed in a logical order. Key artefacts that would be required were also captured. Here artefacts refer to any object, technology, or organisational platform that supports a process or activity. As always, participants signed research consent forms and the findings of the sessions were captured by digital audio recording. After each session, the findings were collected and circulated by the researcher to the participants for comments.

Subsequently, ETHICS steps six ('diagnosis of efficiency need') and ten ('design of the new system') were employed to adapt the sustainability tasks, and information needs. The impact of these tasks in terms of resource requirements, user needs and working constraints was also reviewed. The objective of these sessions was to obtain a description of working constraints, such as time, resources, skills, training, expertise, synchronising activities; and also to describe the user activities, such as problem prevention, operating (regular tasks) co-ordination, system development and control activities.

The work undertaken so far to identify leverage points, key tasks, artefacts and information needs for the key tasks was reviewed. The adapted key tasks were made available on an A2 worksheet and displayed around the room. Firstly, the participants were asked to describe the activities required to fulfil the task and then the DG reviewed the system and resource constraints. This was followed by a discussion about the division and degree of responsibilities. The DG tried to identify any artefacts, required contracts, enforcement activities, objects, software, hardware or documents that would assist in delivery of the key tasks. The following questions were used to prompt these activities:

a) What additional activities are needed?
b) What constraints exist for this activity (resources, time, financial, skills, communication, regulatory interfaces)?
c) Responsibilities: how? What? Who? When? Why?
d) Information: when and in what form?
e) What artefacts or documentation need to be linked to this activity?
f) Do you have any reaction to potential opportunities lost or gained with this reframing?
    - Can you explain your reaction?

Many opportunities for sustainability innovation were identified and considered during the research project. The researcher was able to keep a record of these in the researcher's diary. On a number of occasions, employees of the WaSC who were aware of the research agenda, but who were outside the recorded research activities, approached the researcher with suggestions for sustainable innovations that could be pursued by the research project. All these opportunities were incorporated within the research project and each tells a small part of the story of the sustainability innovation processes.

Each innovation opportunity is characterised as follows:

- **Innovation Type:** Two principal types of innovation: 'technical' and 'administrative' (Gopalakrishnan and Damanpour 1997). 'Technical' innovations are those that alter the process by which the basic activity of the organisation is produced. These are in contrast to 'administrative' innovations, which are not directly related to basic work activity, such as managerial roles, organisational structure or administrative processes.
- **Innovation Form:** There are four forms of innovation: 'business model', 'process', 'product' and 'service' innovation (Crossan and Apaydin 2010). The form of the innovation correlates to the area of the organisation on which the innovation has an impact. A business model innovation alters the means by which an organisation creates sells and delivers value to its customers (Davila, Epstein et al. 2006), while 'process' innovation relates to new management approaches, including the technologies that improve those processes 'Product' innovation introduces new products to the organisation and 'service' introduces new service-based innovations to the organisation.
- **Innovation Magnitude:** This is the innovation's degree of novelty with respect to the referent; in this case the existing WaSC process and structures. The magnitude of innovation change ranges between incremental and radical innovation. A radical innovation would be a clear departure from existing practices.
- **Innovation Stages:** These plot the process from innovation development opportunity to adoption and incorporation into the organisation. Table 26 on page 203 presents the adaptation and synthesis of innovation stages. Here the researcher describes the innovation stage that the innovation opportunity

reached and selects the description from Table 10 page 114 that best fits the research experience of the innovation stage.

- **Initiate:** This refers to the person/s that first identified the opportunity for innovation as well as their relationship to, and position within, the WaSC. For the research opportunities the initiate for the innovation was either a product of the ISD guided activities, was initiated by the Design Group (bottom up), or was a manager from within the WaSC.
- **Researcher's Notes:** These are the experiences of the researcher throughout the project gathered in the researcher's diary.

From these, opportunities and barriers to the exploitation of innovation opportunities were distinguished.

4.2.2 Results

The researcher was embedded in the WaSC for a period of thirty months. Independent of the researcher-led activities, the researcher attended and/or observed over fifteen different workshops, and worked in four different locations around the business, all of which contributed to a process of familiarisation between the researcher, the aims of the research project and the WaSC.

The aim and overall research project direction established in the first workshop was: '*to develop and pilot processes and innovations for improving the sustainability of the WaSC through engagement with partners in its delivery of capital schemes.* From this point onwards, the research focused its innovation efforts on changes to the WaSC that would target asset infrastructure proposed and constructed by the WaSC EPO partners with the aim of reducing the WaSC's business risks. By way of preparation, the researcher undertook a two-day training course on the WaSC capital delivery process. The researcher used the ISD methodology ETHICS in a series of workshops, focus groups and interviews, the results of which are below.

Table 14 Reframing of the WaSC sustainability practice developed by the researcher for the innovation development workshops

Present versus proactive sustainability management approach	
WaSC present sustainability approach	**Sustainability proactive approach**
Regulator drives our behaviour and activities forcing process adaptation that increases costs.	*Predicting regulation to lower adaptation costs and ensuring our assets/processes have a robust compliance life.*
The WaSC's investment planning/delivery tendency towards a focus on capex saving and short-term returns	*The investment case is generated and delivered for long-term benefits: extending the period over which reward is calculated (CS's, RR); true transition to culture of WLC and operational expenditure focus.*
Incorporate a few additional sustainability impacts during program planning	*Assessing and selecting our investments with full comprehension of the impacts*
We have found it difficult to find solutions that are not end of pipe.	Alternative options are explored alongside technical options
The WaSC have a residue of operationally high cost assets from which we seek to make incremental efficiency improvements	We design our assets to minimise operational costs and identify large reductions in expenditure from our existing assets
Sustainability is not a recognised driver for the WaSC, it is considered an ancillary benefit of efficiencies	Sustainability is the driver with which application of sustainability principles to our investment enables the WaSC to realise efficiencies.

Step one of the innovation development process, the ETHICS step 'why change?' tried to establish within the DG: a shared comprehension of sustainability, an understanding of the benefits of a proactive sustainability stance and the potential pitfalls of a reactive stance towards sustainability. To help participants recognise areas of potential change or realise the degree of change a proactive position towards sustainability entailed, the researcher reframed the repeated negative sustainability statements as positive messages using a synthesized proactive counterpoint (see Table 14 above). The order of change and the WaSC's difficulty with adopting sustainability is reflected in the findings and the synthesis in Table 14.

The subsequent activities moved to establish a more specific, localised understanding of sustainability change and to identify the structure and processes utilized to appraise and manage sustainability by the WaSC. The objective: to *'maximise the sustainability performance of the infrastructure assets designed and built in capital delivery'* was developed by the DG. It was employed to identify eight potential opportunities for influencing the sustainability performance of the asset infrastructure designed and built by EPO: batch development, batch contract, partner awards, ways of working, notional solution, engineering specification, asset standards and key performance indicators. The sustainability leverage points, and potential opportunities for sustainability innovation, identified during these research activities for capital delivery are depicted in Figure 14 and are described below.

The research activity, which was guided by ETHICS steps two and three, identified the following ten leverage points:

1. *Batch Development:* this is the logic that underpins collating a set of infrastructure asset risks into a batch. The risks selected for inclusion in a batch could be deliberately formulated to exploit opportunities to improve sustainability performance.

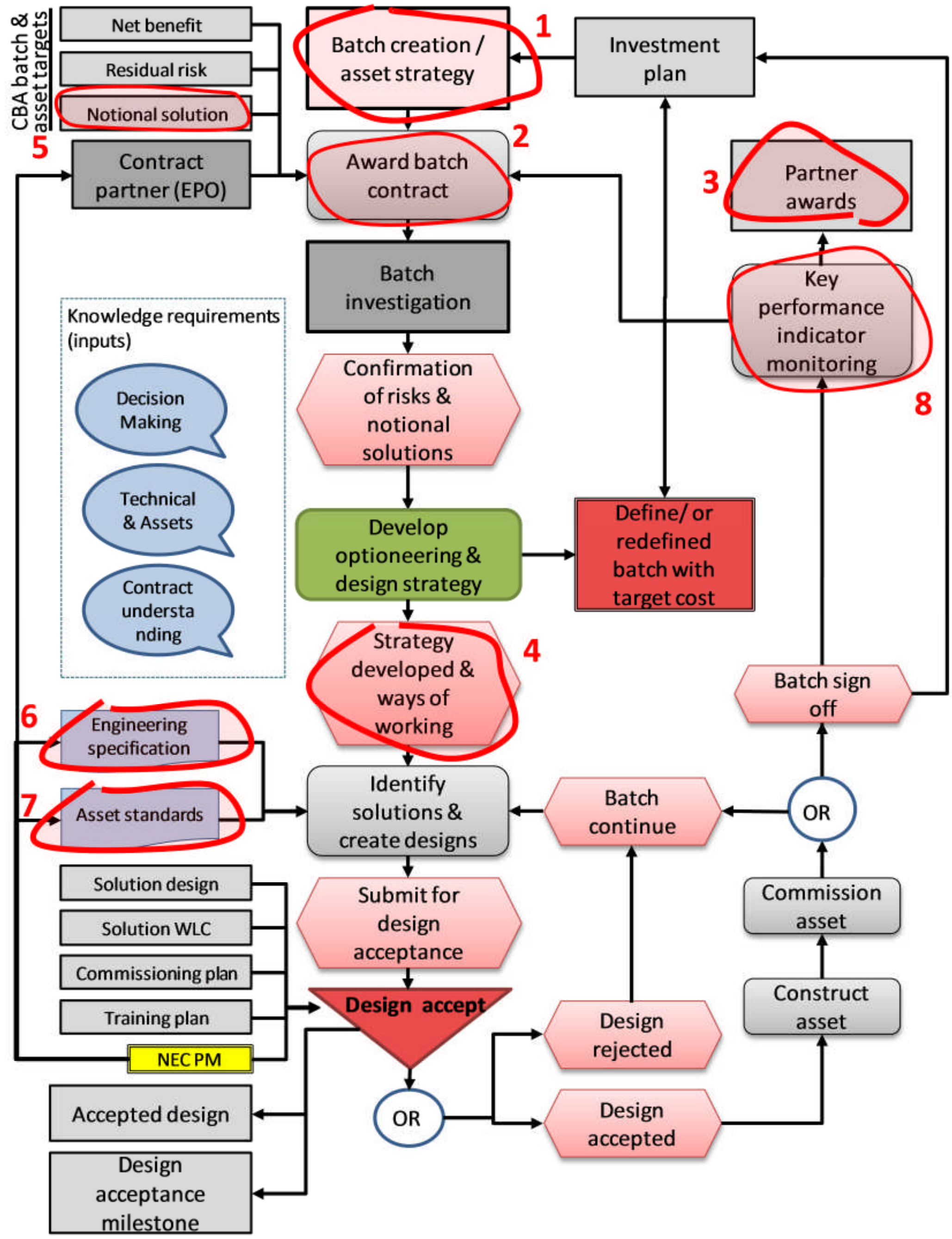


Figure 14 The flow chart of the WaSC capital delivery unit procurement process with sustainability leverage points identified during innovation development workshops

2. *Batch Contract:* the existing batch contract pays little regard to sustainability and the environment. Although an environmental schedule exists, it is deep within the appendices of the contract as an appendage to the engineering specification. It was suggested that the sustainability performance of the infrastructure in

development could be influenced by incorporating sustainability into the batch contract, and even potentially highlighting batch-specific opportunities or sustainability priorities.

3. *The WaSC Awards to EPO*: It was suggested that partners should be encouraged to target sustainability performance improvements through a sustainability award, which would be awarded to partners that have developed a specific sustainability infrastructure innovation, and/or that have contributed to ongoing improvements in sustainability.

4. *Ways of Working:* It was suggested that sustainability could enter into the corporate culture between the EPO and the WaSC employees through meetings and meeting plans with sustainability checklists that would be incorporated into batch review meetings. It was also suggested this is supported by high-level leadership statements on sustainability.

5. *Notional Solutions* are the infrastructure solutions to risk that the WaSC used in the previous asset investment period. These assets are used to benchmark the next investments in terms of service performance and cost performance. It was suggested that the best sustainability performance from across these asset types should be included as a means to evaluate the suitability of proposed infrastructure solutions.

6. *Engineering Specification* is an appendix to the partner contract. The document stipulates suitable materials for any given function and context, and the handling and construction methods associated with stipulated materials. The engineering partners are contractually obliged to adhere to the engineering specification unless they have been given special dispensation that must be agreed by a panel of senior WaSC directors. Sustainability performance could be improved by

changing the engineering specification to improve the sustainability performance of the materials specified.

7. *Asset Standards* is an appendix to the partner contract. The document stipulates the infrastructure options available to the contracted engineering partners to resolve the infrastructure risk and the design specifications and critical design features of that infrastructure. The engineering partners are thereby contractually obliged to adhere to the asset standards unless they have been given special dispensation, which must be agreed formally by the WaSC employee responsible for the asset standard and by a panel of senior WaSC directors. Sustainability performance could be improved by changing the asset standards to improve the sustainability performance of the processes and technologies specified.

8. *Key Performance Indicators* are sets of evaluative measures associated with the design, construction and commissioning of new infrastructure by engineering partners. They are used by the WaSC post-design and construction of the infrastructure asset in order to assess the engineering partners on the quality of their delivery. The KPIs both signal and influence partners as to key business concerns and are used elsewhere in the business to identify best practice to share around the business. It was suggested that developing a set of KPIs based on the sustainability performance of the infrastructure might influence the EPO to improve sustainability performance and/or help the WaSC identify best practice.

A further two areas were discussed that are not in the figure as they fall outside the WaSC capital delivery process. These were the programme planning and supply chain:

9. *Programme Planning* is the identification of investment strategies (asset strategy) over a long-term investment period and was recognised by all participants as a key point from which to leverage sustainability improvements for the WaSC. It relies on computerised risk modelling, cost benefit calculations, and strategic thinking. It was suggested that the parameters in these decision information support systems is limited and could be enhanced to take a better account of sustainability.

10. *Supply Chain* partners are identified organisations that provide the WaSC with parts or maintenance. It was suggested that the sustainability performance for the WaSC infrastructure could be improved by the addition of sustainability-orientated procurement strategies that select supply chain partners on the merits of their sustainability credentials.

After having identified a number of potential sustainability innovation intervention opportunities, the following workshops focussed on developing some meaningful potential sustainability innovations that would meet the needs of the WaSC and from which the research project could profit. The sessions used fourteen participants across four sessions totalling over nine hours of digital audio recording. Using the ETHICS steps four to six the DG went through the capital delivery process identifying opportunities and establishing the key tasks, information needs and artefacts that would support these. The results are in Figure 15 below.

The findings indicate a growing understanding of that which was required to develop the sustainability innovation and what form the innovation was likely to take. These findings are summarised below.

Objective: seek to continuously improve the sustainability performance of our assets

Receive the investigated Batch with confirmed risks

Issue Definition

1. Key Task: Reference what is sustainability… --- **Identify working sustainability understanding**
   For WaSCn.b concern lack of strong organisational steer on sustainability: Asset Strategy, Finance etc
   For the Stream Stream specific sustainability goals to be defined
   For the Batch The Batch is generated with sustainability drivers for SM to move with.
   > If not the core team - reflect on sustainability drivers for batch contents

2. Key Task: Share Sustainability Ambition with Partner
   Sustainability: General/Stream/Batch?)

3. Key Task: Collecting Asset Understanding
   collected by Core Team and WaSC specialists :
   Asset Management; Operations; Local Area; Asset Knowledge; Supply Chain etc

4. Key Tasks: Benchmarking targeting:
   Current WaSC Asset Performance (inc Sustainability impacts) Best Of Kind understanding

1

Some Artefact Notes:

Operational definition of Sustainability

Sustainability Impact Assessment process

Platform to share Sustainability with partner s

Platform to collect and share understanding of Investment performance and understanding

Sustainability Impact Assessment process

Sustainability Measures (Calculation Methods)

Criteria Setting

5. Key Task: Understanding and Prioritising future risks for investment area
   Identified future Regulatory risks
   Identified future cost trend risks to WLC calculation

6. Key Task: Understanding and Prioritising sustainability impacts of capital solutions: ← 1
   Identified sustainability impacts of Investment
   Ensuring a balanced output

7. Key Task: Share with Partners: WaSC Priority impacts → 2
   X Sustainability Steer shared with partner

8. Task Needs: Generate quantifiable basis for evaluation
   identify measures for assessing options
   Linking of Sustainability understanding to measures
   Measures must be quantifiable
   Methodology for measurement transparent (for sharing)

   Partners are not contractually obliged

Some Artefact Notes:

Some Regulation Steer on Trends and concerns

Facility for input costs to be remodelled

Process of prioritisation of impacts to be addressed

Platform to share prioritisation of concerns with partners

Identify and share appropriate measures and methods of calculation:

Must be simple easy to use for partners as much as possible reliant on data that partner is contractually obliged to submit –

Rather than requiring additional work-----which may result in comp event

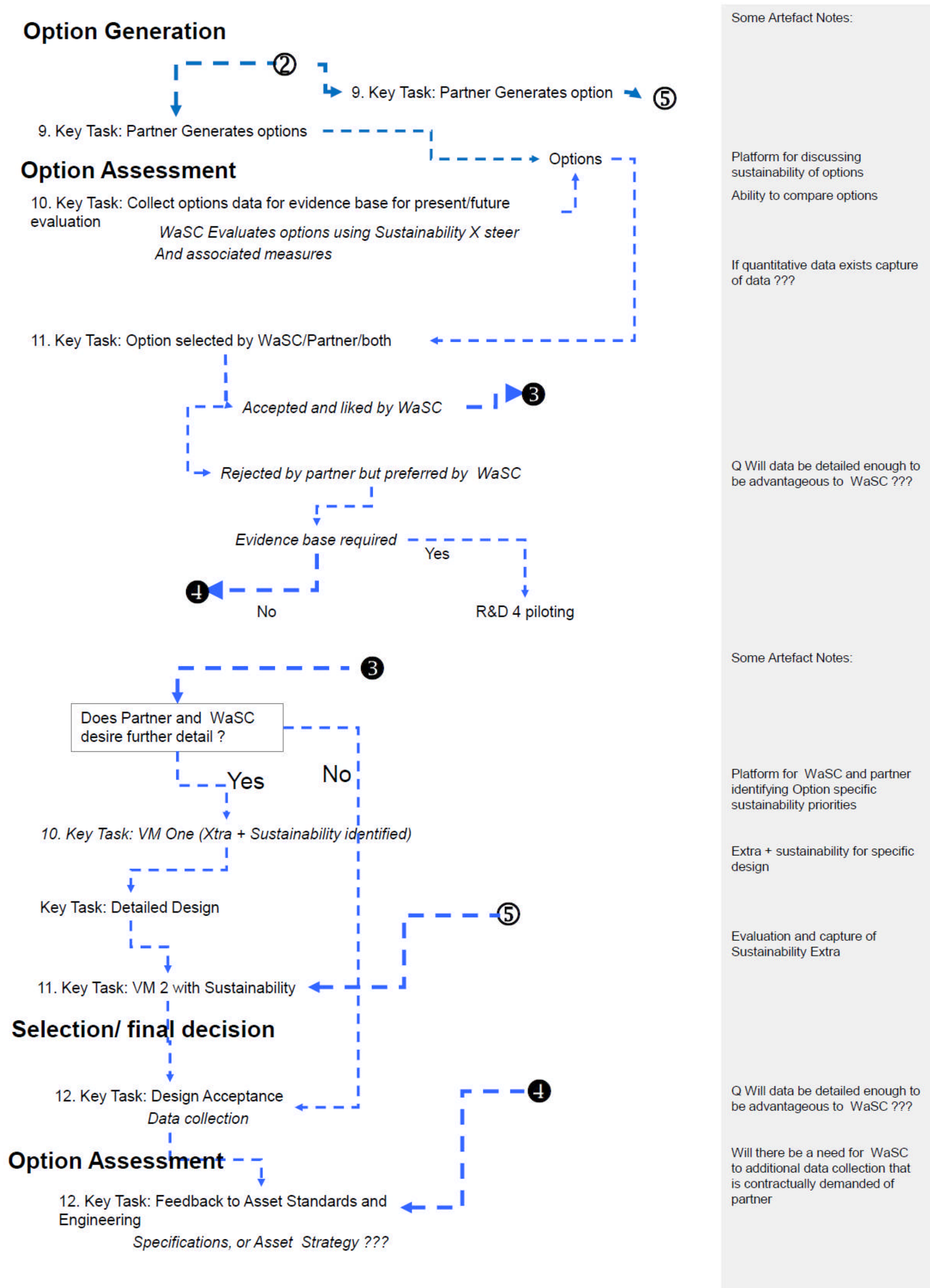


Figure 15 Synthesis of the findings from the innovation development workshops- identifying innovation opportunities

The summary of findings:

- While the overall objective was to influence the investment selection to maximise the sustainability performance of the asset infrastructure already in place, the DG participants felt strongly that the WaSC would not adopt any sustainability innovation that would alter the asset infrastructure.

- This is because the participants believed that, prior to any sustainability innovation commitment; the WaSC needed a much stronger comprehension of sustainability. This understanding would need to reveal the distinction (if any) between the assets the WaSC is replacing and investing in, and the best assets available, as well as the potential impact of adopting the best sustainability infrastructure to the business over all.
- Although Asset Standards, Engineering Specifications and asset strategy are recognised as the most significant points of leverage for generating sustainability change, pre-existing contracts prevented the possibility of alteration to these elements, as it was believed that any alteration would result in a financial compensation event, or potentially jeopardise the investment delivery commitments made to the regulator.
- Soft influencing opportunities from the WaSC on the EPO to alter the selection of infrastructure assets were advocated, as they would reduce the risk of compensation events.
- Moreover, engaging directly with employees of either the WaSC or the EPO would require either high-level influence or a financial inducement. High-level buy-in and representation would be required to motivate and/or convince both the WaSC employees and the EPO that engagement with the project is genuinely in the interest of the WaSC.
- Any proposal for sustainability innovation in the capital delivery process would need to be very simple and have minimal impact on the workload of the BM or

SM as most additional innovations already promoted to these employees are commonly ignored unless they are contractually necessary.

- It was also acknowledged that sustainability was likely to mean different things to different investment streams with each investment stream likely to have its own impacts and priorities. Thus, there would need to be a platform on which a shared understanding of sustainability could be nurtured, and which should recognise the discrete needs of differing investment streams.

The above information is a synopsis of the information collected across a number of workshops with the DG. A more complete account of the notes circulated are available in the Appendix Annex D and E. Following these activities, the SG selected the three innovation opportunities to be developed further into sustainability innovation proposals to be made to the WaSC – asset standards, engineering specification and key performance indicators.

The above sustainability innovation development process provided a crucial framework for the proposal of sustainability innovation opportunities and a justification for action. However, innovation opportunities also arose simply because the WaSC was able to capitalise on the presence of a sustainability advisor within the organisation, which acted as motivation for the generation of sustainability innovation opportunities.

Table 15 below summarises the seven sustainability innovation opportunities that the researcher engaged with: *Large schemes, Capital delivery, Influencing core team meetings, Sustainability schedule; Sustainability based Key Performance Indicators, Asset Standards* and *Engineering specifications.* The table characterises the innovations by type, form, magnitude, innovation process stage, instigator, and includes the researcher's notes reflecting his understanding of the innovation development key factors. Below we present a brief description of those innovation opportunities:

- 'Large schemes', is a sustainability based evaluation of the proposals made by EPO for large schemes on in AMP 5.

- ‘Capital delivery’ refers to the wholesale embedding of sustainability into the WaSC process and structure.
- ‘Influencing core team meetings’, referred to developing support materials to enable the WaSC SMs to engage the EPO in discussion on the sustainability of proposed infrastructure solutions,
- ‘Sustainability schedule’ is the development of a contractual sustainability MOU.

The following three innovation opportunities were selected for development by the design group: i) Key performance indicators- used by the WaSC to evaluate the EPO batch delivery; ii) Asset Standards and; iii) Engineering specifications both altered to improve the sustainability performance by specifying technologies and techniques that must/can be employed by the EPO in the delivery of infrastructure assets.

The research project generated more administrative innovation opportunities than technical. The researcher’s reflexive notes acknowledge that his technical expertise would have an impact on the exploration of research opportunities, this expertise may also have influenced the types of innovation opportunities that the WaSC looked to explore with the researcher.

None of the innovation opportunities generated in this research can be described as radical opportunities if our referent is the existing WaSC processes and structure. The magnitude of opportunities can be characterised as incremental, generally choosing to adapt a pre-existing process and incorporate sustainability within these processes.

Over half of the innovation opportunities were sufficiently exploited in order to achieve a clear proposal of innovation that could result in an adoption decision. For these, the five stages to the adoption decision that can be seen in Table 10 could not be distinguished as separate events.

Table 15 Characterisation of sustainability innovation opportunities generated as a result of an embedded sustainability researcher within the WaSC

Innovation Opportunity	***Large schemes Evaluation***	***Capital delivery development***	***Influencing core team meetings***	***Sustainability Schedule***	***Key Performance Indicators***	***Asset Standards***	***Engineering Specification***
	Sustainability of design proposals	Process redesign	Piloting during batch delivery	Addition of contract leverage	Identifying and proposing	Sustainability design challenge	Sustainability design challenge
Type **Form** **Magnitude**	Administrative Process Incremental	Administrative Process Incremental	Administrative Process Incremental	Administrative Process Incremental	Administrative Process Incremental	Technical Product Incremental	Technical Product /Service Incremental
INN (Stage) Descriptor	*(2) Knowledge/ Awareness*	*(2) Initiation push*	*(1) Idea conception*	*(6) Decision*	*(6) Decision*	*(6) Decision*	*(5) Decision*
Instigator **Initiate**	Ra-Manager Opportunistic	Ra-Manager (SG) Opportunistic	Design Group ISD framework	Manager Opportunistic	Design Group Opportunistic	Design Group ISD framework	Design Group ISD framework
Researchers notes on: **P**.Process +opportunities –[Barriers	**P**.Research into opportunities and contracts –[Locked out of sustainability evaluation by existing contract –[Insufficient time to work around	**P**.Initiated WS and data collection ETHICS alongside existing process –[WaSC resources oversubscribed –[Unable to compete for allocated resources. –[Poor relation with process development manager due to above –[SG manager leaves hands over project responsibilities –[Loss of legitimacy	**P**.Initiated meetings on ways of working –[Competing priorities of the WaSC –[Could not integrate with WaSC –[Insufficient resources (time) for process –[Danger of EPO comp event	**P**.Researcher developed (alone) sustainability schedule +Planned Contract making event –[Manager not aligned and therefore lost interest –[Manager fishing for opportunities –[No drivers –[Overlap with Environment schedule –[Limited position for environmental schedule let alone growth	**P**.Ra-Manager (SG) **P**.Researcher integrated with KPI development activities +New KPI development process +Supportive project sponsor with £ + Aligned resources + Aligned Leadership and responsibilities	**P**.Consultation with sector experts **P**.Consolidation of findings and share results with WaSC +Supportive project sponsor with £ +Allocated resources +multi-sector feedback –[Poor researcher communication with AS holders at interpretation limited efficacy by adopting a wrong strategy –[Poor WaSC costing made difficult to evaluate - Novelty of new processes	* **P**.Consultation with sector experts * **P**.Consolidation of findings and share results with WaSC +Supportive project sponsor with £ +Allocated resources –[Limited feedback – [Could not get level of expertise required for persuasion –[Infrastructure risk –[Costing models not sensitive enough to reflect impact in alteration of new materials
Outcome	**Stalled** by researcher	**Stalled** by process manager	**Stalled** by researcher	**Stalled** by opportunistic manager	**Some adopted & rejected** by KPI (& SG) manager	**Rejected** by AS manager	**Rejected** by ES manager

Abbreviations: Steering Group (SG); Design Group (DG); Responsibility aligned with SI opportunity area (Ra)

Three opportunities failed to be exploited beyond stage two of the innovation stage model. For these three opportunities, the change agent (researcher) or the management support evaluated the conditions and realised that the conditions were not conducive to the development of a new sustainability innovation.

For the innovation opportunities; 'Large schemes' and 'Sustainability schedule' the researcher was approached directly by managers, aware of the researcher's sustainability role within the WaSC, who were seeking to exploit the opportunity of available resources, and align those extra resources to innovation opportunities under their responsibility. For the DG workshops the opportunities identified both aligned with their own roles and responsibilities – Influencing capital delivery, core meetings – and also (bottom up) identified a number of areas that they had no responsibility over or role within, such as the AS and ES. All the innovations in this case study were generated internally rather than an adopted innovation sourced from an external party.

One commonly articulated barrier was the availability, or allocation, of resources, in particular the human resources to commit time to the project against competing interests within the WaSC. Where this was the case, the innovation failed to surpass innovation stage 2. An additional barrier was time, which manifested both as insufficient time to undertake the necessary development activity and being contractually locked out of change for a period of time stipulated by a contract. Other barriers noted in the researcher's diaries concerned the relationship between the innovation opportunity and key managers vital to the provision/generation of support for the project. When the innovation opportunity was not aligned with management support responsible for the operating area of the innovation, this was experienced as a barrier to the exploitation of the innovation opportunity. Finally, and conversely, where management buy-in was strong and allied to the manager's area of responsibility, and the provision of resources was made available, the innovation opportunity was exploited to a later innovation stage (as in opportunity KPI).

4.2.3 Discussion

A number of sustainability innovation considerations were revealed during the process of identifying sustainability innovation opportunities. The innovation development process started with a researcher who interacted with the WaSC with the objective of generating sustainability-orientated change within the organisation. Caldwell (2001) claims the innovation process is driven by motivated agents of change, such as champions, adapters, and consultants. This view is supported by Markus and Benjamin (1996), who believe that innovation and change is not driven by 'the magic bullet' of technology or technology developers, but requires the specific skills and motivational qualities of change agents (Markus and Benjamin 1997). While such agents or initiates of innovation may be internal or external to an organisation (Taylor and McAdam 2004), they are necessary and in short supply in the UK water sector (Thomas and Ford (2005; 2006). This suggests that the one important condition for improving sustainability innovation is an agent motivated to bring sustainability innovations into the business. Such an agent could be internal or external to the organisation and with or without a research agenda.

To engage with the business the researcher employed a strategy for delivering sustainability innovation, which drew on elements of an ISD methodology ETHICS. However, the strategy could have been more or less formulaic. The research strategy of engagement competes with other business activities to draw sufficient resources to undertake the strategy and therefore creates an immediately competitive context within which the researcher operates. Thus, the researcher looked for opportunities to assist his objectives, and to support undertaking the strategy, which included taking advantage of planned restructuring events that would bring resources together. The researcher experienced the process of matching of research and activity steps to the availability of resources as necessary to encourage engagement. The availability of slack resources was also understood to be crucial to enable interaction with the research activities. Damanpour (1991) suggests that slack resources influence the organisation's innovation adoption capacity. This research found that the availability of slack resources was necessary to gain the requisite employee contact time to develop and propose sustainability innovations. This demonstrates that the availability of resources can influence the innovation strategy, thus any strategy for innovation development must be matched to an availability of resources.

The innovation opportunities 'sustainability schedule' and 'large schemes' were not identified from within the researcher's innovation strategy. Within an organisation it is not uncommon for the availability or access to a resource to become an opportunity for managers to exercise their capacity to gain control, power or advantage within the organisation (Coopey, Keegan et al. 1998). Here, the managers that approached the researcher were not motivated by a perception of a performance gap resulting from direct researcher interaction, nor were managers motivated by their work responsibilities as their job descriptions paid scant attention to sustainability. Despite this, some opportunistic managers sought to exploit the sustainability researcher as a resource. This suggests that the availability of resources and the researcher's title (Sustainability Advisor) were able to motivate managers to attempt to understand and close a performance gap, despite a lack of clarity over the meaning of the gap or clear drivers in the business. This experience seems to corroborate research findings that the lexicon of sustainability has entered the WaSC but its impact on practice is in its infancy (Thomas and Ford 2005; Brown, Mitchell et al. 2010). However, the drivers were insufficient to warrant a commitment or further investment of resources to support sustainability innovations from those managers.

The following section describes the method and results obtained in the development of the three sustainability innovation opportunities identified in the innovation development process.

5 SUSTAINABILTY INNOVATION CASE STUDIES

This chapter presents the activities undertaken and results of the development of three sustainability innovation opportunities. The three innovations were developed to take advantage of opportunities to influence the sustainability performance of the asset infrastructure constructed by capital delivery. The three innovations developed were incremental adaptations to organisational processes used within the capital delivery process of a WaSC: Key Performance Indicators, Asset Standards and Engineering Specifications. Each innovation has the opportunity to influence sustainability performance in a different way.

a) Key performance indicators are measures used by the capital delivery unit to evaluate the engineering partners in the delivery of the investment batch. This data is also used to gather asset performance data, which enables the WaSC to identify best practice so that it can be replicated. The KPI can only influence partners when they are selecting what infrastructure to construct and how it will be constructed. As identified in Table 15 this makes the KPI an administrative innovation.

b) The asset standards are contractual documents that specify the built infrastructure. The engineering partners use the asset standard to tailor the design of the infrastructure solution to the possible risks. If there is an asset standard for the infrastructure type, the engineering partner must design infrastructure as specified in the asset standard contract (unless given special dispensation). Thus, the contents of the asset standard documents can determine the infrastructure solutions to risks. Asset standards are therefore technical innovations as they determine the technologies (infrastructure) of the WaSC.

c) The engineering specification is a contract document that stipulates the construction materials and methods for the building of infrastructure. The engineering partners use the engineering specification to tailor the infrastructure solution specifications to the risks. The engineering specification contains detail about matching construction demands to the material, or the construction methods to the material; it specifies the components of infrastructure solutions. Engineering specification are therefore technical innovations as they alter the technologies (infrastructure) of the WaSC.

These three innovations were modified in order to influence the sustainability performance of the infrastructure solutions designed, built and commissioned by the engineering partners to improve the sustainability performance of the WaSC.

Below, the methodological activities employed to modify these elements is presented as three separate case studies: KPIs, AS, ES. Each case study is followed by a description of the resulting modifications, and a discussion concerning what the activities teach us about the process of sustainability innovation development in the WaSC.

5.1 Key Performance Indicators

This section presents the key performance indicator case study. It includes the role of 'Key Performance Indicators' (KPIs), the process of selecting and developing specific key performance indicators and the innovation case study adoption results.

Key performance indicators are sets of evaluative measures associated with the design, construction and commissioning of new infrastructure by engineering partners. KPIs are used as data sources in the following processes: to assess the engineering partners on the quality of their delivery of services to the WaSC; to compare and contrast activities involved in infrastructure solutions across the business; to help the WaSC identify best practice to roll out throughout the business; as a mechanism to encourage competition between engineering partners on key business concerns. The KPIs are a mechanism by which the WaSC conveys any concerns it has to its partners. The development of KPIs centred on sustainability objectives was identified as a potential mechanism by which the sustainability performance of the infrastructure assets built by capital delivery could be influenced.

5.1.1 Method

The following three activities were undertaken: activity one identified the sustainability performance gap between the sustainability principles of the Five Capitals framework and the capital delivery, and then proceeded to identify business beneficial objectives and targets for KPIs. Activity two developed these objectives into a proposal of sustainability based key performance indicators, which incorporated additional WaSC constraints. Finally, activity three was used to reveal and capture the innovation adoption outcome and clarify what influenced the adoption outcome.

For the development of sustainability KPIs, the research continued to employ the user-centred approach that is advocated in the ETHICS methodology. The method employed purposive sampling; deliberately targeting the views of WaSC employees with a user-based relationship to the innovation.

Identifying the WaSC sustainability performance gap and opportunities

In order to identify a performance gap between sustainability principles advocated in the Five Capital framework and the existing practices of the WaSC capital delivery, the following activities were undertaken.

Two focus groups were held with project managers from capital delivery, which represented geographically separate managed areas of the WaSC and covered both water and sewerage service provision. Together with the researcher, the participants read the presented 'adapted Five Capitals principles' (Table 13).

The participants were then asked to respond to the following questions for each principle:

a) How does your business manage this sustainability principle?
b) Do you believe this principle is effectively managed by the business?
c) Can capital delivery influence the performance of this principle? If so, how?

Participants were asked to consider the life-cycle of an infrastructure asset in capital delivery (investigation, design, construction, operation and decommissioning), the business units which have an impact on capital delivery (Human Resources, Program Planning, Supply Chain and Procurement), and the tools employed by the WaSC during capital delivery (company policy, asset standards, engineering specifications, key performance indicators, and cost models etc).

The participants' perceptions of the principles were captured by digital audio recording and on a white board, and they were then allocated to one of the following categories: 'under managed', 'requiring management', 'conditional' (under managed in some situations), 'effectively managed', 'did not know', or 'not relevant' (to the work of the water company). The researcher then used the information gathered to identify those principles perceived, on balance, as least well managed. The researcher assumed that consensus on principles least well managed equated to a readily recognised performance gap between the WaSC and sustainability.

To identify opportunities where exploitation of the performance gap would be more likely to be supported by a WaSC business, and where there was an appetite for new sustainability KPIs, the researcher deliberately allowed the WaSC to select their KPI objectives. This decision was taken when it became apparent that any change to the WaSC would be difficult to achieve, and the innovation process therefore sought to optimize the opportunity for change to occur. The researcher acknowledges that by reducing the principles of sustainability that the organization seeks to manage, it may erode overall sustainability while improving against the selected principles. However, the researcher justifies this approach by noting that small changes in the name of sustainability may contribute to the building of a business case, or lead the way to more radical changes.

The researcher carried out one-to-one interviews with Stream Delivery Managers (SDM) of capital delivery. SDM interviewees identified the specific investment stream in which they had most experience and took part from the perspective of that stream. This was to ensure that the interview captured relevant and informed information on specific investment streams. Each SDM interviewee was given a description of the methodological activities undertaken so far. The SDM interviewees were presented with the adapted Five Capitals principles, and principles identified in the previous activity as less well managed were already highlighted in orange. The following activities were undertaken in the SDM interviews:

SDMs reviewed all the principles and placed a mark alongside each principle upon which they believed their stream had a significant impact. From the marked principles, interviewees then marked those that they believed their stream should prioritise (Table 17 'marked principles'). The researcher then asked the participants to review their selection using two adoption criteria: 1) those principles which would be easiest to make strong performance improvements against and, 2) those principles which are most likely to result in business benefits and therefore likely to be adopted (Table 17 'selected principles'). Finally, interviewees were asked to select a maximum of two principles and to describe investment stream improvement objectives they aspired to by adopting the sustainability principles for the stream. They were also asked to describe the means by which these objectives would be met (Table 17 'Desired stream investment improvements').

The purpose of this process was to guide the development of sustainability indicators towards so called 'win win' situations, in which the adoption of sustainability would also equate to assisting the WaSC in meeting its desired performance improvements. These ‘win-win’ opportunities were clarified into objectives and means from which sustainability indicators could be developed.

Development into a proposal for sustainability key performance indicators

This activity utilised the information gathered in KPI activity one to engage the WaSC with an ongoing KPI development activity. Those taking part in the project were introduced to, and asked to engage with, an external consultant (EC) responsible for the development of KPIs for the ensuing AMP period.

To develop stream-specific sustainability concerns into indicators, the researcher turned to sustainability indicators identified in the initial literature searches, which were carried out in research phase one. Using an Excel spreadsheet, sustainability indicators were first compiled and then allocated, by impact, to each of the five capitals. They were then sorted again into (where possible) specific principles. The worksheet roughly related indicators to sustainability principles in order to help the researcher develop and propose KPIs that could meet the stream sustainability objectives.

The spreadsheet was presented and discussed in a series of meetings with the WaSC. The meeting participants are primarily: the Environmental Strategy Team members (ESM), the capital delivery ‘Reporting and Financial Manager’ (RFM), an External Consultant (EC). The RFM was responsible for the collection and dissemination of financial and technical data relating to the activities of capital delivery, and the EC was charged with the development and delivery of performance measures to be applied to ADU partners as they deliver assets for the WaSC. To inform the development of the KPI, summaries of these meetings with the key performance indicators DG were captured.

Establish the adoption position of the sustainability innovation.

Once the WaSC had finalised its decision on adopting the proposed KPIs (or not), a series of interviews were held with the RFM, EC and ESM. These interviews were designed to capture data on the adoption outcomes for the proposed sustainability KPIs and to identify the influences on the adoption decision of the KPI. Participants reviewed the proposed sustainability KPIs and responded to the following questions:

a) Was the KPI adopted or rejected?
b) What characteristics of the KPI contribute to its adoption position?
c) What organisational factors contributed to its adoption position?
d) What methodological process contributed to the adoption position of the KPI?
e) Are there any specific internal or external events that altered or gave rise to the adoption position of the KPI?

The digitally recorded interviews were transcribed and analysed using narrative-based investigation, applying thematic content analysis, axial coding and the construction of an event-based diachronic visual map for the KPI.

The following section presents the results of the methodological activities, followed by reflections on the implications of the activities for our research question.

5.1.2 Results

KPI activity one was concerned with identifying the sustainability performance gap between the adapted Five Capitals principles and the behaviours and management activities of the WaSC as perceived by the project managers in the capital delivery.

The results obtained for this exercise are available in Table 16 below. The results reveal that there was a large disparity between the perceived performance gap and the sustainability principles across the five capitals. Outputs from this activity suggest that sustainability principles under the capital headings Social, Financial and Human were perceived as well managed.

Table 16 The perceptions of WaSC sustainability management practices captured during innovation development workshops (ETHICS steps 1-3)

The perception of the management of each of the Five Capitals by the WaSC's Capital Delivery Unit across 6 aspects of asset delivery - *'Investigating Risk'; 'Design'; 'Construction'; 'Operation'; 'Decommissioning'* and *'Post project evaluating, monitoring and learning'*. (Principles are shown numerically coded according to capital e.g. NC.1 is Natural Capital principle 1, NC.2 is Natural Capital principle 2 etc.)

Classification of Responses:

A. Principle perceived as under managed by the WaSC
B. Principle requiring management (but no additional comments or discussions)
C. Conditional- perception of management efficacy dependent on interpretation /application of the principle
D. Principle perceived as effectively managed by the WaSC
E. Respondents did not know
F. Principle deemed irrelevant to the process

	% comments undermanaged (A+B) as proportion of total comments SUM (A:F)	%
Natural Capital		
NC. 1	Protect/improve habitat, biodiversity and ecosystem function.	58
NC. 2	Reduce emissions of substances to a concentration that can easily be assimilated by natural systems: a. chemical concentrations and nutrient loads; b. GHG , Ozone depleting substance; c. Etc	**83**
NC. 3	Reduce dependency on materials that are naturally scarce.	**83**
NC. 4	Reduce use of virgin materials and resources	**83**
NC. 5	Reduce dependency on and accumulation of manmade substances that may prove harmful to ecosystem or human health substitute all with substances that can be easily assimilated broken down by natural systems.	**100**
NC. 6	Use renewable resources only from well-managed and restorative eco-systems.	**89**
NC. 7	Reduction/elimination of waste	**73**
NC. 8	Increase/full recycling of resources	**100**
NC. 9	Reduce/eliminate dependency in the use of fossil fuels (thereby increasing use of renewable energy resources).	**82**
NC. 10	Reduce energy demand	58
Human Capital		
HC. 1	Ensure adequate Health and Safety standards are met	0
HC. 2	Respect human rights throughout their operations and geographical regions	9
HC. 3	Respect human values and their different cultural contexts	11
HC. 4	Give employees (where possible) access to training and education	10
HC. 5	Educate and promote for higher standards of health and support mental wellbeing.	11
HC. 6	Provide a reasonable living wage and fair remuneration for employees and business partners.	11
HC. 7	Allow for and enhance recreation time and support individuals' active involvement in society.	11
HC. 8	Ensure supply chain partners apply the same principles to fulfilling employee needs.	**89**
HC. 9	Create opportunities for varied and satisfying work.	25
Social Capital		
SC. 1	Source materials ethically and treat suppliers, customers and citizens fairly.	50
SC. 2	Reduce emissions of persistent compounds that are harmful to ecosystem or human health.	60
SC. 3	Respect and comply with local, national and international law.	60
SC. 4	Provide a supportive family friendly labour policy.	60
SC. 5	Prompt and full payment of taxes and support of social infrastructure.	60
SC. 6	Minimise of the negative social impacts of products and services or maximisation of the positive	43
SC. 7	Support the development of the community in which the organisation operates, including economic opportunities).	**100**

SC. 8	Assess the wider economic impacts of the organisations activities, products and services on society e.g. in creating wealth in the communities in which the organisation operates	**100**
SC. 9	Encourage and engage in transparent consultation and communication with relevant internal and external stakeholders,	**67**
SC. 10	Fulfil commitments made with suppliers, customers/citizens and regulators.	50
SC. 11	Effective Communication throughout the organisation , reflecting shared Values and objectives	0
Infrastructure Capital		
IC. 1	Ensure that systems, processes and infrastructure performance is maintained under a robust set of future operating scenarios.	**70**
IC. 2	Seek to maximise the flexibility and adaptability of infrastructure to respond to diverse set of future operating scenarios.	**70**
IC. 3	Develop infrastructure that facilitates ease of maintenance: a. Design for disassembly ; b. Modular designs (to minimise potential negative opex spend)	22
IC. 4	Have sought to reduce or eliminate waste and emissions in production systems.	**70**
IC. 5	Where appropriate replace products for service contracts.	**67**
IC. 6	Optimisation of infrastructure/technologies and processes in a way that uses resources most efficiently.	**70**
IC. 7	Optimise the recycling of resources.	**70**
IC. 8	Identifying and utilising synergistic production systems where one organisation's waste streams are another's resources.	**91**
IC. 9	Seek improvements and innovation in the design of product systems (eco-efficiency and eco-innovation).	**88**
IC. 10	Apply sustainable construction techniques when looking at new infrastructure.	**67**
Financial Capital		
FC. 1	Employ prudent financial management	0
FC. 2	Efficient use of financial resources (reducing and minimising costs)	0
FC. 3	Management of financial risk (over both short and long term)	0
FC. 4	Internalise environmental and social costs and assign an economic value to them.	8
FC. 5	Effective total costs under a robust set of future scenarios e.g. : a. Unit running costs; b. Unit capital costs; c. Remediation costs of infrastructure; d. Internal manpower costs; e. External services costs ratio; f. Imported (raw and treated) water costs ratio; g. Energy costs ratio h. etc.	0
FC. 6	Effective management of financial risk exposure.	0
FC. 7	Timely fulfilment of contracts	0

The consensus was that these principles aligned with the WaSC's existing leadership vision and the policy: *Service, Compliance, Value* and *People* (SCVP, see Annex F). However, sustainability principles related to infrastructure capital were perceived by capital delivery as significantly less well managed or under managed by comparison, and the SCVP policy had little or limited inclination towards the management of these principles. Similarly, Natural Capital, was perceived by capital delivery as significantly less well or under managed even though the WaSC Policy does focus on the environment, '*We always comply and where it is good business we do more than we need to*'. However, environmental concerns in the WaSC policy are defined by regulation rather than providing a specific view on sustainability. Many of the principles of sustainability are more far-reaching than the corresponding regulatory controls, they were therefore considered perceived as undermanaged.

The results show that principles perceived as well managed were supported by the WaSC policy and thereby managed effectively by the WaSC business processes. Additionally, principles that allude to responsibility beyond regulatory requirements and principles, which demand greater incorporation of externalities, were perceived as less well managed. For example, the treatment of principles associated with Natural Capital was by far the poorest performing of the capitals followed by Infrastructure Capital.

These findings were then used in interviews with SDM. The sustainability principles identified as less well managed were marked in orange. From the list of principles, the SDM first marked principles that concerned their stream, then selected a few from which a stream specific objective was discussed. The understanding of the stream objective and the means of meeting the objective was used to develop the KPI. (See Table 17)

The objectives for the development of the sustainability KPI were overwhelmingly expressed in terms of a cost saving. The means of achieving the cost saving was typically to seek a reduction or substitution of inputs (energy/chemicals or building materials). Different streams articulated different concerns. Networks and Reservoirs are primarily concerned with cost saving in construction, and the stream Medium Treatment was understood to have greater potential in concentrating efforts to achieve cost saving in operational inputs. This indicates that the impact of sustainability priorities is distinct from the attributes of the core activities of the investment stream. This is most apparent in large schemes where the infrastructure is passive, such as sewers. In the case of sewers, the sustainability concerns would be construction, however, a large sewage treatment plant would be primarily concerned with operational impacts.

Table 17 Stream managers selection of sustainability objectives for KPI

Streams Marked Principles Selected	Stream Objective	Means of meeting objective
Reservoirs NC: 1, 3, 4, 8; IC: 1, 2, 3, 9; HC 1, 4, 7; FC: 3, 6, 4; SC; 3, 7, 8,	Cost savings as a result of reductions in material inputs (including fuel and energy) and costs associated with waste in the delivery of related assets.	Increases in the recycling of spoil on site; Reductions in the percentage of virgin aggregates and additives used in construction of assets, Reduction in waste to landfill Reduction in associated fuel and energy costs
Networks NC: 4, 8 IC: 1, 2, 8		
Medium Treatment NC: 2, 5, 9, IC: 1, 6, 9 HC: 8 FC: 4 SC: 2	Cost savings as a result of reduction in inputs, ensuring assets are less vulnerable to changes in input prices.	Reduction in volumes of chemicals used Seeking chemical substitution Reductions in (operational) energy use Seeking increases in renewable energy
Other installations NC: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 IC: 1, 2, 6, 9, HC: 8, FC: 4,	Cost savings as a result of reduction in inputs, ensuring assets are less vulnerable to changes in input prices and activities maximize efficient use of resources.	Reductions in (operational) energy use Seeking increases in renewable energy Reduction in the transportation costs
Large Schemes NC: 7,8,9,10 IC: 2, 3, 6, 8, 9, 10 HC: 1, 3, 4, 8, FC: 1, 2, 3, 5, 7 SC: 1, 2, 3, 6, 7, 9, 10, 11	For large schemes, it is believed the biggest benefits will be achieved by encouraging information sharing for best practice.	Innovation improvements through sharing of best practice. Eco innovation and eco efficiency

The objectives identified in Table 17 are a reduction from the principles of the Five Capital Model, which was selected for its completeness of coverage. The sustainability principles were revised down from the comprehensive understanding of sustainability proposed by the researcher, to those principles that were perceived by the business as also benefitting the WaSC. These benefits were typically expressed in terms of cost saving.

This presents as a problem if the goal is a holistic incorporation of sustainability for the WaSC rather than a more piecemeal and incremental adoption of sustainability. If sustainability principles excluded from the KPI process have negligible impact or are effectively managed elsewhere by the organisation, the WaSC could still make a reasonable claim to be comprehensive in its management of sustainability. However, where there is some sustainability impact and a failure of the business to manage this elsewhere, it can be said that the WaSC was failing to be comprehensive in its approach to sustainability management.

For the WaSC in question, the principles not directly managed by the objectives of the stream managers, but which were identified as undermanaged in previous focus groups, are presented in Table 18 below. Within Table 18, IC 1,2,3, and 6, and NC 1 and 2 are marked by stream managers (implying the principle could be relevant to the infrastructure stream in some way) and are not identified as an objective for KPI development. Thus, the resultant KPI would not target the behaviours inferred in the principle.

With a greater understanding of stream managers' desired sustainability objectives, the researcher returned to the DG with the findings for discussions. Table 19 (KPI development constraints) synthesises the key concerns from the DG. The dialogue articulated a persistent demand on the sustainability change that the '*data acquisition must be cost neutral'*. This limited changes to options that relied on existing routines or knowledge stocks, and made no, or as little as possible, alteration to the allocation of resources. Cost neutral demands also limited the number of KPIs, and the RFM explicitly limited the number of KPIs to '*not more than ten, twelve at the outside*' that could be proposed, as each KPI inevitably carries with it some resource burden.

Table 18 'Undermanaged' sustainability principles not selected for KPI development

NC. 2	Reduce emissions of substances to a concentration that can easily be assimilated by natural systems: a. chemical concentrations and nutrient loads; b. GHG , Ozone depleting substance; c. Etc
NC. 3	Reduce dependency on materials that are naturally scarce.
NC. 6	Use renewable resources only from well-managed and restorative eco-systems.
NC. 7	Reduction/elimination of waste
HC. 8	Ensure supply chain partners apply the same principles to fulfilling employee needs.
SC. 7	Support the development of the community in which the organisation operates, including economic opportunities).
SC. 8	Assess the wider economic impacts of the organisations activities, products and services on society e.g. in creating wealth in the communities in which the organisation operates
IC. 1	Ensure that systems, processes and infrastructure performance is maintained under a robust set of future operating scenarios.
IC. 2	Seek to maximise the flexibility and adaptability of infrastructure to respond to diverse set of future operating scenarios.
IC. 4	Have sought to reduce or eliminate waste and emissions in production systems.
IC. 5	Where appropriate replace products for service contracts.
IC. 6	Optimisation of infrastructure/technologies and processes in a way that uses resources most efficiently.
IC. 7	Optimise the recycling of resources.
IC. 8	Identifying and utilising synergistic production systems where one organisation's waste streams are another's resources.
IC. 10	Apply sustainable construction techniques when looking at new infrastructure.

Applying these constraints and expectations to the development of the KPI proposal, the researcher developed a proposal that relied on data that was either already collected by the business for their reporting expectations or would be accessible providing EPO had a basic level of project level financial management. As a result, ten KPIs (see Figure 16) were proposed to the business, centred on sustainability objectives identified by stream managers as priority impacts that would result, if managed, in business benefits (see Table 17 above).

All the KPIs developed were guided by the objectives described in Table 17 and the conditions laid out in Table 19 below.

Table 19 Innovation development constraints for KPI specified by the WaSC design group

Source	Change characteristic
RFM EC	The number of separate indicators/measures used to assess the sustainability of CDU decision making should be as few as possible, in order to minimise administration costs.
RFM EC	The data used in the development of the indicators/measures should be already collected by the business.
EC	The existing contractual arrangements between the WaSC and its contract partners cannot be contravened. The resultant measures/indicators can only be applied as soft influencing measures.
ESM	The addition of operational and embedded carbon should be a business priority.

Engineering consultant (EC), Reporting Finance Manager (RFM), Environment support manager ESM)

By rejecting some of the proposed KPIs, two further sustainability principles that were identified as both not being effectively managed and a stream concern for management, were precluded from management within this innovation: NC 5. 'Reduce dependency on and accumulation of manmade substances that may prove harmful to ecosystem or human health and substitute all with substances that can be easily assimilated or broken down by natural systems' and NC. 9 'Reduce/eliminate dependency in the use of fossil fuels (thereby increasing use of renewable energy resources)'.

The three KPIs adopted were: Waste Reduction, Material Intensity, and Energy in Construction (See Figure 16). All three are related to cost trends that the indicator would seek to mitigate. KPI Waste Reduction seeks to reduce the waste materials to landfill as a proportion of construction materials, in order to mitigate the cost trend of increasing cost of landfill. KPI Material Intensity, which aims to increase the recycled content used as a proportion of construction material, was also associated with the trend of a rise in landfill and the cost of construction materials in general. KPI Energy in Construction seeks to drive down energy use to reduce the cost burden of fuel and electricity costs. The three adopted KPIs are all associated with construction impacts rather than sustainability impacts arising from operation.

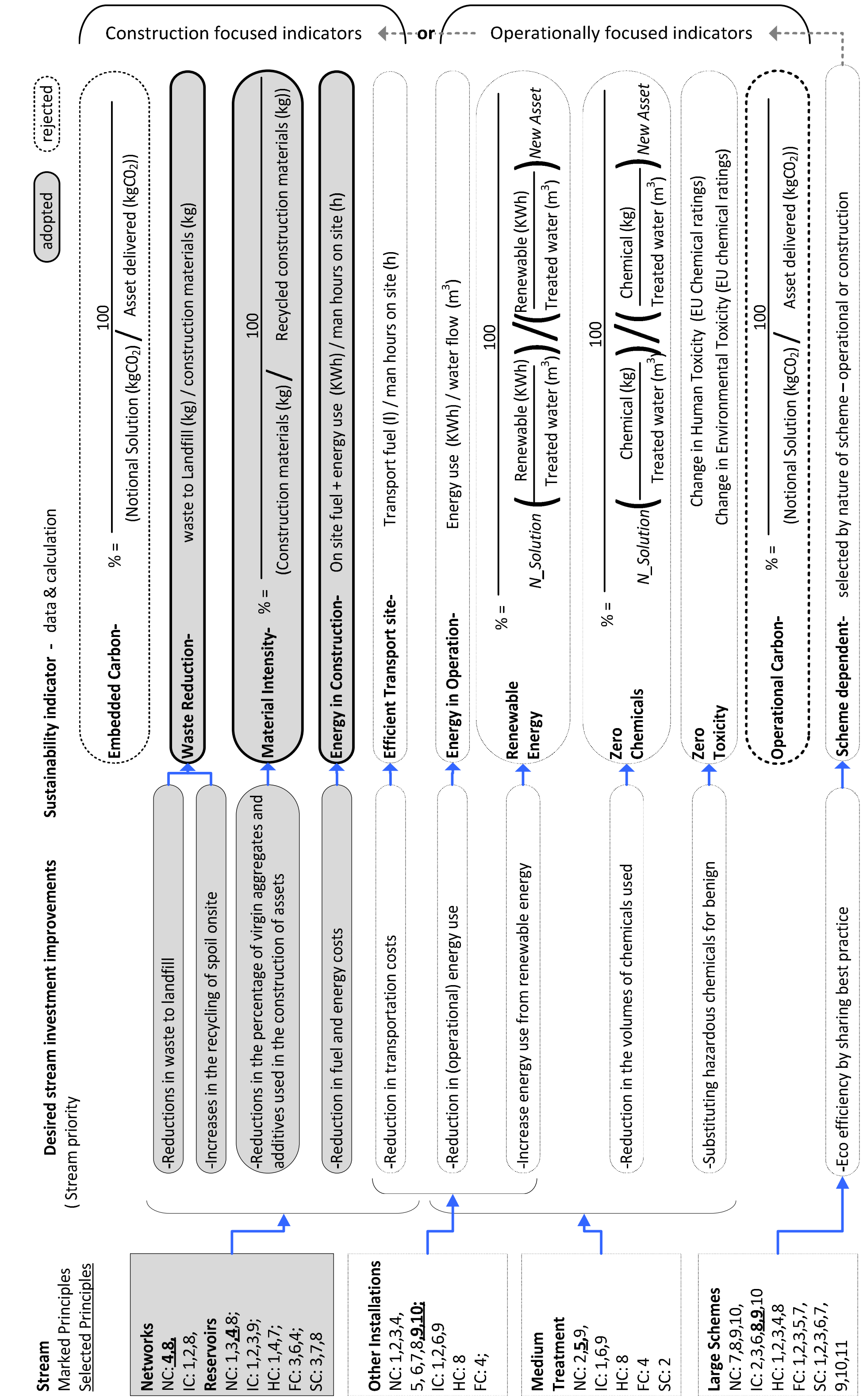


Figure 16 Summary of the KPI innovation development from stream sustainability concerns to KPI adoption status.

In terms of helping to improve the sustainability performance of infrastructure assets, the indicators adopted will benefit the passive infrastructure or construction intensive infrastructure, such as networks and reservoirs, more than infrastructure that has higher operational impacts than construction, such as medium treatment.

Interviews suggested that capital delivery was very clearly incentivised by the regulators and through the CDU management to reduce capital costs in delivery. There are therefore strong incentives for the adoption of construction-focused indicators. KPIs that focused on operational cost reductions, such as Energy in Operation, or Zero Chemicals, were rejected. Operational Carbon was also rejected, which was not cost based, but was operation related. All respondents mentioned that operational concerns lie outside the roles and responsibilities of the department CDU and they are the responsibility of the business unit production, which operate and maintain the infrastructure.

Interviewees most frequently commented that data already being collected by the business was a significant factor. Datum already collected by the business were not subject to the following barriers: the need to demonstrate data utility to partners and the WaSC, the additional cost associated with data acquisition, the development and sharing of methodology and boundaries for data collection or the development of relevant technical authority and leadership.

The indicator for embedded carbon revealed that the adoption position of proposed indicators could fluctuate significantly and rapidly, with the business's interpretation of the regulator's plans. In this case, the business had decided not to adopt a KPI based on embedded carbon as there was a lack of external leadership (from the regulator) or internal expertise, both of which made it difficult for the business to select and promote a methodology for the capture of data. However, when the WaSC came to believe that Ofwat was to start measuring embedded carbon, the WaSC changed its adoption position despite the concerns stated. When it was later decided that their interpretation of the regulator was incorrect, they again rejected the indicator immediately. This anecdote suggests the WaSC is strongly influenced by the regulator.

5.1.3 Discussion

During the process of developing and proposing KPIs, a number of sustainability innovation considerations were identified. The WaSC policy ‘SCVP^{+}’, seemed to demonstrate that where policy was evident, the management activities kept closely to the terms of the policy. This suggests that principles which are explicit in the policy are well managed by the CDU. This clear relationship indicates that the WaSC is able to cascade work tasks (organisation, mission and policy) through the organisation. Technologies and actors (employees with responsibilities) were correspondingly well-suited to the delivery of the WaSC’s policies.

UK WaSCs have already been characterised as risk averse (Thomas and Ford 2005; Cave 2009). High levels of uncertainty and risk have been identified as innovation barriers (Rogers 2003) unless the expected returns are understood to be worth the risk (Nooteboom 1989). Unfortunately, the outcomes of long-term sustainability strategies, in terms of benefits and costs, cannot be ascertained (Ascher 2006). Given that the consequences of implementing sustainability objectives are not yet fully understood, this uncertainty may be experienced as a barrier to the adoption of stronger sustainability statements, policies, or missions. This research indicates that the WaSC’s policy agenda closely correlated to key management concerns of the regulator. However, the WaSC was not comprehensive in its management of the many domains of sustainability, in particular environmental and infrastructure-focused sustainability principles.

As the WaSC would not commit resources to a process in which they could not identify benefits (expressed in cost-saving opportunities), the researcher believes that targeting 'win-win' opportunities is necessary in order to guarantee adoption. Moreover, the RFM imposed a limit on the number of sustainability KPIs to be proposed. However, in this process, 14 sustainability principles were not directly targeted in the sustainability indicators (see Table 18 above), and the process of matching the proposed KPI to the WaSC structure further reduced the set of principles managed by this innovation, despite the benefits of the indicator being apparent to the SDM.

The notion that organisations may have to change their structure, roles, and responsibilities in order to adopt sustainability innovations is prevalent (Doppelt 2003; Rainey 2006; Epstein 2008), and is implicit in the Leavitt model. This research found that for operationally-focused KPIs, the roles and responsibilities of the CDU would be transgressed and there was insufficient will or flexibility in the WaSC to accommodate this.

Data availability was a major concern in the development of the KPI. Here, reporting data played a vital role in establishing data familiarity and reducing the perceived cost of data acquisition. Again, this suggests that the proximity of the innovation to accepted roles may influence adoption. Clearly, for KPI innovations the relationship to the existing knowledge and knowledge supporting activities within the WaSC was incremental, rather than radical. A more radical innovation would have required the development of new knowledge and knowledge supporting activities. However, the adopted KPI innovations relied heavily on existing processes and built on existing knowledge bases. The adoption of sustainability-focused KPIs was therefore incremental, because the platform for KPI reporting was already established within the WaSC and the data used was already being collected and used elsewhere in the business.

Many authors have identified the influential role that regulation plays in determining the WaSC's sustainability focus and practices (Legge 2000; Thomas and Ford 2007; WATERUK 2008; Cave 2009; Ofwat 2010). This case study suggests that the adoption of sustainability and related innovations will proceed in an uneven manner, determined by factors such as regulatory incentives, existing roles and responsibilities, and cost impacts.

In summary, the KPI innovation case study suggests that sustainability innovations are influenced by the degree to which sustainability principles are apparent in the WaSC policy, and that the selection of sustainability principles to be retained by a WaSC is influenced by perceived cost benefits. The study also suggests that WaSC incentives (regulatory or other) may amplify the benefits of the adoption of some sustainability principles over others and also that innovations which are aligned with the existing roles and responsibilities are more easily adopted than those that are not.

5.2 Asset Standards and Engineering Specification

This section describes the role of asset standards and engineering specifications, the process of selecting the specific asset standard and engineering specification, and the process for adapting and converting them into a sustainability innovation and a review of the eventual adoption outcomes.

Asset standards are contractual documents that stipulate the infrastructure options available to the contracted engineering partners to resolve the infrastructure risk. They also stipulate the design specifications and critical design features of that infrastructure. The asset standard typically presents a decision tree that describes a possible set of service requirements or context. This may be population equivalent, or refer to existing site conditions, existing site infrastructure, discharge consent, processes, ground conditions etc. The decision tree will lead the user through to a design specification for the type of infrastructure the partner is proposing. How this looks is highly dependent on the type of infrastructure. Engineering specifications are contractual documents that stipulate suitable materials, electro-mechanical parts, supervisory control and data acquisition (SCADA) technologies, network pipes, valves, and the British or ISO standards for materials and parts. Similarly, decision trees are used to direct the user to the specified component.

The innovation opportunity development activities, guided by the ETHICS methodology, repeatedly directed the focus of the workshops to asset standards as a crucial piece of contract that directly defined the solution space or solution options available to engineering partners. The development activities also referred to engineering specifications as a piece of contract that dictates the materials and construction methods and conditions to engineering partners. It was suggested in these workshops that these contracts and documents would dictate the sustainability performance of the asset infrastructure designed and built by EPO. Furthermore, this would leave the engineering partners no incentive to identify or propose more sustainable treatment options, thereby limiting the WaSC's access to alternative sustainable treatment options. Thus, the sustainability innovation was to modify these documents to enable EPO to design and deliver asset infrastructure with improved sustainability performance.

5.2.1 Method

The following three activities were undertaken to modify these contractual documents to facilitate sustainability performance improvements. Activity one was concerned with selecting a target asset standard and engineering specification for sustainability innovation. Activity two incorporated and presented sustainable options to the WaSC. Finally, activity three recorded the innovation adoption decisions and rationale. The research methods for these activities are presented below followed by the results obtained and reflections on those results.

Selecting the asset standard and engineering specifications for modification

At the time of the research twenty different asset standards had been developed covering both water and wastewater infrastructure assets (see Table 20 below).

Table 20 WaSC contract reference documents- Asset Standards and Engineering Specifications

Asset Standards	
Wastewater Treatment	Water Treatment
1. ASP and FST	1. Chemical Dosing
2. Asset Standard Digestion	2. Chlorination Fail-Safe
3. Flow Splitting	3. Ground Water - Boreholes, Springs, Adits and Aqueducts
4. Grit Removal	4. Distribution Management Areas
5. Mineral Media Filters	5. Large Diameter Treated Water Mains
6. Plastic Media Filters	6. Pumping Stations
7. Primary and Humus	7. Reservoir Safety
8. Pumping Sewage	8. Service Reservoirs
9. Sand Filters	
10. Screens	
11. Process Selection Matrix	
12. Thickening and Dewatering (STF)	
Engineering Specifications	
Civils	15. LV Electrical Installation
1. General	16. Motors
2. Materials	17. Pumps, Compressors, Blowers
3. Excavation, Backfilling & Restoration	18. HV Electrical Installation
4. Concrete & Formwork	19. Valves, Penstocks and Actuators
5. Construction of Pipelines, Tunnels & Ancillary Works	20. Control and Monitoring Philosophy
	21. Instrumentation Standard
6. Building Works	22. Telemetry
7. Testing and Disinfection	23. Programmable Logic Controllers (PLC)
8. Road works	24. SCADA
9. Sewer Renovation	25. Outdoor Kiosks
10. Water Main Restoration	26. Fire Protection and Fixed Gas Detection
11. Tunnelling and Shaft Sinking Works	27. & M Manuals
Mechanical	28. Chemical
12. Mechanical	29. Security
13. Power Supplies	30. Environment
14. Panel Assemblies, Low Voltage Switchgear & Control Equipment	31. Specialist Modelling

The engineering specification is a standard document for civil engineering activities undertaken by, and/or on the behalf of, UK WaSCs. As such, the document is a large volume with many sections which, due to resource and time limitations, could not be revised in detail or in full (Table 20). Instead, the researcher concentrated the focus of the sustainability innovation process on selecting materials and contexts commonly used by the WaSC.

Due to time limitations and reasonable expectations for the scope of the research project, the researcher decided to reduce the task by focusing on one asset standard and a number of engineering specifications. It was assumed that not all asset standards or engineering specifications had an equal capacity to improve sustainability performance. Therefore, the researcher enlisted the assistance of an engineering consultant (EC) to help select the relevant AS and ES. The engineering consultant was selected on the basis of his intimate knowledge of the asset standards and engineering specifications. He was also familiar with the research project and the researcher's role within the WaSC.

To identify the AS and ES targets for innovation, a brief description of sustainability was developed (see Box 2 below) from which the consultant could evaluate the potential for a likely performance gap between the asset standard and the sustainability performance opportunities of solution alternatives. The sustainability objectives utilised a selected subset of sustainability principles that were identified as least well managed. These were the principles upon which the design and construction of the infrastructure asset had a direct impact (NC.1 to 10 and IC.4 to 10).

The consultant was asked to use the sustainability statement to identify the asset standards that he believed could be altered to provide the most significant opportunities to improve the sustainability performance of WaSC assets. From asset standards, only the wastewater related asset standards are considered (not those on drinking water treatment) because wastewater treatment was the consultant's specialism and because investment in wastewater treatment infrastructure was to occur earlier in the AMP period.

Box 2 Sustainability statement applied to the research expert consultation process

Sustainability Objectives

We the WaSC recognises that economic well-being and the provision of water and wastewater services is fundamentally dependent on the sustainable maintenance of environmental and technical functions and capabilities. the WaSC has therefore identified the objectives described below as priority concerns in the delivery of sustainability performance for the WaSC. partners are being asked to apply the following objectives to best enable the WaSC to achieve the following:

- Reduce dependency on and accumulation of man made substances that may prove harmful to ecosystem or human health and substitute all with substances that can be easily assimilated broken down by natural systems.
  e.g. Reduce dependency on chemicals

- Reductions in energy demand,
  e.g. reduce/eliminate dependency in the use of fossil fuels
  e.g. increase use of renewable energy resources.

- Reduce use or release of persistent compounds that may prove harmful to ecosystem or human health
  e.g. Reduction in greenhouse gases

- Apply sustainable construction techniques when looking at new infrastructure and optimising of infrastructure/technologies and processes in a way that uses resources most efficiently.
  e.g. Reduce dependency on materials that are naturally scarce.
  e.g. Reduce use of virgin materials and resources.

- Have sought to reduce or eliminate waste and emissions in production systems.
  e.g. Increased or full recycling of resources
  e.g. Reduction of waste to landfill

- Identifying and utilising synergistic production systems where one organisation's waste streams are another's resources. Seeking opportunities for eco design and bio mimicry.

To undertake the selection of the engineering specification and asset standard, the engineering consultant constructed a matrix, which was informed by the sustainability objectives statement. He then selected the AS and ES and assigned them a score from one to five, where one represented no direct impact, and five represented a significant impact. Using this matrix, the engineering consultant advised the researcher on the selection options.

The engineering consultant used the sustainability statement in Box 2 to select the asset standards (in sewerage services) and the engineering specifications that would have the best opportunity of realising sustainability performance improvements as a result of a performance gap between the existing infrastructure proposed in the documents and the sustainability performance opportunities of potential solution alternatives.

From ten potential sewerage-related asset standards, the wastewater treatment process selection matrix was identified by the consultant as the most appropriate target for sustainability innovation (see Table 21). Two asset standards achieved a higher total score than the process selection matrix, suggesting they may have a more significant impact on the sustainability concerns. However, these were both sludge related and were therefore excluded because the WaSC was already undertaking a review of the sludge use and digestion processes. The selected asset standard was the 'wastewater process selection matrix'. This document dictates the water treatment options (preliminary, primary, secondary and tertiary) for a given population and discharge consent conditions.

Table 21, also captures the EC's understanding of how the different sections of the engineering specification impact sustainability. He suggested that the specifying of electrical equipment is critical to the efficiency of all aspects, including the construction of the plant. Further discussion with the EC, however, concluded that the level of detailed design and understanding needed to reveal these factors was unlikely to be achievable within the time frame and available resources of the research project. Thus, the consultant suggested that the researcher concentrate on material selection opportunities for improvement in sustainability performance.

Table 21 Framework used by consultants to select the research asset standards & engineering specification targets

	Sustainability concerns						
Asset Standards	Harmful substances	Energy demand	Persistent Compounds	Sust Construction	Waste/ Emissions	Synergistic production	**Total**
Digestion	2	5	2	4	4	5	**22**
Thickening/ dewatering	3	4	3	3	3	5	**21**
Process Selection	2	5	2	4	3	4	**20**
Primary tanks	3	2	3	5	2	4	**19**
ASP and FSTs	2	4	2	5	2	2	**17**
Grit	1	4	1	4	2	2	**14**
Polymer dosing	3	1	3	1	1	5	**14**
Pumping sewage	1	4	1	4	2	1	**13**
Screens & screenings handling	1	2	1	4	2	2	**12**
Flow split	1	3	1	4	1	1	**11**
Engineering specifications							
Engineering Spec -Gen	2	4	2	2	4	2	**16**
Engineering Spec -civil	2	2	2	5	4	2	**17**
Engineering Spec - M&E	3	5	3	5	3	2	**21**

For Asset Standards, given the time available to the research project for the expert panel of participants, it was necessary to constrain the service performance to two effluent conditions and a population equivalent of >10,000. This specific set of conditions was chosen because the highest proportion of wastewater treatment sites serve a population equivalent of over >10,000. The participants were asked to propose wastewater treatment technologies that would meet the population demands under two effluent consent conditions (see Table 22).

Table 22 Asset standard - process selection conditions

Population Equivalent	> 10000
Primary Treatment Stages	▒ Screens ■ Grit Removal ○ Fe Chemical dosing (optional) ○ Primary tank

Effluent standards							
		Solids	BOD	COD	NH3	P	Fe dose
Med	WRA 95 %ile (mg/l)	40	15	-	4	2	-
	WRA Upper Tier (mg/l)	-	53	-	20	-	4
Low	96 %ile (mg/l)	-	50	-	12	-	4
	Upper Tier (mg/l)	20	5	-	3	1	-
			With				
Both	UWWTD Reg Standards	BOD 25 mg/l or 70 % reduction					
		COD 125 mg/l or 75 % reduction					

For the engineering specification, the consultant selected the following materials/functional specifications on the basis that they were frequently applied in the business of the WaSC:

- Steel for reinforcement of concrete and mechanical parts
- materials for gangways used
- cement for tanks or buildings or roads
- sealants for tanks and reservoirs
- Pipe materials for distribution networks and inter stage processes
- Filter media material
- Reed beds/lagoon beds
- Roads
- Kiosks / buildings

As tanks vary in size (which alters the structural demands), according to functional requirements these were then disaggregated into functional types to allow (if necessary) respondents to specify alternatives, as the functional type varies. Once appropriate asset standard and engineering specifications were identified, the research proceeded to the following activities.

Identifying and incorporating sustainability for AS and ES innovation targets

The following activities were undertaken to modify the asset standard and engineering specifications to specify infrastructure options that would improve the sustainability performance of the WaSC.

The researcher identified a list of academics, engineering partners and some key employees in the WaSC to consult on infrastructure options. The academic experts identified had a professional history in the infrastructure type specified by the asset standard. The engineering partners were the two major technical advising partners to the WaSC. The WaSC employees were the AS holders.

The expert panel was consulted by email and each participant was emailed an excel spreadsheet. The spreadsheet contained the service objectives or infrastructure requirements of the target asset standard and engineering specifications. The participants in the research were asked to propose infrastructure options that would meet the same service requirements, but also maximise the likelihood of improving sustainability performance of the proposed solution. The previously developed sustainability statement (see Box 2 above) was given to the participants to ensure a shared understanding of sustainability to apply to the task. For each proposed change, the expert panel were also asked to define their level of confidence in the technologies they advocated from a drop down list in the Excel spreadsheet. The confidence levels are defined in Table 23 below.

Alternative infrastructure options were proposed by the expert panel and placed in the Excel spreadsheet. The proposed options that had a high or absolute confidence were retained as innovations to be incorporated into a modified contract document, or to be discussed with the WaSC as sustainability innovation options for adoption. Proposals with a medium or low data confidence were rejected in order to ensure that the research would only promote proven infrastructure alternatives to the new asset standard. Following this, the high and absolute confidence options were collated and presented in an accessible form to the WaSC employees.

Table 23 Proposal confidence assessment applied in the expert consultation

Confidence	Description
Absolute	Direct experience or exposure to the data
High	Indirect exposure, (research articles, work colleagues (with no vested interests) who have made a professional evaluation of the data
Medium	All the laws of science and engineering indicate that the data should be achievable but the researcher is unaware of this being applied at this scale or in such an arrangement to prove the case.
Low	There is little evidence or scientific logic that can explain

Establish the adoption outcome for proposed sustainability innovation.

The revisions to the asset standard and engineering specifications were then proposed for adoption to the WaSC. The proposed sustainability innovation was presented in a focus group consisting of five WaSC employees who were responsible for the asset standards and engineering specifications, and the embedded EC. The researcher recommended that the WaSC should adopt changes to the contract's asset standard and engineering specifications in line with the findings of the research. The participants of the focus groups were then ask to respond to the following:

a) Would any of these proposals be considered for adoption?
b) What characteristics or factors contribute to the selection or rejection of the proposal?
c) Explain the conditions required to improve the adoption position of the proposed solutions.

Presented below are the results of these methodological activities.

5.2.2 Results

Asset standards and engineering specification are dealt with separately in the results and discussions below. For both these contractual documents, the results of the expert panel consultation are presented, followed by a summary of reactions to the proposal for sustainability innovations. Finally, the case studies are discussed in the light of the research questions.

Asset standards - expert panel consultation.

Responses to the asset standard consultation were given by two relevant WaSC employees, one academic and two engineering partner experts. The result of the consultation was that over sixteen different technologies were identified with high to absolute confidence, and so were placed in the new process selection matrix (see Table 24 below). Five of these technologies, which are highlighted in blue, were already specified in the process selection matrix. Five were processes selected by participants in the research, but that had been explicitly rejected by the original process selection. These are marked in red, below. The remaining six options are new to the process selection matrix.

The process selection matrix treatment options below were proposed to the WaSC asset standard holders as potential sustainability innovations that would enable the WaSC to accrue sustainability benefits. The innovation to the asset standards was an incremental innovation, which involved making more wastewater treatment process technology options (identified for their sustainability performance potential) available to the EPO. This would give the EPO the freedom to arrange wastewater treatment solutions with the best sustainability performance.

Table 24 Proposed innovation to asset standards for wastewater treatment selection matrix

Effluent Standard (95 %ile)	Population Equivalent
	> 10000
	▒ Screens
	■ Grit Removal
	○ Fe Chemical dosing (optional)
	○ Primary tank
Med-Consent	**Proposed Treatment Technologies:**
Solids 40 mg/l **BOD** 15 mg/l **NH_3** 4 mg/l **P** 2 mg/l	o Activated sludge treatment o Activated sludge treatment (with biological nutrient reduction, incorporating anoxic and anaerobic phases of treatment to create an enhanced biological phosphate removal process o Tertiary nitrifying filters o Tertiary nitrifying filters (in ADF mode) o Passive aerobic technology - i.e. trickling filters o Hybrid Submerged Aerated Filter in filter mode (HSAF) o Moving Bed Bio Reactor (MBBR) / Integrated Fixed Film o Integrated Fixed film Activated Sludge (IFAS) o Sand filter o Waste Stabilisation Pond (WSP)- or Lagoons o Algal reactor removal P *(unknown data confidence)* o Expanded Granular Sludge Bed Digestion (EGSB) o Hybrid Bacillus Activated Sludge (HYBACS) o Membrane Bio Reactor (MBR) - Aerobic o Additive - Organic Polymer o Upflow anaerobic sludge blanket digestion (UASB)

Asset standards - reactions to the proposal for sustainability innovations

The WaSC had negative experiences with the proposed wastewater treatment technologies: HSAF, MBBR, and IFAS. The participants in the focus group claimed that the WaSC had struggled to operate or maintain them with any degree of success, and they were therefore considered a liability. The participants proceeded to comment that it was common in the previous AMP periods that assets new to the business would end up being run in a sub-optimal way, and therefore these assets rarely achieved the treatment efficiencies required of them or the operational stability. The participants offered the following explanations for this:

- When an EPO partner hands over a wastewater treatment plant to the WaSC, it commits a larger amount of operational support to the asset than the WaSC is able to replicate, thereby the asset performance will decline after the EPO hands over operation to the WaSC. (Operations and maintenance are stretched)
- When the responsibility of running or maintaining an asset is handed over from one person to another, much of the knowledge is lost and, as result, there is a reduction in asset performance or, worse, an asset failure.
- That a varied asset base for the WaSC has presented problems for the organisation: in managing the knowledge skills and expertise required to support and maintain such assets, as the required skills and experience are hard to build and a challenge to maintain.

With regard to the (newer) process technologies - HYBACS, MMBR, EGSB - the participants suggested that newer technologies represent an investment in building new knowledge and understanding in the business. This new knowledge also requires maintenance and, the depth of understanding of the components of the newer process technologies is limited should an operational fault occur at any stage. Thus, the WaSC is limited in its ability to access the relevant skills and expertise for the maintenance of an asset comprising newer technologies and is constrained by the availability of skills and experience within the sector in general.

As a result of the experiences outlined above, the WaSC had implemented a strategy built around the available operational resources and expertise. The WaSC reduced wastewater process options to passive trickling filters and activated sludge plants (ASP). By using only two very familiar technologies, the WaSC aimed to benefit from assets that could be easily maintained and optimised within the operational constraints of the business, and assets in which all EPO have rich experience and skills. Thus, the WaSC benefits from a reliable and well-understood asset base. More broadly, this strategy of generating well understood, easy to maintain and easy to operate asset base, has been extended to include standardising the lay-out and arrangement of the technologies across the infrastructure base in order to further improve operability.

5.2.3 Discussion Asset Standards

The process of developing and proposing asset standards identified a number of sustainability innovation considerations.

When evaluating the asset standards and engineering specifications, the engineering consultant suggested that not all asset standards (i.e. infrastructure assets) have the same capacity to improve against a set of sustainability principles. This suggests that there may be limitations to targets for an improvement in sustainability performance. In turn, this suggests that the sustainability innovation activities would benefit from an initial triage to determine the priorities for action. Sustainability impact assessments may help in this process for the identification of priority impacts from within a range of impacts and activities (Rabl and Peuportier 1995; Wackernagel and Yount 2000; Gibson 2006; Ness, Urbel-Piirsalu et al. 2007).

The changes to the asset standard itself suggested that there was no clear consensus on the technologies to improve sustainability performance. This indicates that within the water sector there is still debate over the technologies required to achieve optimum sustainability performance. It is also true that this problem is a context-specific challenge, which is linked to the prevalent stakeholders concerns in a given situation. As such there are numerous tools developed to assist in context-specific asset investment decision making (Alegre, Jeffrey et al. 2004; Ashley, Booker et al. 2004; Ellis, Deutsch et al. 2004; Balasubramaniam and Voulvoulis 2005; Ashley, Blackwood et al. 2008).

The WaSC rejected the proposal of an asset standard which increased flexibility. The reasons for this rejection elucidate the causes of innovation failure and the consequences of multiple innovation failure. Prior innovation failure in wastewater treatment assets was attributed to lack of understanding about the innovation support requirements in terms of resources for operation, maintenance and expertise. Knowledge management was also a concern for the WaSC, a problem that was amplified when the responsibility for running an asset changed internally. Verloop's (2004) description of the innovation process includes aligning the innovation strategy to the strategy of the organisation so the experience and logic of the institution is a good fit with that of the innovation. If the innovation strategy is in conflict with that of the organisation it must be compelling enough to supersede or alter the existing strategy.

The research activities revealed that the WaSC has opted for a strategy of reducing the knowledge and expertise resources required for operation, an alternative solution to the challenges presented could have been to invest in knowledge management and operational support that enable the WaSC to operate effectively a more diverse asset base, taking into account the suitable timeframes required for the WaSC to embed the requisite knowledge in the business. The WaSC's infrastructure selection strategy is deliberately (legitimately) conservative in the asset types it will adopt. The proposed asset standard contradicted this strategy by specifying and broadening the available process options, and proposing options where availability of expertise in the sector and within the WaSC may be limited. This suggests that the innovation must pay attention to the existing strategy of the business process.

The results of the expert panel consultation on engineering specification are presented below, followed by a summary of reactions to the proposal for sustainability innovations. Finally, the case studies are discussed in the light of the research questions.

Engineering specification - expert panel consultation

Responses to the engineering specification consultation were given by two engineering partner experts. Only proposals with high to absolute confidence assigned by the engineering consultant were placed in a table of proposals for innovations to be made to the engineering specifications (see Table 25 below).

The proposed engineering specification innovation (Table 25) separates guidance for construction activities from material selection. For construction guidance, the engineering consultants placed the guidelines in an order of consideration. The guidelines sought first to minimise the use of materials by minimising construction activities unless absolutely necessary and, when necessary, to try to minimise waste in material use through specifying prefabricated, off-site opportunities. For materials, the innovations generally sought to improve on existing materials through specifying a greater concentration of reused or recycled materials or, in the case of a few opportunities identified, specifying appropriate material substitutions.

The sustainability innovation also advocated that the engineering specification made use of third-party material references or processes to be adopted, i.e. BREAM, BRE Green Guide, LEAN construction methods, where available.

Table 25 Proposed innovations to the WaSC's engineering specification

Construction Guidance General requirements

Construction guidance hierarchy

1. Re-use or retrofit existing assets wherever possible to avoid the need to construct new ones
2. Where possible use of offsite manufactured elements (e.g. structural frame, walls, roofing and doors) as opposed to in situ concrete pouring to avoid wastage.
3. Where in Situ construction is necessary apply 'Lean' construction methods.
   - Minimise dig, (especially in hard ground);
   - Minimise wall thickness by reducing depth while optimizing overall tank to minimize overall materials usage
   - Also limit the use of machinery to reduce the carbon footprint by use of fuel

Material/Function specific requirements

Functional use	***Sustainability Innovation***
Steel for reinforcement of concrete & Operational parts	Steel 100% recycled content
Gangways instead of galvanised steel	Substitute steel for timber with gripped coating.
Cement for tanks or buildings and roads	Cement Preference: 1st) 50% fly ash 2nd) 50% blast furnace slag 3rd) General Portland (CEM I).
Sealant instead of Epoxide resin.	Use urea formaldehyde
Pipes for inter stage processes	A. Pipe material preference: 1st) Aluminium (100%) recycled. 2nd) HDPE (50% recycled content) 3rd) HDPE recycled Cont. 4th) PVC B. If in doubt whole life carbon calculation or LCA C. Where feasible avoid the use of stainless steel.
Pipes PVC for non potable water and sewerage distribution/ Non pressurised (life: >100 yr)	Substitute PVC for HDPE (PVC has embodied carbon of 2.5 kg CO_2 /kg whereas HDPE has 2 kg CO_2/kg),
Filter Media	100% recycled content for both plastics and minerals
Reed Bed	Select reeds that are hardy and can be cultivated efficiently
Reed Bed / Lagoon Bed	Review the use of the membrane barrier and investigate the most sustainable on the market.
Roads	• Follow BREEAM standards for construction on Roads (Desired Excellent) • Asphalt / Bitumen use embodied Carbon data to inform selection of different materials (desired lowest embodied Carbon)
Kiosk/Buildings	• Where possible select building materials Any A+ rated building elements in the BRE Green Guide to Specification for Industrial Buildings (2008). • For overall energy efficiency of a building follow CIBSE's guidelines F • For Heating, Ventilation and Air Conditioning, Duct work, Refrigeration and Heat Rejection, Noise and Vibration Control for HVAC guidance follow CIBSE's guidelines B

Interestingly, one of the two respondent engineering partner organisations had a consistently higher degree of confidence and skill in identifying alternatives that would improve sustainability performance against the sustainability statement. This illustrates that throughout the sector there is a variation in the available expertise on engineering and material specification of improving sustainability performance.

Engineering specification - reactions to the proposal for sustainability innovations

The proposals for sustainability innovations to the engineering specification were rejected, as there was a great deal of concern about introducing changes to the engineering specification without a commensurate amount of research on the risk to service. For example, changing the material selection for networked pipe would result in thousands of km of pipe being laid in the specified material. Thus, the risk was great due to the volumes of material being used and the impact of the material failure on service.

Concerns about cost risks arose. For example, limiting the material options to EPO partners may weaken the supply chain and render it unable to deliver the required quantity. Similarly, competition for the material may push the price up and, by limiting the EPO facility to seek cost savings by seeking any appropriate material at the lowest cost, construction costs would increase. There was a general perception that the supply chain could not fulfil the demands, however, participants also agreed that there was insufficient expertise in the room to confirm or deny this. A risk was typically expressed in terms of service risks or the risk of cost increases.

The dialogue around service risk centred on introducing new materials that may fail. There was a concern that materials with a higher degree of recycled content may be weaker and that pipes and concrete must be well understood before being specified. Some materials, such as clean water pipes, materials for the construction of public access roads and some other processes, must be signed off by regulators (e.g. DWI and the highway commission) before adoption can take place.

The advocated changes to kiosks, buildings, and roads (if the roads are private) were considered more likely to be adopted and considered in the future review of engineering specification. As risks to service were low, there are no regulatory gatekeepers and the cost difference was likely to be negligible. The external consultants advocated the adoption of third party sustainability assessment methods to guide material selection and construction for kiosks, roads, buildings. These innovations were looked on more favourably because the third party bodies were recognised relevant authorities that advice the construction and building trade.

5.2.4 Discussion Engineering Specifications

The process of developing and proposing engineering specifications identified a number of sustainability innovation considerations. For engineering specifications, the engineering consultant suggested that opportunities for improvement against the sustainability objectives are not equal and that therefore the capacity of a sustainability innovation to generate sustainability improvements is, in part, a product of the target of the innovation. Forms of life cycle assessment tools are advocated for assessing the variations in environmental impacts of the products or materials deployed in a WaSC (Jonsson 2000; Tukker 2000; Niederl-Schmidinger and Narodoslawsky 2008).

Heather Cruickshank (2007), Mihelcic (2003) and Fenner (2006) suggest that, in addition to these environmental and social impact tools, sustainability presents new challenges to engineers and should change the way engineers think about, learn about and go about their tasks. Between the two engineering partners consulted there was a large variation in the skills and expertise with which the task was completed. Although a sample size of two is not statistically significant, the research experience affirms that organisations inevitably differ in skills and expertise. This is also likely to be true for the skills and expertise in the subject of material selection for improved sustainability performance. This indicates that not all engineering partners will be equally able to identify sustainability innovations for the WaSC and that engineering companies may need to be selected in relation to their ability to support sustainable decision making if it is desired.

For proposed changes to the engineering specifications, the innovation adoption decision was discussed in terms of the degree of importance of the asset. High uncertainty surrounding the risks associated with adoption is a barrier to adoption (Rogers 2003). Moreover, if there is the perception that adoption would result in the failure of the service then the perceived usefulness (Venkatesh and Bala 2008) or relative advantage of the innovation (Rogers 2003) would similarly be eroded. The research indicated a reluctance to promote changes to any critical assets as this might result in a negative impact on cost and/or service. Thus, innovation requires a detailed understanding of its potential impact on the service performance and supply chain.

The theoretical framework for the Technology Acceptance Model (Figure 13) indicates that social influences will to some extent determine 'perceived usefulness' and 'perceived ease of use' of a technology, and therefore influence its adoption. The current research seems to indicate that this social influence, and the perception of trialability, uncertainty and observability, was altered when engineering specification changes were associated with third-party accreditation. This association seemingly aided the likelihood of innovation adoption, as did specific sector-committed research, which would decrease uncertainty surrounding adoption. Thus, sector-specific research can potentially increase trialability and observability.

In summary, it seems that the sustainability innovation was influenced by the risk of innovation to service provision and risk was expressed in terms of cost implications.

The following section examines the results obtained in these case studies and those collected in the process of innovation development. The section uses an analytical visual mapping tool to gain further insights into the factors that contribute to the adoption of sustainability innovations.

6 Analysis

The purpose of this chapter is to explore the influences on sustainability innovation adoption through the analysis of the narrative data recorded and captured during this research project. The following sections present the methods and the results obtained from a process of conceptual mapping. The conceptual map depicts the factors that influenced the sustainability innovation adoption during the innovation adoption process.

6.1 A Conceptual Map of Sustainability Innovation Adoption (AIM)

This section describes the method and results obtained in the development and evaluation of a conceptual map of the influences on innovation adoption. Firstly, the methodological and analytical tools employed are presented. Then, the results of the methods employed and the resultant conceptual map are presented. To evaluate and modify the conceptual map the researcher first compared the conceptual map with the findings from the thematic content analysis and axial coding. Secondly the conceptual map was compared with the literature on innovation and organisation and subsequently applied as a schema to arrange the coded sustainability references into Nvivo, to examine variations between innovation stages and across innovation types. Finally, the researcher applied the conceptual map as a framework to interpret the innovation case studies.

6.1.1 Method

To develop the conceptual map the researcher interacted with the business as a '*change agent*' charged with identifying and incorporating sustainability innovations. These innovations would alter the sustainability performance of the infrastructure assets a WaSC chooses to invest in, or improve the organisation's understanding of their sustainability impacts and opportunities. The researcher then immersed himself in the qualitative transcript data from the workshops, focus groups, interviews and the notes from the researcher's diary arising from these interventions. The following activities are undertaken to sensitise the researcher to the data and to enable the researcher to create a conceptual map. The researcher transcribed the digital audio recordings of the workshops, focus groups and interviews, and the transcriptions were placed in Nvivo (a qualitative software tool) to enable the easy coding and management of the data. Within Nvivo the words of the researcher were coded separately to the participants. The transcribed responses of the participants are the whole discourse used or formulated by the participant, and are referred to as the *Surface Narrative.* The researcher identified and coded all parts of the *Surface Narrative* that related to sustainability, where sustainability is any narrative that related to:

- *The adoption or management of sustainability principles,*
- *The adoption and management of innovations that are understood to affect sustainability performance.*

These coded pieces of text - 'the sustainability related narratives' - are the principal data set extracted from the data corpus upon which all further analytical tools are applied (see Figure 17 below the data step- 'D1').

The sustainability related narratives are first coded thematically (D2 Figure 17) and subsequently underwent axial coding (D3 Figure 17 or see methodology). Thematic content analysis was used to group elements or characteristics that occurred within the narratives, using the qualitative data software Nvivo. Passages of sustainability narratives (data units) are grouped around commonalities and these commonalities are themes that arise from the data units. The subsequent axial coding disaggregated themes into components and helped identify new commonalities that could establish new themes (D4 Figure 17). Again, the product of this process was captured and sorted using the Nvivo software. Coded components could be any number of things, for example, an actor (that interacts with the WaSC) such as the '*WaSC solution manager'* was coded, as was a motivation for an action such as '*seeking capital cost reduction'*, which was axially coded as a subset of the thematic group. Only coding nodes that had references from two or more sources were retained as relevant coding nodes.

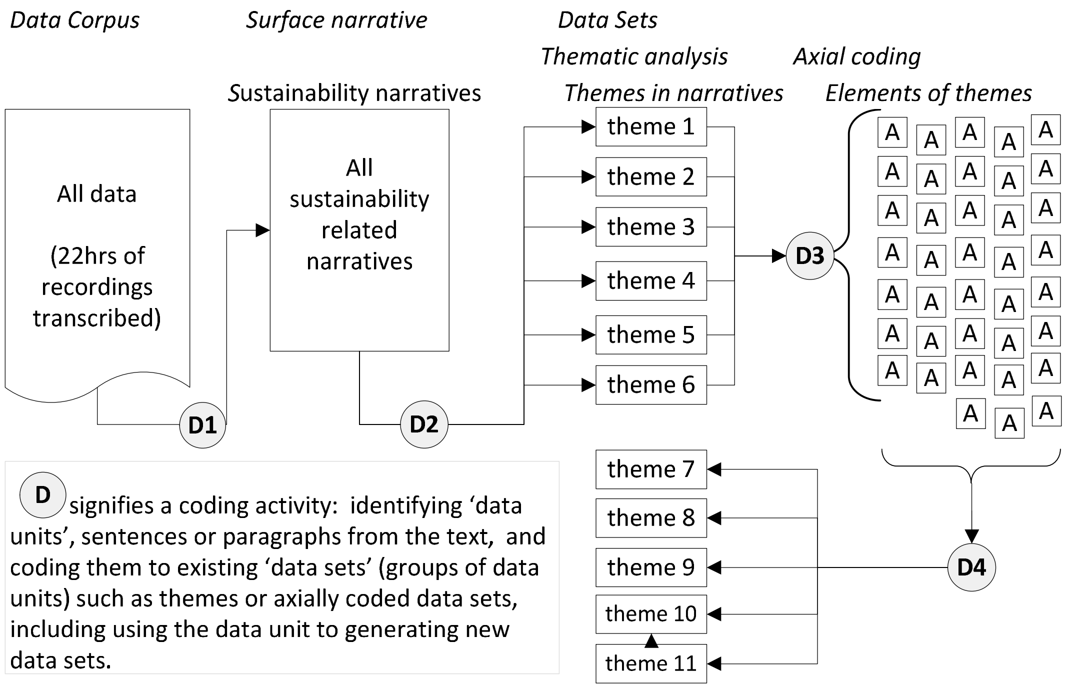


Figure 17 Diagram depicting the transcript data coding steps

To develop a conceptual map the researcher adopted a focus question around which the knowledge would focus. The question adopted was the Research Question B. *What factors influence a WaSC*'s *selection and uptake of sustainability innovations?* Informed by the research activities undertaken thus far, the researcher employed conceptual mapping to generate a visual representation of the knowledge accumulated by this research on innovation adoption.

The researcher's familiarity with the sustainability narratives, the themes within the sustainability narratives, components of those themes and the direct experience acquired during the following research was used to collect and arrange concepts that related to the concept question. Building the conceptual map was an iterative process of constructing representations and evaluating them by returning to the sustainability narratives. The researcher repeated this process until he was satisfied that the conceptual map was able to explain the research experience.

To evaluate and modify the conceptual map the researcher compared the thematic content analysis and axial coding of the sustainability narratives. This comparative process was used to identify coding groups that are not yet contained in the conceptual map. Any concepts or themes that arose from the thematic and axial coding – but that were not arranged into the conceptual map - were identified and reviewed. If the references were pertinent to the research question and not otherwise already incorporated, the researcher incorporated these references or coding groups into the map. In order to reveal proximity to and/or variance from the literature, the researcher identified the determinants from within the literature review that sought to explain research question B *(What factors influence a WaSC*’s *selection and uptake of sustainability innovations?)*

To verify and test the conceptual map externally, the research compared the conceptual map with the literature on innovations and organisations. These determinants were used to compare and contrast with the conceptual map.

Subsequently, the conceptual map was used as a schema, to arrange the coding groups that arose from the thematic and content analysis. Incorporated into Nvivo, the different domains of the conceptual map and their categories are compared for coding prevalence. The data could also be divided longitudinally, through the research phases, and in the decision phase by the innovation type (Table 26). The research adopts Rogers (2003) innovation process stages: Agenda Setting , Matching and Decision. The Rogers model is adopted as its distinction within the innovation stage Agenda Setting of Problem Identification (generating a performance gap), and Locating Innovations, closely relates to the research experience and the research phases.

Table 26 Data availability by innovation process stages and type

Innovation process stage	***Research phase***	***Innovation***		
		KPI	*AS*	*ES*
Agenda setting- pt1. problem identification	RS3.Appraising sustainability practices		ALL	
Agenda setting- pt2. locate innovations	RS4. Opportunity development		ALL	
Matching – develop and propose innovation	RS5. Develop / propose	*KPI*		
Decision -adoption / rejection	RS5. Evaluation	*KPI*	AS & ES	

The research data was divided into four different innovation process stages: *agenda setting part one*, *agenda setting part two*, *matching* and the *decision*. As indicated by Table 26, the research data can be evaluated by both innovation process stage and by innovation type. The two innovation types that can be distinguished are *administrative* and *technical (Crossan and Apaydin 2010)*. The three case studies used in this research are divided (where data allowed) by innovation types: KPI is an administrative tool for post-investment evaluation, whereas AS and ES are both technical type innovations as they specify technologies for investment.

The first part of the innovation process stage is *AGpt1*. *Agenda setting*, '*occurs when a general organisational problem is defined and creates a perceived need for an innovation'* (Rogers 2003, p.422). The first part of *agenda setting* is the identification of a need by the organisation and the prioritization of these needs and problems. This innovation stage correlates with the early ETHICS steps one to three, which focused on establishing a consensus on the need for change and examining the existing organisation in terms of that established consensus. The data from these activities was collected during research phase three, 'Appraising sustainability practices'.

The second part of the innovation process stage is *AGpt2* the process of *'searching the organisation's environment to locate innovations of potential usefulness to meet these organisational problems'* (Rogers 2003, p.422). This innovation stage correlates with the data gathered under research phase four, 'innovation opportunity development'. The data for *agenda setting* stages part one and two cannot be separated by innovation type as the innovation type was not yet determined because the WaSC was in the process of exploring multiple innovation alternatives.

Innovation process stage *matching* refers to the period in which the innovation is developed to fit the organisation. The data for this third innovation process stage was collected during research phase five. Unfortunately, while the stage *matching* for the administrative innovation KPI consisted of a continuation of focus groups and interviews with the user group that could later be used in qualitative analysis, the stage *matching* for innovations ES and AS was not able to facilitate the same data collection. This is because, the development of AS and ES used email to consult technical expertise for advice on alterations, rather than a dialogue with WaSC employees as was the case for KPI (see chapter five for details). Thus, there is no coding data for the innovation stage *matching* for the technical innovations AS and ES.

The fourth innovation process stage recorded is 'decision adoption/rejection'. Data for this process stage is gathered from interviews and focus groups with key decision makers at the final stages of research phase five. The interviews are focused on establishing the adoption outcome for the proposed sustainability innovations as well as the reasoning for that adoption outcome. The data for both technical and administrative innovations is recorded in the process stage 'decision adoption/rejection'. Unfortunately, the AS and ES data in process stage 'decision adoption/rejection' cannot be divorced from one another.

By separating the research data by innovation type and by stage, the research could identify variation in the focus of sustainability narratives using the conceptual map. Moreover, the method enabled a better understanding of when different sustainability narratives are employed and their particular focus. Finally, for each innovation the conceptual map was applied as a framework for recounting the sustainability innovation stories.

6.1.2 Results

As a result of the axial coding, over three thousand elements (references) within the sustainability narratives were coded, and ninety-two different coding nodes were developed to which the coding references are attached. The processes of examining the transcripts and assigning them to themes, and axial coding the sustainability narratives immersed the researcher within the data and helped to identify the following influences on sustainability innovation adoption.

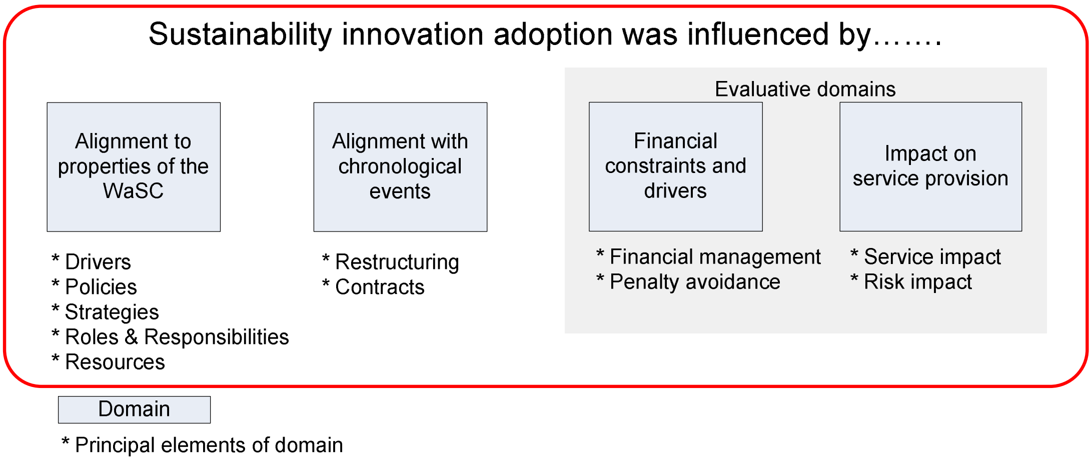


Figure 18 Conceptual map summarising the domains that influenced the sustainability innovation adoption process and the principal elements of each domain (Adoption influence model: AIM)

The researcher found that the adoption of a sustainability innovation could be expressed in the following terms. The alignment of the innovation to 'properties of the WaSC', the alignment to 'financial constraints and drivers', the desired or acceptable changes to the 'service provision', and the innovation's relationship to the 'chronological opportunities' available to the innovation. See Figure 18 above the Adoption Influence Model (AIM).

Figure 18 presents the AIM conceptual map, which consists of four domains (*Properties of the WaSC*, *Chronological events*, *Financial constraints and drivers* and Impact on *Service provision*) and the principal elements associated with those domains. The AIM model domains: *Impact on service provision* and *financial constraints and drivers*, are evaluative domains. Evaluative domains are the factors used to appraise the innovation adoption (see Figure 19 below). The conceptual map is discussed in detail below, with an account of elements within each domain. The crossovers or relationships between each domain are then discussed.

Alignment to *properties of the WaSC*

This domain refers to the fit of the innovation to the organisation with which it must integrate. Innovations may be closely aligned, sharing many similar characteristics and objectives with the organisation. Alternatively, it may be radically different to the characteristics of the organisation and the desired area of innovation adoption. The degree of alignment of the innovation to the existing organisational practices positively influences the adoption of innovations, since radical departures from the organisation require greater changes to the organisation and are therefore more complicated to adopt. The alignment of the innovation to the practices of the existing organisation refers to the similarity of the innovations' support requirements and strategy for achieving its objectives to the drivers and strategies, existing roles and responsibilities and the objectives of the targeted process of WaSC in which it is proposed to be embedded.

The research identified two types of drivers: firstly, drivers sourced directly from the WaSC environment as the organisation actively seeks to minimise its penalties and maximise its awards and, secondly, drivers developed or prioritised as the organisation develops a distinct identity based on local concerns and interests and in accordance with the WaSC management strategic concerns. Drivers may be subject to rapid changes in immediate business concerns, which may be as a result of unpredicted changes in the market, weather, leadership or customer concerns and behaviours.

> *"energy has gone through the roof, so there's been a big C&R to create our own energy by CHP's, hydro turbine, wind turbine, things like that; looking at how the types of pumping are changing."*

Strategies are the means that the WaSC devises in order to meet its goals. The innovation adoption may be influenced by how compatible the innovation is with the objectives/strategies of that business process with which it integrates. An innovation may be aligned (helps to deliver existing strategy) misaligned (impedes the delivery of the existing strategy) or unaligned (neither impedes nor aids the delivery of the existing strategy). Unaligned and aligned objectives did not result in an impediment to the adoption of the innovation. However, misaligned strategy was a barrier to the adoption of the innovation. One can speculate that the degree to which this misalignment is a barrier will depend on the attachment to the existing strategy.

> *"Well unless that strategy changes, I mean, it may well be in subsequent AMP's, as I say in AMP4 we did adopt, because we had a big freshwater fish directive programme we did a strategic study to come up with this signature design and the signature approach and by and large that process has worked, the perception of the business is that process has worked and so therefore this next AMP is following along the same lines but a bit more prescriptive"*

Alignment to the existing roles and responsibilities refers to the WaSC's organisational structure (which defines roles and responsibilities), its relevant and available expertise and knowledge, and its allocation of resources within that structure. Additionally, management support, and the position of that support relative to the prospective position of the innovation, influenced innovation adoption. This suggests that the innovation process and the eventual adoption are influenced by the alignment of management support to the target area for the innovation.

> *"Deciding whether I felt something should be in or out in the very early drafts, was, has it already been gathered."*

The constructs within the domain of properties of the organisation do not all influence innovation equally. The WaSC drivers (at the top) are recognised and developed into

WaSC policies, for which strategies for achieving the policy goal are developed and which then cascade through the organisation. This is because the research showed that the WaSC operated within a mechanistic structure, whereby a centralised decision-making authority sanctions the objectives of the organisation and manages those objectives by identifying , where organisational objectives cascade down through the organisation (Robbins 2007). Thus, drivers and policies have a strong influence on the other aspects of the organisation structure. This is followed by business processes which are designed such that roles and responsibilities are allocated relevant resources to allow the policy goals to be achieved. As there is a direct relationship between each of these elements, alterations to one should necessitate the alteration of the others. Small changes in roles and responsibilities in a discreet arm of the business may only require minor changes in stated strategies. However, for the specific business unit, changes in policy goals ought to result in significant change across multiple roles and responsibilities.

Chronological opportunities

This domain refers to temporal windows of opportunity in which an innovation may be more easily accommodated either preceded or followed by windows of inopportunity: periods where an innovation may be more difficult to accommodate. The periods during which these windows of opportunity are open or closed are the significant variables in *chronological opportunities*. Within *chronological opportunities* two groups are clearly distinguished by the research, firstly, ‘restructuring events’ and, secondly, ‘contractual events’. Restructuring events are those during which the organisation, in pursuit of its goals, may seek to change its policy, goals, strategies, roles, responsibilities, divisions of labour, or the role of technology. These restructuring events vary in magnitude, from affecting the whole business to the adaptation of a single process. Contract-making events determine the relations and interactions between two or more parties for a given period of time, or until the requirements of the contract have been fulfilled, or superseded, by a further contract.

"the contracts out there and he isn't expecting you to now say push sustainability into the current contracts."

Contract-making events are associated with restructuring events, and many organisational restructuring events may necessitate the use of contracts. Similarly, the termination of a contract inevitably reduces barriers to the restructuring of the surrounding system as the prospect of penalties for a contravention of the contract has been removed.

A decision to adopt an innovation is based on the evaluation of the (perceived or real) risks and costs against the benefits. An innovation that has perceived benefits that outweigh the risks and costs will be adopted, whereas when the risks and costs outweigh the benefits, the innovation will be rejected. Risks and benefits are described in the narratives using two domains: *financial constraints and drivers* and *impact on service provision*. These are referred to as the evaluative domains and are distinguished from the other domains due to their distinct role in decision-making. The properties of these domains are discussed below.

Financial constraints and drivers

This domain is an evaluative domain, where by the innovation is understood in terms of its perceived alignment to the WaSC's cost drivers as well as its financial constraints. An innovation may impact on the cost chemistry of the WaSC and the degree to which the innovation supports existing cost drivers and is within budgetary constraints influences its adoption position. On top of the direct costs attributable to administering change, changes to organisational costs such as operational, capital, administration or resulting from financial penalties or rewards, influences the adoption position of an innovation. A WaSC has a variety of cost constraints and drivers to which it adheres. Cost increases negatively influence the adoption of an innovation, while reductions in financial costs are a benefit, and will positively influence the adoption of the innovation. However, there are conditions where a reduction in costs could result in a risk associated with failing to meet the investment targets agreed between the regulator and the WaSC (this may be considered a subset of financial targets or of contracts). Failure to meet regulated investment targets would result in financial penalties; conversely the WaSC would benefit from meeting the investments targets with reduced capital expenditure.

> *"they will only approve cost savers or cost neutral. Because everything that goes into asset standards that would increase costs, would increase costs across the program which would make our program not deliverable"*

Inter-departmental budgets and targets are all aspects of the organisation's financial system upon which an innovation can impact.

Impact on service provision

'Impact on service provision' is also an evaluative domain, where by the perceived or a real impact of innovation adoption is evaluated in terms of impact on the WaSC provision of service. An innovation may alter the service provision by improving or degrading the performance of the WaSC against a set of service performance targets. An innovation may also, without affecting the service performance, alter the risk in the WaSC service. For example, a technology that is new to the WaSC may achieve the same service performance (or improved performance); however, its newness is a greater risk as operator's errors are more likely to occur. A new material or process entered into a system may have an associated perceived risk thus, in order for an innovation to be adopted; the perceived benefits must be greater than the perceived risks.

> *"Pipes have a significant cost impact, but the impact of getting the choice of pipe material wrong or the correct pipe wall and trench structure wrong is certainly greater than smaller aspects of the decision ..."*

The conceptual map (AIM Figure 18) suggests that innovations closely aligned to a WaSC's existing practices will be more easily adopted than those that are unaligned or misaligned and that *chronological opportunity* can reduce barriers to adoption. The model also suggests that should the benefits in terms of financial rewards or improvements to service be sufficiently radical, departures from the existing organisation will be possible. Figure 19 below rearranges the AIM model domains to suggest that innovation adoption is influenced by the fit between the innovation and a set of conditions that includes meeting the WaSC evaluative standards and benefiting or not from chronological opportunities, which can grease the cogs of the innovation process or not.

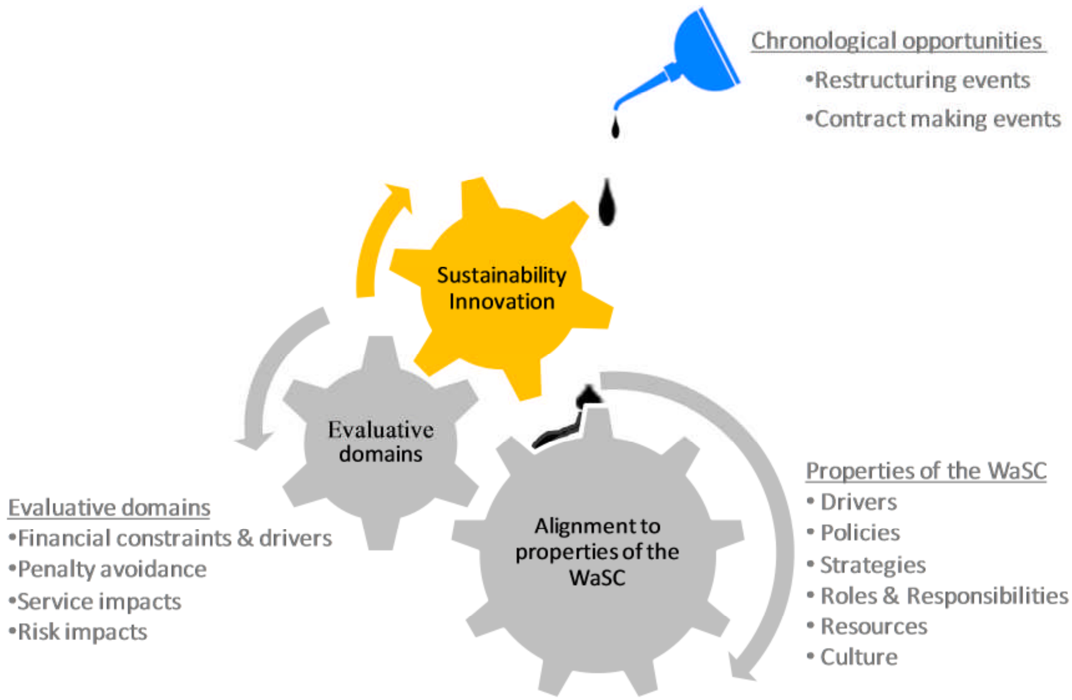


Figure 19 Innovation adoption presented as a relationship of 'fit' between sustainability innovations, the properties of the WaSC and the elements used to evaluate 'fit'.

Below we briefly characterise the outputs and activities of this research (see Figure 20 below). First, we look at the innovation characteristics followed by a description of the organisation; finally, we associate the AIM model to the literature on the perceived characteristics of the innovation.

Innovation characteristics

All three innovation opportunities are identified using the same ETHICS user-centred development methodology. However, where the KPI case study continued with the internal team when developing the innovation opportunity into a proposal, the AS and ES used external expertise. The AS and ES proposals were misaligned with the ways the

WaSC innovates in technical innovations and the AS proposal was strategically misaligned with the department strategy. This may not have occurred if a user centred approach had been continued. To characterise the innovation process employed for all innovations, it is fair to say it was a group-level process that was driven internally by available resources, for example, knowledge and time.

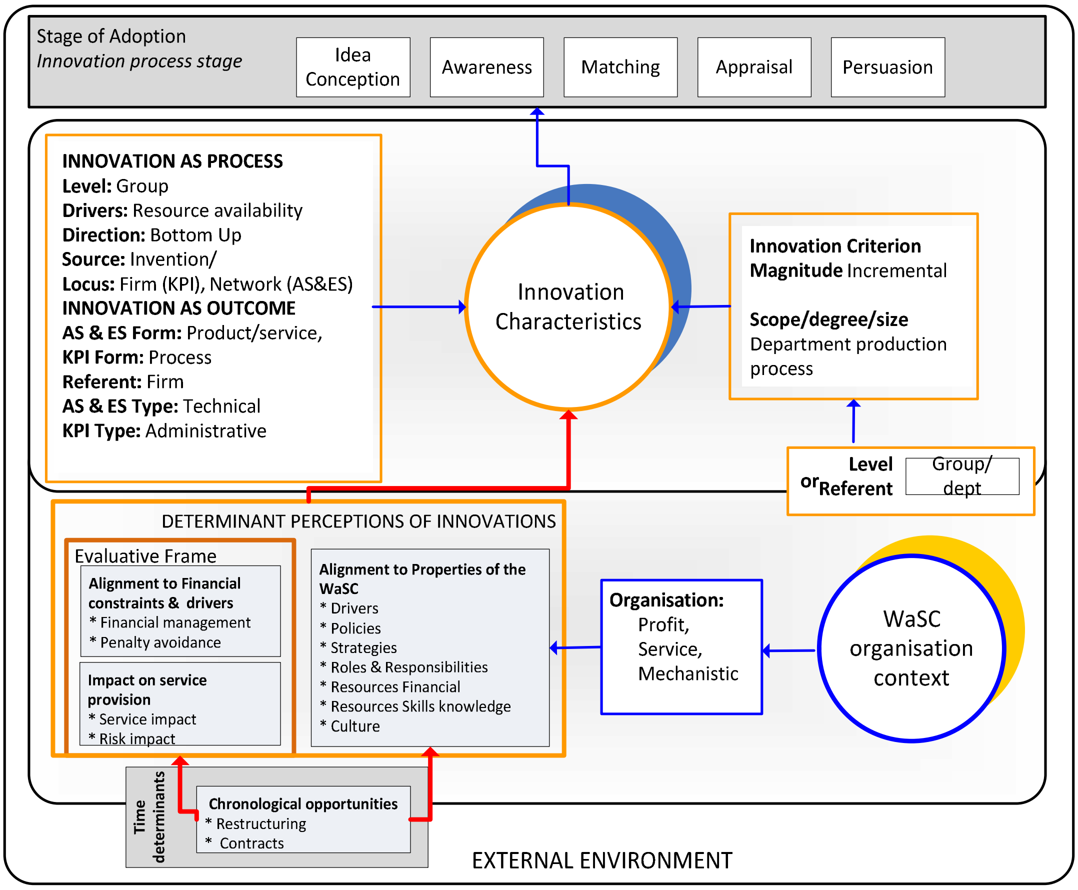


Figure 20 Schematic representation of the research (innovation content, the organisational context, the principal research findings, and the conceptual map AIM).

As the innovation was not prescribed by senior management the innovation development was a bottom-up process and the locus of the innovations was internal for KPI but from a network for AS and ES. The innovation source was ideation and invention rather than external adoption. The source of the innovation was invention by the WaSC and facilitated by the researcher and his resources as applied within the innovations process, therefore the driver was available resources. The innovation process or adoption stages that this research progressed through runs from idea conception to persuasion and the adoption decision.

Innovation as an outcome refers to the kind of innovation under consideration, the *form*, the *type* the *magnitude*, the *scope* and *scale*. Within the case studies, there are differences between the type of innovations, while KPI was an *administrative* tool for post-investment evaluation, AS and ES are both *technical*-type innovations whereby adoption would have directly resulted in changes in the technologies with which the WaSC provided its services. All three case studies took the form of a business process innovation. The magnitude, in all cases, was an adaptation to an existing business process and therefore can be characterised as incremental.

Organisation characteristics

The organisation type of the WaSC was a profit-seeking organisation

> *"I mean the land assets on each works come under pressure from key land because obviously they want to exploit them for profit."*

that provides water and sewerage services and takes a mechanistic organisational form.

Determinant perceptions of innovation characteristics

The domains and elements of the AIM model can most clearly be compared to the determinants' *relative or economic advantage*, *compatibility*, *complexity*, and *uncertainty* (See Figure 12) are all apparent in the conceptual map. The conceptual map does not allude to the terms of *trialability* or *observability*, although the researcher could find evidence of discussions that would infer that *trialability* and *observability* did influence the sustainability narratives of the WaSC.

Relative or economic advantage has clear parallels to the domains of the conceptual map. Within the narratives of the WaSC capital delivery, perceived usefulness or *relative advantage* is understood in terms of service impacts on service provision, and an improvement in service provision would represent a relative advantage over existing or preceding technologies. A metric of *relative advantage* can be economic, which is also reflected in the conceptual map as *financial constraints and drivers*.

When considering *compatibility*, the conceptual map has the domain 'alignment to the properties of the WaSC'. This domain infers a relationship of *compatibility* to the properties of the WaSC. An organisation's policies expresses its existing values and past experiences inform the strategies that a WaSC employs to pursue its goals, and the needs are reflected in the conceptual map in terms of drivers and resources.

When considering *complexity*, one could argue that the *complexity* of the innovation is inferred from the degree to which the innovation aligns with the knowledge, resources, skills and expertise as properties of the WaSC, and the degree to which it aligns with its existing roles and responsibilities.

> *"But we don't know where we are on the scale do we of ... on the sustainability scale? So unless we found out we haven't done any benchmark of our own equipment and assets and what have you."*

The conceptual map captures these two components of complexity. As already mentioned, the case study innovations are incremental adaptations to existing systems and as such it was expected that the component of *complexity* would be a less significant influence on adoption.

Trialability 'is the degree to which an innovation can be experimented with on a limited basis'(Rogers 2003, p.258). Within the conceptual map there is no clear development of the notion that *trialability* influenced the adoption of the sustainability innovations. However, the term 'risk' does appear within the conceptual map. The purpose of trialling an innovation is to enable the organisation to evaluate the extent of its compatibility with that innovation.

> *"Yes, you need to be able to clearly demonstrate to the business, we almost would need to do a pilot, to say this is what the benefits are doing at the start of the business and then have that as a separate scheme"*

This is a means of evaluating the risks of adoption, thus, the conceptual map can be used to identify piloting and trials as a means to reduce or identify risks.

Observability is the degree to which the results of an innovation are visible to others. Although the conceptual map does not directly refer to *observability*, if a driver of the WaSC is to be seen to be innovative, or to profit through positive press coverage of a sustainability innovation, then *observability* would influence the adoption of the innovation. A motivation for the WaSC to accrue positive PR was identified within the sustainability narratives, which would indicate that *observability* would play a role. However, the *observability* was not highly regarded during the evaluation of adoption of the proposed sustainability innovations.

> *"I think the primary driver for the business at the minute is reducing cost and if that's environmentally sustainable as well, that's great and we get some positive PR out of it but that's not the driver. Would be my view ..."*

This is perhaps because PR was not an immediate consideration for these decision makers as it is not in their job role, or that the innovations that are proposed did not obviously lend themselves to promotion.

In the conceptual map, *uncertainty* is expressed in terms of risk under the domain of impact of service. However, the term *uncertainty* is broader than the term risk and connotes the degree of certainty with which the true state is known. This inevitably links to *trialability*. In one example, a third-party accredited system for the evaluation of environmental impacts in the building trades was associated with a proposed change to the engineering specification. In the example, certainty of outcome was pursued, which increased the likelihood of adoption:

> *"If it is BSE or standard it will perform, we can have confidence in using it"*

Here, the authority of the third-party accreditation system reduced the perceived risk associated with adoption. Similarly, in the case of KPIs the degree of certainty over the methodology and boundaries for embodied carbon accounting influenced the adoption decision. Also in the case of KPIs the degree of certainty over the methodology and boundaries for embodied carbon accounting influenced the adoption decision.

Time phase determinants are the third, characterisation factors for innovation. They used either the diffusion of innovation through a population, or the stages through which an innovation passes from conception to infusion in a populace. While the conceptual map does not incorporate these factors, the following section uses Nvivo to characterise changes in coding to the conceptual map across different stages of the innovation development process.

In summary, the influences on innovation adoption identified by the conceptual map relate most strongly to the literature regarding the perceived characteristics. The process of reviewing the literature findings against the conceptual map helped the researcher address the placement of coding groups into Nvivo logically. As a result of this review of the conceptual map in relation to the literature, the coding group for accruing positive PR was added to as a subgroup to WaSC drivers in the domain of properties of the WaSC.

Exploring and validating the adoption influence model through coding

To verify the AIM using the data developed by the research project the researcher first arranged the thematic and axial coding into a framework that closely resembled the AIM (see Annex G).

The researcher could not find any significant axially coded element or coding category (with more than twenty references coded to it) that could not be contained within the AIM and that related to research question B. However, 'behaviour and culture', which was not originally placed in the AIM, was added as a characteristic of the organisation to which the innovations should align. The researcher would argue that behaviour and culture are entrenched within employees' understanding of a role's responsibilities, as well as the drivers of the WaSC, this is supported in the organisation innovation (Smircich 1983; Nightingale 1998; Ward, Brown et al. 2005). This research views organisation culture as a shared language, comprehension of meaning, symbolism (Robbins 2007) normative behaviours and values (Scott 2008) and institutional logic (Dambrin, Lambert et al. 2007). It is emergent as a result of common goals, administrative systems, socio-cultural systems, production systems, technology and structure (a systems theory approach [Smirich, 1983]).

To verify that the conceptual map was pertinent in some way to all sustainability innovation stories collected during the research, the researcher ran a coding query to establish the percentage of references coded as a 'sustainability innovation event', and coded to the conceptual map itself and the domains of the conceptual map. The results indicated that all two hundred WaSC texts coded to 'sustainability innovation events' employed at least one domain of the conceptual map. Of the 'sustainability innovation event narratives', 79% mentioned the properties of the WaSC, 46% mentioned the impact on service provision, 37% mentioned financial awards and penalties and 17% mentioned temporally bound events (see Figure 21).

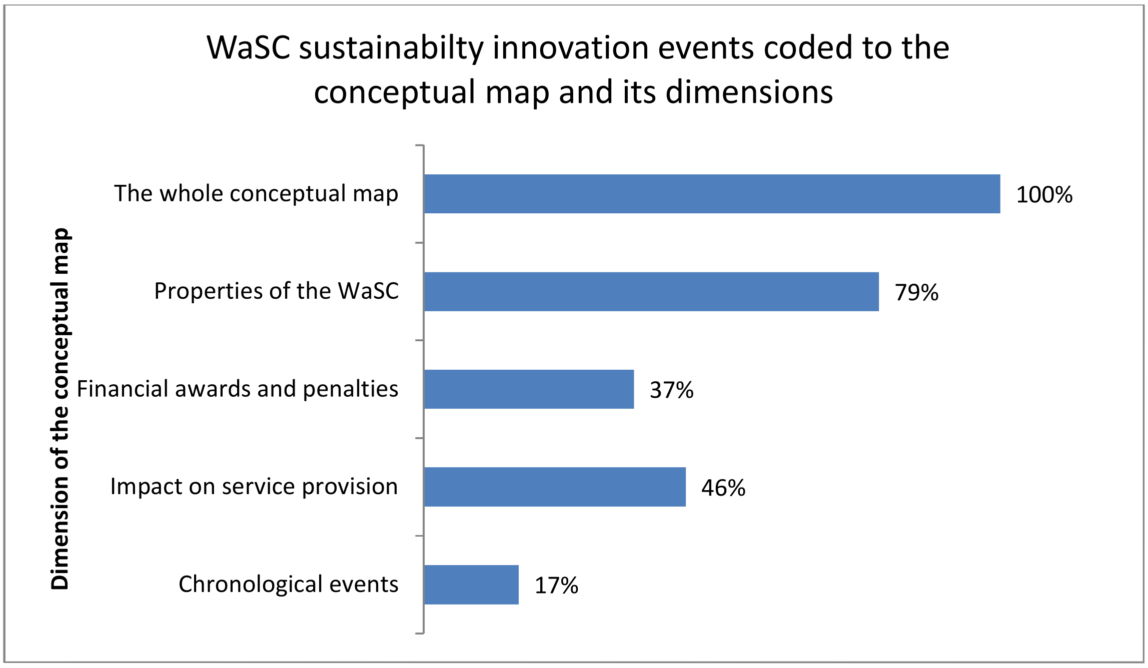


Figure 21 The percentage of the WaSC's innovation events that are coded to the AIM model and / or one of its domains.

The following section looks more closely at the AIM model exploring the research data with the software tool Nvivo.

Exploring AIM conceptual map by innovation stage and innovation process

The following section uses Nvivo to explore different coding prevalence within and across domains, the conceptual map has identified four domains that influence the sustainability innovation adoption. These domains are: *properties of the WaSC*, *chronological opportunities*, *service provision* and *financial constraints and drivers*. The research will explore the following questions in relation to the conceptual map:

a) Are all domains equal?
b) Are all categories of domains equally important?
c) Does the prevalence of coding vary between innovation types?
d) Does this vary between innovation stages?

This quantitative account of qualitative data demonstrates the degree to which the conceptual map is supported by the transcript data. The quantitative account of the transcript tells us the frequency with which a category within a narrative is returned to in comparison to other coded categories. Highly coded categories indicate that the research participant returned to the category on multiple occasions while exploring the sustainability practices of the WaSC or sustainability innovation development or adoption with the researcher. This suggests it was a more dominant concern, or more strongly associated with the subject than categories that were not coded to at all, or were coded to less. The numerical account of how often a specific subject category was broached (coded) cannot tell us the meaning applied to the subject by the WaSC employees. For example, that 'benchmarking' was coded to 27 times can only be understood in relation to other coding of quantities. The meaning of the coding is in the transcript data and will be used by the researcher to provide a deeper understanding of the role played by a specific coding subject in the narrative.

The coding variation to the conceptual map is analysed below. Firstly, the overall trends of the four domains are explored and then each is explored in detail. This analysis is carried out across the four innovation stages: *agenda setting problem identification*' (*AGpt1*), 'agenda *setting locating innovation* (*AGpt2*), *matching* of innovation to the business, and 'decision' evaluation of adoption or rejection of innovation. Within the context of the innovation stage 'decision' the researcher also identifies coding variation between the two innovation *types administrative* and *technical (Damanpour 1991)*.

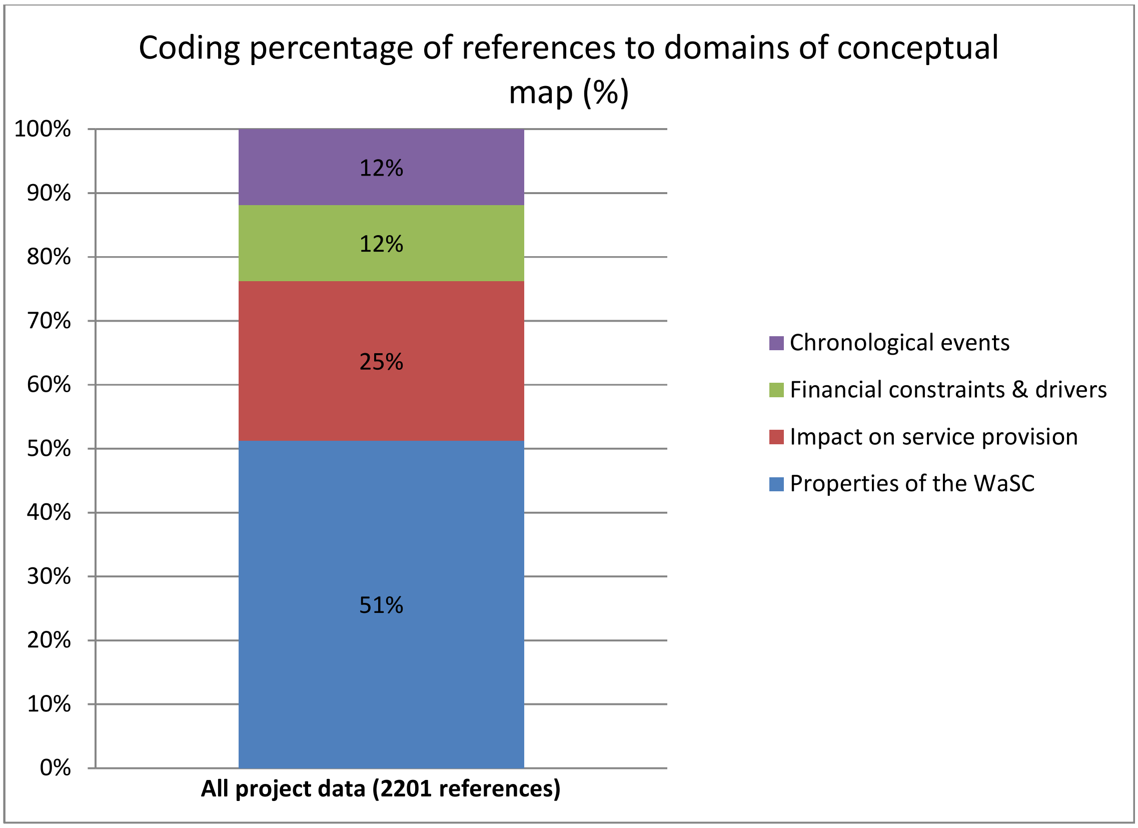


Figure 22 The coding prevalence (percentage) to each of the domains of the conceptual map AIM.

The conceptual map posits that sustainability innovation is influenced by the properties of the WaSC, evaluated against financial, service and risk concerns, and influenced in addition by certain temporal events. Figure 22 depicts the percentage of coding to each domain of the conceptual map from all sustainability narratives. In total, 2201 references are coded to aspects of the conceptual map. The figure indicates that 'properties of the WaSC' are the most frequently referred to in the sustainability narratives employed by the WaSC. This is followed by 'impact on service provision', with equal reference frequency to 'financial awards and penalties' and the 'temporal bound events'.

Figure 23 (below) illustrates the variation of coding to domains of the conceptual map by innovation stages and innovation type. Consistent with Figure 22, sustainability narratives frequently mention topics concerning the properties of the WaSC followed by topics relating to service provision. This trend is identified throughout the four innovation stages and across both innovation types.

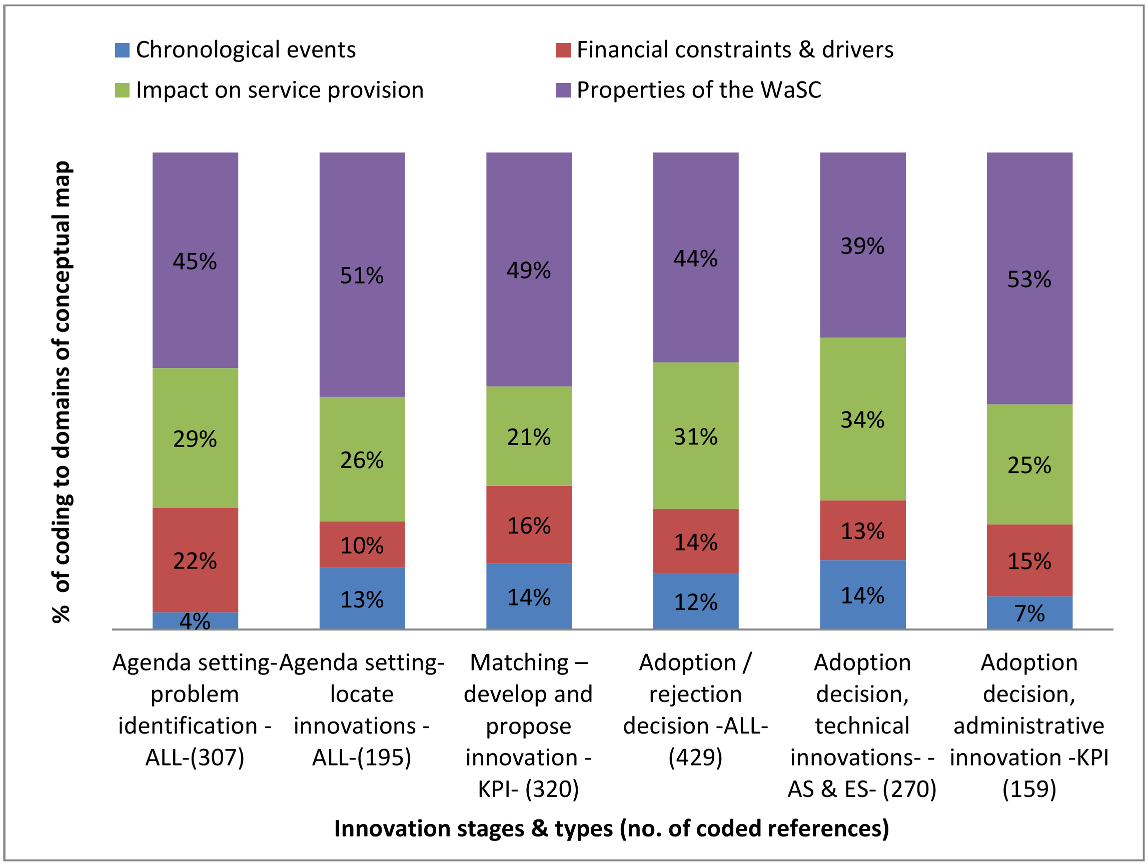


Figure 23 Variation in the coding prevalence (percentage) to each of the domains of the conceptual map AIM across innovation stages and also by the innovation types.

Looking more closely at the transcript data, it is clear that across the innovation stages, the first stage has more coding to financial constraints and drivers. Comments coded here are comments such as:

> *"Well, I would say, I mean, we are doing environmentally sustainable things but it is driven by cost, reducing cost, rather than any desire to be perceived as environmentally friendly"*

Or

> *"It's down to costing, - You've got two options to resolve an issue. It may be in the future that environmental impact has a bigger bearing on which one we choose but at the moment it is purely down to cost. "*

During this early stage of *agenda setting*, the WaSC employees are evaluating the extent to which sustainability principles are already embedded in the business and what governs these conditions. Within this stage, the domain 'temporally bound', has little coding as they are concerned with restructuring events and contracts. At this early stage, the WaSC employees' narrative is more focused on establishing and discussing if principles of sustainability should be incorporated, as well as the reasons for incorporation or non-incorporation of sustainability. In order to do this the employees look to the properties, drivers and policy of the WaSC (Figure 25).

> *"Well I think the regulator does not incentivise us in that direction"*

> *"I think if a solution manager went with a scheme to the board to do the normal approval process, and the scheme was any more than to achieve the bare minimum environmental credentials, it would get rejected"*

> *"Customers: 'what they want is cheap bills, reliability of water supply and when they flush the toilet it goes away and they never have to see it again"*

Within the category of service provision, the narratives indicate that, at this stage the workshop, participants are reflecting on the WaSC's practices in order to frame their thoughts on whether service is sustainable or is moving towards the principles of sustainability (Figure 25).

> *"Yeah I think we still have a long way to go. I think at the moment we are 50% to incinerators, 20% to SPC, and 30% to landfill, so we still have a long way to go. "*
> *" I'd say we have done quite well on that the EA set their consent limits and service ability targets, which is 50% of that, we have driven quite a lot down, to make sure we are well under the serviceability targets. "*

At this point, policy and the regulators with whom the WaSC interact are frequently cited and dominate the sustainability narrative (Figure 28).

For the following innovation stage of *agenda setting*, Figure 24 illustrates that the narratives change focus to refer to other aspects of the WaSC's properties. The focus of the narrative now concentrates on roles, responsibilities, leadership and management, as well as external resources, such as engineering partners and internal resources such as knowledge skills and expertise. The contracts used by the WaSC (from the domain 'temporally bound') are discussed as leverage points and barriers.

> *"I think we need a business direction of where we want to go and it needs to be put into asset standards or the engineering spec."*

In this second phase of *agenda setting*, concerns over financial and cost drivers are reduced, although not eliminated.

Within the innovation stage, *matching* has a very similar profile to that of *agenda setting*. The narratives employed in the stage of 'decision' show a marked increase in the coding to domain service provisions and to that of roles and responsibilities. This makes sense as it is at these stages within which the fit between the organisation and the innovation must be appraised. However, the quantitative data here is misleading and the innovation phase of 'decision' is better understood by analysing the separate innovation types.

Technical innovation narratives in the innovation stage 'decision' present many references coded to the domain service provision, as technical innovations alter the technologies with which the WaSC delivers its services and, subsequently, *service provision* becomes the focus of the narrative. In looking at the transcript data the reluctance to adopt changes to AS or ES is validated by a series of stories concerning innovations that had been implemented and failed to achieve the desired benefits. These failures would manifest typically as *"Flavour of the month" innovative* technologies, that could not be operated or maintained properly due to a poor fit between the WaSC operation and maintenance resources and the knowledge and expertise of the WaSC to the innovation technologies.

"You end up of with bits of everything and not really understanding any of them"

This is a situation which results in maintenance and operation problems.

> *"They* (operations and maintenance managers) *have got very tight budgets, and if they do not understand what needs to be done and something goes wrong on say, I don't know, the chemical cleaning system breaks down and it needs £5000 to repair, they are going to say, well I am not doing that, and so you are facing that every day."*

The issue that these narratives sought to explain was that the current strategy employs highly prescriptive asset standards, which are designed to endow the WaSC with infrastructure assets that are well understood by the WaSC and easily supported by the sector at large. The current strategy enables the WaSC to guarantee performance (demanded in policy drivers - 'Ofwat commitments') and fulfils operational, maintenance and knowledge based support requirements.

> *"You know, we've got processes that everybody in the business understands and they have been designed in a similar way so that, I mean, the other thing, the configuration, you are talking about processes, the configuration of individual processes can be very different so an activated sludge plant can look very different on two different sites which can also make it harder to operate. So we've tried to, if you like, standardise the configuration as well. So over time, what we are trying to do is migrate to a position where we have well understood assets in a similar configuration, so sites have the same look and feel and people moving from site to site don't have much trouble in understanding how to operate the next site. But we've also tried to build in energy efficiency and capital efficiency in those rounds as well."*

The other half of the technical innovation data was accounting for the proposal of changes to the engineering specification. The narratives of the engineering specification centred on risk of innovation failure, and the impact on service provision. There was also frequent reference to insufficient expertise with which to analyse the perceived risk.

> *"I think it is fair to say that, although we think adoption of these technologies and material, might result in risks, there is just not enough understanding in the room to comment on market prices or market effects of changing the specification"*

The narratives employed for the ‘decision’ stage of administrative innovations had less frequently addressed aspects of *service provision* and a greater percentage of the data was coded to the properties of the WaSC. This, together with the transcribed data, suggests that the *service provision* is less of a concern for these innovations.

Figure 24 (below) presents the coding percentage to the domain ‘properties of the WaSC’ a domain that dominates sustainability narratives both through innovation stages and across innovation types. The domain ‘properties of the WaSC’ has been separated into four components:

- Behaviour and culture, which is coded when a narrative suggests something about the norms of culture and behaviour of the WaSC;
- Drivers and policy, which holds categories that the WaSC references when determining how it goes about its business;
- Resources, which are the internal and external resources it may draw on (excluding financial);
- Roles and responsibilities, which are the work tasks employed by the WaSC.

Figure 24 shows that there is no clear dominant category that is true for either innovation stages or type, and that the category of behaviour and culture is least dominant in the domain coding. As discussed earlier, AGPt1 concerns are dominated more by policy and drivers than either roles and responsibilities and resources, a trend that alters for all later innovation stages of this research project. It can be observed that the drivers and policy maintain a distribution within narratives that is similar to both resources and roles and responsibilities.

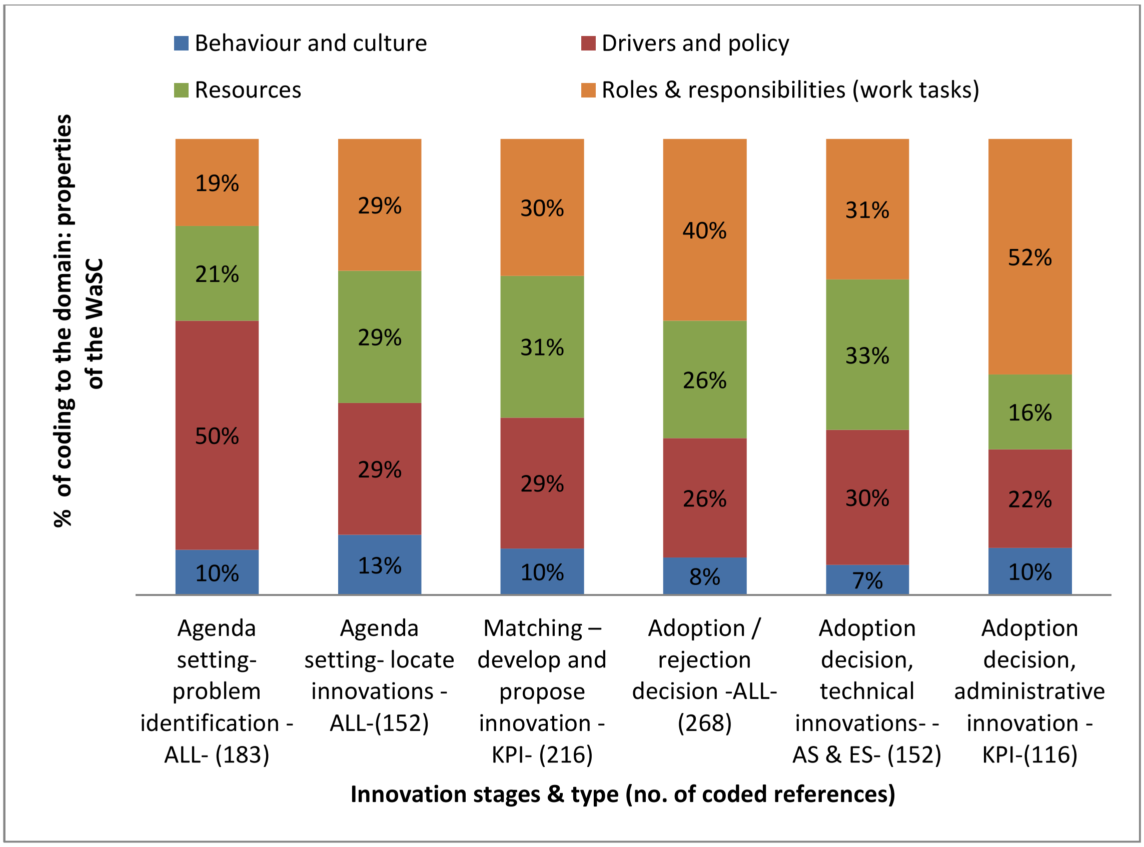


Figure 24 Variation in the coding prevalence (percentage) to elements of the domain 'Properties of the WaSC' from the conceptual map AIM across innovation stages and also by the innovation types.

Looking more closely at the distribution of coding for innovation types it can be observed that, for the administrative innovation of KPI, the job task roles and responsibilities are clearly dominated by one subcategory. The subcategory is 'influencing activities/ environmental forum'. The environmental forum had been set up to manage and report environmental data and to share environmental goals and practices between the WaSC and the EPO. The Forum was important as only cost neutral KPIs are adopted, and the forum was the platform that typically established environmental data activities. Data sharing behaviours in the environmental forum was therefore an antecedent condition that would influence whether or not a KPI would be adopted.

> "*My understanding is that that waste to landfill has been captured by the environmental forum during AMP4. So it's a well-established measure. So that's in.*"

Within the category ‘drivers and policy’ for administrative innovation, closer inspection of the coding indicates that the subcategory ‘environmental policy’ makes the largest contribution and therefore requires closer inspection of the transcript data. The environmental policy is important to the narrative of KPI adoption because partner organisations have to adhere to the environmental policy and are also required to share data and to participate in the environmental forum. This policy therefore played a supporting role in the forum in ensuring the availability of data.

Figure 25 (below) presents the coding percentage to the service provision. To achieve this, domain ‘properties of the WaSC’ are separated into five components:

- Investment planning DIS, which is coded when reference is made to the IT platform that is used to support planning of infrastructure investment for the WaSC. This is done by selecting the most cost beneficial of investments against a desired risk reduction;
- Capital delivery DIS, which is coded where reference is made to the IT platform that is used to support the evaluation of infrastructure solutions proposed by engineering partners to the WaSC. This is done by evaluating their WLC and resulting change in risk;
- Data for DIS, which is any reference made to the availability of data that is required for sustainability evaluation and includes sustainability benchmarks or best of kind technologies;
- Risk evaluation and attitude are coded when any reference is made to the processes or culture of the WaSC towards risk taking;
- *Service provision* is coded when any statement or artefact regarding direct service provision is referred to, e.g. statements on different technology types regarding their successes or failures.

The impact of some of these categories is included in the discussion of Figure 25 below.

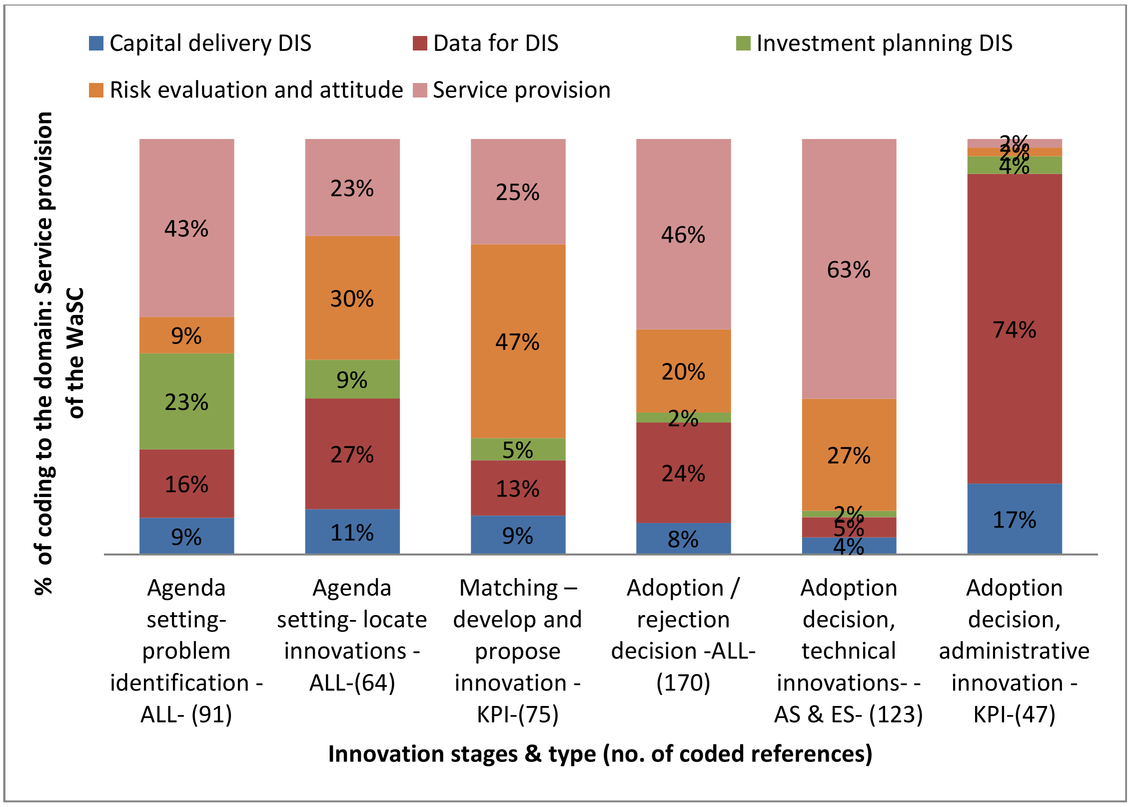


Figure 25 Variation in the coding prevalence (percentage) to elements of the domain 'Service provision' from the conceptual map AIM across innovation stages and also by the innovation types.

The domain 'service provision' is the second most prevalently coded domain from the conceptual map. There seems to be no clear trends between the components of the domain across types or stages of innovations. With reference to innovation AGpt1, the WaSC group of employees are in the process of defining the problem and establishing a need, and they are recalling past experiences of sustainability-based initiatives: over 50% of the narratives look at service provision (technologies employed) and risk. These are typically multiple stories of WaSC capital investment failures and successes.

> *"On the understanding thing, there is a lack of understanding or commitment within the business in terms of reed bed solutions here and a lack of commitment within the business to go forward because of previous poor experience with performance."*

> *"Energy was always reasonably plentiful and reasonably cheap and I think now we are in a different situation predominately over the last five years or so, apart from probably the scare in the early seventies, in terms of oil production, and energy is now very expensive but we are left*

with a residue of ... look at work that has been done at ~~XXXX~~ over the last five years in terms of energy we must have, go last few years there hasn't been a concern around energy – goodness knows how much additional energy we've put in to produce the quality and technology doesn't give us an easy answer at this stage it"

"We are looking more to move to I would say end of pipe, but rather than having big sewerage systems can we do more flow splitting? But again, that takes a lot of preparation and investment initially. But we are certainly going forward to the more sustainable especially with urban drainage…"

Also evident in AGp1 of the domain 'service provision' is a larger proportion of the reflection on the strategic investment planning, such as questioning whether this process is fit for such a purpose, or how, and to what extent, these tools influence the sustainability direction.

"And is that because we are investing on a five year cycle instead of a long term? And is it because over 25 years the cost doesn't matter as much as it did before?"

"No, as potentially fossil fuels become more and more rare, or per amount needed the availability goes down and the prices going to go up, (and) that's going to become more significant in those calculations. Also we do put the value of carbon on energy when we are trying to do calculations, though that's been more in the planning upfront"

Within the process AGpt2, as the WaSC employees reflect on how or where sustainability innovations can be applied to the WaSC, the employees realise the WaSC would not recognise what is good sustainability performance and benchmarks. This then arises as a notable constraint to the WaSC adopting or interpreting data from sustainability related innovations.

"But we don't know where we are on the scale do we of ... on the sustainability scale? So unless we found out. We haven't done any benchmark of our own equipment and assets and what have you."

Both in AGpt2 and in the innovation stage, *matching* the category of risk evaluation and attitude is employed in increasing frequency as the employees identify, evaluate and develop opportunities. Here, the WaSC employees see that the pace of sustainability innovation adoption is influenced by the culture.

> *"It has the potential to provide a different direction for AMP6 and its a ... it takes a long time ... things don't change quickly at this WaSC unless something major happens outside to influence that tells us we are doing something differently. We do move ... we move very cautiously and we are pretty risk averse, especially if its spending pennies and we've got to do it on a form basis. So what I would say about this is starting to get the education going; starting to collect the information to build up this base to then say yes it is worth doing something differently."*

The statement above suggests that the WaSC is risk averse, and therefore sustainability innovations that develop the organisational knowledge and understanding will precede those which have a direct impact on the way in which it delivers services.

The variation between the coding to the two innovation types is significant and is a corollary of the impact of adoption to the WaSC, or the resources the innovation requires in order to adopt them. For KPI (administrative), the availability of data, which is employed in the various IT decisional formation support platforms, would determine, in part, the adoption outcome. Naturally, and necessarily for KPI, there is much coding to the DIS data, and it does not follow that the coding balance for all administrative innovations have such a high degree of reliance on data availability and the organisational features that enable or constrain access to that data. As mentioned above for the technical innovations, stories of innovation failure and the risk entered into the system as a result of innovation dominated the coding to the domain of *service provision* for the technical innovations (AS and ES).

> *"Well pipes have a significant cost impact but the impact of getting the choice of pipe material wrong or the correct pipe wall and trench structure wrong is certainly greater than smaller aspects of the ..."*

Figure 26 below presents the coding percentage to the domain 'financial constraints and drivers'. To achieve this, the domain has been separated into six components:

- Cost attitude, which refers to statements in narratives that are indicative of a culture or behaviour of the WaSC to do with financial management concerns
- Cost reduction event, which is any narrative where cost reductions are realised or inferred.
- Cost increase event, which is any narrative where cost increases are realised or inferred
- Financial decision making, which refers to the financial management decision frameworks that govern financial decisions
- Market driven, this refers to any point at which market changes are used in sustainability narratives.

The impact of some of these categories is included in the discussion of Figure 26 below.

From Figure 26 it can be concluded that the concept financial decision-making frameworks are significant in the early stage appraisal of whether or not the WaSC is sustainable and what are the causal conditions for this. This is also the innovation stage where the domain 'financial constraints' share the largest percentage of coverage. Here, the WaSC narrative is relating how the existing financial frameworks inhibit or facilitate sustainability and, unfortunately, the emphasis seems to be on the inhibiting elements of existing financial frameworks.

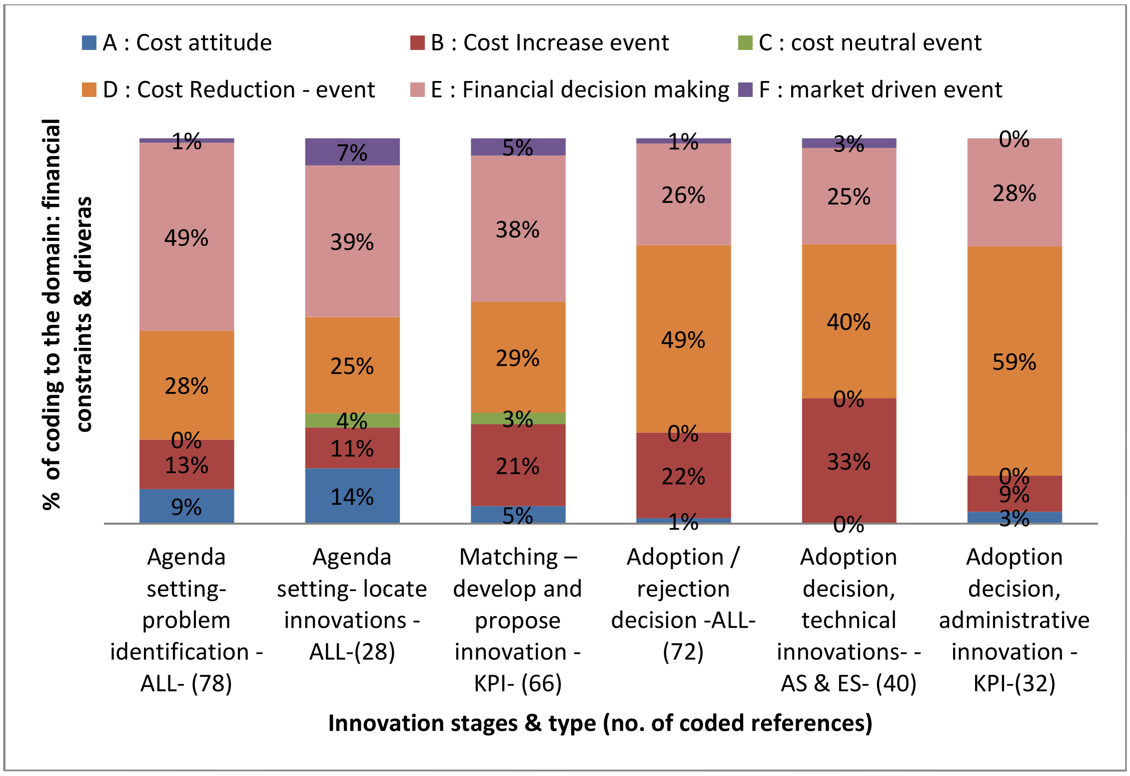


Figure 26 Variation in the coding prevalence (percentage) to elements of the domain 'Financial constraints and drivers' from the conceptual map AIM across innovation stages and also by the innovation types.

"Why we've already been trying also within BRM plus they have tried to put schemes that are not regulatory driven and something that could be beneficial to us like planting trees in catchment system and stuff. It doesn't get out very highly ranked in priorities for the company but I suppose it's a start in all this. But I don't think at the moment it's taken into account at all ..."

"Does this mean that improvement then could be ... if we did ... You know that we class schemes as cost savers if they payback over four years , do you think if we looked at that over a longer period of time it might be more along the lines of sustainability and less along the lines of cutting costs?"

"Well I think that comes back to your Ofwat funding though doesn't it? At the end of the day that's how we are funded and unless we can do things more efficiently and create opportunity for choices I suppose this sustainability becomes a choice doesn't it, about where we choose to spend our 'outperformance'."

"I think one of the biggest problems is, its whole life costs based on current energy prices."

"Well we do whole life costs when we are shutting works down for the best option whether it's to improve the works or whether it's to main it out."

The concept of a financial decision-making framework persists in its influence through the innovation stages until the innovation stage 'decision', where it has much less bearing on the sustainability narratives.

The second most frequently appearing concept is 'cost reduction' narratives that have coded to this concept and are generally stories regarding the adoption of an innovation motivated by cost reductions, but also achieved by sustainability performance improvements. There was also the WaSC's general and continued/ongoing ambition to reduce costs. Employment of these narratives, and the desire to reduce cost, are coded with equal prevalence throughout the innovation stages AGpt1 AGpt2 and '*matching*'. During the stage of 'decision', the prevalence of coding jumps in the KPI innovation where cost reduction was always equated with the adopted KPI indicators:

"I think there would be a number of reasons why it liked that one, assuming it was adopted. Number one, landfill has a clear financial pain against it, landfill tax and all the gate fees etc; it's quite an expensive business these days... "

For the technical innovation there was also a concern over cost increases resulting from limiting partners' supply chain options

"I think, very, very specific clauses about types of material, especially if it needs to be 100% recycled, would actually limit what they can do on that front and therefore increase costs, and the other thing is the actual availability of those materials."

Figure 27 (below) presents the coding percentage to the domain temporally bound. To achieve this, domain properties of the WaSC was separated into five components:

- Asset standards, which is any mention of the contract and mechanisms of AS

- Engineering specifications, which is any mention of the contract and mechanisms of ES
- Engineering partner contracts, which is any mention of EPO contracts
- Framework suppliers contracts, which is any mention of the contracts between the WaSC and its supply chain
- Restructuring events, which is any mention of a planned or known event that will result in the reorganisation of resources roles or responsibilities or any aspect of the properties of the WaSC.

Four of these components are specific contracts that the WaSC employs to manage its environment and relations. The fifth was identified by the researcher from his own experience and not from analysis of the transcript data.

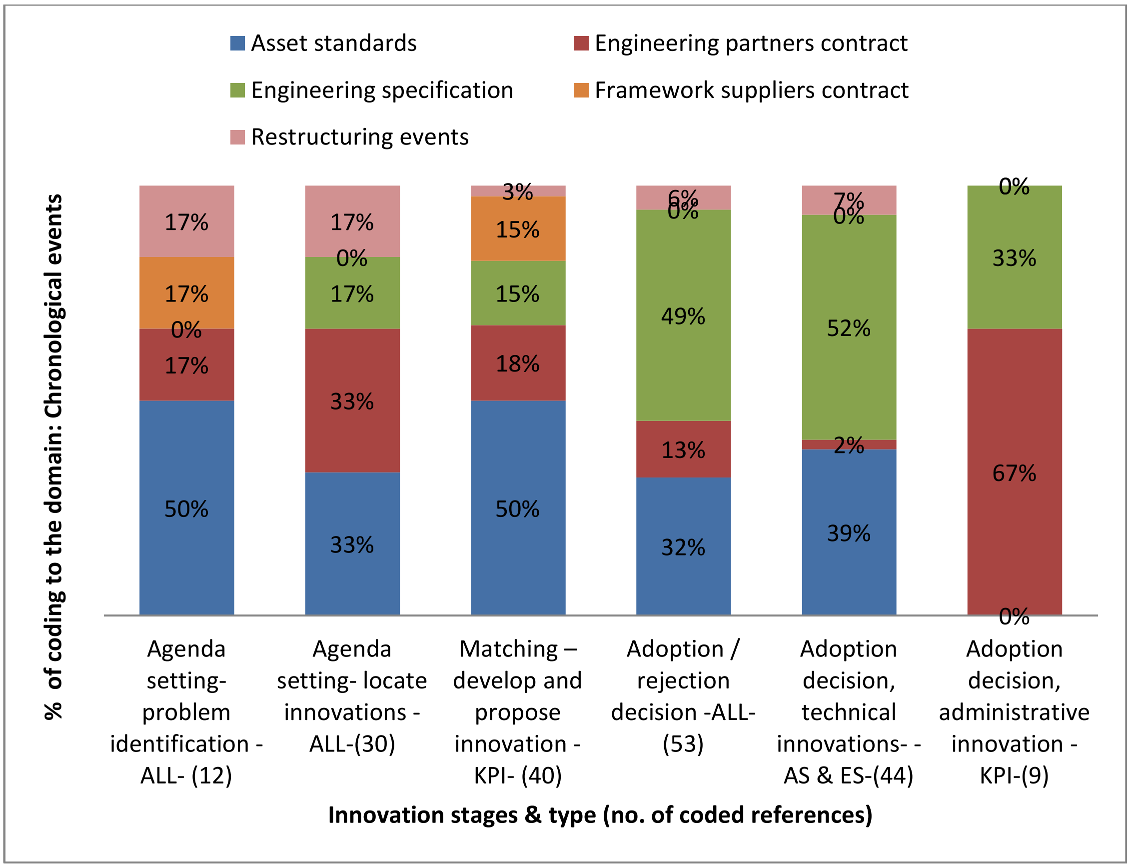


Figure 27 Variation in the coding prevalence (percentage) to elements of the domain 'Chronological events' from the conceptual map AIM across innovation stages and also by the innovation types.

The narratives refer to the temporally bound impacts with the least frequency of all the domains. Within the innovation stage AGpt1 there are very few narrative events that discuss concepts such as how the detail of contracts may influence the sustainability adoption. With the subsequent innovation stage we see that the employees of the WaSC, when reviewing the influence of three contracts, have identified influences on sustainability performance

> *"I think like you said they're your biggest leverage points at the minute aren't they? Your engineering spec and standards…"*

> *"AMP5 is set, contracts are in place. They do not take into account sustainability as an identified criteria from a selection of options or for choices to be made at this present moment in time…"*

And also the opportunities for sustainability innovations:

> *"'But the point at the minute is the partner will not bring it to the table because there is no incentive for them to do it and the delivery side, the solution managers can't impose it on them because there is nothing contractually for us to ..."*

The innovation stage of *matching*, which is only concerned with KPI development activities, has a relatively high degree of narratives that discuss the contract asset standards. A review of the transcripts of this suggested that the contract asset standards may limit the potential for KPI to influence significantly the sustainability performance of the infrastructure.

> *"I think the answer to your question on all of these, is they could all be done within the design phase but we at the present time, we haven't got the standards to adhere to these so if we, say reduce use of virgin materials and resources, there is nothing in our standards that says you must use recycled material .."*

The differences between the innovation types coding for the domain 'temporally bound' are significant. Firstly, the administrative innovation has very few references at all and, secondly, the category coding coverage is very different. However, this is not a fair comparison as the technical innovations are also categories under which coding has been distributed, so the coding is self referential, i.e. the innovation in ES is coded heavily to ES as is the innovation to AS to AS. Closer examination of the transcript data, however, allows us further insights into what the employees are saying about ES and AS specifically within this ‘decision’ phase. In both sets of data the employees used histories and evolutions of these contractual documents, revealing how the strategies of innovating change are not well matched to the strategic experience that governed the evolution of these contracts.

Figure 28 presents the percentage of coding for each of the domains categories of the conceptual map dicussed by innovation stage. The figure illustrates similarities between the coding to the key topic areas, across the conceptual map. The topic ‘restructuring events’ has very little coding to it, however, this has been identified as influence on adoption not through looking at the distribution of coding, but was recognised by the researcher to influence the innovation opportunitiy development.

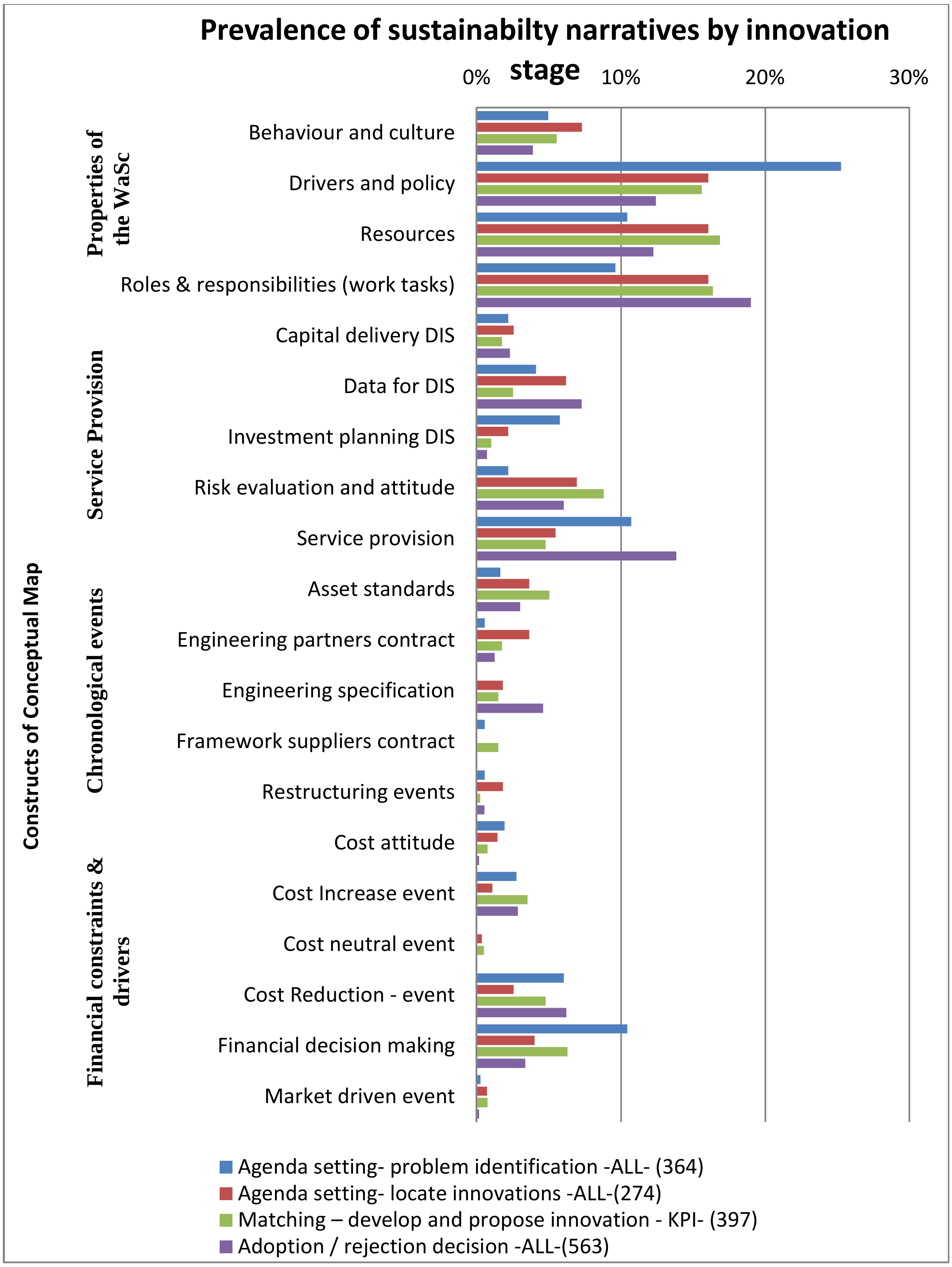


Figure 28 Variation in the coding percentage for selected elements of the conceptual map AIM across the four innovation development stages

Below the four domains of the AIM model and their properties are used as a framework to explain the innovation process and outcomes.

The conceptual map AIM, an explanation of case study 'Key Performance Indicators'

Alignment to properties of the WaSC

*Drivers
*Policies
*Strategies
*Roles & responsibilities
*Resources, Culture

All proposed KPI innovations align with the strategy of KPI principles to influence partners' behaviour, enable identification of improved practices, and they do not interfere with the aim to evaluate partners for the allocation of future investment delivery contracts. As the innovations are adaptations to the existing business processes all KPI innovation are aligned to roles and represented very little change to work load or tasks.

Adopted and rejected KPIs differ in their relationship to drivers and the various aspects of responsibilities in the following way: all the KPI innovations are aligned (directly or indirectly) to the financial drivers of reducing costs (with embodied carbon the only exception). All the adopted KPIs are additionally aligned to the regulatory incentives to reduce capital costs. Rejected KPI innovations, despite having alignment to cost reduction drivers for the WaSC in general, were not aligned to the capital reduction incentives. The department CDU was clearly responsible for the delivery of reductions in capital costs, so proposed innovations that aligned with the business drivers for capex reductions also aligned with CDU responsibilities. Rejected KPIs developed to evaluate and influence operational impacts, transgressed the responsibility of CDU and were rejected. In addition, in terms of R&R, the project sponsor (RFM) was responsible for the delivery of new KPIs and therefore all the proposed innovations benefited from aligned management with decision taking authority.

Alignment with chronological events

*Restructuring
* Contracts

Both adopted and rejected sustainability KPIs shared the same relationship to restructuring and contract making. A major planned and resourced restructuring of the capital delivery unit was undertaken, which incorporated a review of both the reporting and information capture between the WaSC and its engineering partners, and of the KPIs between the WaSC and its engineering partners. A contract between the engineering partners and the WaSC stipulated the data sharing expectation had been agreed before the KPI review process, and the contract was set for a minimum period of five years.

Alignment to cost drivers and constraints

*Financial management
*Awards & penalties

All the KPI innovations are adaptations to existing business processes and structures. They were developed on the understanding that any cost increase would result in the rejection of the KPI. Objectives of the KPIs (developed by the stream managers) were all based on perceived cost advantages. Therefore many were developed with specific market based cost trends in mind (chemicals, energy, landfill). Rejected KPIs did not benefit from amplified cost advantage of a focus on capital cost reduction. Some rejected KPIs also did not have a well-established data collection history, despite the perceived negligible administrative costs if the data sharing was not entrenched in the contract the WaSC would not adopt the KPI for fear of triggering a compensation event, which would drive up costs.

Impact on service provision

*Service impact
* Risk impact

The proposed KPIs innovations would not directly (or immediately) result in changes to infrastructure and so there was no evidence of an influence of service failure concerns or of concerns about alterations to the risk in service provision which could result from adoption.

The conceptual map AIM, an explanation of case study 'Asset Standards'

Alignment to properties of the WaSC	*Drivers *Policies *Strategies *Roles & responsibilities *Resources, Culture

The proposed asset standard innovations align the WaSC drivers and policies with proposed technologies which ensure the company meets its increasingly stringent discharge consents. The market drivers affecting the organisation are increasing cost of energy, chemicals and landfill; the proposed technology options have low energy consumption and are aligned with the driver: to reduce energy costs.

As the sustainability innovation is an adaptation rather than a reinvention or redesign to the existing business processes and structure, there is no apparent additional administrative burden that is directly associated with the process adaptation. The changes to the asset standard are aligned with existing roles and responsibilities and the work tasks required to implement the asset standards. In advocated technologies new to the organisation the proposal does not match the WaSC expertise to evaluate design, operate, manage, repair and maintain new technologies. Furthermore the WaSC suggested novel technologies are not aligned with availability of expertise/experience in the sector. The proposed asset standards are misaligned with the CDU strategy of limiting infrastructure technologies to two well-understood processes, in a configuration that was to be standardised across the WaSC, thereby ensuring the WaSC invested in well-understood technologies with which the WaSC could reliably meet its discharge consent. In addition, the asset standard innovation did not generate aligned management buy-in and the project sponsor was unaligned with the targeted business area.

Alignment with chronological events

*Restructuring
* Contracts

A major redevelopment of the business for the AMP period was undertaken during the research project, and the focus of the restructuring event was the CDU. This restructuring event was lead by a change in the contract strategy that also affected the asset standards. The restructuring events associated asset strategy and standards were all but completed when the research project began engagement. A major restructuring event like this would only occur at the expiration of the existing contract strategy (5 years min).

Contractually the asset standards are fixed for the immediate future, but not for the entire AMP. Opportunity was available to make changes to the asset standard, should the proposed changes be persuasive, as the contract design enabled the evolution of the asset standards when required, and changes would affect all subsequent contracts within the AMP.

Alignment to cost drivers and constraints

*Financial management
*Awards & penalties

No additional financial burden was associated with administrative costs of the proposed asset standards, as the innovation was an adaptation to existing business processes and structures, and therefore by design did not incur additional operational costs. There was a degree of cost uncertainty, associated with the capital cost of proposed technical innovations. Any changes in proposed technologies would have to be capital cost neutral or cost negative against standard options or run the risk of jeopardising the regulated investment plan, a contract of investment between the regulator and the WaSC.

Impact on service provision

*Service impact
* Risk impact

The changes to the asset standard proposed novel technologies that would require novel knowledge and expertise to run and these therefore present a service risk. In addition the introduction of a non-prescriptive asset standard risked introducing multiple technologies to the business, which increased the knowledge and expertise resources required for operating and maintaining assets, and thereby introduced greater opportunity for asset infrastructure failure to the business.

The conceptual map AIM, an explanation of case study 'Engineering Specification'

Alignment to properties of the WaSC

*Drivers
*Policies
*Strategies
*Roles & responsibilities
*Resources, Culture

The change in engineering specification did not directly respond to existing regulatory drivers or drivers prioritised by the organisation. Nor did it directly respond to any market or service related additional drivers. As the sustainability innovation is an adaptation rather than a reinvention or redesign to the existing business processes and structure, there is no apparent additional administrative burden that is directly associated with the process adaptation, and no alteration to works tasks or roles and responsibilities. However, the engineering specification innovation required the WaSC to seek to adopt or apply third party knowledge resources to accredit or evaluate materials and inform selection, thereby identifying a knowledge resources requirement for the WaSC. In addition, the engineering specification innovation did not generate aligned management buy-in and the research sponsor was unaligned with the targeted business area.

Alignment with chronological events

*Restructuring
* Contracts

There was a planned sector-wide consultation on the revision of the engineering specifications due to begin after the research project. There was therefore opportunity for the sustainability innovation to feed into the WaSC thoughts prior to the consultation. There was an opportunity to make changes to the engineering specifications as the contract design enabled the evolution of the engineering specifications when required, and changes would impact upon only subsequent contracts within the AMP (rather than existing). Any changes in proposed materials would have to be capital cost neutral or cost negative in comparison to the typical options or run the risk of jeopardising the regulated investment plan, a contract of investment between the regulator and the WaSC.

Alignment to cost drivers and constraints

*Financial management
*Awards & penalties

No additional financial burden was associated with administrative costs of the proposed engineering specifications as the innovation was an adaptation to existing business processes and structures, and therefore by design did not incur additional operational costs. There were a cost concerns that arose in that, in specifying different materials (and reducing material options), additional capital costs would incur when constructing infrastructure. Those materials, with improved environmental performance, would be more expensive, and there would be difficulty with supply meeting demand. This would result in increased capital costs for delivery partners and requests from these partners for compensation.

Impact on service provision

*Service impact
* Risk impact

The potential for failure of the materials specified in the engineering specification was recognised as a business risk. Sustainability innovations are more likely to be adopted on low risk assets that are not critical to service delivery e.g. kiosks etc. Proposals that employ third party (accredited) impact assessments were considered more favourably than those that did were not supported. For proposed changes to critical asset infrastructure (e.g. concrete mixes, or pipe network) the respondents suggested the risk (perception) would need to be mitigated by investment in research, expertise and knowledge commensurate with risks.

On reflection, the AIM conceptual map is a useful framework to identify influences on the adoption of sustainability innovations, as it was able to tease out the core concerns that influence the innovation adoption decisions. However, the AIM model does not recognise the relative commitment that the decision-making unit or WaSC holds to any aspect of the influence factors. To explore this in a little more detail the research developed an event-based visual map. From a event based visual map patterns can be used to identify causations and relationships between antecedent and output (Pentland 1999). Van de Ven (2004) suggests that it is through an event-based understanding that the process of change is revealed. To develop the event-based visual map the following activities were undertaken:

1. Firstly, the researcher coded (in Nvivo) the sustainability narratives of the WaSC employees by events that related to the process of incorporating sustainability innovations or to histories of sustainability innovations.
2. Secondly, events were placed on a time line. Once all relevant data was coded, events were given durations and an approximate date at which it occurred. This enabled the sequential positioning of events and their influence through time.
3. Thirdly, using the thematic coding of previous analytical tools, the constituent entities or actors in events were identified and associated to the event. In addition, the thematic coding was used to establish the evaluative frame of narratives in terms of sustainability. This meant that narratives pertaining to the improved incorporation of sustainability were coded as pro sustainability narratives. These

were coded separately to those that pertained to an impaired facility to incorporate sustainability, which where coded under negative sustainability narratives. All the event data was compiled and events were grouped by themes, which were developed inductively during the thematic analysis. This information was placed into the visual map. The narrative data was also a coded, so that narratives of each of the sustainability innovations could be seen separately.

4. Finally, the events were grouped by relationship to, or role within, the WaSC, as a logical and useful way to classify the event data that enabled a simple visual access to the themes in the diachronic visual map.

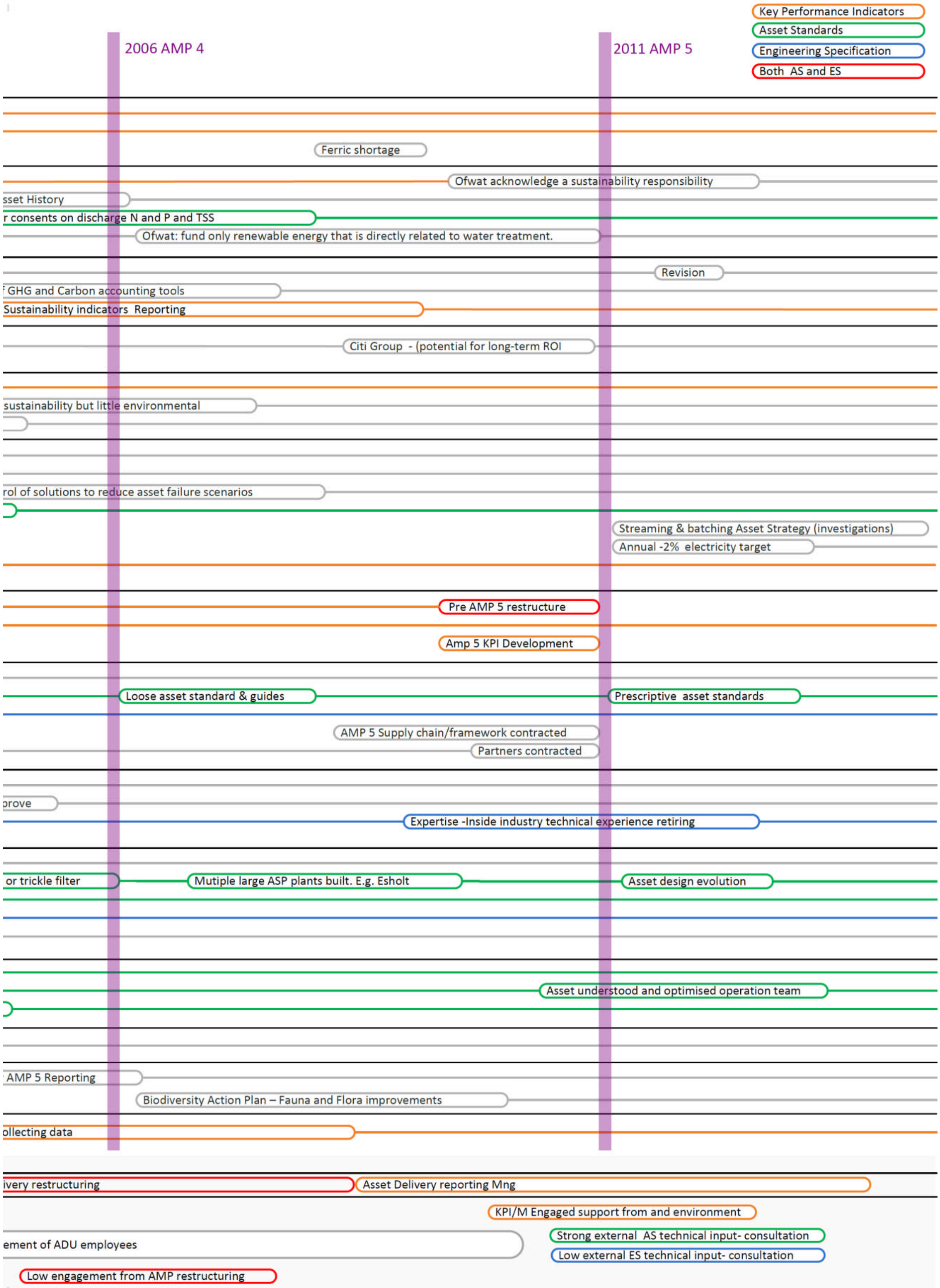
The visual map enabled the researcher to present both immediate and distal factors that are brought to bear on sustainability decision making (see Figure 29 below).

Event based comprehension for the innovation case studies

The event-based story for the adopted KPIs (see Figure 29 below, green line) indicates that market forces placed an adoption pressure and the regulator incentives amplified the beneficial value of the market pressure. The WaSC had the necessary human resources that are familiar with the data type, and also the contractual relationships that enabled data collection due to an environmental forum and sustainability indicator reporting. The project process benefited from aligned corporate sponsorship, resources and a planned restructuring event.

For the case study AS (see Figure 29 below, orange line) a careful look at the event history illustrates that the strategy adopted by the WaSC to limit technology selection options and design has evolved over a 20 year period. It has evolved as a direct result of other less prescriptive strategies failing to deliver reliable assets, and more prescriptive strategies generating positive feedback. The event history makes apparent that the proposed alterations to the asset standard would require the WaSC to abandon institutional logic and behaviours (Tushman and Romanelli 1985).

Figure 29 An event based account of the WaSC's sustainability innovation experience. Highlighted events were employed in the adoption decision narratives for the project innovation case studies.


Key Performance Indicators
Asset Standards
Engineering Specification
Both AS and ES
2006 AMP 4
2011 AMP 5
Ferric shortage
Ofwat acknowledge a sustainability responsibility
sset History
r consents on discharge N and P and TSS
Ofwat: fund only renewable energy that is directly related to water treatment.
Revision
GHG and Carbon accounting tools
Sustainability indicators Reporting
Citi Group - (potential for long-term ROI
sustainability but little environmental
rol of solutions to reduce asset failure scenarios
Streaming & batching Asset Strategy (investigations)
Annual -2% electricity target
Pre AMP 5 restructure
Amp 5 KPI Development
Loose asset standard & guides
Prescriptive asset standards
AMP 5 Supply chain/framework contracted
Partners contracted
prove
Expertise -Inside industry technical experience retiring
or trickle filter
Mutiple large ASP plants built. E.g. Esholt
Asset design evolution
Asset understood and optimised operation team
AMP 5 Reporting
Biodiversity Action Plan – Fauna and Flora improvements
ollecting data
ivery restructuring
Asset Delivery reporting Mng
KPI/M Engaged support from and environment
Strong external AS technical input- consultation
Low external ES technical input- consultation
ement of ADU employees
Low engagement from AMP restructuring

In the case of ES the event history (see Figure 29 above, blue line) illustrates that the WaSC has a long experience of changes to the engineering specification (since 1978). Typically changes to the specification are supported by detailed research and with the support of cross sector support (financial and political). The ways of working for changing the engineering specification are written in the event history.

6.1.3 Discussion

The process of developing and evaluating the conceptual map identified a number of sustainability innovation considerations.

For the first part of the innovation stage 'agenda setting' the narratives of the WaSC employees are engaged on a comparative exercise establishing to what extent the sustainability principles represent a change from current practice. This process can also be understood as a process of recognising or generating the performance gap between the WaSC ambitions and goals and those of sustainability. The organisational artefacts that are repeatedly referred to is the policy, goal and mission statements that the WaSC has employed, or the regulatory framework within which the WaSC operates.

That the regulator has broadly determined the actions of the WaSC is not surprising (Legge 2000; Cashman and Lewis 2007; Cave 2010). However this research indicates that these employees utilised the organisation's policy goals as they reflect on the sustainability principles that they are presented with. Authors such as Epstein (2008), Rainey (2006) and Doppelt (2003) all clearly advocate changes to an organisations policy, goals and mission statements, as necessary for sustainability orientated organisational change. For this WaSC it was evident that the sustainability principles are not represented evenly within the WaSC policy. In the circumstances when environmental sustainability principles were tackled outside of the regulatory framework it was considered a product of cost drivers rather than any WaSC sustainability ambition. Where policy and principles did align the WaSC had pre-existing practices to manage the relevant policy and the sustainability principle.

For the second part of the innovation stage ‘agenda setting’ the narratives focused on roles and responsibilities and work tasks around the WASC that might leverage sustainability. Lyytinen and Newman (2008) use Leavitts (1965) model to suggest that when a new ‘task’ is identified the following relationships may result between task and the other three constructs of the model:

> ‘Task-actors: The actors do not understand or accept the task or cannot carry out the task.
> Task-structure: The structure is not aligned with the task or no adequate structure is defined for a given task.
> Task-technology: The technology is not adequate to support the task or it is unreliable or inadequate in its support.’ (p596, Lyytinen and Newman 2008)

In this research experience the WaSC employees were scanning predominantly aspects of actors’ roles and responsibilities and the adequacy of existing technologies to manage the sustainability principle. For the innovation stage ‘matching’, the innovation development team were concerned about risks to infrastructure, cost benefits of adoption, and how roles and responsibilities fit in with the innovation.

Matching stage is the third stage, the movement from a condition of multiple innovation solutions to refining and identifying the preferred innovation. Here examination of the narratives suggests that the framework employed in this process is not solely about the roles, structure and responsibilities, but more commonly participants made assessments of the allowable risk and uncertainty associated with the innovations. Again authors such as Rogers (2003) and Frambrach (2002) have identified these as determinant perceptions of innovation characteristics. At this innovation stage attitudes and behaviours in relation to innovation development became more observable, with opinion stating that, at present, the WaSC is very cautious over innovation and that it will wait until a large body of evidence has been established before making a decision to innovate. Lam (2004) suggests that organisations share cognitive frameworks about how learning is achieved, this research suggests that innovation adoption has similar cognitive frameworks for the innovation process and conditions necessary for innovation adoption.

For the innovation stage, 'Decision: adoption/ rejection', the technical innovation was found to be highly influenced by the impacts and risk to 'service provision' and also to cost. Furthermore the fit of innovation to the strategy and ways of innovating was a significant influence. The innovation strategy towards technical innovations was based on reasoning which incorporates an approach to risk and uncertainty. The research found that technical innovations need to be supported with a large body of evidence that will reduce perceived risks by reducing uncertainty around adoption impacts. Figure 12 shows six determinant perceptions can influence innovation adoption. This research indicated that uncertainty and relative (economic) advantage dominated the narratives of the final phase of adoption decision making. In contrast the administrative innovation adoption decision narrative was more heavily influenced by the compatibility with the roles and responsibilities that would correspond to the innovation. In summary, the stages of innovation and types of innovation have distinct influences.

Presenting the event history the research was able to indicate the attachment to the strategy undertaken for asset standards, and also the ways in which changes to the engineering specification had historically been supported. The event history of these factors is clearly a good indicator for identifying entrenched norms about the way things are done in the organisation, and why they are done. The retained event history of the organisation is invested with meaning learned and shared within the organisation. From these retained events and the meaning with which these events are imbued a narrative of organisational logic can be revealed. As Pentland (1999) suggests, such narratives are like ‘ruts in the road’ and can therefore influence future outcomes by influencing decision making. This research seems to demonstrate that by capturing a retained event history, researchers can benefit from an understanding of relative attachment to the factors that have been identified to influence adoption process.

The following sections seek to discuss the results of these research activities and synthesise the findings to respond to the research questions.

7 Discussion

This study investigated the adoption influences on sustainability innovations in WaSCs, where a sustainability innovation is defined as an innovation in technologies, structure and processes, behaviour and culture, and knowledge and skills which, when employed, improve the WaSC's management or understanding of sustainability principles. The research views the adoption of sustainability innovations as integral to the transition to a sustainable WaSC.

The researcher's attempts to identify and propose sustainability innovations to the WaSC were recorded and the results obtained reveal the influences on the process of sustainability innovation adoption in WaSCs. The aim of the study was to facilitate the selection, development and proposal of sustainability innovations, in order to evaluate innovations with respect to the factors that influence the innovation process and adoption outcomes. The research then sought to capitalise on these activities and to generate knowledge of the opportunities and barriers that enable or inhibit a WaSC's transition towards more sustainable practices across the organisation. To support these aims the following research questions were developed:

A. How has a specific UK WaSC incorporated sustainability innovations?
B. What factors influence a WaSC's selection and uptake of sustainability innovations?
C. What changes would assist the WaSC in improving its potential to adopt sustainability innovations?

The responses to research questions A and B are discussed in the sections below. The response to research question C is presented with the research in the following chapter.

7.1 *How has a specific UK WaSC incorporated sustainability innovations?*

To respond to research question 'A': for a user-centred innovation process, when new sustainability principles are introduced to drive innovation development, the research found that participants first establish a performance gap at the task level of the WaSC drivers of policy goals and regulatory commitments. Participants then identify innovation opportunities focusing on the properties of the WaSC in terms of technologies, processes and responsibilities. The process of selecting innovations for development was influenced by the cost considerations and the relationship to chronological opportunities that enable or limit innovation. Finally, the adoption decisions were evaluated in terms of the cost and risk for technical innovations and the cost and impact on the existing organisational structure for administrative innovations.

Below these findings are separated into innovation process stages, distinguished by the knowledge output generated from each innovation stage and the specific stage focus (see Table 27 below). The innovation process stages developed below are a useful distinction in the context of change agent centred intervention to identify sustainability innovations in WaSC. Each stage is presented with the key inputs, outputs and understanding about the key factors that influence the different innovation development stages. The research findings that are attributed to each stage are explored and discussed below.

Innovation stage one termed 'generating a performance gap', is a product of the input of 'new sustainability vision, principles and goals'. The research indicates that the product is a result of the WaSC examining the existing WaSC policy, goals, vision and drivers such as regulatory drivers, with the new proposed sustainability, vision goals and principles. The result of this process of comparison is a perception of the performance gap at the level of drivers and ambitions of the WaSC.

Table 27 Summary of research experience of innovation process: process stage: inputs, outputs and narrative focus

Innovation process stage	**Stage inputs**	***Stage outputs*** *'stage knowledge'*	**Stage focus**
1.Generating performance gap	New sustainability vision, principles or goals etc.	Performance gap (WaSC ambitions). '*How, and where does sustainability adoption manifest as a performance gap (high level)*'	WaSC sustainability ambitions: policy, goals and vision, the regulatory framework, and drivers.
2.Identifying of innovation opportunities	Perceived performance gap (high level) and understanding of new sustainability vision, principles or goals etc	Innovation opportunities (practical performance gap). '*Scope of sustainability innovation opportunities identified*'	WaSC sustainability practices: roles responsibilities, resources (knowledge, expertise), tools DIS.
3.Developing innovation proposals	Awareness of a number of potential innovation opportunities to reduce the practical performance gap.	Sustainability innovations selected or rejected. '*Which innovations are selected for adoption and which are not (why)*'	WaSC sustainability practices: roles responsibilities, resources, practices (knowledge, expertise). Innovation impacts: cost
4.Decision: adoption/ rejection	One or more sustainability innovations developed for proposal to decision making unit	Sustainability innovations selected or rejected. '*Which innovations are selected for adoption and which are not (why)*'	***Technical innovation:*** risks to service provision, financial ***Administrative innovation:*** existing administrative practices and cost

Innovation stage two termed 'identifying innovation opportunities' is also a process of comparison. It is a process of comparison between the perceived performance gap in drivers and ambition being compared to the WaSC actual practices. In this innovation stage the research findings indicate that participants focus on the properties of the WaSC to identify where the performance gap exists in practice.

For innovation stages one and two, 'generating the performance gap' and 'identifying innovation opportunities', the research suggests that the output of these stages will be highly dependent on the selection of the 'new sustainability vision, principles or goals'.

The role of a clear vision of sustainability is common to the literature concerning innovation and sustainability. According to Paech and Lehmann-Waffenschmidt (2007), organisations require '*an understanding of sustainability which, along with the actual ecological and social contents, also has process-related components of the necessary modes of change as its focus*' (Paech and Lehmann-Waffenschmidt 2007, p.137). Gleich (2007) suggests that the guiding principles for sustainability need to function both to orientate the WaSC and to effect an emotional response which motivates sustainability change.

Fichter (2007) characterises six different 'search and discovery pathways for sustainability innovations' from a study of 68 examples from business:

i) 'Sustainability is the dominant goal to be achieved by the innovation process
ii) Sustainability is an integral corporate goal and strategic success factor
iii) Sustainability as a coincidental discovery in the ongoing development process
iv) Sustainability standards as a possible correction of the ongoing innovation process
v) A retroactive attribution of sustainability and its use as a sales argument
vi) Sustainability as an invisible hand' (Fichter, Pfriem et al. 2007, p.107)

The six approaches differ according to the role of sustainability goals in the innovation process and the point at which sustainability goals are attributed to the innovation (or not) during the process. At present, innovation associated with sustainability at the WaSC in question can be more closely associated with the 'search and discovery pathway' five, where sustainability is attributed retroactively after the innovation process.

> *"Yeah I'm not saying that but I don't think it's a driver in terms of what comes into our asset standards. I think cost is and I'm not so sure sustainability is at the moment. I think we get sustainability as a secondary benefit wherever we can and I'm not saying that we don't diminish that but it's not a driver at the moment."*

This finding corresponds to Thomas and Cave's assertion that WaSCs have barely begun to institute sustainability principles. Moreover, Brown and Farelly's (2009) review of the literature on barriers to sustainable urban water management (SUWM) identified both poor organisational commitment and a lack of will as barriers to the adoption of sustainable practices in 25% of SUWM.

The research findings also suggest that the perceived performance gap between existing policies at the WaSC and the performance required to meet the principles of the Five Capitals Model varied from principle to principle and across capitals. Principles associated with human, social and financial capitals were perceived, on balance, as well managed by the WaSC, and principles associated with natural capital and infrastructure as less well or under-managed. Those sustainability capitals and principles that were well managed were strongly represented in the WaSC's vision and objectives. These findings indicate that the WaSC's existing policy coverage is not comprehensive in its management of principles of sustainability, and that existing policy influenced the perception of effective management of the corresponding sustainability principles.

The Cave Review (2009) and Thomas and Ford (2006) both suggested that innovation in UK WaSCs tended to focus innovation towards service measures rather than the environment. Thomas and Ford (2006) suggest that key areas of the environment, and social and technical need, were not being addressed in the 'innovation pipeline' of water, and they argue that the regulatory system is unable to drive innovation in these areas of societal need.

The findings of this research project suggest that there is a relationship between the innovation process and the policy visions and goals expressed by the WaSC and that the scope of sustainability embodied in those policy goals will influence the scope of innovation. For process innovation stage two, the 'new sustainability policy principle and vision' are compared to the existing practices in order to identify opportunities for innovation. This comparison is a crucial factor in determining the scope of innovation opportunities identified by the research because it is by adopting a comprehensive set of sustainability principles, that sustainability is understood and sustainability innovations may be identified and potentially adopted.

Innovation stage three, termed, 'developing innovation proposals', seeks to find innovations compatible with the existing practices, roles, responsibilities and resources. This stage found that the cost of the innovation process and outcome influences the innovation adoption decision, as does the innovation process relationship to chronological opportunities, such as contracts and restructuring events.

Innovation stage four, termed 'Decision for adoption/ rejection', found that both technical and administrative innovations were evaluated in terms of cost, and that technical innovations were more highly concerned with risk to service provision than administrative innovations. In this case, three sustainability KPIs were adopted and integrated into the existing KPI framework (administrative innovation). No technical innovations were adopted, even in conditions where risks to service were low.[10]

[10] The research suggests that administrative innovations are more easily adopted by a WaSC than technical innovations, a finding that Thomas and Ford (2005) suggest is entrenched in a culture of technical conservatism in the water sector in the UK. However, this research project was not designed to

7.2 *What factors influence a WaSC's selection and uptake of sustainability innovations?*

The research findings in response to research question 'B' identified thirteen factors that influenced the adoption of sustainability innovations and their relationship to the adoption decision (See Figure 30 below).

The opportunities for sustainability innovation adoption increased when: the sustainability impacts were recognised as a WaSC concern (typically identifiable as a regulatory commitment or the organisation leadership's vision, policy, mission and goals); when the innovation could demonstrate cost and service advantages at limited risk; and when the innovation closely approximates the organisation's existing roles and responsibilities, practices skills and expertise. Conversely, the likelihood of innovations being adopted was reduced if: the innovation was perceived to increase costs; the innovation conflicted with the organisation's existing strategy; the innovation was not compatible with the available resources (knowledge, skills, operational maintenance and financial), or the innovation was not compatible with the established roles and responsibilities in the WaSC (see Figure 30). Finally, the relationship of the innovation to time-bound events of the WaSC, such as AMP periods and contracts, was found to either reduce or increase the likelihood of innovation adoption.

These findings are discussed below and are compared with the findings of previous research into innovation in organisations and innovation in the water sector in particular.

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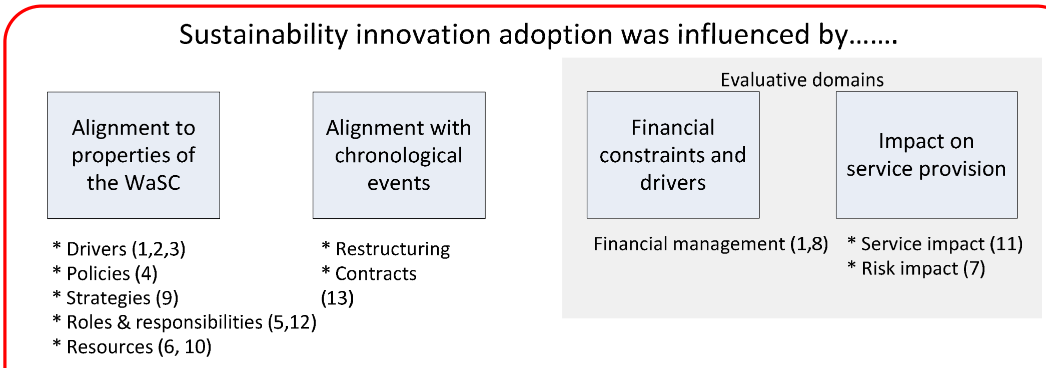
evaluate this issue so the suggestions, though supported by the literature, are not accounted for in this research methodology.



Opportunities for sustainability innovation adoption were increased when :

1. The sustainability innovation was perceived to reduce cost.

2. Market forces exert a cost pressures on the WaSC that are aligned with principles of the sustainability innovation.

3. Regulatory framework incentives and penalties are aligned with principles of the sustainability innovation.

4. Policy, vision and goals of the WaSC aligned with principles of the sustainability innovation.

5. Leadership with decision making authority is aligned with sustainability innovation (p).

6. Resources were allocated made available for the development of sustainability innovations (p).

7. Validation expert research was demonstrated to support innovation proposal.

Opportunities for innovation adoption were reduced when :

8. The sustainability innovation was perceived to increase costs.

9. The innovation strategy conflicted with the strategies of the business process

10. The resources (knowledge, skills, operational, maintenance, financial etc) requirement of the innovation and the resource allocated/ and or available to the WaSC was mismatched.

11. Technical innovations targeted changes in assets critical to service delivery. (critical assets: treatment process (critical), distribution (critical common)

12. Roles & responsibilities of the organisation were broached

Opportunities an barriers to innovation adoption were influenced by:

13. The barriers and opportunities to innovation adoption are not constant and are influenced by the relationship of the innovation process timing to the restructuring and contract making events.

Domain

* Principal research finding for elements of domain (p- innovation process)

Figure 30 Influences on sustainability innovation selection and adoption and how these relate to the domains and elements of the conceptual map AIM.

This research found that perceived or expected costs, or cost benefits, influenced the WaSC's adoption of sustainability innovations. Anderson and Narus (2004) found that economic incentives for innovation adoption should exceed the alternatives. This view is also supported by Rogers (2003), who describes economic advantage as one dimension of a *relative advantage*. *Relative advantage* is '*the degree to which an innovation is perceived as better than the idea that it supersedes'* (Rogers 2003, p229). Afuah (2003) notes that having recognised the potential of an innovation, that demonstrates economic advantages, an organisation still must find the finance to put together a team and formulate strategies to exploit those innovation opportunities. More specifically to the water sector, Thomas and Ford (2006) state that ' *innovation fails to interest water companies until it offers significant commercial and strategic benefits*' (Thomas and Ford 2006, p.57). They proceed to warn that as a result of this focus on economic considerations, future strategic benefits can be overlooked. This research project suggests only those sustainability innovations in which there was a clear and recognised opportunity for cost saving were selected for adoption. Where there was the perception that additional cost burden may result from innovation adoption, this was expressed as a barrier to innovation adoption. In the case of operational KPIs, the research demonstrated that even innovations that are selected on the basis of generating cost advantages may not be selected for adoption. The research suggests that the selection of sustainability innovations will favour adoption of those innovations that can generate clear cost advantages at minimal disruption to the existing ways of working.

The organisational context, or the WaSC environment, is also able to influence the perceived relative economic advantage. The research identified that market-based cost pressures and the regulatory framework have an influence on the perceived relative economic advantage of the sustainability innovations. These factors can either augment or reduce the perceived economic advantages of the proposed sustainability innovations. Sustainability innovations that fail to meet these conditions are less likely to be adopted by the WaSC. These findings are substantiated in the literature, which suggests that sustainability concerns can manifest as pressures on societies and cost pressures to a WaSC, such as pressures from population growth, climate change, water and energy demand (Cosgrove and Rijsberman 2000; SIWI. 2005; DEFRA 2008; UNESCO

2009; Gleick and Palaniappan 2010). The literature also explores the role that the regulator plays in framing or generating the conditions which enable sustainability innovation adoption (Legge 2000; Smith, Stirling et al. 2005; Cashman and Lewis 2007; APPWG 2008; Cave 2009; Spiller 2010). The findings from this research project suggest that progress towards sustainability will therefore centre on innovations that benefit from, or align with, strong market forces and or align to the regulatory reward and or penalty system.

These findings suggest that in order to encourage sustainability innovations that do not currently have a clear cost driver, it is important to consider mechanisms which place the sustainability principle (or WaSC-related impacts) into the economic decision. One example of such an initiative is carbon emissions trading, currently being ‘rolled out’ to support the UK’s carbon reduction commitments (Prescott 2009). Similarly, triple bottom line accounting is also being encouraged (Kenway, Howe et al. 2007). However, these mechanisms may still fail to alter decision outcomes if the monetised value does not justify a change in practice. For example, the Stern review (2008) stated that with the social cost of carbon at £25 per ton the additional cost burden will not alter water utility infrastructure investment decision making (Sarwar 2008; Palmer 2010).

Another means of monetising the impact of sustainability innovations is through direct penalties (e.g. for pollution events). The WaSC’s regulatory framework not only influences behaviour through penalties, but also uses incentives and rewards. The regulator should therefore ensure it is incentivising behaviours that enable the adoption of sustainability innovations. Such penalties and incentives frameworks are very powerful as the WaSC aligns its structure, targets, resources and responsibilities to maximise its opportunities to capitalise on incentives and avoid penalties (assuming that the incentives and penalties are significant in the economic decision).

In terms of the relationship between the innovation and the properties of the WaSC, the research identified a number of factors that influenced the selection and adoption of sustainability innovations. The research demonstrated that the alignment of leadership vision and policies to the sustainability principles had an impact on which principles were incorporated into WaSC decision making. The findings, that leadership (Romanelli and Tushman 1994; Eisenbach, Watson et al. 1999; Poole and van de Ven 2004; Tidd, Bessant et al. 2005), shared vision (Jick, Kanter et al. 1992; Kotter 1996; Burton Swanson and Ramiller 1997; Lueke 2003; Tidd, Bessant et al. 2005), *compatibility* with existing values (Rogers 2003; Tidd, Bessant et al. 2005) and/ or perception of management support (Leonard-Barton and Deschamps 1988) are supported by the academic literature. This suggests that a realignment of leadership visions and policies to incorporate principles perceived as poorly managed will support sustainability change processes.

Such realignment may be achieved rapidly only through transformational change that discards existing frameworks and practices and implements new policies and visions, referred to as 'second generation organisational development (OD) approaches'(Seo, Putnam et al. 2004). Another method is 'third generation OD approaches', which allow past orientation and frameworks to play a role in the change by re-orienting the existing policies, a change event referred to by Nadler (1989) as 'organisational frame bending'.

Again, the literature suggests that a WaSC would benefit from improved long term vision (Thomas and Ford 2005), and from steering innovation towards societal needs rather than being driven by short term commercial goals (Thomas and Ford 2006). This current situation is perpetuating incrementalism in the UK water sector, which persists in investing only in the bare minimum to conform to regulations; an investment strategy that, as Heather and Bridgeman (2007) note, could result in the wrong assets long term.

The adoption of sustainability innovations is also influenced by the match between the requirements needed to support the innovation – in terms of resources, expertise, roles and responsibilities – and the adoption strategy. The research demonstrated that when the characteristics of the innovation departed from those of the WaSC it was a barrier to the selection and adoption of sustainability innovations.

In terms of knowledge resources, these findings are borne out in the innovation and organisation literature, which suggests that more radical innovations can result in 'frame-breaking', requiring the organisation to abandon institutional logic and behaviours (Tushman and Romanelli 1985), and that technical innovation may either build on existing competencies and skills or may render those competencies obsolete (Tushman and Anderson 1986). According to Cohen and Levinthal (1990), this prior knowledge-related experience enables an organisation to innovate and/or exploit innovation opportunities. Damanpour (1991) relates the knowledge type to the innovation type or form; in this case technical knowledge resources to facilitate the adoption of technical innovations, and 'specialisation' (the availability of specialist knowledge) to improve innovation adoption. Innovation adoption is understood, therefore knowledge dependent, and to be a process of acquiring or creating, knowledge. This means that in order to acquire innovations, the organisation must always be in a process of learning (Senge 1992).

Similarly, Brown and Farelly (2009) found a lack of expertise and skills to be a barrier to the adoption of SUWM. Heather Cruickshank argues that, as a result of sustainability considerations, engineers need to '*embrace a range of additional skills beyond the engineering science they have traditionally relied upon to solve engineering problems*' (Heather J. Cruickshank 2007, p.111).

In a recent paper on the adaptation to climate change Berkhout (2006) argues that the adaptation approach is shaped by existing core competencies, which suggests that knowledge can act as a barrier and that existing knowledge resources will dictate future decisions. Zahra and George (2002) use the term 'absorptive capacity' of an organisation, referring to the availability of an organisation to relevant skills, knowledge and resources to recognise and exploit innovation opportunities. They suggest this consist of four knowledge capabilities: acquisition, assimilation, transformation and exploitation.

In accordance with existing research, this study demonstrates that innovation adoption will favour areas where there is pre-existing expertise and knowledge, and that innovation adoption is less likely if the WaSC does not have access to the relevant knowledge capabilities. Under these conditions, the WaSC will have to invest in relevant knowledge to enable innovation adoption in areas where there is not pre-existing expertise and practices.

The research findings also suggest that the availability of human or labour resources influenced the adoption of the sustainability innovations, and that those innovations that were perceived to require additional resources in administration or support were less likely to be adopted. A finding substantiated by the existing literature, and is termed by Damanpour as 'slack resources', which are the resources (all resources) available to embed and maintain the innovation within the organisation (Damanpour 1991). Corroborating the findings of this research: that making resources available to sustainability innovation will influence its adoption.

The likelihood of sustainability innovation adoption was also diminished if the proposed innovations were perceived to transgress the existing organisational structure of the organisation, or deviated from pre-existing responsibilities. Again, these findings seem to resonate with the existing literature, which suggests that bureaucratic structures (typical of mechanistic organisations) work well in stable environments, but that organic structures - where employees are given greater freedoms in determining their tasks, roles and responsibilities - are better suited to cope with innovation and change (Mintzberg 1979; Damanpour 1991). While an organisation will require both these qualities (Tushman and O'Reilly 3rd 1999), different periods may demand a different balance between mechanistic and organic roles and responsibilities (Tushman and O'Reilly Iii 1996). Brown and Farelly found that for SUWM responsibilities and unclear roles were a barrier to adoption. In a simpler water manager context (asset investment), sustainability adoption requires adaptation or change to the existing roles and responsibilities. Damanpour (1990) refer to the ease with which an organisation can modify and adapt organisational routines and behaviours in response to external drivers of change as 'Organicity'.

The facility to adopt innovation and change has also been referred to as 'adaptive capacity' (Staber and Sydow 2002) or 'dynamic capabilities' (Teece, Pisano et al. 1997). Organisations with these qualities will allocate resources and manage their organisational structure in order that they can reconfigure themselves rapidly in changing environments. Organisations with these qualities rather than more rigid structures are likely to be better able to adopt sustainability innovations.

The current study found that existing roles and responsibilities were a barrier to innovation adoption. It suggests that sustainability innovations may often require a WaSC to redefine its roles and responsibilities, a process which would require justification through sufficient buy-in. The research findings suggest that innovation adoption would have been more likely had the WaSC benefited from greater adaptive capacity and organicity.

Adoption of innovations was inhibited also, when the proposed innovation ran contrary to the existing strategy. Verloop and Wissema (2004) describe the matching of the innovation strategy to the business strategy as a 'toll gate' to evaluate whether the innovation should proceed. Additionally, Tidd et al (2005) note that if an innovation proposal '*does not fit with the existing ways of seeing then it has a very poor chance of entering let alone surviving in the strategic portfolio'* (Tidd, Bessant et al. 2005, p.408). This can also be understood as an aspect of the *compatibility* of values, norms and fit with past experiences. Strategy is causally connected to past events and experiences (Thomas and Ford 2005).

The values norms and strategies that have been developed through the interpretation of past experiences (Daft and Weick 1984) may signal either a correct or an incorrect interpretation of causal relationships (Levitt and March 1988). Frambrach, suggests that *'by reducing the risks associated with early adoption of an innovation, including implementation (use) risk, financial risk and operation risk, the adoption of an innovation can be stimulated' (Frambach and Schillewaert 2002, p.166)*. Rogers (2003) refers to *trialability* as an innovation characteristic that can influence adoption; an innovation that can be trialled can confirm or refute perception about the innovation and its adoption impacts. Organisational culture influences the way organisations respond to risk (Berkhout, Hertin et al. 2006), and many authors believe that UK WaSCs have adopted risk averse behaviours and strategies, which they will need to depart from in order to effectively tackle sustainability (Thomas and Ford 2005; Cave 2009; Cave 2010).

This research found that the WaSC under investigation had adopted a risk-averse strategy for technology innovation, which reduced the opportunity for innovation to critical assets. This suggests that where the WaSC, through its past experience of innovation has become risk-averse, sustainability innovation will favour non-critical assets. However, where innovation is targeting critical assets, activities that reduce the perceived risk to the WASC will facilitate adoption. This study suggests that sustainability innovation to critical assets will be slow and will only occur in conditions of limited uncertainty.

In this highly risk averse culture, the collection of relevant research and data to inform decision makers is increasingly important. The research identified a demand for data to help reduce uncertainty with regards to adoption impacts and to begin to build experience knowledge that would lead to understanding within the WaSC and a higher propensity for adopting sustainability-related innovations. There is clearly a need for WaSCs to gain access to more and improved sustainability-related data. Arguments have been made for data on benchmarking the best of sustainability (Thomas and Ford 2005), for broadening the currently narrow range of data used in decision making (Ashley, Blackwood et al. 2008) for moving reporting data into the decision making framework (Palme and Tillman 2008), and for expanding existing tools to accommodate more data needs (Prescott 2009).

Two key aspects of the process of sustainability innovation further influenced the adoption of sustainability innovations. These were: a reduction in the barriers to adoption when the innovation was supported by an alignment between leadership with decision-making authority, coupled with the authority to allocate resources. Both these observations are supported by the literature. Klein and Knight (2005) suggest that both management support and financial resources 'enhance the likelihood of successful implementation' and that without demonstrable management support employees will tend to believe that the innovation is a passing fancy. Klein and Sorra (1996) note that in order to generate a strong implementation climate for innovation adoption, managers must throw their weight behind groups favouring adoption. The successful allocation of resources is a requisite of research and development (Tidd, Bessant et al. 2005), and/or the availability of slack resources (Damanpour 1991). Brown et al (2006, p.416) identify political support as *'necessary for promoting organisational change by redistributing funding, facilitating broader community awareness and maintaining professional and organisational momentum for innovation*'. Similarly, support from champions within the WaSC has been identified as crucial to innovation successes (Thomas and Ford 2005; Brown, Sharp et al. 2006).

Early Water UK sustainability indicators included dedicated management responsibilities. This indicator was later removed as the WaSC argued that the indicator was of no value. In contrast, these findings suggest that sustainability innovation adoption would be improved by aligning the responsibilities of managers with decision-making authority with sustainability goals, as well as making financial resources available for investment in sustainability innovations.

Finally, the barriers and opportunities to innovation adoption are not fixed and are influenced by the relationship of the innovation process timing to restructuring and contract-making events. A number of authors have identified different ways in which timing can influence innovation. Orlikowski and Yates (2002) suggests that people, draw on temporal structures which they both shape and are shaped by. Temporal structures are patterns of event through time, for example quarterly reporting to scheduling work through a week. They suggest that well-established temporal structures may require explicit force to challenge. Tyre and Orlikowski (1994) suggest that the innovation process is subject to '*fits and starts',* and also that the value of innovation is not likely to be constant. Moreover, Rogers (2003) suggests that through time the cost of entry for innovations into a market place is not constant. A number of authors also seek to explain innovation by a confluence of conditions which includes time (Lutz, Meyer et al. 2007) relating both to the internal and environmental innovation support requirements that enable innovation to take place (Kanter 1988; Geels 2002; Sartorius and Zundel 2005; Adner 2006). Specifically the '*Transitions'* literature, which is useful for guiding innovation from a systems perspective, and guiding governance for innovation or sociotechnical systems transitions.

The UK WaSCs are subject to annual and five-year asset management cycles, which punctuate a series of contract and reorganisation opportunities that the WaSC will undertake in preparation of the next five-year cycle. Similarly, various interdepartmental restructuring and reorganising processes, which are carried out at various intervals also present themselves as periods of innovation opportunity or barriers. Thomas and Ford (2006) note that the time scale of AMP periods could be experienced as either a ‘weak barrier’ or a ‘strong enabler’, and the Cave Report (2010) suggests that the AMP periods are often too short to allow sufficient time for some piloting requirements. Thomas and Ford (2006) also suggest that the contract strategies (i.e. partnering commitments relating to the supply of technical information) may be a barrier to external innovation opportunities. While investment commitments (in cost and type) made by the WaSC with the regulator and the engineering partners are windows of opportunity to lock in innovation, when closed, they provide a barrier to innovation. In these analyses, sustainability innovation adoption can be determined by these rhythms of restructuring events and contracts and the timing of the innovation in relation to these chronological events.

The following section presents the research conclusions.

8 Conclusions

By comparing a comprehensive set of sustainability principles to the management practices and policies of the WaSC the research found that, for the WaSC under consideration, the management of sustainability principles in organisational policies and practices was uneven. The performance gap (in policy and practice) was most apparent for the principles associated with natural capital and infrastructure capital. Well-managed sustainability principles, such as human, social and financial capital, correlated with the stated visions, policies, goals, and objectives of the WaSC. This indicates that the alignment of a WaSC's stated visions, policies, goals, and objectives will encourage the adoption of related innovations, and that, in turn, will improve the management of these sustainability concerns.

The research suggests that the impact of sustainability on infrastructure assets varies in the degree and types through their life cycle, and that not all infrastructure types are subject to the same barriers to innovation. Technical innovations to assets that were perceived as critical to the provision of services were subject to greater barriers to innovation than non-critical assets. Adoption decisions for technical innovations were mostly concerned with risks to service and cost impacts. For administrative innovations, the adoption decision was dominated by cost concerns and concerns over the impact on existing roles and responsibilities.

The selection and adoption of sustainability innovations was limited to those that provided a clear cost advantage for the WaSC, which could be rapidly realised and immediately recognised. Selected innovations would therefore typically benefit from alignment to strong market forces, also be subject to an amplification of the cost advantages through the regulatory framework. Furthermore, sustainability innovation adoption also favoured conditions where the WaSC had established roles, responsibilities, skills or work tasks and had accrued knowledge and understanding closely associated with the innovation. Finally, innovation propositions would benefit if they satisfied the WaSC's cautious risk position.

The conditions described above suggest a skewed selection and uptake of sustainability innovation adoption, which favours a set of innovation opportunities limited by the WaSC's policies and goals, the innovation cost advantages, chronological opportunities and the perceived risks to service associated with the innovation. Furthermore, rather than driving innovation, respondents believed that sustainability was attributed most often retroactively, after the innovation process had taken place. In these circumstances, the outlook is bleak for a WaSC to generate any radical improvements to the sustainability performance through the adoption of sustainability innovations.

To reformulate these findings into a useful framework for action, described below are the changes that could be made to the WaSC to improve its ability to adopt sustainability innovations.

8.1 *What changes would assist the WaSC in adopting sustainability innovations?*

The research suggests that the following alterations to the WaSC would reduce the barriers to sustainability innovations and thereby improve the adoption:

Identify sustainability principles that are comprehensive in coverage and far-reaching. The research found that identifying sustainability principles is a necessary step in the development and comprehension of a perceived performance gap between the WaSC's ambitions and its practice.

Embed sustainability ambitions in the policy, goals, vision and objectives of the WaSC. The research identified a link between the WaSC's policies, vision and goals and its practices and that the early stages of sustainability innovation are influenced by the WaSC's stated or (understood) policy goals, visions and sustainability rhetoric.

Delegate sustainability responsibilities to managers who should support the principles of the innovations by seeking sustainability innovation. Sustainability innovation adoption was shown to be influenced by the support of managers and alignment with responsibilities. This may be achieved by appointing new leaders for sustainability, identifying champions and leaders around the WaSC, or incorporating sustainability into the managements systems.

Market sustainability commitments would ensure that employees of the WaSC and their partners cultivate a culture of commitment to sustainability-centred innovations and are therein more inclined to engage with sustainability innovation opportunities. At the time of the research, the WaSC employees had no clear understanding of what sustainability meant, furthermore, they were convinced that it was not a commitment of the WaSC. This perception of the WaSC's commitment influenced the innovation opportunities developed.

Acquire relevant data, to support decision-making. The research demonstrated that the WaSC could not make informed decisions because much sustainability-relevant data was not available to the WaSC or was not being collected. Incorporating new sustainability frameworks into decision making for a WaSC would necessitate new forms and types of data. The WaSC should be able and prepared to support and accommodate sustainability data.

Develop relevant knowledge resources in related to data expertise, skills and training to generate the required understanding in order to:

a) acquire and synthesise sustainability-related data
b) transform assimilate and exploit sustainability related data

The research showed that in contexts where the WaSC had experience and familiarity with the management of related data, sustainability opportunities for innovation were improved. Investing in skills to interpret sustainability data would reduce uncertainty and thus would increase the pace of innovation. It is also important to identify EPO and knowledge support that have strong and relevant expertise.

Adaptability ensures that the roles and responsibilities and the organisational structure are flexible and able to incorporate sustainability innovations. The research found that sustainability innovations could transgress the WaSC division of roles and responsibilities, however, these structures were a barrier to sustainability innovation.

Allocate financial resources to the development and support of sustainability innovations. The research suggested that the perceived cost impact of the sustainability innovations influenced the selection of the innovations and the types of innovation opportunities explored. Thus, making finance available to sustainability innovation would reduce these barriers.

Allocate human resources to the development and support of sustainability innovations. The research suggested that the availability of human resources (with expertise) encouraged WaSC managers to seek to seek to exploit those resources, and thereby encouraged identification of sustainability innovation opportunities. Therefore, the WaSC would benefit from making available human resources for sustainability innovation.

Remove or overcome chronological barriers to ensure that AMP periods and contracts do not dictate the pace of innovation. The research demonstrated that the timing of the innovation with chronological events, such as contracts and restructuring events, influence innovation adoption. The WaSC must maintain mechanisms to ensure contracts do not become barriers to sustainability innovation. Efforts should also be made to ensure that investment commitments made to the regulator, or between the WaSC and the EPO, do not obstruct opportunities for sustainability innovations.

Risk management rather than risk aversion would maximise opportunities for success by matching knowledge and operational support requirements to the innovation requirement, and framing innovations that do not meet the performance requirement as an opportunity to learn. The research demonstrated that a long history of negative sustainability innovation experience has increased barriers to innovation. A WaSC might want to employ strategies that reduce risk when innovating, for example, sharing risk exposure by embarking on collaborative research with other WaSCs, the EPO or the regulator.

The aim of the research was to facilitate the selection, development and proposal of sustainability innovations in order to evaluate innovations with respect to the factors that influence the innovation process and outcome. In accordance with these aims, the research has inductively generated a model of the factors that influence water sector innovation adoption. Crucially, the sustainability innovations were purposefully generated while the researcher was embedded in the business.

Identifying the constituents of this process provided insights into how a WaSC generates sustainability innovation opportunities (see Table 27), and resulted in the development of the AIM model. The innovation model developed has a specific descriptive power, as it captures the prevalent concerns during the adoption of innovation. The AIM model can be used to categorize multiple data points in the innovation process, to enhance understanding of the innovation process, and to locate potential problems or opportunities in the innovation process. Figure 28, above, present thirteen factors that influence the selection and adoption of sustainability innovations in the WaSC. As a result, the research project recommends eleven ways in which the WaSC should adapt in order to improve the likelihood that sustainability innovations will be adopted. While the findings of this research are supported by the existing organisation and innovation literature, they highlight factors which have not previously been proven to influence the innovation process for WaSC's. Furthermore, the research identifies a number of influences which, though discussed in the literature, have not yet been empirically demonstrated. These include AMP and contract-making events held within the AIM model domain 'chronological opportunities'.

The findings of this research therefore make a valuable contribution to a growing body of literature concerned with encouraging innovation in a UK WaSC. The research responds directly to calls for a water and sustainability research agenda which is 'grounded in an operational and practice-based assessment of change involving direct interaction and observation'.

The main beneficiary of this research project is the WaSC, within which all findings have been disseminated (Brown, Ashley et al. 2011, p.4047). The WaSC benefit directly from the innovation process and the resultant innovations, as well as all from all the key findings of the research. The work is also relevant to those water sector stakeholders - such as other WaSCs, engineering firms, academics and water sector regulators and customers – who are interested in promoting the uptake of sustainability innovations within WaSCs. The following section discusses the limitations of the research and to what extent the findings of the study may be applicable to UK WaSCs in general.

8.2 Study Limitations

This study employs an inductive research strategy whereby generalisations are formulated from an analysis of the data without selection or preference, and are then tested. Rather than relying on statistical relationships to infer causal relationships, this method depends on immersion in the narrative provided by the data about the research subject and its operational environment. The researcher was able to identify those factors that influence innovation adoption by a detailed knowledge of the research subject and maintaining an open form of enquiry. The researcher examined the outcomes of three case studies within the capital delivery department of a UK WaSC and recorded the narratives of WaSC employees, specifically those responsible for the delivery of capital infrastructure.

A number of research findings on innovation in the UK water and sewerage sector suggest that WaSCs differ in their approach to innovation adoption and research and development. Thomas and Ford (2005) stated that innovation practices are ‘not uniform’ across the sector and, what is more, the Cave Report (2009, p11) identifies variation in R&D spend across WaSCs from zero to point six percent of turnover, which could represent an annual outlay ranging from zero to over five million pounds. This suggests diversity in both the capacity and the appetite for innovation.

The WaSC that was studied in this research is one of the largest, in terms of both total spend and the percentage of turnover attributed to R&D, and would be considered one of a group of major UK WaSCs. To take one example, Clark et al. (2000) demonstrated that stated motivations for the adoption of aluminium-based polyelectrolyte for four major water WaSCs was varied. Furthermore, these motivations for adoption were not readily predictable. They conclude that: ‘understanding the diversity of motivations and perceptions which characterise individual organisations’ operational experience is central to managing the adoption process. It is through an understanding of these nuances of perception that variations in preference for adoption will be revealed’ (Clark, Jeffrey et al. 2000, p.255).

These findings suggest that the results of the current research may be applicable only to a limited extent outside the context of the capital delivery unit of the particular WaSC involved in this study. It may be the case that the findings, though generalizable, are nuanced. However, we will not know how, or to what extent, the findings are nuanced until a similar study is undertaken on a number of other UK WaSCs.

However, it is likely that the factors that have been identified will, in some way, be applicable across those WaSCs that are committed to sustainability innovation activities. However, the relative importance of each domain, and its prevalent component categories, will be influenced and nuanced by each organisation's norms and logic.

The research suggests that the WaSC's policy position on sustainability plays a significant role in forming the innovation outcome. The outputs of this thesis pertain to a specific period during which a WaSC adopted the rhetoric which re-frames its responsibilities in terms of sustainability, but is only just beginning to incorporate those responsibilities into practice. The findings are therefore not time-bound but are relevant so long as the water sector is challenged to adopt new goals and ambitions that necessitate further innovation adoption.

8.3 Recommendations for Further Research

The research project identified a number of additional research concerns related to influences on the adoption of sustainability innovations for WaSC.

- How do the relative influence of factors from the AIM conceptual map and the uptake of sustainability innovations differ between UK WaSCs?
- How do the relative influence of factors from the AIM conceptual map and the uptake of sustainability innovations differ between private and public WaSCs?
- How does the selection of sustainability principles influence the type and quantity of innovations opportunities identified and those adopted?
- How does the selection of sustainability principles influence the sustainability performance that can be leveraged by the innovation opportunities adopted?
- What costs risks and benefits associated with the selective sustainability concerns are expressed by narrow framed sustainability policy?
- How do UK WaSC normative or institutional logic differ, and how does that difference manifest itself in the strategies and activities of the WaSCs?
- How does variation in UK WaSC institutional logic influence sustainability innovation outcomes?
- How does the sustainability innovation portfolio differ between WaSCs with clear and comprehensive sustainability policies to those with unclear or few stated policies?
- How does the evolution of sustainability WaSC incrementalism differ to radicalism?
- Which administrative sustainability innovations are most able to affect sustainability performance of technical infrastructure?

9 REFERENCES

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard Business Review* 84(4): pp.98-107.

Afuah, A. (2003). Innovation management : Strategies, implementation and profits. New York ; Oxford, UK, Oxford University Press.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50(2):pp. 179-211.

Alasuutari, P., Bickman, L. and Brannen, J. (2009). The sage handbook of social research methods. London, UK, SAGE.

Alegre, N., Jeffrey, P., Mcintosh, B., Thomas, J. S., Hardwick, I. and Riley, S. (2004). Strategic options for sustainable water management at new developments: The application of a simulation model to explore potential water savings. *Water Science and Technology*. 50**:**pp. 9-15.

Anderson, J. C. and Narus, J. A. (2004). Business market management : Understanding, creating and delivering value. Upper Saddle River, NJ ; USA, Pearson Prentice Hall.

Anderson, N., De Drew, C. K. W. and Nijstad, B. A. (2004). The routinization of innovation research: A constructively critical review of the state-of-the-science. *Journal of Organizational Behavior* 25(2):pp. 147-173.

APPWG. (2008). The future of the UK water sector. [online] available from: http://www.water.org.uk/home/news/press-releases/appwg-sector-report/appwg---inquiry-report---the-futue-of-the-uk-water-sector---formatted----1-april.pdf [accessed; 19/09/2011]

Armenakis, A. A. and Bedeian, A. G. (1999). Organizational change: A review of theory and research in the 1990s. *Journal of Management* 25(3):pp. 293-315.

Armenakis, A. A. and Harris, S. G. (2009). Reflections: Our journey in organizational change research and practice. *Journal of Change Management* 9(2):pp. 127-142.

Ascher, W. (2006). Long-term strategy for sustainable development: Strategies to promote far-sighted action. *Sustainability Science* 1(1): pp. 15-22.

Ashley, R., Blackwood, D., Butler, D., Jowitt, P., Davies, J., Smith, H., Gilmour, D. and Oltean-Dumbrava, C. (2008). Making asset investment decisions for wastewater systems that include sustainability. *Journal of Environmental Engineering* 134(3):pp. 200-209.

Ashley, R. M., Booker, N., Smith, H. and Sustainable Water Industry Asset Resource Decisions, P. (2004). Sustainable water services : A procedural guide. London, UK, IWA.

Balasubramaniam, A. and Voulvoulis, N. (2005). The appropriateness of multicriteria analysis in environmental decision-making problems. *Environmental Technology* 26(9): pp. 951-962.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs; London, UK, Pearson Prentice-Hall.

Baumgartner, R. J. and Ebner, D. (2010). Corporate sustainability strategies: Sustainability profiles and maturity levels. *Sustainable Development* 18(2):pp. 76-89.

Beck, M. B. and Speers, A. (2006). 2nd IWA leading-edge conference on sustainability. London, UK, IWA.

Bedeian, A. G. (1984). Organizations: Theory and analysis: Text and cases. Hinsdale, Ill.USA, Dryden Press.

Bell, S. and Morse, S. (1999). Sustainability indicators: Measuring the immeasurable? London, UK, Earthscan.

Bellagio. (2011). The bellagio principles [online] available from: http://www.Iisd.Org/pdf/bellagio.Pdf [accessed; 19/09/2011].

Berkhout, F., Hertin, J. and Gann, D. (2006). Learning to adapt: Organisational adaptation to climate change impacts. *Climatic Change* 78(1): 135-156.

Blaikie, N. (2007). Approaches to social enquiry. Cambridge, UK, Polity Press.

Brown, L. E., Mitchell, G., Holden, J., Folkard, A., Wright, N., Beharry-Borg, N., Berry, G., Brierley, B., Chapman, P., Clarke, S. J., Cotton, L., Dobson, M., Dollar, E., Fletcher, M., Foster, J., Hanlon, A., Hildon, S., Hiley, P., Hillis, P., Hoseason, J., Johnston, K., Kay, P., Mcdonald, A., Parrott, A., Powell, A., Slack, R. J., Sleigh, A., Spray, C., Tapley, K., Underhill, R. and Woulds, C. (2010). Priority water research questions as determined by uk practitioners and policy makers. *Science of The Total Environment* 409(2):pp. 256-266.

Brown, R., Ashley, R. and Farrelly, M. (2011). Political and professional agency entrapment: An agenda for urban water research. *Water Resources Management*:pp. 1-14.

Brown, R. R. and Farrelly, M. A. (2009). Delivering sustainable urban water management: A review of the hurdles we face. *Water Science Technology* 59(5): 839-846.

Brown, R. R., Sharp, L. and Ashley, R. M. (2006). Implementation impediments to institutionalising the practice of sustainable urban water management. *Water Science and Technology* 54(6-7):pp. 415-422.

Bryman, A. (2008). Social research methods. Oxford, UK, Oxford University Press.

Burke, W. W. (2011). Organization change: Theory and practice. Los Angeles, SAGE.

Burke, W. W. and Litwin, G. H. (1992). A causal model of organizational performance and change. *Journal of Management* 18(3): 523-566.

Burton Swanson, E. and Ramiller, N. C. (1997). The organizing vision in information systems innovation. *Organization Science* 8(5):pp. 458-474.

Butler, D. and Memon, F. A. (2006). Water demand management. London, IWA.

Cabrera Jr, E., Ellison, D., Olivier, D., Redaudd, J. L. and Rorhofer, K. (2009). ISO 24500 standards as a support tool to manage assets. *Strategic Asset Management of Water Supply and Wastewater Infrastructures*: 123.

Caldwell, R. (2001). Champions, adapters, consultants and synergists: The new change agents in hrm. *Human Resource Management Journal* 11(3):pp. 39-52.

Camison-Zomoza, C. S., Lapiedra-Alcamã-, R., Segarra-Cipres, M. and Boronat-Navarro, M. (2004). A meta-analysis of innovation and organizational size. *Organization Studies (01708406)* 25(3):pp. 331-361.

Capello, R. (2002). Spatial and sectoral characteristics of relational capital in innovation activity. *European Planning Studies* 10(2):pp. 177-200.

Carson, R. (1962). Silent spring. London, UK, Penguin Books in association with Hamish Hamilton, 1999.

Cashman, A. and Lewis, L. (2007). Topping up or watering down? Sustainable development in the privatized uk water industry. *Business Strategy & the Environment (John Wiley & Sons, Inc)* 16(2):pp. 93-105.

Cave, M. (2009). Independent review of competition and innovation in water markets: Final report (cave review). Ergon House, Horseferry Road, London, UK**:** 144.

Cave, M. (2010). Changing course. Delivering a sustainable future for the water industry in England and Wales, UK, Sever Trent Water.

Charter, E. (2000). The earths charter c/o university for peace, p.O.Box138 6100, san josé, costa rica [online] available from: http://www.Earthcharterinaction.Org/invent/images/uploads/echarter_english.Pdf [accessed: 19/09/2011].

Child, J. (1972). Organizational structure, environment and performance: The role of strategic choice. *Sociology* 6(1):pp. 1-22.

Clapp, R. W., Jacobs, M. M. and Loechler, E. L. (2008). Environmental and occupational causes of cancer new evidence, 2005–2007. *Reviews on Environmental Health* 23(1): pp.1-37.

Clark, T., Jeffrey, P. and Stephenson, T. (2000). Complex agendas for new technology adoption in the uk water industry. *Technovation* 20(5):pp. 247-256.

Clegg, S., Hardy, C. and Nord, W. R. (1996). Handbook of organization studies. London, UK, SAGE.

Cohen, W. and Levinthal, D. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35(1). pp. 128-152.

Connell, D. W. (1999). Introduction to ecotoxicology, London, UK, Wiley-Blackwell.

Cooke, P., Gomez Uranga, M. and Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy* 26(4-5):pp. 475-491.

Cooper, R. B. and Zmud, R. W. (1990). Information technology implementation research: A technological diffusion approach. *Management Science* 36(2):pp. 123-139.

Coopey, J., Keegan, O. and Emler, N. (1998). Managers' innovations and the structuration of organizations. *Journal of Management Studies* 35(3):pp. 263-284.

Corbin, J. M., Strauss, A. L. and Strauss, A. L. B. O. Q. R. (2008). Basics of qualitative research : Techniques and procedures for developing grounded theory. Thousand Oaks, Calif., Sage Publications, Inc.

Cosgrove, W. J. and Rijsberman, F. R. (2000). World water vision : Making water everybody's business. London, UK, Earthscan.

Crossan, M. M. and Apaydin, M. (2010). A multi-dimensional framework of organizational innovation: A systematic review of the literature. *Journal of Management Studies* 47(6):pp. 1154-1191.

Cruickshank, H. J. (2004). Embedding the concepts of sustainable development into practical civil engineering. School of civil engineering. Cambridge, UK, Cambridge University**:** p**.** 254.

CST (2009). Improving innovation in the water industry: 21st century challenges and opportunities.[online] available from: http://www.bis.gov.uk/assets/bispartners/cst/docs/files/whats-new/09-1632improving-innovation-water-industry.pdf [accessed: 19/09/2011].

Czarniawska-Joerges, B. (1997). Narrating the organization : Dramas of institutional identity. London, UK, University of Chicago Press.

Daft, R. L. (1995). Organization theory and design. Minneapolis/St. Paul, USA, West.

Daft, R. L. and Becker, S. W. (1978). The innovative organization : Innovation adoption in school organizations. New York; Oxford, UK, Elsevier; Distributed by Thomond Books.

Daft, R. L. and Weick, K. E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review* 9(2):pp. 284-295.

Damanpour, F. (1991). Organizational innovation: A meta-analysis of effects of determinants and moderators. *Academy of Management Journal* 34(3):pp. 555-590.

Damanpour, F. (1996). Organizational complexity and innovation: Developing and testing multiple contingency models. *Management Science* 42(5):pp. 693-716.

Damanpour, F., Walker, R. M. and Avellaneda, C. N. (2009). Combinative effects of innovation types and organizational performance: A longitudinal study of service organizations. *Journal of Management Studies* 46(4):pp. 650-675.

Dambrin, C., Lambert, C. and Sponem, S. (2007). Control and change--analysing the process of institutionalisation. *Management Accounting Research* 18(2):pp. 172-208.

Davila, T., Epstein, M. J. and Shelton, R. D. (2006). Making innovation work : How to manage it, measure it, and profit from it. Upper Saddle River, N.J., USA, Wharton School Pub.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 13(3):pp. 319-340.

Davis, F. D. (1993). User acceptance of information technology: System characteristics, user perceptions and behavioral impacts. *International Journal of Man-Machine Studies* 38(3):pp. 475-487.

Defra. (2002). Sustainable Development. [online] available from: http://www.sd-commission.org.uk/presslist.php/40/defras-sd-strategy [accessed: 19/09/2011]

DEFRA (2002) *Directing the flow : priorities for future water policy,* [online] available from: http://archive.defra.gov.uk/environment/quality/water/strategy/pdf/directing_the_flow.pdf [accessed: 19/09/2011] London, Department for Environment, Food and Rural Affairs.

DEFRA (2007) conserving biodiversity the UK approach 2007. Nobel House, 17 Smith Square, London SW1P 3JR. [online] available from: http://www.defra.gov.uk/

publications/files/pb12772-conbiouk-071004.pdf [accessed: 19/09/2011], UK biodiversity partnership

DEFRA (2008) *Future water: the Government's water strategy for England*. [online] available from: http://archive.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf [accessed: 19/09/2011], TSO.

Denscombe, M. (2003). The good research guide for small-scale social research projects. Maidenhead, Open University Press.

Denzin, N. K. and Lincoln, Y. S. (2005). The sage handbook of qualitative research. Thousand Oaks ; London, UK, Sage Publications.

DETR. (1999). Sustainable development : A strategy for sustainable development in the UK. Retrieved 15 September, 2011, from http://www.sustainabledevelopment.gov.uk/publications/uk-strategy99/summary.htm [accessed: 19/09/2011],

Great Britain, Department of the Environment, Transport and the Regions.

Donaldson, L. (1995). American anti-management theories of organization: A critique of paradigm proliferation. Cambridge, UK, Cambridge University Press.

Doppelt, B. (2003). Leading change towards sustainability: A change-management guide for business, government and civil society. Sheffield, UK, Greenleaf.

Dreborg, K. H. (1996). Essence of backcasting. *Futures* 28(9):pp. 813-828.

EA. (2001). Water resources for the future: A strategy for Thames region. Bristol, Environment Agency.

EA (2007). Hidden infrastructure: The pressure on environmental infrastructure. Bristol, Environment Agency: 17 p. [online] available from: http://publications.environmentagency.gov.uk/PDF/GEHO0307BMCD-E-E.pdf [accessed: 19/09/2011], Environment Agency.

Edwards, A. R. (2005). The sustainability revolution: Portrait of a paradigm shift, Philadelphia, USA, New Society Publishers

Eisenbach, R., Watson, K. and Pillai, R. (1999). Transformational leadership in the context of organizational change. *Journal of Organizational Change Management* 12(2):pp. 80-88.

Eisenhardt, K. and Graebner, M. (2007). Theory building from cases: Opportunities and challenges. *The Academy of Management Journal ARCHIVE* 50(1):pp. 25-32.

Ellis, J. B., Deutsch, J. C., Mouchel, J. M., Scholes, L. and Revitt, M. D. (2004). Multicriteria decision approaches to support sustainable drainage options for the treatment of highway and urban runoff. *Science of The Total Environment* 334-335: pp. 251-260.

Enid, M. (2001). Advice for an action researcher. *Information Technology & People* 14: pp. 12-27.

Epstein, M. J. (2008). Making sustainability work: Best practices in managing and measuring corporate social, environmental and economic impacts. Sheffield, Greenleaf.

EU. (2005). EU (draft) declaration on guiding principles for sustainable development. [online] available from: http://eurlex.Europa.Eu/lexuriserv/site/en/com/2005/com2005_0218en01.Pdf [accessed;19/09/2011].

Fagerberg, J., Mowery, D. C. and Nelson, R. R. (2005). The Oxford handbook of innovation. Oxford, UK, Oxford University Press.

Fenner, R. A., Ainger, C. M., Cruickshank, H. J. and Guthrie, P. M. (2006). Widening engineering horizons: Addressing the complexity of sustainable development. *Engineering Sustainability* 159(ES4):pp. 145-154.

Forum for the Future (FFF) (2011). Forum for the future five capitals model london forum for the future [online] available from: http://www.Forumforthefuture.Org/sites/default/files/images/forum/projects/fivecapitals/the%20five%20capitals%20model.Pdf [accessed:19/09/2011].

Fichter, K., Pfriem, R. and Lehmann-Waffenschmidt, M. (2007). Leading innovations to sustainable future markets. Innovations towards sustainability. Lehmann-Waffenschmidt, Netherlands, Physica-Verlag HD:pp. 103-116.

Fishbein, M. and Ajzen, I. (1975). Belief, attitude, intention, and behavior: An introduction to theory and research. London, UK, Addison-Wesley.

Flick, U., Kvale, S., Angrosino, M. V., Barbour, R. S., Banks, M., Gibbs, G. and Rapley, T. (2007). The sage qualitative research kit. London, UK, SAGE.

Foxon, T. J., Mcilkenny, G., Gilmour, D., Oltean-Dumbrava, C., Souter, N., Ashley, R., Butler, D., Pearson, P., Jowitt, P. and Moir, J. (2002). Sustainability criteria for decision support in the uk water industry. *Journal of Environmental Planning and Management* 45(2):pp. 285-301.

Frambach, R. T. and Schillewaert, N. (2002). Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research. *Journal of Business Research* 55(2):pp. 163-176.

Furco, A. (2002). A comparison of traditional scholarship and the scholarship of engagement. Promoting civic engagement at the University of California: Recommendations from the strategy group on civic and academic engagement. In Anderson J. & Douglass, J. A. E. A., Berkeley, CA, USA: Center for Studies in Higher Education. **:** 10.

Garcia, R. and Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: A literature review. *Journal of Product Innovation Management* 19(2):pp. 110-132.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy* 31(8-9):pp. 1257-1274.

Gibson, R. B. (2005). Sustainability assessment: Criteria and processes. London, UK, Earthscan.

Gibson, R. B. (2006). Beyond the pillars: Sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision-making. *Journal of Environmental Assessment Policy & Management* 8(3):pp. 259-280.

Giddens, A. (1979). Central problems in social theory: Action, structure and contradiction in social analysis. London,UK, Macmillan.

Given, L. M. (2008). The sage encyclopedia of qualitative research methods. London, UK, SAGE.

Gleich, A. (2007). Innovation ability and innovation direction. Innovations towards sustainability. Lehmann-Waffenschmidt, M., Physica-Verlag HD**:** p.141-153.

Gleick, P. H. and Palaniappan, M. (2010). Peak water limits to freshwater withdrawal and use. *Proceedings of the National Academy of Sciences* 107(25):pp. 11155-11162.

Gopalakrishnan, S. and Damanpour, F. (1997). A review of innovation research in economics, sociology and technology management. *Omega* 25(1):pp. 15-28.

Grbich, C. (2007). Qualitative data analysis : An introduction. London, UK, SAGE.

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P. and Kyriakidou, O. (2004). Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Quarterly* 82(4):pp. 581-629.

Gunderson, L. H. and Holling, C. S. (2002). Panarchy: Understanding transformations in human and natural systems. London, UK, Island Press.

Hage, J. and Meeus, M. T. H. (2006). Innovation, science, and institutional change. Oxford, UK, Oxford University Press.

Hall, R. H. (1987). Organizations : Structures, processes, and outcomes. London, UK, Pearson Prentice-Hall International.

Hanover. (2000). Hanover principles. [online] available from: http://www.Hannover.De/data/download/lhh/umw_bau/energie/download_sustainable_hannover/hannover_principles.Pdf [accessed on: 19/09/2011].

Heather, A. I. J. and Bridgeman, J. (2007). Water industry asset management: A proposed service-performance model for investment. *Water and Environment Journal* 21(2): pp.127-132.

Heather J. Cruickshank, R. A. F. (2007). The evolving role of engineers: Towards sustainable development of the built environment. *Journal of International Development* 19(1):pp. 111-121.

Hobsbawm, E. J. (1987). The age of empire, 1875-1914. London, UK, Weidenfeld and Nicolson.

Hodge, B. J. and Anthony, W. P. (1988). Organization theory. London, UK, Allyn and Bacon.

IPCC (2007). Climate change 2007: The physical science basis: Summary for policymakers. Paris, [online] available from: http://www.ipcc.ch/SPM2feb07.pdf [accessed: 19/09/2011], IPCC Secretariat.

Jabareen, Y. (2004). A knowledge map for describing variegated and conflict domains of sustainable development. *Journal of Environmental Planning and Management* 47(4):pp. 623-642.

Jaffee, D. (2001). Organization theory: Tension and change. London, UK, McGraw Hill.

Jick, T., Kanter, R. M. and Stein, B. (1992). The challenge of organizational change: How companies experience it and leaders guide it. New York, USA, Free Press.

Jick, T. D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly* 24(4):pp. 602-611.

Jonsson, A. (2000). Tools and methods for environmental assessment of building products - methodological analysis of six selected approaches. *Building and Environment* 35(3): 223-238.

Kanter, R. M. (1988). When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organization. *Research in Organizational Behavior* 10: pp.169-223.

Karahanna, E., Straub, D. W. and Chervany, N. L. (1999). Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. *MIS Quarterly* 23(2):pp. 183-213.

Kenway, S., Howe, C., Maheepala, S., AWWA Research Foundation. and CSIRO Land and Water. (2007). Triple bottom line reporting of sustainable water utility performance. Denver, USA., AWWA Research Foundation: American Water Works Association ; IWA Publishing.

Kettinger, W. J., Teng, J. T. C. and Guha, S. (1997). Business process change: A study of methodologies, techniques, and tools. *MIS Quarterly* 21(1):pp. 55-98.

Klein, K. J. and Knight, A., P. (2005). Innovation implementation: Overcoming the challenge. *Current Directions in Psychological Science* 14:pp. 243-246.

Klein, K. J. and Sorra, J. S. (1996). The challenge of innovation implementation. *Academy of Management Review* 21(4): pp. 1055-1080.

Kotter, J. P. (1996). Leading change. Boston, USA, Harvard Business School Press.

Lam, A. (2004). Organizational innovation, London, Brunel research enterprise. [online] available from: http://www.brunel.ac.uk/2146/brese/docs/lam_wp1.pdf [accessed: 19/09/2011].

Leavitt, H. J. (1965). Applied organizational change in industry Handbook of organizations. . March, J. G. New York, USA, Rand McNally**:** pp. 1144-1170.

Legge, D. (2000). The sustainability of the water industry in a regulated environment. *Journal of Environmental Law* 12(1):pp. 3-20.

Leonard-Barton, D. and Deschamps, I. (1988). Managerial influence in the implementation of new technology. *Management Science* 34(10):pp. 1252-1265.

Levitt, B. and March, J. G. (1988). Organizational learning. *Annual Review of Sociology* 14:pp. 319-340.

Lewis-Beck, M. S., Bryman, A. and Liao, T. F. (2004). The sage encyclopedia of social science research methods. London, UK, SAGE.

Logic, N. (2010). Sustainable business: A declaration of leadership. [online] available from: http://www.Natlogic.Com/wp-content/uploads/2010/02/naturallogic_declarationofleadership.Pdf [accessed: 19/09/2011].

Lueke, R. (2003). Managing change and transition. Boston, Mass. ,USA, Harvard Business School Press; London, UK, McGraw-Hill.

Lutz, C., Meyer, B., Nill, J. and Schleich, J. (2007). Windows of opportunity for radical technological change in steel production and the influence of co2taxes. Innovations towards sustainability. Lehmann-Waffenschmidt, M., Physica-Verlag HD**:** pp. 3-17.

Lyytinen, K. and Newman, M. (2008). Explaining information systems change: A punctuated socio-technical change model. *European Journal of Information Systems* 17(6):pp. 589-613.

Macdonald, J. P. (2005). Strategic sustainable development using the ISO 14001 standard. *Journal of Cleaner Production* 13(6):pp. 631-643.

Mahdi, S. (2003). Search strategy in product innovation process: Theory and evidence from the evolution of agrochemical lead discovery process. DRUID Winter Conference Korsor, Denmark, JAN 18-20, 2001. UK, Oxford Uinoversity Press, 12**:**pp**.** 235-270.

Maheepala, S., Evans, M., Sharma, A., Gray, S. and Howe, C. (2006). Assessing water service provision scenarios using the concept of sustainability. *2nd IWA Leading-Edge on Sustainability in Water-Limited Environments* 10: 25.

March, J. G., Simon, H. A. and Guetzkow, H. (1958). Organisations. N.Y., USA., Wiley.

Markus, M. L. and Benjamin, R. I. (1996). Change agentry - the next is frontier. *MIS Quarterly* 20(4):pp. 385-407.

Markus, M. L. and Benjamin, R. I. (1997). The magic bullet theory in it-enabled transformation. *Sloan Management Review* 38(2): 55-68.

Marlow, D. and Burn, S. (2009). The inclusion of externalities in asset management decision making. *Water Asset Management International* 5(1):pp. 20-26.

Marlow, D. R. (2011). Sustainability-based asset management in the water sector. Definitions, concepts and scope of engineering asset management. Amadi-Echendu, J. E., Brown, K., Willett, R. and Mathew, J., Springer London. 1**:**pp. 261-275.

Mcniff, J., Lomax, P. and Whitehead, J. (2003). You and your research project. London, UK, Routledge Falmer.

Meadows, D., Randers, J. and Meadows, D. (2005). The limits to growth: The 30-year update. London, UK, Earthscan.

Michael, J. G. (2001). Organizational adoption and assimilation of complex technological innovations: Development and application of a new framework. *SIGMIS Database* 32(3):pp. 51-85.

Mihelcic, J. R., Crittenden, J. C., Small, M. J., Shonnard, D. R., Hokanson, D. R., Zhang, Q., Chen, H., Sorby, S. A., James, V. U., Sutherland, J. W. and Schnoor, J. L. (2003). Sustainability science and engineering: The emergence of a new metadiscipline. *Environmental Science and Technology.* 37(23):pp. 5314-5324.

Mintzberg, H. (1979). The structuring of organizations: A synthesis of the research. Englewood Cliffs; London, Prentice-Hall.

Mintzberg, H. and Westley, F. (1992). Cycles of organizational change. *Strategic Management Journal* 13:pp. 39-59.

Moore, G. C. and Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information system research* Vol 2 (No 3): pp 192-222.

Moulaert, F. and Sekia, F. (2003). Territorial innovation models: A critical survey. *Regional Studies* 37(3):pp. 289-302.

Mumford, E. (1983). Designing human systems - the ethics model. Manchester, UK, Manchester Business School.

Nadler, D. A. and Tushman, M. L. (1989). Organizational frame bending: Principles for managing reorientation. *The Academy of Management Executive* 3(3):pp. 194-204.

Naiman, R. J. (1992). Watershed management: Balancing sustainability and environmental change, New York, USA, Springer Verlag.

Ness, B., Urbel-Piirsalu, E., Anderberg, S. and Olsson, L. (2007). Categorising tools for sustainability assessment. *Ecological Economics* 60(3):pp. 498-508.

Niederl-Schmidinger, A. and Narodoslawsky, M. (2008). Life cycle assessment as an engineer's tool? *Journal of Cleaner Production* 16(2):pp. 245-252.

Nightingale, P. (1998). A cognitive model of innovation. *Research Policy* 27(7):pp. 689-709.

Nooteboom, B. (1989). Diffusion, uncertainty and firm size. *International Journal of Research in Marketing* 6(2):pp. 109-128.

Ofwat (2006). A sustainable water industry : To PR09 and beyond. London, UK, Ofwat.

Ofwat (2010). Delivering sustainable water : Ofwat's strategy : Water today, water tomorrow. Birmingham, UK, Ofwat**:** 40 p.

Oppenheim, A. N. (2000). Questionnaire design, interviewing and attitude measurement. London, UK, Continuum.

Orlikowski, W. J. and Yates, J. (2002). It's about time: Temporal structuring in organizations. *Organization Science* 13(6):pp. 684-700.

Paech, N. and Lehmann-Waffenschmidt, M. (2007). Directional certainty in sustainability-oriented innovation management. Innovations towards sustainability. Lehmann-Waffenschmidt, M., Physica-Verlag HD**:** pp. 121-139.

Palme, U. and Tillman, A.-M. (2008). Sustainable development indicators: How are they used in swedish water utilities? *Journal of Cleaner Production* 16(13):pp. 1346-1357.

Palmer, S. J. (2010). Future challenges to asset investment in the UK water industry: The wastewater asset investment risk mitigation offered by minimising principal operating cost risks. *Journal of water and climate change* 01(01):pp. 17-35.

Pearce, D. W. and Turner, R. K. (1990). Economics of natural resources and the environment. New York ; London, Harvester Wheatsheaf.

Pentland, B. T. (1999). Building process theory with narrative: From description to explanation. *Academy of Management Review* 24(4):pp. 711-724.

Pettigrew, A. M. (1987). The management of strategic change. Oxford, UK, Basil Blackwell.

Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2004). Networking and innovation: A systematic review of the evidence. *International Journal of Management Reviews* 5/6(3/4):pp. 137-168.

Plouffe, C. R., Vandenbosch, M. and Hulland, J. (2001). Intermediating technologies and multi-group adoption: A comparison of consumer and merchant adoption intentions toward a new electronic payment system. *Journal of Product Innovation Management* 18(2):pp. 65-81.

Poole, M. S. (2004). Central issues in the study of change and innovation. In: Poole, M. S. and Van De Ven, A. H.**:** Handbook of organizational change and innovation. *pp* 3-31.

Poole, M. S. and Van De Ven, A. H. (2004). Handbook of organizational change and innovation. Oxford, UK, Oxford University Press.

Porritt, J. (2007). Capitalism: As if the world matters. London, UK, Earthscan.

Prescott, C. (2009). Carbon accounting in the United Kingdom water sector: A review. 60**:** pp. 2721-2727.

Rabl, A. and Peuportier, B. (1995). Impact pathway analysis: A tool for improving environmental decision processes. *Environmental Impact Assessment Review* 15:pp. 421-442.

RAENG. (2005). Engineering for sustainable development: Guiding principles. 3 Carlton House Terrace, london SW1Y 5DG [online] available from: http://www.Raeng.Org.Uk/events/pdf/engineering_for_sustainable_development.Pdf [accessed: 19/09/2011].

Rainey, D. L. (2006). Sustainable business development: Inventing the future through strategy, innovation, and leadership. Cambridge, UK, Cambridge University Press.

Robbins, S. (2007). Essentials of organizational behavior (international edition).New Jersey, USA, Pearson.

Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological Economics* 48(4):pp. 369-384.

Robson (2001). Real world research: A resource for social scientists and practitioner-researchers. Oxford, UK, Blackwell.

Rogers, E. M. (2003). Diffusion of Innovations. New York, USA, Free Press.

Romanelli, E. and Tushman, M. L. (1994). Organizational transformation as punctuated equilibrium - an empirical-test. *Academy of Management Journal* 37(5):pp. 1141-1166.

Romijn, H. and Albu, M. (2002). Innovation, networking and proximity: Lessons from small high technology firms in the UK. *Regional Studies* 36(1):pp. 81-86.

Ruspini, E. (2002). Introduction to longitudinal research. London, UK, Routledge.

Sartorius, C. and Zundel, S. (2005). Time strategies, innovation, and environmental policy. Cheltenham, UK, Edward Elgar.

Sarwar, N. (2008). The carbon reduction commitment (crc): Impacts on the uk water industry, Huddersfield, UK, Huddersfield University

Schmalensee, R., Willig, R. D., Armstrong, M. and Porter, R. H. (1989) Handbook of industrial organization, Amsterdam; North-Holland.

Scott, W. R. (2008). Institutions and organizations : Ideas and interests. London, UK, SAGE.

Scott, W. R. and Davis, G. F. (2007). Organizations and organizing : Rational, natural, and open systems perspectives. Upper Saddle River, N.J, USA, Pearson Prentice Hall.

Seinfeld, J. H. and Pandis, S. N. (2006). Atmospheric chemistry and physics: From air pollution to climate change. Hoboken, N.J., USA, Wiley.

Senge, P. M. (1992). The Fifth discipline: The art and practice of the learning organization, Minnesota, USA, Century Business.

Seo, M. G., Putnam, L. L. and Bartunek, J. M. (2004). Dualities and tensions of planned organizational change. *Handbook of organizational change and innovation*: pp. 73-107.

Shearman, R. (1990). The meaning and ethics of sustainability. *Environmental management* 14(1): pp. 1-8.

Silverman, D. (2005). Doing qualitative research: A practical handbook. London, UK, SAGE.

Simmie, J. (2005). Critical surveys edited by stephen roper innovation and space: A critical review of the literature. *Regional Studies* 39(6):pp. 789-804.

SIWI, (2005) Challenges of Water Scarcity. [online] available from: http://www.siwi.org/documents/Resources/Reports/Challenges_water_scarcity_business_case_study_2005.pdf [accessed: 19/09/2011]

Smircich, L. (1983). Concepts of culture and organizational analysis. *Administrative Science Quarterly* 28(3):pp. 339-358.

Smith, A., Stirling, A. and Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy* 34(10):pp. 1491-1510.

Soanes, C. and Stevenson, A. (2005). Oxford dictionary of English. Oxford, UK, Oxford University Press.

Spiller, M. (2010). EU water policy: Pollution source control by water companies in England and Wales. School of Applied Sciences, Cranfield University, Cranfield University. Doctoral PhD p. 228.

Staber, U. and Sydow, J. (2002). Organizational adaptive capacity. *Journal of Management Inquiry* 11(4): pp. 408-424.

Stern, N. H. (2008). The economics of climate change : The stern review. Cambridge, UK, Cambridge University Press.

Taylor, J. and Mcadam, R. (2004). Innovation adoption and implementation in organizations: A review and critique. *Journal of General Management* 30(1):pp. 17-38.

Teece, D. J., Pisano, G. and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal* 18(7):pp. 509-533.

Thomas, D. A. and Ford, R. R. (2005). The crisis of innovation in water and wastewater. Cheltenham, UK, Edward Elgar.

Thomas, D. A. and Ford, R. R. (2006). Barriers to innovation in the uk water industry. London, UK, UK Water Industry Research.

Thomas, D. A. and Ford, R. R. (2007). Barriers to innovation in the water sector : Output from the project dissemination conference, DTI conference centre december 2006. London, UK, UK Water Industry Research.

Thompson, R. L. and Higgins, C. A. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly* 15(1):pp. 125-143.

Thompson, R. L., Higgins, C. A. and Howell, J. M. (1994). Influence of experience on personal computer utilization: Testing a conceptual model. *Journal of Management Information Systems* 11(1):pp. 167-187.

Tidd, J. (2001). Innovation management in context: Environment, organization and performance. *International Journal of Management Reviews* 3(3).pp. 169-183

Tidd, J., Bessant, J. R. and Pavitt, K. (2005). Managing innovation: Integrating technological, market and organization change. Chichester, UK, John Wiley & Sons.

Tns. (2011). The natural step principles [online] available from: http://www.Naturalstep.Org/en/usa/principles-sustainability [accessed: 19/09/2011].

Todnem, R. (2005). Organisational change management: A critical review. *Journal of Change Management* 5(4):pp. 369 - 380.

Tornatzky, L. G. and Klein, K. J. (1982). Innovation characteristics and innovation adoption-implementation: A meta-analysis of findings. *IEEE Transactions on Engineering Management* EM-29(1):pp. 28-45.

Tukker, A. (2000). Life cycle assessment as a tool in environmental impact assessment. *Environmental Impact Assessment Review* 20(4):pp. 435-456.

Tushman, M. L. and Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative Science Quarterly* 31(3):pp. 439-465.

Tushman, M. L. and O'reilly 3rd, C. A. (1999). Building ambidextrous organizations. Forming your own "Skunk works". *Health Forum journal* 42(2):pp. 20-3, 64.

Tushman, M. L. and O'reilly Iii, C. A. (1996). Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review*(4): pp. 8-30.

Tushman, M. L. and Romanelli, E. (1985). Organizational evolution: A metamorphosis model of convergence and reorientation. *Research in Organizational Behavior* 7:pp. 171-222.

Tyre, M. J. and Orlikowski, W. J. (1994). Windows of opportunity: Temporal patterns of technological adaptation in organizations. *Organization Science* 5(1): pp.98-118.

UK Government, 2003. *Water Act 2003*. Available from: http://www.opsi.gov.uk/acts/acts2003/ukpga_20030037_en_1 [accessed: 19/09/2011]

UK, Water. (2008). Sustainable water state of the water sector report, Water UK**:** 32. Queen Anne's Gate, London SW1H 9BT [online] available from:http://www.water.org.uk/home/policy/publications/archive/sustainability/state-of-thewater sector [accessed: 19/09/2011], Water UK.

UK, Water. (2011). Sustainability indicators 2009/2010. Water UK, 1 Queen Anne's Gate, London SW1H 9BT, Water UK. [online] available from: http://www.water.org.uk/home/search?q=Sustainability+indicators+2009%2F2010&type=and [accessed: 19/09/2011], Water UK.

UN (2004). The ten principles global compact UN New York, USA. [online] available from: http://www.Unglobalcompact.Org/aboutthegc/thetenprinciples/index.Html [accessed: 19/09/2011].

UNESCO. (2009). World water development report. Retrieved [accessed: 19/09/2011].

Van De Ven, A., Angle, H. L. and Poole, M. S. (2000). Research on the management of innovation : The minnesota studies. Oxford, UK, Oxford University Press.

Van De Ven, A. and Poole, M. (2005). Alternative approaches for studying organizational change. *Organization Studies* 26(9):pp. 1377-1404.

Van De Ven, A. H. (1986). Central problems in the management of innovation. *Management Science* 32(5):pp. 590-607.

Van De Ven, A. H. (2007). Engaged scholarship: A guide for organizational and social research. Oxford, UK, Oxford University Press.

Van De Ven, A. H. and Johnson, P. E. (2006). Knowledge for theory and practice. *Academy of Management Review* 31(4):pp. 802-821.

Van De Ven, A. H. and Poole, M. S. (1995). Explaining development and change in organizations. *Academy of Management Review* 20(3):pp. 510-540.

Van Marrewijk, M. and Werre, M. (2003). Multiple levels of corporate sustainability. *Journal of Business Ethics* 44(2/3):pp. 107-119.

Venkatesh, V. and Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences* 39(2):pp. 273-315.

Venkatesh, V. and Davis, F. D. (1996). A model of the antecedents of perceived ease of use: Development and test. *Decision Sciences* 27(3):pp. 451-477.

Venkatesh, V. and Davis, F. D. (2000). Theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science* 46(2):pp. 186-204.

Venkatesh, V., Morris, M. G., Davis, G. B. and Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems* 27(3):pp. 425-478.

Verloop, J. and Wissema, J. G. (2004). Insight in innovation: Managing innovation by understanding the laws of innovation. Amsterdam; London, UK, Elsevier.

Vos, R. O. (2007). Defining sustainability: A conceptual orientation. *Journal of Chemical Technology and Biotechnology* 82(4): pp. 334-339.

Wackernagel, M. and Yount, J. D. (2000). Footprints for sustainability: The next steps. *Environment, Development and Sustainability* 2(1): pp. 23-44.

Ward, K. W., Brown, S. A. and Massey, A. P. (2005). Organisational influences on attitudes in mandatory system use environments: A longitudinal study. *International Journal of Business Information Systems* 1(1-2): pp. 9-30.

Wateruk (2008). Sustainable water, state of the water sector report. Water UK, 1 Queen Anne's Gate, London, UK. [online] available from: http://www.water.org.uk/home/policy/publications/archive/sustainability/state-of-the-water-sector [accessed: 19/09/2011], Water UK**:** 32.

Wateruk (2012). Sustainability indicators 20010/11, Water UK, 1 Queen Anne's Gate, London, UK. http://www. water. org. uk/home/news/press-releases/sustainability-indicators-09-10/sustainability-2011-final. pdf [accessed on 5 January 2012].

WCED (1987). Our common future. Oxford, UK, Oxford University Press.

Weick, K. E. (1995). Sensemaking in organizations. Thousand Oaks; London, UK, Sage Publications.

Wolfe, R. A. (1994). Organizational innovation: Review, critique and suggested research. *Journal of Management Studies* 31(3): pp. 405-431.

WWF. (2008). One planet living. [online] available from: http://www.Oneplanetliving.Org/index.Html [accessed: 19/09/2011], Godalming, UK.

Zahra, S. A. and George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*: pp. 185-203.

Zaltman, G., Duncan, R. and Holbek, J. (1973). Innovations and organizations. New York; London, UK, Wiley-Interscience.

Zmud, R. W. and Armenakis, A. A. (1978). Understanding the measurement of change. *Academy of Management Review* 3(3): pp. 661-669.

Computer Software

Nvivo, version 8 & 9 (2011). QSR International Pty Ltd.

10 APPENDIX

10.1 Annex A. Participant Consent Form

Cranfield UNIVERSITY

School for Applied Science

PARTICIPANT CONSENT FORM

Please tick each box to confirm that you have read and understood each section of the form:

I, ________________________________ (please print your name in block capitals) confirm that I have volunteered to participate in the interview. ☐

I understand that the discussions will be audio recorded and transcribed for analysis. The analysis will only be used with the 'Sustainability Appraisal Project' funded by the EPSRC, Cranfield University, and the WaSC and for no other purposes. ☐

I understand that the audio recordings and transcriptions will be stored at Cranfield University in accordance with the Data Protection Act (1998). The data recording will be deleted subsequent to transcription, the transcriptions will be stored. ☐

I understand that my confidentiality and anonymity and the confidentiality and anonymity of my organisation are assured. It will not be possible to identify any specific individual or organisation from the final output or publications. ☐

I understand that I am free to withdraw from the interview at any stage. I also understand that, as the data is anonymous, it will not be possible to withdraw my data from the research once my contributions have been transcribed. ☐

Publications will be send to you prior printing for approval of correct reflection of your views and prevention of disclosure of potentially harmful information. ☐

If you have any questions about the research, please do not hesitate to ask.
I confirm I have read and fully understand the information provided on this form and therefore give my consent to taking part in this research.
Full name: ___________________________________ Contact number: ________________________

Email address: _________________________
Signature: ___________________________________ Date: _________________
Researcher Contact Detail: Name: Aaron Tanner; Email 1: a.XXXXner@cranfield.ac.uk; Tel: 079426XXXXX

10.2 Annex B. Results of Sustainability Theory Search

The growth of sustainability theory

Sustainability Awareness. Impact	Dimension of Sustainability
(1780 – 1900) The Industrial Revolution. (Hobsbawm 1987). Man's relationship to nature altered through mechanisation of agriculture, industry and transport; international trading of commodities; migration of labour markets from agriculture to industries and across the world; rapid growth in urbanization	* Technical impacts * Economic Impacts * Environmental impact * Social Impacts of development
. (1949) Leopold, A A Sand County Almanac (Ballantine Books ed.,) Aldo Leopold Ecosystem, Health. His view of ecosystems, where the complex interaction between biota maintains balance is now broadly supported by the scientific community,	* Ecosystems health reliant on all organisms. *All biota relevant
1959 Bolding Organizing Growth. Challenge, 8, 3 (Dec.): 31-36. CP IV, pp. 105-112.	* Concerns the limitations of the earth to support the economic growth
1962The book Silent Spring (Carson 1962). Argued that the prevalent technologies of the 40s and 50s, are resulting in unforeseen and unintended consequences and that the technological quick fix approach that continued to prevail, would lead to seriously damaging consequences, advocating a principle now referred to as the precautionary principle.	* Awareness of emissions on human health, * Awareness of emissions on environmental health * Precautionary principle.
(1968). Abbey, E. *Desert Solitaire*. New York: Ballantine Books, it was argued that Model of development advocated and used by high income countries had resulted in significant negative environmental impacts and had it has also largely failed to raise the quality of life for the worlds poor	* Challenges to Economic * Decoupling Growth from environmental degradation * Equity in wealth distribution
(1972). *The Limits to Growth* Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III. . New York: Universe Books. MIT concluded that the world would face severe shortages of food and non-renewable resources by the middle of a 21st-century	* Concerns over natural resource limitations
(1973) Small is beautiful Schumacher, E That economic and development models based around local resources fulfilling local need was a suitable model for socuiety to ensure environmental and socuial goals couls be mere easily met.	* Decentralisation of production and ownership * Small scale

(1974). Grove, N. Oil the dwindling treasure, National Geographic	* Energy (in particular oil) production would not be able to keep up with demand.
1979Gaia Theory Lovelock, James. Views the whole planet as a living organism where all parts (vegetables, animal, minerals, gases play a role in maintaining a balance conducive to life.	*Globalisation of boundaries. *Biota and abiotic relevant * Biodiversity relevance * Maintain and enhance adaptive capacity of environmental systems
(WCED 1987) Development which meets the need of the present without compromising the ability of future generations to meet their own needs'	* Intergenerational equity * Poverty alleviation.
1980s (Seinfeld and Pandis 2006). Discoveries within the field had globalised the system boundaries of pollution and had a significant impact on the sustainability of human activities and the public perception of pollutants in particular	* Emissions result in global impacts * System boundaries and responsibilities expanded to global impacts
(1990). Daly H.E. "Toward some operational principles of sustainable development." *Ecological Economics* 2: 1–6.	*sustainable yield (harvest =/< rate of regeneration); *for non-renewable resources there should be equivalent development of renewable substitutes * waste generation =/< assimilative capacity of the environment
(1991). IUCN/UNEP/WWF "Caring for the Earth: A Strategy for Sustainable Living." "sustainability is improving the quality of human life while living within the carrying capacity of supporting eco-systems",	* Living off natural capital (strong sustainability)
1992 Natural capital and sustainable development Costanza, R., Daly, H.E. *Conservation Biology* 6 (1), pp. 37-46 Discusses methodological issues concerning the degree of substitutability of manufacturing for natural capital, quantifying ecosystem services and natural capital, and the role of the discount rate in valuing natural capital.	* Strong sustainability non-substitution of natural capital finite resources.
1995 Great Transitions Stockholm environment Institute Retrieved on: 2009-04-12. Admits that the behvaiour transition required to bring human consumption within sustainable limits requires changes across all levels of	* Large behaviour change required across populations

society and across all contexts.	
(1996)"Wackernagel, Mathis & Rees, William Our Ecological Footprint" (New Society Press) Ecological Foot Print A sustainable assessment technique that uses the overall carrying capacity of the planet as a basis of assessment. Sustainability increased by reducing the gap between carrying capacity of the earth and current capacity used.	* Awareness of the limits to the carrying capacity of the world and the resource use energy use and relative targets for society.
(1996) Dreborg, K.H. Essence of backcasting ***Futures***, 28 (9), pp. 813-828	* Future vision
1997 Smil, Vaclav. Cycles of life: civilization and the biosphere Human impacts on the Earth are demonstrated through detrimental changes in the global biogeochemical cycles of chemicals that are critical to life, most notably those of water, oxygen, carbon, nitrogen and phosphorus cycles	* The preservation of function and balance within nitrogen water oxygen carbon and phosphorous cycles is essential to maintaining civilisation.
(1997) Von Weizsäcker, E.U., Lovins, A.B., Lovins, L.H. ***Factor Four: Doubling Wealth, Halving Resource Use***. London: Earthscan Publications suggestive that development must follow a different path: less resource dependent	* Suggesting new eco form required from future growth
Costanza R et al. (1998). "The value of the world's ecosystem services and natural capital1". *Ecological Economics* 25 (1)	Ecological economist try to place a value on the ecological systems or on the role of some natural resources
Anderberg, S. (1998). "Industrial metabolism and linkages between economics, ethics, and the environment". *Ecological Economics* 24: 311–320. Dematerialisation converting the linear path of materials (extraction, use, disposal in landfill) to a circular material flow that reuses materials as much as possible, much like the cycling and reuse of waste in nature.	* Circular material flows * Bio mimicry
December 1999.European Environmental Bureau. EEB Position on the Precautionary Principle. That proponents of a new potentially harmful technology must show the new technology is without major harm before the new technology is used	* Precautionary principle (Strong)
1999 UK Government’s	*Social progress which

“ensure a better quality of life for everyone now and for future generations to come”. Four key objectives are proposed as the means of achieving this:	recognises the needs of everyone *Effective protection of the environment * Prudent use of natural resources * Maintenance of high and stable levels of economic growth and employment
(2000) Gollier, Christian, Bruno Jullien & Nicolas Treich. "Scientific Progress and Irreversibility: An Economic Interpretation of the ‘Precautionary Principle’", Journal of Public Economics 75(2): 229-253	* Precautionary principle (Weak)
(2000). The Earth Charter Initiative "The Earth Charter." a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace.”	* Human rights *Equity in decisions - Participation and transparency * Economic Justice (equity) * Enabling Peace
(2000). Holmberg, J. and Robèrt, K-H. "Backcasting from non-overlapping sustainability principles – a framework for strategic planning." *International Journal of Sustainable Development and World Ecology* 7 291–308. Retrieved on: 2009-04-01. Robert develops a sustainability model based on the laws of thermo dynamics.	Nature is not subject to systematically increasing: *Concentrations of substances extracted from the Earth's crust; *concentrations of substances produced by society; *Degradation by physical means and, in that society, * People are not subject to conditions that systematically undermine their capacity to meet their needs
(2001) Understanding the Complexity of Economic, Ecological, and Social Systems CS Holling - Ecosystems, - Emphasised the dynamic nature of this balance and the potential for ecosystems to suddenly and irreversibly change under different pressures and perturbations.	* Multiple system interface * Diversity capital of control * Vulnerability of systems to permanent change of state
(2001) *Climate Change 2001: Impacts, Adaptation and Vulnerability* GHG C02 emissions are a global concern will result in	* GHG Emissions * $C0^2$ * Infrastructure vulnerability

climate change. Climate change will stress our current infrastructure: agricultural systems and all infrastructure due to changes in weather patterns. Overwhelming cause of this is the Consumption patterns (particular use of non renewable sources of energy and energy in use).	* Energy use * Consumption patterns
(2005) United Nations General Assembly. Resolution A/60/1, adopted by the General Assembly on 15 September 2005. Resolution of the Three pillars	Integrating of all pillars into decision making Environmental Economic Social

10.3 Annex C. Results of Indicator Search

Author	Objective	Dominant SI framework	Focus	Result	Unit of analysis
UN-CSD	Assessment of adherence to advocated UN sustainability policy.	DoS	Reporting, Comparison, DM	Indicators: 135	Multiple territory
Global Reporting Initiative	Reporting to external or internal groups the corporate performance regarding sustainability	DoS	Reporting, Comparing, CSR	Framework 70 Indicators	Organisation,
Ofwat	To Monitor the efficiency of water and wastewater delivery	TQM	Reporting, Comparison, Benchmarking	Performance inds	Water Utility
SWARD – UK	Develop a methodology to aid complex decision making into water utilities	DoS	Day-to-day DM	Primary & secondary criteria in each dimension to- Inds to- Feeding a DST	Water Utility
UK Government	Regional sustainability	DoS	Regional reporting	46 indicators	Regional
Water UK	Demonstration of sector sustainability understanding	DoS	Sector Reporting	Indicators 37 inds 137 reporting measures	Water Utility UK water industry
TBL AWWA	Assessment of the Triplbe Bottom Line for the utility operations	Dos	SoO Reporting	64 Indicators	Water Utility
EA LCA	Life Cycle Assessment for Waste	Environmental Health	SoO Reporting	21 indicators	Waste in operations
Tillman 1998	-	Activities	Decision Making	27 indicators	Waste water
Balkema 2003	-	Impacts	Decision Making	46 indicators	Domestic water system
Foxon 2002	-	DoS	Decision Making	15 indicators	Water Utility
Muga 2008	-	DoS	Decsion Making	15 indicators	Waste water
Sepa 1999	-	-	-	13 indicators	Environmental objectives
Palme 2004	-	-	Decision Making	14 indicators	Sludge handling
LCA Mistral	-	-	Decision Making	29 indicators	Urban water system
Nicola Piereni	-	-	Decision making	35 indicators	Water utility (developing world)
SPSD Maxwell 2003	-	-	Designing products	43 Indicators	
Markrupolous	-	-	-	22 indicators	Urban water utility
Mayer Sphon 1999	-	-	-	127 indicators	Water supply
Graf et al (1997)	-	-	-	20 indicators	Unsustainability of water management
Braken et al	-	-	Decision Making	36 indicators	sanitation options
Balkema 1998	-	-	Decision Making	72 indicators	water utility treatement options
Balkema 2003	-	-	Decision Making	35 indicators	Technology comparison
Balkema 2002	-	-	Decision Making	40 indicators	Wastewater treatment options
Mistra Karmen 1998	-	-	Decision Making	34 indicators	Water utility options

Mista Hellstrom 2000	-	-	Reporting	43 indicators	Water system management assessemnt
Weigert and Steinberg	-	-	Management	19 indicators	Water resource management
Lundin (1997,1998)	-	-	Assessment	37 indicators	urban water systems
AKWA-2100	-	-		13 indicators	
Nilsson 1995	-	-	Assessment	18 indicators	urban wastewater systems
UKWIR 00EQ(141)	-	-	performance	30 indicators	Utility
UKWIR 08WW(203)	-	-	performance	28 indicators	Water Treatment
LCA simple LIME	-	-	Assessment	27 indicators	material Impacts on environmental and human health
WHO	-	-	Assessment	40 indicators	Water utility

NOTE: CSR= Corporate Social Responsibility, DM= Decision Making, DST=Decision Support Tool, EMS=Environmental Management System, Env=Environment, Econ= economy, HDI= Human Development indicators, inds=Indicators, inst= Institutional, Mgm=management, SoE=State of the environment, SoO=State of the Organisation; TQM=Total Quality Management< PSR= Pressure State Response, DPSIR= Driver Pressure State Impact Response

Source:

10.4 Annex D. Results SI Step 1. Summarised and Thematically grouped

Sustainability statements

- Sustainability is a secondary benefit of some of our activities.
- Sustainability not a driver
- If Asset Standards are not thinking about this now will they later?
- Obviously because sustainability is not a driver for us.
- Sustainability is obviously a driver for us.
- We are willing to improve, though financial incentives.
- It is not sustainability being the main driver,
- We don't yet know impacts of our activities'
- We are still working on getting peoples mindset changed to recycle more.
- I don't think that the WaSC has a detailed LCA understanding.
- Sustainability is not a recognised driver for the WaSC, it is a ancillary benefit of cost saving activities.
- We do not understand how our WaSC can be more sustainable.

Sustainability is not a recognised driver for the WaSC, it is a ancillary benefit of cost saving activities. We do not understand how our the WaSC can be more sustainable.

Regulation statements

- We are constrained by what Ofwat has told us to do
- Planning constrained by regulator.
- WE are constrained by what Ofwat has told us to do and by our customer survey . We are a regulated industry with targets set by Ofwat and aims from customer surveys
- An Ofwat driven thing and they drive us to operate at less than half the consented level our target of EBU to have zero sample failures.
- So again it is kind of over driving on the regulatory, within the regulatory framework we are quite good at driving emissions, if its within regulatory framework or cost driven
- Not looking at what ecosystems do but at what regulation is.
- Regulation being a grey area, the WaSC cannot develop all its recycling routes
- We have used reduction in staff as a means of achieving OPEX budget reductions, to satisfy OFWAT
- Driver should be to have it done before the regulation comes into place.

The regulator at present drives our behaviour and constrains our activities however there is a need to pre-empt future regulation rather than be driven by it

Cost

- cost is the driver not sustainability issues
- sustainable investment is cheaper.

- to lower costs may benefit from considering expensive options that deliver long term gains
- we are investing on a five year cycle
- Should SDS drive costs to matter over longer term 25yr now
- whole life cost, which is generally costed over 40yrs.
- Cost savers are calculated over 4 years
- opportunities for choice occur when we deliver capital efficiencies.
- what way we choose to spend our out performance
- Driven by cost. PR
- the cost of landfills, chemicals, etc. drives our decision-making.
- Resource consumption reduced for cost reduction and efficiencies reasons.
- fiscal penalties conglomerated around performance drive decisions.
- Platelets Innovation was driven by cost
- present day decision making is driven purely by cost (present day)
- materials pumps are typically supplied from the most cost effective source.

We as an organisation tend to focus on short-term investment .rather than long-term impacts. Capex is often preferred over WLC due to marginal difference and clarity of computation, but we do use WLC to determine investment

Process issues

- Some broader aspects of sustainability are present at program level.
- Principles and benefits are rationalized across the business.
- There are a lot of things we don't even measure and don't know what to measure
- Capital schemes will construct without even looking at the carbon footprint or anything like that would not even be a factor.
- All we do is comply with legislation.
- But actually we don't do it we have no idea of what the carbon footprint is of solutions.
- Information on the Carbon footprint is included in BRM+ prioritization.
- Environment ISO14001 where not everyone is committed to it
- Investment tool (BRM) does not take a robust account of positive benefits.

At program level we incorporate carbon and other benefits in the IT decision information support technologies, this practice is not transferred to scheme level to dictate decisions. At scheme level we use cost and few other measures. we have a tendency to rationalising solutions

Energy

- Regulatory drivers for improved discharge water quality have generated massive energy consumption
- Previous investment decisions have left us with a residue or energy intensive technology.
- Regulatory (WQ) Drivers have pushed us away from sustainability in terms of energy use

- We are looking at energy efficiency now due to costs and changes in energy
- We are running energy reduction teams (ASP) to minimise the cost consumption of our assets.
- Energy initiatives have not been driven by sustainability they have been driven by costs.
- We will exceed the regenerative capacity of the ecosystem until we find a way to reduce energy consumption below this level
- We are searching to use less energy by identifying small % efficiencies

Our process is energy intensive we therefore concentrate on identifying small efficiencies, the energy intensity leaves us with a residue of high cost (opex) assets (example site).

Technology selection

- the technology may not be available for ten 10/15 yrs
- our design is outsourced
- we are building new asset standards
- sustainability principles built into asset standards
- If we are not thinking about it now, is there any reason why we would think about it when they are updated?
- safe to say that most of our solutions are end of pipe solutions.
- Tech innovation has burned us in past (reed beds).
- Quality is driving us to end of pipe solutions
- Asset standards is Key
- regulatory levels do not allow implementing different options.
- HS does not influences technology choices
- Difficult to influence 3rd Party activities (nitrates with farmers…).

Asset standards may be crucial point of influence we have found it difficult to find solutions that are not end of pipe. Or build full measure of sustainability measures into our decision making when selecting technology options. WQ dictating solutions

Finance and investment decisions

- Ofwat wants us to be capital efficient, so revenue budgets down. be more profitable if we switched did more maintenance investment and less capital
- Owned by foreign investors requiring slower returns (City bank the majority shareholder of which is the US government after the banking crisis) may mean less drivers for cap efficiency.
- Producing a return on investment within the timescale given by owners limits the timescales for investment returns.
- Investment limited to “hard” delivery of our product and regulatory drivers.
- Investment tool (BRM) does not yet take account of positive benefits of this and does not cost these benefits.
- Period over which Cost Savers have to achieve payback 4 years.
- WLC is calculated across a limited number of aspects.

- WaSC return on investment is derived from income from services therefore desires high service usage.
- WaSC understands its position as a big driver within the local economy.
- We look at things under a rate of return basis (Net beneficial).

There are limitations placed on the financial models used by both regulators and form of ownership, but there are opportunities for change, by extending are cost saver calculations,

Renewable energy

- Renewable generation is set on the payback period.
- We are trying to identify small efficiencies in Carbon.
- Set on break even in terms of carbon neutrality or sustainability
- Renewable energy efforts do not generate enough power for are activities.
- Our energy requirements are met by renewable energy generation activities. (suggested payback for this would be 20 yrs plus)

Reuse

- Maintenance investments come out of revenue and therefore reduce profit.
- SPC was driven off the back off other legislation but we didn’t need to go down that route and that was a company decision to go to look at that root and turn it into a commodity rather than a waste
- About 50% to incinerators 20% or less to SPC’s
- we have yet to make the transition from reactive maintenance to proactive maintenance,

Customers

- Customers’ surveys suggest they are not willing to pay more for environmental benefits.

What the WaSC are doing right

- pollution incidence, where we have set ourselves a target for that which is something that is internally driven
- they have been trying to put schemes that are not regulatory driven but something that can be beneficial to us like planting trees in catchments
- SPC proactively thinking well incineration is not going to be a viable alternative forever so lets start finding viable alternatives routes now rather than wait for the legislation
- if this pyrolisis trial works then there are some incredible benefits,
- Given our sludge phyto-conditioning with sludge going to land as a fertilizer, Id’ say we are good at this.
- We’re encouraged to turn lights and electrical equipment off when they are not in use and have installed taps with the aim of preventing water wastage.

- Glass for sand filters is being researched jointly with a sand filter supplier to give both supplier and customer data on suitability of the material. Currently no financial benefit for using this material
- Do we not have those bricks in water cisterns and also cheap water butts
- Our FOG (Fats Oils and Grease) initiatives swell
- Generate energy (wind, hydro, solar, biomass
- Catchment management program pilot 5yr to prove concept
- Rather big sewerage systems, can we do more flow splitting- have SUDS understanding
- To commercial customers we try and do an audit
- website informs on water saving and leakage detection
- put water coolers in schools so that they don't use bottled water
- won an award for our grey water recycling in our offices
- optimise a bit more with automation and control
- New assets designed to minimize consumption and all remote monitoring and control which saves money reduces time and travel requirements
- 42 days of pay from the receipt of invoice but they have bought it down to 20 odd days to try and help the suppliers in this current climate
- are ahead of the pack in consulting our customers for the willingness to pay surveys
- good attitude towards health & safety
- maximise the calorific value of the sludge you produce
- EAP forum that looks into environmental and sustainable options.

The WaSC are searching for alternatives and have many projects running that do deliver sustainability benefits, although it is not made explicit that they are sustainability

10.5 Annex E. Results SI Step 3. Constraints and Project Requirement

Over all need Process objective:

1. To influence investment selection to maximise the sustainability performance of the assets
2. To reveal the distinction (if any) between the assets the WaSC is replacing and investing in and the best available, and the impacts ion the business of adopting the best available.

Generating Buy In- That motivation for participation is of primary importance to the success of the project. It has been suggested that the most feasible manner in which this can be achieved is with High Level Buy in and representation to motivate/convince both the WaSC employees and partners that engagement with the project is genuinely in the interest of the WaSC.

Process - Any process must play an influencing role and cannot be deterministic about the method and means of adoption of sustainability appraisal tool, as the WaSC contracts does not facilitate this, and therefore participation is on a voluntary basis, and informal processes will not be in ARIS.

Artefacts/tools- Must be a simple to use tool that does not require excessive resource use. Additionally most resources supplied to SM are not used or paid cursory attention (accept contracts).

Information: the WaSC needs comprehension of sustainability and there needs to be a platform to share this comprehension. This understanding must additionally help identify appropriate quantitative measures by investment type/stream/batch.

Roles Understanding

The WaSC Business:

- Does not understand sustainability
- Does not know the sustainability performance of its assets
- Does not know what is best of kind
- Will not commit to sustainability without a business case
- In AM5 the target should be generate business case understanding to allow the business to drive in AMP6
- When we believe in the business case as a business we will go forward and influence our regulators
- Will only buy in to quantifiable evidence
- Likes using simplified indexes like risk matrices

The WaSCW Team:

- Need to understand sustainability,
- Need to be motivated to engage,
- Need inducement,
- Must believe the business is committed to sustainability and this project or they will not engage or be reluctant participants
- Need to be trained in the project
- Need to be briefed on sustainability
- Need to hear from High in the business to believe as this goes against understanding and traditional behaviours.

Partners:

- Need to understand sustainability,
- Need inducement, Need to be motivated to engage,
- Must believe the business is committed to sustainability not wasting there time and money.
- Need to believe there is some fringe benefit to them in assisting us in this project as time is volunteered.
- Need to be trained in the project: Need to be briefed on sustainability
- Many partners will have a greater understanding than us but we never receive that knowledge: Ideas get dropped and lost to the WaSC, as partners believe that they are not good fit to the WaSC.
- Business challenge awards, convey to partners.
- Designers will have the best idea of what is available and what is best –they are our target for sourcing sustainability understanding

Others

- The Business Case is meant not just for the WaSC but ultimately will need to be spread to influence: Customers, Ownership, Ofwat Perspective, EA, DWI, all stakeholders.

Process findings

Roles and responsibilities Training Skills Required

- The WaSC needs to be trained in the project
- The WaSC needs to be trained sustainability understanding.
- Partners need to be trained in project brief and understand The WaSC vision and sustainability ambitions
- The researcher not the The WaSC team should play the role in the core team to push sustainability

Artefacts required

- No IT based solutions as we are miles off it and this is a small pilot

- Training and soft processes preferred
- A shared Best practice statement and booklet seems to achieve this- but needs to demonstrate high level business backing
- Need for a document that follows and traces the understanding and change this as a record.
- That results be conveyed in a simple matrix or are easy to read and quantifiable
- Must be simple easy to use for partners as much as possible reliant on data that partner is contractually obliged to submit – Where not notional understanding is shared
- The ref doc should brief on the sustainability, disaggregate sustainability, identify or make access to some quantifiable measures
- Identify and share appropriate measures and methods of calculation
- *Present off peg documents are not used so why would a new one be adopted*

Project Scope

- Should be trailed on one or two batches
- Not Reservoir safety
- Suggest AGT EBU and CW – Avoid Reservoir safety & Networks

Information needs

Sustainability:

- Sustainability Best practices
- Our sustainability impacts
- Our current position
- The ideas we are missing
- What is the business case for adopting sustainability

Process Efficacy

- Is the system functioning if so why if not why
- How to improve

Resources required

- This is a soft and volunteered process you will have to A soft document would work no IT based solutions as we are miles off it.
- Time for teams for training
- Time from Designers and partners for interviews
- Time in delivery team meetings
- Communications--spruce up document make it look good to brief them

Broader reflections (user Requirement Motivations

- Need motivation of all
- This needs influence from the highest level possible

Constraints

- The contract nor ARIS stipulates no form of Optioneering it may be a myth that Optioneering takes place
- Any additional work undertaken by the partner that is above the minimum required by the contract is a potential comp event

Future Project Demands

- That the formula for engagement be simple not being dependent on the researcher in the future- therefore must be implemented in future without researcher by core team or relevant role within the area.
- Data capture must be simple and quantifiable not using lengthy interviews etc
- That the project could grow to across a whole stream before it then grows across the whole business
- Findings feed into Asset Standards and Engineering Spec or to RD for further investigation and generation of a business case.
- Business excellence awards- sustainability? For partners and The WaSC Or KPMs (too late)

10.6 Annex F. WaSC Policy SCVP +

	Aspirations	SCVP WaSC Policy Objectives	Sustainability Principles
SERVICE +	We provide a quality of service which is significantly better than any other UK utility	• Our service never fails • We always meet our commitments • We always keep our customers informed • Where we can we always resolve the problem to the customer's satisfaction	IC.1
	We always, always consider the customer's point of view	• We always treat the customer the way we would want to be treated ourselves • We provide a personalised service to all our customers • We recognise the specific needs of our business customers • We always understand each customer's contact history and previous issues • We always design our service processes 'outside in'	
	Dealing with us is enjoyable	• We have recognised and eliminated all causes of customer frustration • Our people are committed to and enthusiastic about delivering the customer experience	
	We are trusted	• We always do what we say we'll do when we say we'll do it • As a company we are always straight forward, open and honest	
	We achieve 100% compliance with legal & regulatory obligations	• We provide the best tasting, highest quality water in the UK • Everyone always recognises the quality of our water	
COMPLIANCE +	We achieve 100% compliance with legal & regulatory obligations	• We move to No 1 spot for **every** compliance measure • We eliminate all pollution incidents and prosecutions are a thing of the past	
	We go beyond compliance when we believe the benefit exceeds the cost	• We always comply and where it is good business we do more than we need to • We always meet new standards ahead of time • We are the best business in the environment	SC.3
	We proactively conserve and enhance the environment	• We treasure and protect all our SSSI's • We have more green projects every year • We are the most energy efficient water company • We are recognised for the quality of our environmental expertise • We lead the way on bio diversity	NC. 1 NC, 10
	We enjoy a constructive relationship with our regulators and stakeholders	• We have the best relationship in the UK with all our regulators and environmental stakeholders • Everyone has open access to our easily understood environmental records • We're good neighbours in everything we do • We're proud of the appearance of all our sites	SC.11
PEOP	All our people are proud to work for and act as ambassadors for	• We are all proud to say we work for the WaSC, but we are never arrogant • Our business values guide everything we do • We all understand and are committed to the direction the	

	the company	WaSC is taking • We all know how our contribution connects to business success • We all view the WaSC and what it does in terms of 'I' and 'We' not 'Them' and 'They' • We are always prepared to learn from others	
	We are recognised as a great place to work	• We all feel that our views and ideas are listened to, respected and acted upon • Work is challenging and stretching and we aim to get the best from each other • We all feel we get a fair deal and a good work life balance • We have an excellent working environment • We have zero accidents	HC.1 HC.7 HC. 9 SC.4
	We attract, develop and retain the best people	• We always have the right people in the right roles • People from every background want to work with us • We have a diverse and talented workforce that truly represents the communities we serve • We have high expectations of our people • Because our reputation is excellent, our people are sought after	HC.3 HC.4 HC.6
	We always celebrate success	• We all know our personal contribution is valued • Celebration and recognition come naturally to us • We are always realistic about our achievements, but we never undervalue them	
PARTNERS	We continuously listen and talk to service providers to achieve win/win	• Our service partners see us as the best client - we see service partners as leading edge partners • We have excellent two way communications at all levels • Service partners processes are open, clear, effective at all levels • Service partners say 'we' and 'us' not 'them' and' they'	SC.10
	Win win means better service, lower cost and healthy profits for all	• Our service partners treat our customers as we would • Our cost of service is clearly lowest in industry • Our service partners consistently meet expected margins	
	We set absolutely clear expectations of service partners	• Our service partners understand precisely what we expect of them and consequences of shortfalls • We share with our service partners our long-term plans and programmes of work • We and our service partners understand what really matters to our respective businesses	
	Our service partners continually bring new ideas to the table Service partners are excellent employers and operate safely	• Year on year the number of shared innovations increase and the cost of service reduces • We work together to ensure that all contracts incentivise innovation • Service partners have best in sector performance and zero accidents • Service partners all have a stated aspiration to be excellent employers	HC.8
S	Society recognises the	• We are recognised as providing excellent value for money • We are recognised for our economic contribution to our	SC.5 SC.6

	value of what we do	operating region • We are recognised for our positive impact on the communities we serve • -Stakeholder advocates speak on our behalf • -Environmental lobby groups are advocates of the WaSC • We are recognised for our positive impact on the environment • We are recognised as a high quality provider of sustainable water and wastewater services	SC.7 SC.8 SC.9
	Our land and reservoirs delight all visitors	• All of our visitors are aware that they have visited the WaSC land and reservoirs and go away with a better • understanding of what the WaSC does • We have exceeded the expectations of visitors • We have an excellent relationship with special consumer interest groups and they are advocates for the WaSC • Our land is open and accessible to all	
	We are a national role model for employee volunteering	• We support and create worthwhile opportunities for our people to volunteer • We celebrate the contribution that our people make to society through volunteering • Stakeholders endorse and showcase the WaSC as a national role model for volunteering	
	the WaSC managers have significant external leadership roles	• We support and create opportunities for our management to take up significant external leadership roles. • Participation in key external leadership roles is recognised as a key personal performance development • objective for senior managers	
	We have strong personal relationships with regional leaders at all levels	• We have a strategic, planned and effective programme of meetings and events with regional leaders at all levels	
	We have a strong influence on matters related to water	• We have a meaningful dialogue with water policy makers and influencers at all levels • We monitor and track key water industry issues and influence where appropriate	SC.9
VALUE +	We are outperforming regulatory and other key financial targets	• We are the most efficient company in the water industry for operating costs and capital expenditure • We provide the best dividend performance of any WASC • We are all proud of our ability to deliver more for less initiatives year on year • We are recognised for our world class use of technology and best practise in delivering efficiencies	FC.1 FC.2
	We are clearly Ofwat's frontier company	• We are Ofwat's frontier company in water and sewerage capital maintenance and operating costs • We have unit costs of construction which are significantly lower than the rest of the industry • The comparative efficiency methodology properly takes account of the WaSC' s excellent performance	FC.3 FC.6

	in PR99 • We all understand the comparative efficiency methodology and what we need to do to be frontier company
Share Price is outperforming the sector and we have an excellent reputation in the city	• Our holding group shares trades at a premium to it's peers • We are recognised in the City as having the best people in the sector • The City recognises the value of our non regulated activities
We have increased our non-regulated services profit and we are the major player in the water contract operations market in the UK	• We will have delivered and built upon the projected profits from our existing non-regulated businesses. • We will have been successful in at least one bid for a large profitable water contract operation in the UK

10.7 Annex G. Conceptual Map: AIM Nvivo coding

Name	Sources	References
Conceptual map of innovation adoption influence	31	2201
Properties of the WaSC	31	1129
Drivers and policy	25	435
Regulator-Goals_targets & requirements	19	226
Ofwat comitments and goals	18	129
service-ability targets	13	53
funding framework	15	41
discharge consents	6	35
Comitments to other regulators	13	73
Carbon reduction comitment	7	15
Health and safety executive	4	14
Planning authorities	6	14
EA abstraction and water resources	2	10
Waste licencing authority	4	9
Highways authoity	4	6
Drinking Water Inspectorate	2	3
European Union regs	2	2
Perceived regulators sustainabilty culture	9	24
Policy	17	129
Policy supports action,strategy,decision etc	11	34
Policy building event action strategy etc	7	18
Policy does not support action,strategy,decision etc	11	16
Environmental Policy	2	11
25 year Direction Statement	4	5
Leadership and management	15	45
Owners	2	3
Customer concerns exctetra	10	22
PR concerns or value	4	13
Roles and responsibilities (work tasks)	26	327
Operation and maintenance	19	106
Operational tasks	15	51
Maintenance of infrastructure	14	33
Standard operating procedure	7	22
Scanning and planning	20	63
Planning	16	38
Research and development	11	21
Scanning	3	4
Influencing activities	12	57
Environmental forum	6	39

Name	Sources	References
Incentives	3	8
KPI KPM	3	6
Capital delivery	18	54
Building and design	16	34
Solution managers	6	20
Reporting	3	8
Resources	27	281
External resources	24	152
Engineering partner organisations	21	116
Suppliers	13	36
Expertise knowledge skills training	22	87
Time, land, human , energy resourses	13	25
Land	6	9
Human	6	8
Time	5	5
Energy	3	3
Behaviour and culture	18	86
Behaviour of WaSC to authorities	14	36
Impact on service provision	27	549
Decision information support tools for risk, service cost plannin	23	256
Data for DIS	19	89
Benchmarking for success and DIS	12	27
Capital delivery DIS	17	35
Investment planning DIS	13	35
Service provision	22	196
Technology infrastructure	21	186
New infrastructure solutions	18	66
Failed infrastucture solutions	9	33
Biological Filter	3	22
Materials	7	21
ASP	6	18
Existing infrastucture	7	17
Pipes	3	6
Precast tanks	2	2
Customer service	5	10
Risk evaluation and attitude	21	97
Financial awards and penalties	23	262
Cost change events	22	131
Cost reduction - event	21	85

Name	Sources	References
Capex cost reduction event	20	51
Opex cost reduction event	12	31
Cost increase event	14	43
Capex cost increase event	10	23
Opex cost increase event	11	20
Cost neutral event	2	3
Financial decision making	21	109
Financial decision making rule	14	33
Income stream development	8	13
Cost Savers rule	6	9
Gain share	4	6
Penalty avoidance event	3	5
Cost attitude	9	15
Market driven event	4	7
Alignment to temporally bound events	22	261
Contracts	21	249
Asset standards	14	53
Engineering specification	12	39
Engineering partners contract	8	26
Framework suppliers contract	3	8
Restructuring events	6	12
Imediate context process influence	4	6