Knowledge mapping for enhancing sustainability in large public sector funded urban redevelopment

Daniel James Gilmour

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This research programme was carried out in collaboration with Dundee City Council

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I certify that this is the true and accurate copy of the thesis approved by the examiners

Signed…………………………… Date……………………………

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Abstract

The thesis describes a programme of research work to develop and apply knowledge mapping and knowledge management techniques to effectively assess and enhance sustainability within urban redevelopment projects. The research programme was initiated in collaboration with Dundee City Council to support sustainable development in a major programme of urban redevelopment. There is limited evidence that the body of knowledge arising from research in sustainable urban development is being holistically integrated within real life decision making practices to operationalise sustainability. Sustainability assessment has the potential to influence decision making and consequently by improving sustainability assessment practice project decision making should be enhanced. In addition, closer integration between assessment and decision making may not only lead to improve decisions, but also to the improved learning of those involved. This can be greatly facilitated by knowledge management, which can be used to understand and then facilitate greater learning amongst stakeholders.

A theoretical framework for the assessment, monitoring and enhancement of sustainability was developed and applied in two parts to a case study, a monitoring component and an enhancement component. As a result of the case study a sustainability assessment and monitoring framework was successfully established for Dundee Waterfront in line with the assessment component of the theoretical framework. The indicators are now used by Dundee City Council at project and departmental level, providing the link across policies, programmes and projects. The key challenge addressed in developing the benchmark indicators was establishing robust governance for the monitoring framework. An enhancement framework was successfully established for Dundee Waterfront in line with the enhancement component of the theoretical framework. Decision mapping and knowledge elicitation techniques were successfully developed and applied to the case study to

identify, key points in decision process, the information decision makers' need and which knowledge objects are being used in decision making.

It is concluded that the knowledge elicitation and mapping approaches applied were effective at identifying both existing processes and knowledge objects used in infrastructure provision. This allowed a Knowledge Map for Sustainability to be developed to identify what information is currently used to influence sustainability and identify future opportunities to enhance practise. The map was effective in capturing the role of each stage in the process towards translating the sustainability vision as proved by user verification. The Map showed for the first time the aspects of sustainability in infrastructure provision and can be used to systematically operationalise sustainable development. However, the use of the map to embed sustainability into learning process could not be verified by practise in the currency of the thesis. A limitation of the case study application is that the integrated sustainability assessment and enhancement framework has been applied in a Scottish local authority context, to an organisation with a Quality Management System and outcome based indicators. These factors have been identified as contributing factors to the success of the sustainability assessment and enhancement framework as applied in the case study. This has the potential to limit the exportability of any findings. However, whilst considering the monitoring component it is recognised that similar outcome based indicators may exist at other local authorities and private organisations. In addition, the knowledge elicitation and mapping technique is an adaptive framework and as such is designed to respond to other organisation structures. Therefore by its nature it should be exportable to other applications. However three main questions remain to be addressed prior to the research question being answered in full. Firstly, uncertainty related to governance and long term use of the framework. Secondly, testing how the Knowledge Map for Sustainability is used in practice and thirdly the exportability of findings from the case study. It is recommended that these limitations be addressed in future work.

Major Outputs

Gilmour D., Blackwood D., Falconer R., Isaacs J. and Taylor A. 2013. A knowledge map of sustainability for urban redevelopment projects. In: Smith, S D (Ed.) and Ahiaga-Dagbui, D D (Ed.), *Proceedings 29th Annual ARCOM Conference, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management.* pp.579–588.

Gilmour D., Blackwood D., Banks I. and Wilson F. 2011. Sustainable development indicators for major infrastructure projects. *Proceedings of the Institution of Civil Engineers - Municipal Engineer*. 164(1): pp.15-24.

Isaacs J., Falconer R., Gilmour D. and Blackwood D. 2011. Enhancing urban sustainability using 3D visualisation. *Proceedings of the Institution of Civil Engineers - Urban Design and Planning*. 164(3): pp.163-173.

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Gilmour D., Blackwood D., Banks L. and Wilson F. 2007. A Sustainability Enhancement Framework for Dundee Central Waterfront Development. In: M Horner, C Hardcastle, A Price, J Bebbington (Eds.), *Proceedings International Conference on Whole Life urban Sustainability and its Assessment*. Glasgow, 2007.

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List of abbreviations

DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department for Environment, Transport and the Regions
COSLA	Convention of Scottish Local Authorities
CCP	Community Planning Partnership
SOA	Single Outcome Agreement
ODPM	Office of Deputy Prime Minister
RTPI	Royal Town Planning Institute
RIBA	Royal Institute of British Architects
CIOB	Chartered Institute of Building
OECD	Organisation for Economic Co-ordination and Development
UNCSD	United Nations Committee for Sustainable Development
UNESCO	United Nations Educational, Scientific and Cultural Organisation
GRI	Global Reporting Initiative
UNDSD	United Nations Division for Sustainable Development
MDG	Millennium Development Goals
SOLACE	Society of Local Authority Chief Executives
KPI	Key Performance Indicators
KDP	Knowledge Disclosure Points
KO	Knowledge Objects
QMS	Quality Management System
DCC	Dundee City Council
CDM	Construction Design Management
SWMP	Site Waste Management Plan

1 Chapter 1 Introduction

1.1 Context for the research

The need for sustainable development of the urban environment presents the research community with a number of challenges and opportunities. A considerable volume of research has been undertaken into the constituent parts of this complex problem (Leach et al. 2010). However, there is limited evidence of the holistic integration of the body of knowledge arising from the research within real life decision making practices. This research programme was initiated in 2007 in collaboration with Dundee City Council to support sustainable development in a major programme of infrastructure provision.

1.2 Need for the research

There is a wide awareness of sustainable development in the built environment (Walton et al. 2005) however it is generally accepted that the real challenge lies in understanding how to put it into practice, i.e. to “operationalise” sustainability (Parkin 2000; Lamorgese and Geneletti 2013). This “operationalisation” of the principles of sustainable development within the urban design and development process must be fostered at a number of levels and requires a number of approaches.

Sustainable development for urban development projects requires an integrated approach delivered across different scales namely policy, programmes and projects.
A large number of tools, techniques and guidance documents have been produced to support decision makers in sustainable development decision making in the context of the built environment. Bartlett and Guthrie (2005) undertook a comparative analysis of seventeen leading documents and concluded that sustainable development could be seen as a process of on-going development and maintenance

of the built environment and secondly as a process toward intergenerational and intragenerational equity. Boyko, Cooper and Davey (2005) recognised much more is needed to be done to demonstrate how where and when sustainability is embedded into the urban design process, and who the decision makers are within the process.

Indicators play a key role in the interpretation of sustainable development on a European, national and regional level. They have the ability to monitor performance, assist in decision making and link impacts across spatial and temporal scales (Hak 2007). Assessment of progress towards sustainability is often evaluated using indicators. There are many examples of sustainability indicator sets that have been developed in the last decade for a wide range of sectors, e.g. for the water industry (Water UK 2000) and for bio-energy systems (Buchholz et al. 2009). CIRIA (2001) developed a suite of sustainable construction indicators and these were piloted by 10 companies in a later CIRIA managed project on their implementation (CIRIA 2004). Whilst the CIRIA project found that the suite provided a suitable source of indicators for supporting the achievement of organisational targets it demonstrated that no standard set of indicators was likely to be adopted by the industry as a whole. This confirmed previous research in the use of sustainability indictors by the researcher (Foxon et al. 2002; Ashley et al. 2008) and by others (e.g. Starkl and Brunner 2004) which recommended that indicators should be selected on a case by case basis.

A review of assessment and decision support tools for sustainable development suggests that tools are currently used in isolation and no tool supports sustainability across the project life. Walton et al. (2005) examined the extent to which current methodologies meet the need for integration. They identified a number of shortcomings including the need for:

- An integrated multi-dimensional tool that could bring existing approaches together

- Transparency and communication in the promotion of sustainability assessment amongst a wide ranging group of stakeholders
- Recognition of the context specific nature of sustainability analysis
- Inclusion of stakeholders in the assessment process

Tools, techniques and guidance documents have been produced to support decision makers. However, in general decision making in practice is seldom structured and that often "satisfactory" solutions are reached in an ad-hoc basis (Simon 1972). An understanding of the ways in which decisions are made throughout the project is required to enable the information needs of key decision makers to be determined. Key decision points in the process, the stakeholders involved in these decisions, their functions and their information needs require to be identified. This is to ensure that information on the potential impact of decisions or actions that will influence the overall sustainability of the project can be provided to the right stakeholders, at the right time and in the right form.

A number of authors have effectively used decision mapping or knowledge mapping to document, understand organisation knowledge management and decision making (Snowden 2000; Wexler 2001; Vestal 2005; Driessen 2007; Yasin and Egbu 2010). It was concluded from the literature that there was potential for knowledge mapping and knowledge management to be used to operationalise sustainability in urban redevelopment. This led the programme of research to focus on the development and application of knowledge mapping approaches to enhance sustainability of a major urban regeneration project.

1.3 Aims and Objectives

As outlined in section 1.2 sustainability assessment has the potential to influence decision making. Improving sustainability assessment practice should be able to help sustainable decision making in projects. Closer integration of assessment into the decision making process could be argued to be not only necessary to improve decisions, but also to improve learning of those involved. This can be greatly facilitated by knowledge management, which can be used to understand and then facilitate greater participation amongst stakeholders. These concepts provided the starting point for the development of the research aims and objectives.

The research aim was:

To develop, test and apply knowledge mapping techniques to effectively assess and enhance sustainability within a major urban redevelopment project.

The objectives were:

1. To establish the current state of the art in sustainability and it’s assessment for major urban redevelopment
2. To establish the current state of the art in understanding decision making process and knowledge management for major urban redevelopment
3. To develop appropriate procedures for sustainability assessment of major urban redevelopment
4. To develop appropriate procedures for knowledge elicitation and mapping to enhance sustainability in major urban redevelopment
5. To apply procedures to a case study

The overall research question was:

Can knowledge mapping approaches be applied to enhance sustainability of a major urban redevelopment project?

1.4 Research methodology

Chapter 4 Methodology provides a detailed description of the philosophical position and qualitative research methods used in the thesis. The methods were designed to address each of the objectives as outlined in Section 1.3.

The initial stage comprised of a literature review which enabled an evaluation of the state of the art in sustainability and its assessment. This also evaluated the state of the art in understanding decision making process and knowledge management. The key conclusions from literature review enabled the development of a theoretical framework for the monitoring and enhancement of sustainability.

The theoretical framework was developed and validated through application to a case study in two parts. Firstly, the Monitoring Component which consisted of the development and reporting of benchmark indicators. This used three main research methods, literature review, interviews and document analysis. Secondly, the Enhancement Component, which consisted of the development and application of knowledge elicitation and mapping methods. This used semi structured interviews and the application of knowledge mapping and elicitation approaches. These approaches included the development of process maps which identified Knowledge Disclosure Points and Knowledge Objects. A workshop was used to identify and categorise sustainability Knowledge Objects. Outputs of the knowledge elicitation and mapping approaches were then drawn together to develop a Knowledge Map for Sustainability.

1.5 Structure of the thesis

The thesis structure is shown in Figure 1.1. Chapter 2 presents the results of a comprehensive literature review of the concept of sustainable development and how this has been interpreted into European, UK and National policy. The review investigates the key concepts in sustainability of the built environment together with approaches and decision support tools for sustainability assessment.

Chapter 3 presents a review of decision theory, decision making and knowledge management principles. Knowledge mapping techniques are examined and appropriate knowledge elicitation and mapping approaches are evaluated.

Chapter 4 establishes the theoretical framework for monitoring and enhancing sustainability arising from the literature review in Chapters 2 and 3. Chapter 4 also provides a justification for the research method and the choice of a case study to develop and apply the theoretical framework.

Chapter 5 describes the development of the sustainability monitoring framework. The conceptual framework, the process of selecting and designing the indicators, is presented alongside the process of interpreting, reporting and maintaining the indicators. The chapter also explores the issues around developing and embedding sustainability monitoring indicators into existing governance processes.

Chapter 6 describes the three stage knowledge elicitation and mapping methodology applied to enhance sustainability. The justification for selection of the elicitation and mapping method is given and the results of its application and the effectiveness of the method are evaluated.

Chapter 7 presents the conclusions of the study and identifies recommendations for areas of further study. Appendices are presented which contain additional information in support of the study and publications arising from the work.

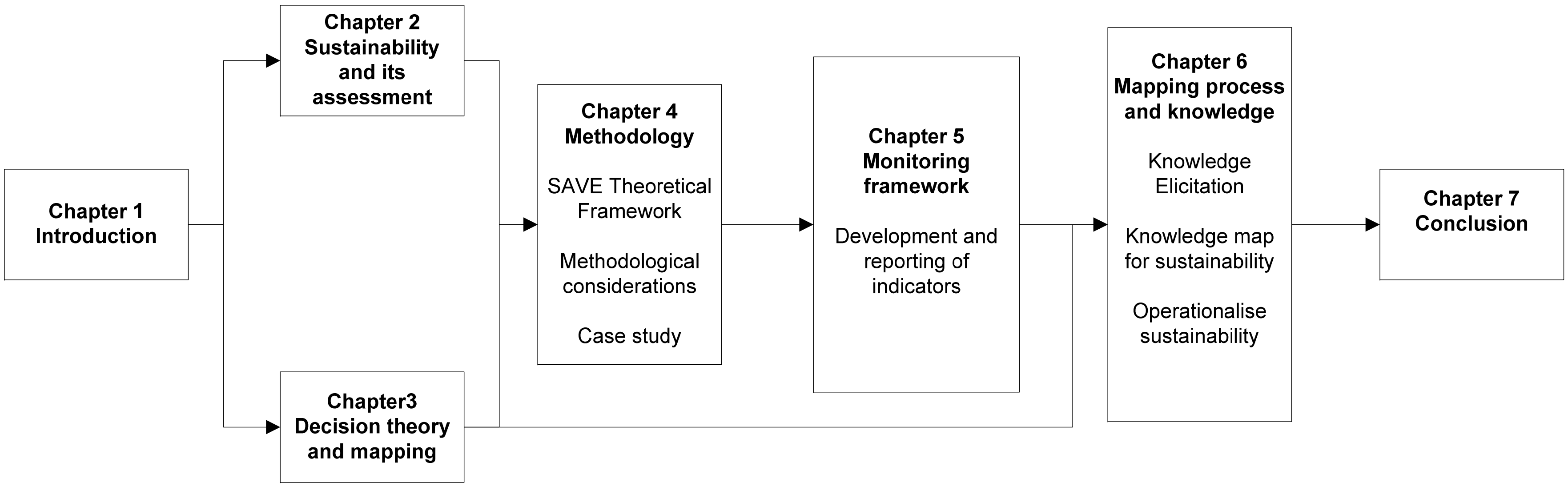

Figure 1:1 Thesis structure

2 Chapter 2 Sustainability and its assessment

2.1 Sustainability concept and theory

2.1.1 Starting point

Sustainable development is a vision of progress which integrates immediate and longer term needs, local and global needs, and regards society, environment and economics as inseparable and interdependent. However for many, sustainable development is often seen as a complex issue that is not definable in practical terms. The difficulty lies in defining sustainable development consistently due to its very broad nature. Often any definition occurs in political statements that are therefore rather general and open-ended. More focused definitions reflect the specifics of diverse fields ranging from agriculture, ecology, economics, construction, particular stakeholders and countries and therefore differ considerably (Drummond and Marsden 1999; Dalal-Clayton and Bass 2000; Holden et al. 2008).

The Bruntland Commission defined their vision for sustainable development in 'Our Common Future' (World Commission on Environment and Development 1987). This report changed the thinking on environment, development and governance and in turn, is considered a watershed in defining the sustainable development concept. Bruntland's definition of sustainable development is the most widely accepted starting point for scholars and practitioners (Sneddon et al. 2006).

"Humanity has the ability to make development sustainable development to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs"

(World Commission on Environment and Development 1987, p.43)

The vision for sustainable development as set out by Bruntland was further developed over the next decade on a global scale, firstly as Agenda 21 at the 1992 Rio de Janerio Earth Summit and then in Johannesburg 2002. Agenda 21 recognised the requirement to transform the industrial economy and create a sustainable economy guided by the principles of social equality, economic prosperity, environmental responsibility and cultural authenticity (Vlachos 2003; McKay 2005). The Rio Declaration (1992) set out 20 principles which reaffirmed and built upon the Stockholm Declaration 1972 (United Nations General Assembly 1972). These principles were summarised as “Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system, recognising the integral and interdependent nature of the Earth, our home” (United Nations General Assembly 1992, p7). The Agenda 21 movement occurred alongside the Convention on Biodiversity (United Nations 1993) and the Convention on Climate Change (United Nations 1994). The World Summit on Sustainable Development in Johannesburg, 2002, Millennium Development Goals (UN Millennium Project 2005) and World Urban Forum 2006 further developed the sustainability agenda on a global scale. Holden et al. (2008) and Quental (2011) identified the cyclic nature and importance of the political initiatives coinciding with earth summits acting as catalysts of societal and political action.

There was a remarkable increase in environment related policy making in both international and national level in the decade following the report of the Bruntland Commission. The 1992 Rio earth summit can be considered the springboard for the internationalisation or globalisation of science such as the Intergovernmental Panel on Climate Change (Hibbard et al. 2007). However, this link is not direct as a distinction between environmental and sustainability policy making has to be made. Sustainable development involves reconciling the demands of economic efficiency, social equity and environmental protection. Sustainable development strategies therefore need to address and encompass social visioning to a greater extent than would be necessarily associated with environmental policy (Meadowcroft 1999; Spaargaren 2003; Polasky et al. 2011).

2.1.2 Development, welfare and wellbeing

Sustainable development demands that economic activity must take account of both environmental capacities and the needs of future generations, so that any rise in income today is not at the expense of social or environmental welfare today or tomorrow (Purvis and Grainger 2004). This intergenerational and intragenerational equity relates to the distributional fairness and encompasses both rights and duties towards the future as well as present generations (O'Riordan T. & Voisey 1997; Padilla 2002; Vojnovic 1995; While et al. 2010; Bijl 2011).

'Development' itself also needs to be defined as a part of establishing a starting point for discussion on the concept and theory of sustainable development. UN (2008) defines this as an increase in wellbeing across members of society over time. Wellbeing and welfare are integral to sustainability, often used interchangeably (Easterlin 2003; Allin 2007) but have two different meanings. Welfare is defined as the benefit an individual derived from consuming goods and services over time (UN 2008). Dasgupta (2001) identifies that the way in which access to resources or consumption opportunities is distributed across individuals, and how they think they will benefit, is at the centre of welfare. This forward projection with regards to prospects for increased welfare in the future shows the inter-temporal nature of the concept (UN 2008).

Authors such as Vlachos (2003) and Rogers (2012) consider sustainability and sustainable economy in the context of equity and social justice, and the institutional arrangements that will allow each person to contribute fully to social wellbeing. McAllister (2005) provides a comprehensive review of the concept of wellbeing in recognition of the UK government's desire to gain a better understanding and focus on the subject. McAllister's study was used as basis to explore a more comprehensive set of wellbeing indicators to support the UK's policy and priorities for sustainable development. McAllister (2005) concluded that wellbeing remains a contested concept, enjoying a wide variety of definitions, but there is common ground which indicates that: "wellbeing is more than the absence of illness or pathology; it has subjective (self-assessed) and objective (ascribed) dimensions; it can be measured at the level of individuals or society; it accounts for elements of life satisfaction that cannot be defined, explained or primarily influenced by economic growth" (McAllister 2005, p2.).

Building on the work undertaken by McAllister in 2005, the Department for Environment, Food and Rural Affairs (DEFRA) has worked with other government bodies to define wellbeing in a consistent way. "Here, it is understood to be a positive physical, social and mental state; it is not just the absence of pain, discomfort and incapacity. It requires that basic needs are met, that individuals have a sense of purpose, and that they feel able to achieve important personal goals and participate in society. It is enhanced by conditions that include supportive personal relationships, strong and inclusive communities, good health, financial and personal security, rewarding employment, and a healthy and attractive environment." (DEFRA 2010, p106). The understanding of welfare and wellbeing and its use in sustainable development discussion seems unresolved. It is evident the definition of wellbeing needs to remain suitably wide and all encompassing to establish a common understanding across government and other sectors. There remains considerable debate to develop a common understanding, and indeed indicators of wellbeing.

The literature has shown the open nature of Bruntland's definition, together with its influence and wide appeal which has led to much debate. The variety of interpretations developed, together with the gap between high level framework policy, where the reference to sustainable development most often sits, and action on the ground makes it more difficult to provide a clear and common understanding relevant for all stakeholders. Conceptual models presented in section 2.2 show the depth of work around this area of debate.

2.2 Conceptual models

Literature presents a number of conceptual models that present a logical framework and in turn provide a starting point for establishing approaches to sustainable development. The basis to these conceptual approaches are the resources available for societal progress through different sorts of capital. These are deconstructed into natural, human, social and manufactured as shown in the World Bank 1994 four capital model (Serageldin and Steer 1994). Table 2:1 presents examples of the sort of benefits society expect to enjoy if the stocks of each of these capitals were maintained. A sustainable society can be thought of as living off the income generated by capitals rather than degrading the capitals themselves (Forum for the Future 2003).

Table 2:1Five Capital Model stocks and flows (Forum for the Future 2003)

Capital/Resource	Stock	Flow
Natural	Land sea, air, vegetation, ecological systems	Food, water, energy, waste disposal, climate
Human	Knowledge, skills, health, motivation	Happiness, creativity, innovation, work, energy, participation
Social	Families, communities, organisations, governance systems, schools	Security, shared goods(e.g. culture, education), inclusion, justice
Manufactured	Infrastructure, roads, buildings, tools, fixed assets	Living working space assess distribution, recyclates
Financial	Money, stocks, bonds, banknotes	Means of valuing, owning or exchanging other four capitals

A number of authors (Neumayer 2003; Dietz and Neumayer 2007; Ayers 2007; Atkinson 2009) identify a key debate surrounding the substitutability between the economy and the environment in terms of the way that human and environmental resources are valued. The debate can be captured in terms of 'weak' vs 'strong' sustainability. Weak sustainability accepts that there are certain critical natural processes that are essential to life but allow for substitution between other types of natural capital (Magnier 2006). This fits well with economic growth theory where sustainable development is often translated into intergenerational equity and although having different starting points, intergenerational equity and weak sustainability can lead to similar conclusions (Ayers, van den Bergh and Gowdy 1998). Strong sustainability rests on the concept of non diminishing life opportunities by conserving the stock of human capital, technological capability, natural resource and environmental quality (Brekke 1997). Strong sustainability extends the definition of critical natural resources and does not allow the substitution between natural capital and other forms of capital (Holden and Linnerud 2007; Nilsen 2010).

The movement from a simple Venn diagram (Levett 1998) or triple bottom line (Becker and Janh 1999) to a ‘Russian Doll’ or embedded model of understanding (O’Riordan 2001) is shown in Figure 2:1, Figure 2:2 and Figure 2:3. This demonstrates a process of change towards a greater sophistication of understanding of the interactions between the economic, environmental and social pillars of sustainable development. In the Russian doll model the basic principle is all economic activity should be biased towards social progress and that this must be achieved within environmental limits. There is, therefore, suggestion of a slight move away from the ‘weak sustainability’ model that was originally put forward by Brundtland towards a more eco-essential approach. However, the potential to achieve ‘win-win-win’ scenarios is increasingly being rejected as over-simplistic and practicably unattainable (Scottish Executive Social Research 2006). Forum for the Future five capital model of sustainability (Forum for the Future 2003) as shown in Figure 2:4 illustrates that common ground is required. This point is also made by Englebrect (2009) who identifies that the measurement of natural capital and its management during the economic development process are important aspects of the capital approach to sustainable development.

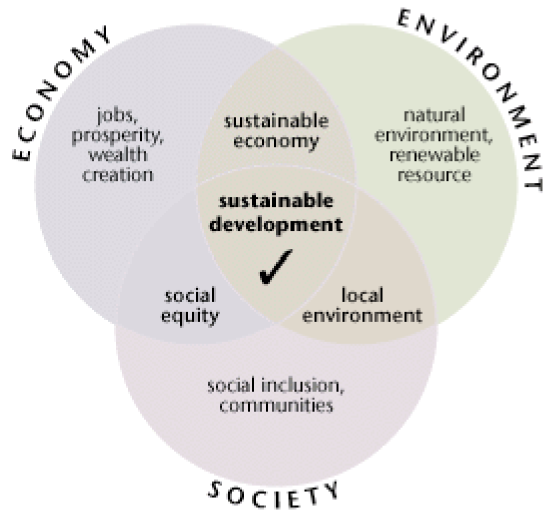

Figure 2:1 Venn diagram of sustainable development (Levett 1998)

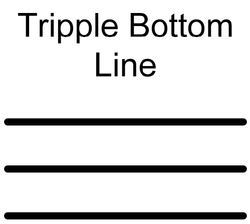

Figure 2:2 Triple Bottom Line (Becker and Janh 1999)

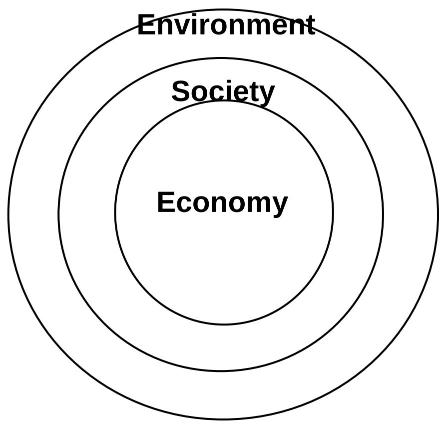

Figure 2:3 Russian Doll model of sustainable development

(O'Riordan, Cameron, and Jordan 2001)

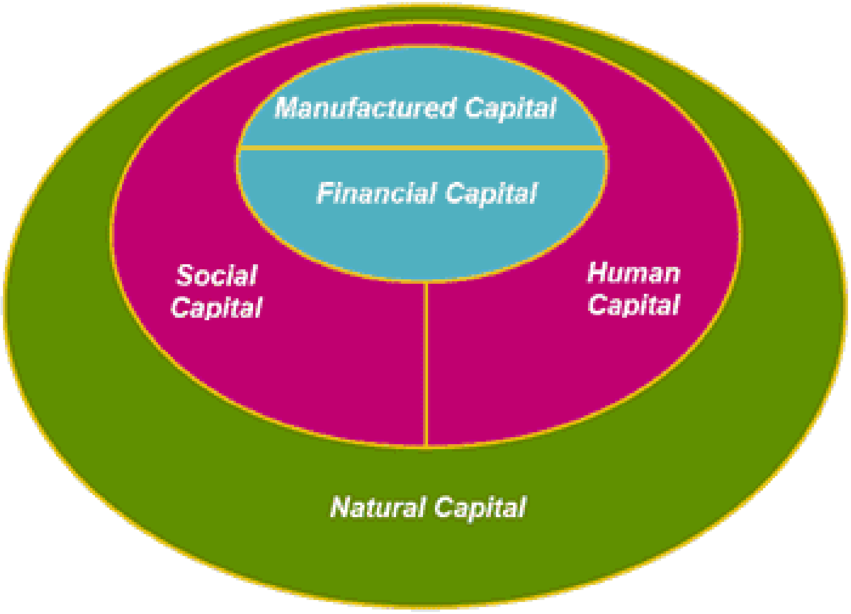

Figure 2:4 Five Capital Model of sustainable development

(Forum for the Future 2003)

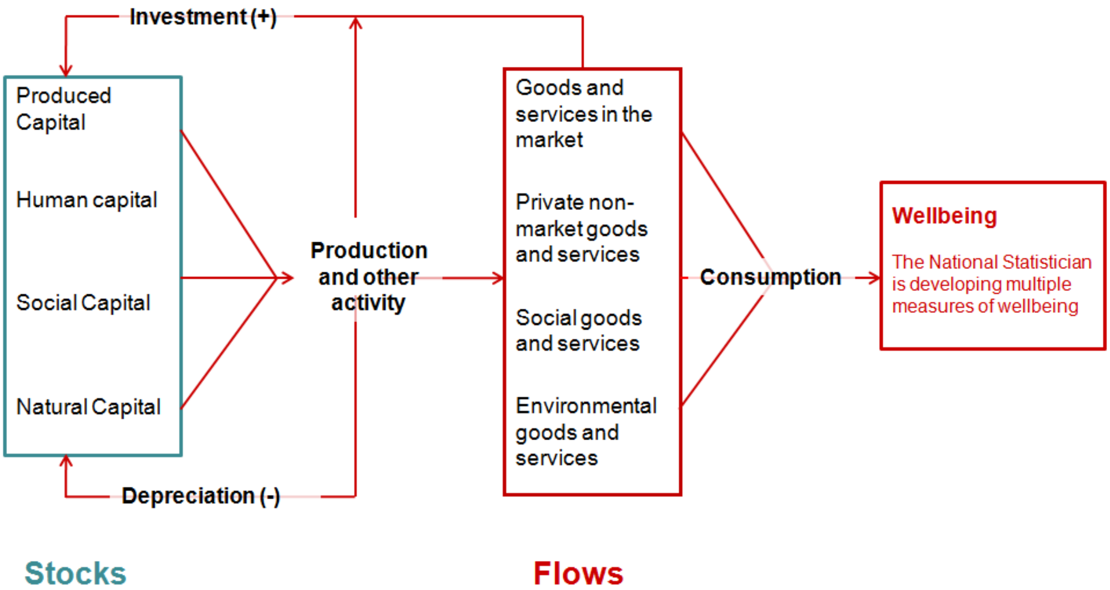

Figure 2:5 A framework for understanding the social impact of policy and their effects on wellbeing (DEFRA 2011)

Figure 2.5 sets out the conceptual framework developed by DEFRA (2011) as the basis for understanding the relationships between the different components of capital, the production of flows of goods and services using the stock of capital; the consumption or experience of those goods and services by society, and their combined impact on wellbeing. Both production and consumption of goods and services have social impacts.

In a final point of clarification, Forum for the Future (Forum for Future 2005) distinguishes between sustainability and sustainable development; sustainable means something that has the ‘capacity for continuance’ and sustainability is therefore a ‘quality’. Sustainable development is the process over time by which we achieve sustainability and therefore more about how society behaves in the environment. Forum for the Future emphasises this as “A dynamic process which enables all people to realise their potential and improve their quality of life in ways which simultaneously protect and enhance the Earth’s life support systems” (Forum for the Future 2000). The definition also highlights a key point often missing from other definitions, that a sustainable society is for all people and policy towards sustainable development should ensure that everyone has the opportunity to fulfil their potential, enjoy a high quality of life and is about equity, fairness and justice (Parkin 2000). du Plessis and Cole (2011) develops this dialogue further where sustainability moves beyond a simplistic model of achieving the balance between economy, society and environment to a model based on resilience and adaptive capacity. This partnership between humans and natural environment of which they form part, is aimed at regeneration of social-ecological systems (du Plessis and Cole 2011).

Sections 2.1 and 2.2 have introduced the concept of sustainable development. A further understanding of how the concept of sustainable development shapes our political environment and how these concepts and ideas have been adapted into policy is now required. This will provide a first step towards operationalising sustainability.

2.3 Current Sustainable Development policy and implementation

Sustainable development is often seen as an environmental issue and this is well illustrated by the fact that these sustainable development conventions are usually made the responsibility of environment ministries and departments, traditionally amongst the weakest and least influential in government (Dalal-Clayton and Bass 2000).

However, sustainable development is now being given recognition by policy makers, as seen in a number of Key EU and UK documents (Commission of European Communities 2005). In 1999, the UK Government, in its strategy document "*A better quality of life*" (DETR 1999), set out four objectives to meet its targets for sustainable development which were; 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. These have since been developed by successive governments but provide a useful starting point when addressing the concept of sustainable development.

The European Union is a strong supporter of sustainable development. The declaration made at the 1992 United Nations Earth summit and in 1997 at RIO +5, demonstrates that member states have committed themselves to adopt sustainable development strategies. The Amsterdam treaty 1997 (EU 1997) introduced sustainable development as a core objective of the European Union and the European Union adopted its sustainable development strategy in Gothenburg 2002.

Furthermore, it published declaration on guiding principles for sustainable development (Commission of European Communities 2005) which was adopted by the European Council of June 2005, and in July 2009 the Commission adopted the 2009 Review of the EU Sustainable Development Strategy (Commission 2009). The review takes stock of EU policy measures in the areas covered by the EU Sustainable Development Strategy and launches a reflection on the future of the EU Sustainable Development Strategy and its relation to the Lisbon strategy.

2.3.1 UK Guiding principles

Within this context, the UK government accepted that current trends in the UK were unsustainable and that the future seemed vulnerable (DEFRA 2004). The UK Sustainable Development Strategy (DEFRA 1999 and DEFRA 2004) took account of developments both domestically and internationally. It also reflected the changed structure of government in the UK with devolution to Scotland, Wales and Northern Ireland; greater emphasis on delivery at regional level and the new relationship between government and local authorities. It took account of new policies since 1999, and it highlighted the renewed international push for sustainable development from the World Summit on Sustainable Development in Johannesburg in 2002. DEFRA chaired the Programme Board to oversee delivery of the Strategy, but all UK Departments shared responsibility for making sustainable development a reality. DEFRA (2005) and in response to this set out four priority areas for further action, 1) Sustainable Consumption and Production, 2) Climate Change and Energy, 3) Natural Resource Protection and Environment Enhancement, 4) Sustainable Communities.

The UK Government framework for sustainable development (DEFRA 2005) allowed for the devolved administrations to pursue sustainable development. The UK framework required that economic growth and improvement in standards of living should not be at the expense of the environment and its resources. Additionally, it encouraged practices that increased awareness of the issues involved in achieving the goals of sustainable development. DEFRA (2010) explored the capacity of civil society organisations to contribute to tackling major sustainability issues, especially climate change. It set out principles for how government and civil society should work in partnership on this agenda. DEFRA established a vision for 2015 “mobilising and inspiring others to tackle climate change and maximising the social, economic and environmental opportunities of action.” (DEFRA 2010, P8).

As outlined in DEFRA (2011) the UK Government stated its intention to move sustainable development beyond being considered as a separate, ‘green’ issue which is a priority for only a few government departments. The UK coalition government acknowledged that the report’s vision and underlying principles were fully consistent with their vision for the Big Society, and that the report continued to provide a valid template for action both by civil society and government. (DEFRA website accessed 28/03/2012).

2.3.2 Scottish Government National Performance Framework

In 2007 the Scottish Government developed a National Performance Framework (Scottish Government 2007) based on outcome focused working. The framework was designed to help public services and other key contributors to work together effectively to tackle Scotland’s key long-term economic, social and environmental challenges. The Framework contains National Indicators which link to, and show progress towards, National Outcomes and support high level Purpose Targets (Scottish Government 2011). The focus of the Scottish Government’s Performance Framework is on creating sustainable economic growth to deliver a ‘fairer’, ‘smarter’, ‘healthier’, ‘safer’ and ‘greener’ society (Scottish Government 2011). National

Wellbeing is covered through a wide range of social and environmental indicators and targets including mental wellbeing, income distribution and carbon emissions as well as economic growth. These priorities sit comfortably within the three pillars of sustainability.

Since the introduction of the National Performance Framework in 2007, the Scottish government monitors the delivery of Scottish Government's Purpose and National Outcomes. At a local level, Community Planning Partnerships support the delivery of the National Performance Framework. The Concordat between the Scottish Government and COSLA agreed in November 2007 (Scottish Government 2007) sets out the terms of the relationship between the Scottish Government and local government and underpins the funding provided to local government. A central element of the relationship was the ending of ring fencing of local government funding and the creation of a Single Outcome Agreement (SOA) between each Community Planning Partnership (CPP) and the Scottish Government (Improvement Service 2012). A SOA is the means by which CPPs agree their strategic priorities for their local area and express those priorities as outcomes to be delivered by the partners, either individually or jointly, while showing how those outcomes should contribute to the Scottish Government's relevant National Outcomes (Scottish Government 2011).

This section has provided the political context for, and illustrated how sustainable development has been adopted and interpreted into policy from European context to regional level. There now needs to be an understanding of how organisation and practitioners responsible for the provision of infrastructure and the built environment has adapted and embraced sustainable development.

2.4 Sustainability in the Built Environment

The built environment encompasses, land-use and transport, planning, housing and other infrastructure provision, but it also has a significant impact on issues such as energy use and consumption, sustainable communities and lifestyles. Jenks and Jones (2010) identify the considerable amount of research that defines what makes a sustainable city and in particular which urban forms most affect sustainability, in particular size shape, land use open space, but also the complex interaction of economic and social issues.

Magnoli et al. (2002) identifies the sustainability potential of urban living and notes the critical importance of public space to the processes of social learning, public participation, social inclusion and social integration. These can be considered a strong policy driver and a foundation for creating sustainable communities as identified in Section 2.1.2. The Urban White Paper (ODPM 2000) emphasised the need to create environmentally sustainable built environments, enabling communities to create and share wealth. Scottish Executive (2002) aimed to tackle the inequalities between communities by narrowing the gap between the disadvantaged and those who are not. This report acknowledged a need for a more strategic approach to the delivery of core public services to maximise their effect in disadvantaged areas and sought to ensure that such communities have the necessary social capital to take advantage of opportunities open to them. This represented a more focused approach which relied on community planning implemented through the Local Government in Scotland Act (2003). The Egan Review (ODPM 2004) developed a definition of a sustainable community and proposed this become a common goal for all sectors “Sustainable communities meet the diverse needs of existing and future residents, their children and other users, contribute to a high quality of life and provide opportunity and choice. They achieve this in ways that make effective use of natural resources, enhance the environment, promote social cohesion and inclusion and strengthen economic prosperity" (ODPM 2004, p7). The review presented the Egan Wheel components of sustainable communities namely, Governance, Transport Connectivity, Environment, Economy, Housing and Built Environment, Social and Cultural (ODPM 2004).

The concept of better place-making has been a way that sustainability and the concept of sustainable communities have been integrated into the built environment (Williams and Dair 2007; Dempsey 2008; Sargeant et al. 2009). Place-making believes that distinctive, high quality places as well as high quality buildings are vitally important to the social, environmental and economic success of cities, towns and rural communities (RTPI 2009). The Scottish Government in its policy consultation on architecture and place-making (Scottish Government 2012) suggested that good place-making can provide environments which function and linked well with surrounding settlements. It presents an opportunity to have a profound effect on the sustainability of lifestyles, in respect of the impact on the land and other resources.

Scottish Planning Policy is set out in the National Planning Framework (Scottish Government 2009). Within this development plans are obliged by law to be prepared with the objective of contributing to sustainable development. Legislation also requires planning authorities to consider guidance on sustainable development issued by Scottish Ministers. The planning system influences where development is located, how the development performs in terms of need for heat and power and how reliant the occupants of the development are on walking, cycling, public transport and private cars. Sustainable development in the built environment is therefore a very broad topic area that includes climate change, flooding, waste, energy, transport, place, people and health.

Sustainability is at the centre of regeneration strategies such as 'sustainable communities building for the future' (Scottish Executive 2002a; ODPM 2003), with The Urban Task Force promoting compact urban forms that support economic prosperity, are environmentally responsible and promote social integration (Urban Task Force 1999; Urban Task Force 2005). However, regeneration often requires multi-agency working, often working to different ideals of sustainability, relying on Private – Public Partnerships (PPP) or Private Finance Initiative schemes (PFI) in the delivery of sustainable development (Hill and Collins 2004). These partnerships can often struggle to find consensus over meaning of sustainable development and deliver the triple bottom line of sustainability in regeneration projects (Evans and Jones 2008).

McDonald et al. (2009) and Winston (2010) identify the nature of urban regeneration policy that has developed over last two decades. Today, a "sustainable community" is a key issue in an ambitious Government programme (McDonald et al. 2009). Building our sustainable future (Scottish Government 2011a) sets out the Scottish government's vision of regeneration and recognises the varying scale that regeneration can take from large scale development activities that promote economic growth to neighbourhood interventions that improve quality of life. Regeneration is the holistic process of reversing the economic, social and physical decline of places where market forces alone will not suffice (Scottish Government 2011b).

Poustie (2004) has highlighted the centrality of the planning system in furthering the substantive or distributive elements of environmental justice. However, although recent planning consultation papers make passing reference to environmental justice, they have not elaborated how the planning system can contribute to environmental justice except in relation to the procedural dimension of involving people more fully in decision-making. Sniffer (2004) report, examining environmental justice in Scotland, concluded that the links between measures of environmental quality and social deprivation are more complex than the presumption often made that there is coincidence between poor environmental quality and deprived communities.

Previous research has documented how the conceptualisation of sustainability in urban sustainability plans varies greatly among cities, particularly with respect to environmental justice. Pearsall and Pierce (2010) suggests that environmental justice efforts are potentially losing traction in public debate over macro-scale sustainability concerns for example climate change, or the need for regionally competitive environmental amenities (Pearsall and Pierce 2010).

2.4.1 Sustainable construction

Government and industry share a vision of construction as a competitive sector which plays a central role in delivering sustainability and prosperity across the economy (HM Government 2008). The economic value of construction has been reviewed by a number of authors (Pearce 2003; Ruddock 2007; Chan 2009). Ruddock (2007) identifies the wide scope of the construction industry in terms of producing and managing the living and working environment of the whole population.

The Chartered Institute of Building (CIOB) identifies sustainability as the construction industry's most important and challenging issue (CIOB 2007). The greater public demand for sustainable products, new government initiatives and targets concerning carbon emissions, as well as statistics showing that the construction and operation of buildings are the biggest carbon producers has increased demand on the construction industry to champion sustainability (RICS 2009). Rodriguez-Melo &

Mansouri (2011) examine which of the following in sustainable development; government policy, managerial attitude and stakeholder engagement, is the most influential on the profitability of companies in the UK construction sector. Their findings indicate that to gain competitive advantage, companies should embark on long-term strategic alliances which adopt the proposals of environmental non-governmental organisations and closely follow public opinion.

The UK government strategy for sustainable construction (HM Governmnent 2008) sets out the factors to be addressed in delivering the vision for sustainable construction. The strategy identifies that the output of the construction industry such as public buildings, commercial buildings, homes or infrastructure has a major impact on the economy overall and the environment. The joint strategy between government and industry recognised that it will not be possible to meet declared environmental targets without dramatically reducing the environmental impact of buildings and infrastructure construction, ultimately requiring a step change in design and build activities. Sustainable construction implies the application of sustainable development principles in the construction industry through all the stages of the construction project from planning, through procurement, construction, operation and maintenance to demolition. The major objective is to ensure that resources are used efficiently at each of the stages in order not to hamper the development potential of future generations (CIRIA 2001).

Schiller (2007) maintained that attention needs to be given to the provision of urban infrastructure, which he argued is as resource-intensive as new-build projects, if policy-making is to derive a long-term view. Shaw et al. (2012) identified the importance of a holistic approach to the consideration of sustainability throughout infrastructure assets life. Panayotou (1997) states a major and integral part of sustainable development is efficient provision of environmentally sound infrastructure, such as water supply and sanitation, power, transport, and telecommunications. The industry has an opportunity to transform the way that infrastructure is created, by rethinking the way it designs and uses resources to create and maintain assets that meet the needs of society. Birley (2001) has stressed the need for a systematic approach to strategic infrastructure provision through a national spatial perspective to replace competitive bidding for infrastructure resources. The shift in recent years from competitive and resource-intensive procurement to more collaborative and sustainable approaches to infrastructure governance is considered a major transition in infrastructure procurement systems (Brown, Furneaux and Gudmundsson 2012).

Sustainable infrastructure is the sum of the many processes through which the construction industry delivers built assets to enhance the quality of life and meet stakeholder expectations. To enhance sustainable development of urban regeneration all steps of the project lifecycle need, where possible, to be considered and influenced. Well established support for sustainable construction has focused on meeting the needs of sustainable buildings such as BREEAM (BRE 2011) and Code for Sustainable Homes (BRE 2009) in the UK and LEED (USGBC 2007) in the US. Theses assessment methods have played a significant role in mainstreaming green building practices and increasingly referenced and adopted by institutions as a performance standard (Cole and Valdebenito 2013). To effectively consider urban regeneration holistically there is a requirement to identify how sustainability might be enhanced for civil engineering infrastructure projects and public realm projects. CEEQUAL was launched by Institution of Civil Engineers in 2003 to reward projects and contract teams in which clients, designers and contractors go beyond the legal, environmental minimum requirements to achieve distinctive environmental performance in their work. One limitation of CEEQUAL was it only operated as an environmental performance assessment. A recent extension CEEQUAL Version 5 (CEEQUAL 2012) responds to some of these limitations and provides transition from environmental assessment towards a more balanced sustainability assessment. Another recent development moving towards the goal of improved practice is RIBA 2013 mapping (RIBA 2013) where the RIBA plan of work has been adapted to a seven point schedule in a bid to integrate practices across the construction industry and accommodate modern collaboration and BIM.

2.4.2 Sustainable Urban Environment

The UK government and industry bodies have produced policy reports and guidance on sustainability in the built environment as outlined in the previous sections. A wide range of resources and assessment tools also exist to assist sustainable built environment practitioners in delivering sustainable urban environments. However, the breadth of perspective required to address complex urban environments and the limited quality, influence and usability of these resources led to the initiation of an extensive programme of research. The Engineering and Physical Science Research Council (EPSRC) Sustainable Urban Environment (SUE) programme 2001–2010 investigated different ways of improving sustainability in the urban environment and generated a significant body of research. The programme funded 18 consortia consisting of 400 researchers and stakeholder partners (Leach et al. 2010). Whilst undertaking this thesis a number of relevant SUE projects were active. Publications arising from these projects have guided approaches used in this research study. These are referenced in Chapter 5 and Chapter 6. Relevant SUE projects are briefly described below:

a. Eastside Sustainability Research (Lombardi et al. 2010) explored how sustainability is addressed in the regeneration decision making process. Within this project Hunt et al. (2008) examined a number of case studies associated with assessment of regeneration and identified stages in development which the authors termed a Development Timeline Framework (DTF). The DTF tool understands the linkages and synergistic effects of decisions on sustainability outcomes.
b. VivaCity2020 (Boyko, Cooper and Davey 2005) created an urban design decision making process model and web based knowledge platform aimed at supporting decision makers in making more sustainable decisions

c. Urban Futures SUE II Cluster project (Rogers et al. 2012) extended Eastside Sustainability Research and VivaCity2020 approaches to provide and assess scenarios in terms of design, engineering implementation and then refined them for alternative futures.

d. Sustainable Urban Regeneration (SURegen) project (Chen 2012) developed the SURegen workbench planning support system which takes a holistic approach to all aspects that have influenced sustainable regeneration. The workbench provided decision support tools, and professional guidance on regeneration processes.

e. Metrics, Models and Toolkits for Whole Life Sustainable Urban Development (SUEMot) project (El-Haram et al. 2007) developed a way to simultaneously assess the economic, social and environmental issues which contribute to sustainable development. An Integrated Sustainability Assessment Toolkit (ISAT) was developed which allowed key decision makers to identify and prioritise all the relevant issues at various levels of detail.

Boyko, Cooper and Davey (2005) recognised much more is needed to be done to demonstrate how, where and when sustainability is embedded into the urban design process and who the decision makers are within the process. To influence and support different stages in infrastructure provision it is evident that a flexible approach is required. Thompson, El-Harem and Emmanuel (2011) advocate sustainability assessment “to provide tangible information on key aspects of built environment sustainability, providing guidance during the decision-making process in a manner that is inclusive of the stakeholders involved” (Thomson, El-Harem and Emmanuel 2011, P143).

2.5 Sustainability Assessment

The theory of sustainability assessment as expressed in literature has largely evolved from work undertaken by practitioners of Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). Atkinson (2009) states that the UK impact assessment process can be considered a bridge between sustainable development strategy, encouraged through framework documents and a specific impact assessment on a development. Pope (2004) reasons the closeness is understandable given that sustainability assessment is often considered to be the next generation of environmental assessment. Literature shows there is a widely held belief that EIA and SEA make valuable contributions towards sustainability along with policy analysis techniques.

There are two themes which could be considered opposing views, of the relationship between SEA and EIA environmental assessment process and their contribution to sustainability. These two views of the potential contribution to sustainability may also correspond to two different conceptions of sustainability (Pope 2004).

Firstly that the environmental assessment process contributes to sustainability by integrating environmental considerations in decision making (Wood 2002; Sheate et al. 2003). This suggests that environmental impacts are at the core of sustainability concerns. The ecological sustainability model is represented in a concentric circle format, ecology within the outer circle, society in the middle and economy in the centre (Sadler 1999; Gibson 2001).

Secondly that environmental assessment methods provide a sound basis that can be extended to include broader sustainability concerns (Gibson 2001; Verneem 2002; Marsden and Dovers 2002). This approach where environmental assessment could contribute to sustainability by extending its scope reflects the three pillars of sustainability approach. This form of extension of environmental assessment results in a form of triple bottom line integrated assessment (Twigger-Ross 2003).

The terms integrated assessment, triple bottom line assessment, sustainability assessment and extended impact assessment are all used in literature. These promote the use of impact assessment as a means of directing planning and decision making towards sustainable development (Hacking and Guthrie 2007).

Despite its widespread use there is no consensus regarding the meaning of integrated assessment (Morrison-Saunders and Therivel 2005). Table 2:2 Videria et al. (2009) presents and compares the three broad frameworks: EIA driven integrated assessment, objective lead integrated assessment and integrated sustainability assessment.

Hacking and Guthrie (2007) identify a number of authors who have identified the meaning of integration with each of these providing a number of meaning or forms. General senses for use of the terminology are provided by Lee (2002) namely horizontal integration (bringing together social and biophysical), Vertical integration, (linking separated assessments at different levels) and integration of assessments at decision level (Hacking and Guthrie 2007).

Table 2:2 A comparison of integrated assessment frameworks (Videria et al. 2009)

	EIA driven integrated assessment	Object led integrated assessment	Integrated Sustainability Assessment
Which are the origins? Which is the entry point in the policy-making process?	Project base EIA: Ex-post, at the end of the policy pipeline	Objective led SEA Ex-ante at the beginning of the policy pipeline	Ex ante and ex post; continuous, iterative process, integrated with governance structures
What is the purpose of the assessment?	Identification of environmental, social and economic impacts of a proposal; comparing impacts with baseline conditions to determine its acceptance	Determining the extent to which a proposal contributes to pre-defined environmental social and economic objective; determining the best available option to achieve goals	Aims to explore sustainable solutions to persistent problems; allows society to derive an interpretation of sustainability and then compare initiatives against this proposal
How are the trade-offs treated? Which is the relation to target?	Minimise negative outcomes on the triple bottom line; aims to ensure that impacts are not unacceptably negative in any of the TBL pillars; measures direction to target; it is most likely to result in weak sustainability and trade-offs	Maximise positive triple bottom line outcomes; aims to determine whether improvements towards TBL objectives can be made; measures direction to target but is difficult to determine if TBL objectives really reflect sustainability	Trade-offs reducible or reconcilable; seeking synergies and a holistic perspective; measures distance from target; potentially higher impact on social-political context via social learning

Figure 2:6 shows the relationship between different types of appraisal. The current approaches for progressing along each axis range from stretching EIA or SEA to developing completely new techniques. A great deal of work to develop these further may be required to deliver practical results capable of supporting policy level commitments to sustainable development (Hacking and Guthrie 2007).

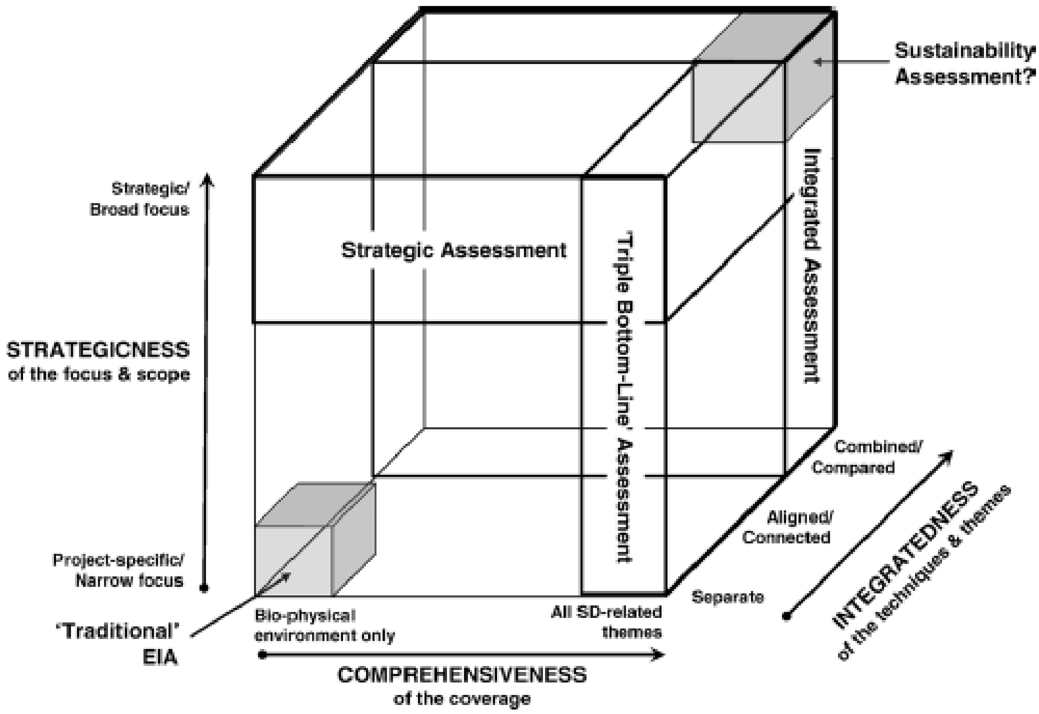

Figure 2:6 Spectrum of SD-directed features within the assessment process. (Hacking and Guthrie 2007)

Ness et al (2007) have attempted to categorise tools for sustainability assessment within a broader objective of lifting the understanding of sustainable assessment from environmental focused to a wider interpretation of sustainability. The framework illustrated in Figure 2:7 is based on three main categories, indicators, product related assessment and integrated assessment tools. The framework presents tools which are able to integrate nature and society, with monetary valuation tools used as part of the numerous tools listed. Spatial and temporal aspects of the tools are also considered. Only seventeen tools marked with this border are capable of integrations representing only a minority of approaches that exist today (Ness et al. 2007). The tools also seem to be heavily in favour of environmental, which largely disregard social and economic aspects. Ness et al. (2007) note the contradiction with the future development of sustainable assessment tools in relation to the requirement for more site specific assessment and the demand for broader tools that are accessible to a wider user group for differing case circumstances and standardised tools which give more transparent results. These are evidently diverging requirements and as such this categorisation highlights the lack of a single integrated tool.

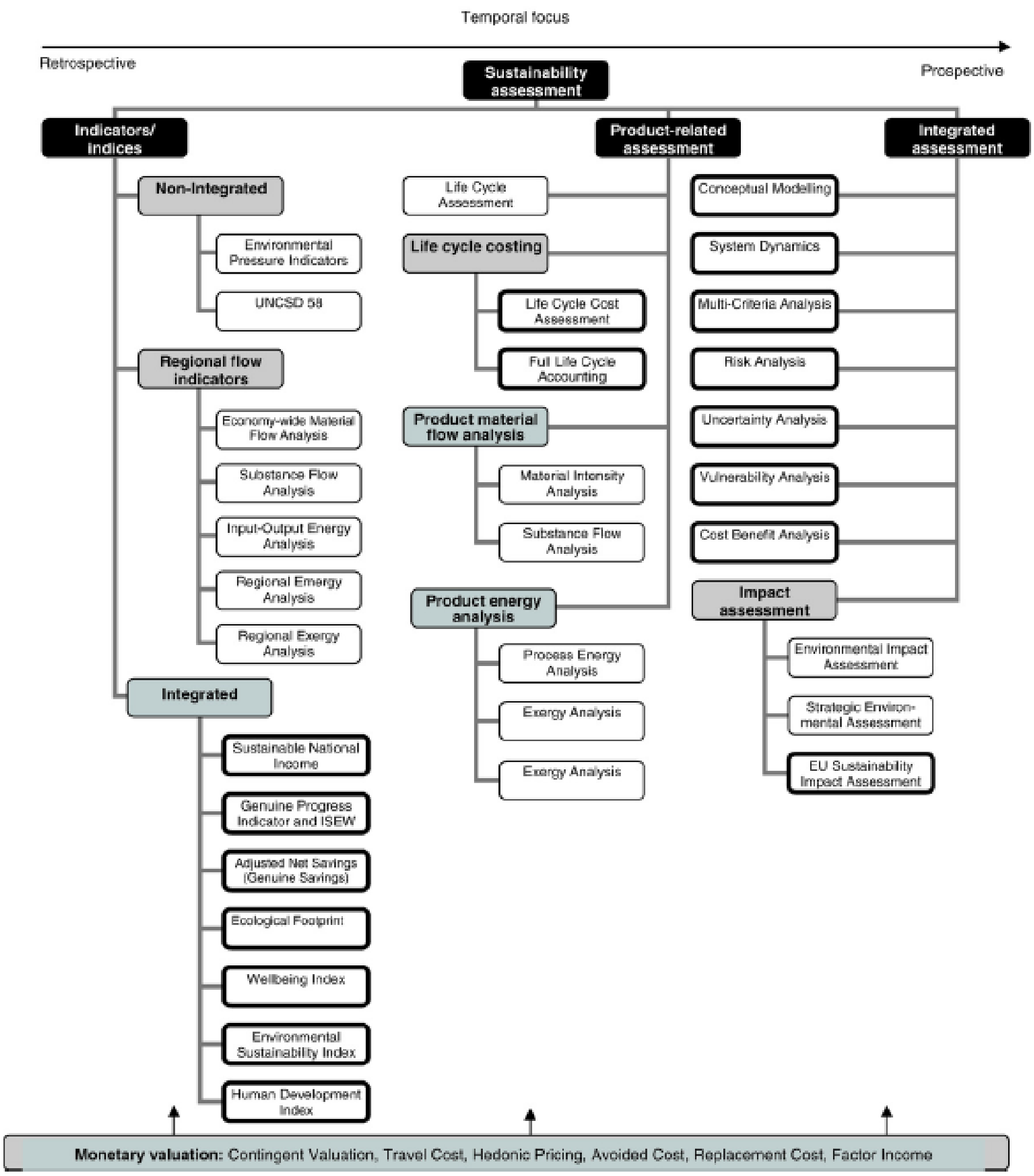

Figure 2:7 Tools for sustainability assessment (from Ness 2007)

Rotmans (2006) identifies the wide range of application contexts and domains of sustainability and argues that it is difficult for a single tool to grasp all dimensions of sustainability assessment. Rotmans calls for flexible approaches to linking elements together, since the one toolkit is still not well equipped enough to address the multi-dimensional complexity of sustainability. Several methods and tools for sustainability assessment have been developed (Videra et al. 2009) as shown in Table 2:3.

Table 2:3 Methods and tools for sustainability assessment (adapted from Videra et al. 2009)

	Examples of methods and tools
Participation and deliberation	Focus groups, consensus conferences, in depth interviews, workshops, visioning open forums, participatory modelling
Multi-Criteria Analysis	Weighted simulation, AHP, PROMETHEE, NAIADE, REGIME, Dominance method
Cost benefit and Cost effective analysis	Market methods, hedonic method, contingent valuation, travel cost method
Macro generational and green accounting	Index of sustainable economic welfare, Genuine progress indicator, human development index, System of Environmental Economic Accounting (SEEA)
Biophysical indicators and accounting systems	Ecological footprint, material flow analysis, global land use accounting, life cycle assessment
Scenario tools	Modelling and simulating, interactive brainstorming, scenario workshops, integrated foresight management model
Socioeconomic and biophysical models	Economic models, demographic models, partial economic models, public health models
Integrated models	Integrated assessment models, qualitative system analysis models, scenario building and planning tools
Indicator sets	Environmental pressure indicators(e.g. Eurostat), Sustainable development indicators (e.g. United Nations Commission on Sustainable development)

Adinyira (2007) suggested sustainability assessment methods can be classified into three groups based on their methodological foundations namely 'environmental in general', 'life cycle assessment methods' and 'sustainability indicator methods'. However, de Ridder (2007) suggests categorising tools in a different way, tools for the integrated assessment of sustainability: 'analytic tools and methods', 'participative tools and methods' and the more' managerial assessment frameworks'.

Sustainability A test (2005) also reviewed tools, methods, methodologies, procedures and tools. This project developed eight categories to describe tools:

- Physical assessment tools- tools that assess some physical parameter
- Monetary assessment tools – tools that assess some financial parameter
- Modelling tools-tools that use computer model
- Scenario analysis tools – tools with a prospective character
- Multi-criteria analysis tools – tools that assist in the consideration of various character
- Sustainability appraisal tools
- Stakeholder analysis tools
- Transition management tools

SUE MOT (Walton 2005) reviewed sustainability assessment tools as part of its goal to develop a comprehensive and transparent framework that encouraged key decision-makers to systematically assess the sustainability of urban development taking account of scale, life cycle, location, context and all stakeholder values. As part of this project (Walton 2005) identified and reviewed 675 tools which were then subjected to a coarse filter based on their market share, novelty, and relevance of the key issues they addressed. As a result, 86 tools were earmarked for further analysis at the most detailed level. Walton identified that the scoping study did not identify any tool that met all the criteria suggested as required for an integrated multidimensional assessment in the context of the sustainability of urban developments. Walton (2005) commented that stakeholders had questioned the actual need for such a tool on grounds of usefulness and practicality, with concerns regarding the difficulty of correctly balancing on the one hand the detail required for a meaningful assessment and on the other, the large number of issues that would have to be considered. This reinforced the findings of previous work by Ashley et al (2008) who identified the need for flexible framework rather than more tools.

Isaacs (2011) reviewed tools for decision support to address the complex issues involved in sustainable development decisions and concluded that there has been huge effort and investment into creating decision support tools, yet despite this most are never or hardly ever used (Sahota and Jeffrey 2005). Isaacs (2011) noted there are a number of reasons for this lack of uptake, usually the decision support tools are designed for a single purpose, to investigate transport issues for example, or that the systems become so generic that any detailed results are lost. Similarly Khandokar et al. (2009) and Paranagamage et al. (2010) highlight that this problem still exists and that no fully holistic tool that is available and accessible for all users yet exists.

There is a strong case for the use of sustainability assessment in promoting learning and informing decision making across the lifecycle of a project. Pope et al. (2004) identifies the evolving nature of assessment from purely technical to promoting stakeholder engagement, dialogue and learning. Sustainability assessment is increasingly being viewed as an important tool to aid decision making (Morrissey et al 2012). The role of sustainability assessment in sustainability management is identified by Thompson and El-Haram (2014). Kaatz et al. (2006) reflects on the opportunities to enhance the effectiveness of assessment practices in influencing construction decision making. Shaw et al. (2012) advocate that in order to achieve the best sustainability outcomes it is important to undertake assessment approach that considers all aspects holistically at all phases of construction process. Eames et al. (2013) concludes a critical challenge is to develop the knowledge capacity within public organisations for sustainable transitions.

In support of this goal, indicators are considered to be effective tools in monitoring communicating complex phenomena, making the concept of sustainability operational, increasing transparency and accountability increasing the availability of information, engaging stakeholders and supporting decision making (Mascarenhas et al. 2010).

2.6 Conclusion

The literature has established that sustainable development is a complex, multifaceted concept with interrelated environmental, social, and economic dimensions. The core philosophical debate regarding weak and strong sustainability and the substitution of capitals provided a number of logical frameworks and in turn a starting point for establishing approaches to sustainable development. Even with this complex starting point, commonality in interpretation in UK and Scottish government policy has established the sustainability agenda and shaped our political environment. Defining how these concepts and ideas can be adapted into policy can be considered the first step towards operationalising sustainability. It can, however be concluded that sustainability requires a form of multi-disciplinary thinking that encourages integration between policies, programmes and projects.

The review has also outlined how sustainable development has been adopted and interpreted into policy from European context to a national and regional level. In Scotland, the key role of indicators in the National Performance Framework and Single Outcome Agreement suggest that monitoring and indicators clearly linked to Single Outcome Agreement can play a crucial role in linking issues and impacts across spatial and temporal scales in a way that is compatible with the decision making process for infrastructure projects.

There is an opportunity to improve sustainability assessment practice within urban redevelopment projects and therefore inform and improve decision making in projects. To achieve this, there needs to be an understanding of how organisations and practitioners responsible for the provision of infrastructure and the built environment have adapted and embraced sustainable development. The review of sustainability assessment and decision support tools for sustainable development suggests that no current approach supports sustainability during the project life. An understanding of the decision making process in these organisations, what tools and information they use, and at what stage of design and construction of built environment, is therefore required. This confirms the starting position outlined by the research question stated in section 1.3.

3 Chapter 3 Decision theory, knowledge management and knowledge mapping

3.1 Introduction

Information needs for decision making in urban development include social, environmental and economic concerns, and are “wicked”, complex and interconnected (Tomkinson 2011). Sustainability assessment has the potential to influence decision making by providing information to support the decision process. Good knowledge management has the potential to greatly help understand the nature of this connection. The three interconnected concepts of sustainability assessment, decision making and knowledge management have been explored within the thesis.

Improving sustainability assessment practice should be able to help decision making in projects. Closer integration of assessment and decision making could be argued to be not only necessary to improve decisions, but also to improve learning of those involved. Learning can be greatly facilitated by Knowledge Management, which can be used to understand and then facilitate greater participation amongst stakeholders. The distinction between the forms of knowledge used in decision making could help practitioners identify and manage sustainability related knowledge (Leblanc and Thompson 2012).

3.2 Decision making

Mintzberg et al. (1976) proposed that literature in the field of the decision process can be classified into three groups, Individual Decision Making in game research by cognitive physiologists, Group Decision Making research by social physiologist and

Organisational Decision Making research by management theorists. This Chapter reviews the principle decision making frameworks and principle research areas of decision making and how these link to decision making in infrastructure provision.

Simon's (1965) Intelligence Design Choice Trichotomy presents a three phase framework for describing decision making. 1) finding occasions for making a decision 'intelligence', 2) finding courses of possible action 'design' and 3) choosing among courses of action 'choice'. Witte (1972) addressed the issue of phases in the decision making process with the research designed to identify whether decisions follow a sequence as identified in literature. This research concluded that the decision process had a number of sub decisions but no clear sequence and the stages are performed in parallel rather than in sequence. Mintzberg et al. (1976) agreed with Witte's conclusions and states that there is "logic in delineating distinct phases of strategic decision process but not in postulating a simple sequential relationship between them" (Mintzberg et al. 1976, p 252). On this basis, Mintzberg et al. (1976) present a non sequential model, based on Simon (1965) three phase model with distinct phases, however these phases do not have a sequential relationship and could be described as more circular or iterative. Phase 1) 'Identification' consisting of two routines, decision recognition and diagnosis, Phase 2) 'Development' consisting of two routines, search and design, Phase 3) 'Selection' consisting of three routines, screen, evaluation-choice and authorisation.

Bazerman (1998) introduces the anatomy of a decision by presenting 6 steps that should explicitly or implicitly occur when applying 'Rational' decision making process. Define the problem, identify the criteria, weight the criteria, generate alternatives, assess each alternative on each criterion and compute optimal decision.

The rational decision making process that Bazerman presents is based on assumptions that prescribe how a decision should be made rather than how it is made (Bazerman 1998). Rowe and Boulgarides (1992) propose a cognitive model for the four phases of decision making, which begins to pick up the issues of judgement deviating from rationality; 1) Perception – information depends on the information taken in based on values, frame of reference, expectations and biases 2) Cognition – reasoning, judgement, goals 3) Personality- deal with power centres, respond to group pressures, accommodate, facilitate 4) Leadership- vision, beliefs, persuasion, influence.

March and Simon (1958) suggested that individual judgement is bounded in its rationality where decision makers are trying to make rational decisions but lack important information. This lack of information and uncertainty, and how bias affects judgment in decision making has been addressed by a large body of research, (Kanhneman 1982; Jackson and Dutton 1988; Bateman and Zeithaml 1989; Bushnitz and Barney 1997; Kahneman 2003; Dane and Pratt 2007). However, most notably Tversky and Kahneman's (1974) initial work on a number of strategies and rules of thumb when making decisions and introduced the concepts of 'heuristics'. Tversky and Kahneman's (1974) article describes three heuristics that influence judgement under uncertainty: firstly; 'representativeness' heuristic employed to judge the probability of an object or event, secondly; 'availability' heuristic availability of instance and scenarios, employed to assess the plausibility of a development and thirdly; 'adjustment from an anchor' heuristic, starting from an original value and adjusting. These simplifying strategies serve as a mechanism for dealing with the complexity around decision making and explain how individuals deviate from a fully rational decision process (Bazerman 1998).

March and Simon's (1958) theory that decision makers 'satisfice', where the decision maker forgoes the best solution in favour of one that is acceptable and they therefore do not examine all the possible alternatives. This theory is particularly relevant when looking at bounded rationality in design. Simon (1972) identified Engineering activities called 'design' have not been addressed under the heading of rational decision making, as classical decision theory had been concerned with a choice between given alternatives. Therefore as design is concerned with discovery of alternative, "the theory of design can be assimilated to a satisfying theory of rational choice" (Simon 1972, p172).

Astley et al. (1982), reviewing the above, concluded that "decision making can be seen as a process of muddling through towards a satisfactory and sufficient outcome as opposed to necessarily obtaining the optimal solution". March and Simon (1958) question the ability of the "rational" decision maker to make optimal choices and distinguish between optimal and satisfactory solutions to problems. Blackwood (1998) identifies that the concept of "satisficing" is particularly relevant to the design process as it is directly comparable with Asimow's (1962) principles of the "bases for decision" within the design process. In essence, the quality of the solution may vary dependent upon the time and effort expended to produce a solution and although many "satisfactory" solutions may exist some will be closer to the optimal solution than others. Blackwood (1998) reviewed the design process and identified that it is essential that the significant components of the design process can be identified and the constituent activities understood before any meaningful analysis of this problem solving process can be made. Blackwood (1998), in reviewing process models developed a generic representation of the design process comprising of three elements.

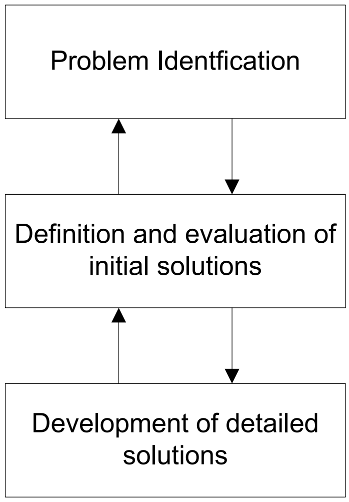

Figure 3:1 General model of the design process (Blackwood 1998)

The general model identifies three key stages in a project's life cycle and recognises that the process is not one directional but that interaction between the various stages are required. This is demonstrated by the feedback loop between the stages. Asimow recognised the iterative nature of design and considered this to be the result of the existence of sub-problems that emerge whilst the main problem is being considered. Furthermore these "horizontal" iterations were taking place within the general "vertical morphology" of the design solution. The two dimensional nature of the design process can be illustrated as shown in Figure 3:2.

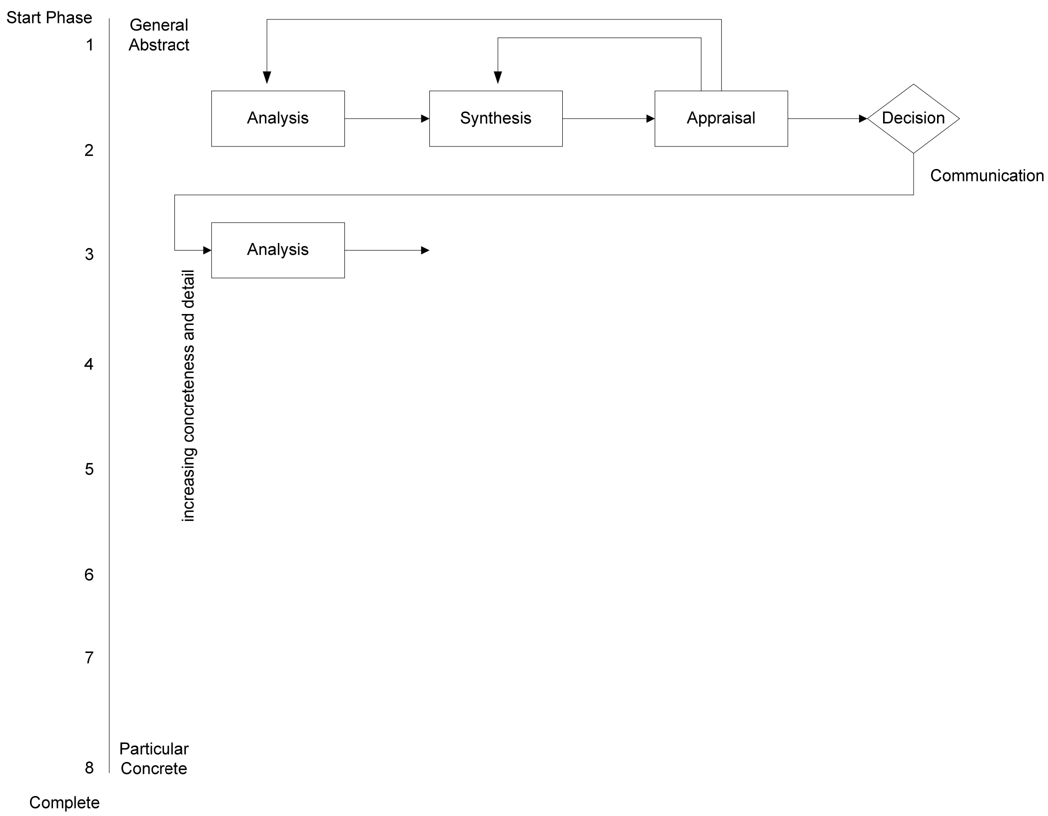

Figure 3:2 Model of the design process (Markus 1972).

Dewhurst and Gwinnet (1990) discussed the human skills that are brought into decision making and these are applicable to the technologically complex problem of design. They classify these skills into three major categories: experience, intuition, and logical deduction. Experience is built over time by individuals and organisations working in and developing an understanding of their environment. Intuition is the acknowledgement of "gut-feeling" which is often routed in experience. Logical deduction is the application of some accepted principles and approaches such as mathematical models. In the early stages of the design process, fundamental decisions, supported by little data are made more complex by the existence of a range of non-technical considerations.

Designers at this stage will place greater emphasis upon experience and intuition in reaching a decision although this will be supported, where appropriate, by logical deduction. In the later stages of the design process minor decisions will rely almost exclusively on the application of accepted principles and mathematical models, or logical deduction. It is apparent that the nature of the design activity is influenced by the irrational nature of the decision making process and complexity of the decisions to be taken. Furthermore, the approaches used to make these decisions change as the morphology of the design progresses. It is therefore necessary to understand the various stages of the design process, identify the nature of the decisions to be made at these stages, and identify the problem solving approaches that are applied in making the decisions.

The following conclusions can be drawn from the above:

- The design process is essentially a decision making process and consists of a series of iterative stages
- The required input to the design process will be greatly affected by extent to which optimal rather than satisfactory decisions are made during the design process
- The degree of rationality of this process will be affected by:
    - the extent to which the problem can be defined
    - the degree of influence of non-technical criteria
    - The extent of the application of intuitive approaches rather than logical deduction to decision making
    - the necessity for creativity in the development of the solution
    - the personal attributes of the designers

Dermaid and Quintas (2006) identify that the everyday mix of technical and business processes give rise to ill structured problems. These can be addressed by a variety of successful strategies and solutions and present themselves as ‘wicked problems’ (Rittel and Webber 1973) such as required for managing knowledge for sustainability.

As part of a review of knowledge and information requirements in engineering, Heisig et al. (2010) identified that knowledge is considered the basis for rational thinking and problem solving. Consequently designers are challenged to find the right balance between experiences, or knowledge and information (Lera, Cooper, Powell 1984). Heisig et al. (2010) sights a number of authors (Kuffner and Ullman 1991; Ahmed and Wallace 2004) who have investigated the use of information and knowledge with the purpose of their studies being to improve the understanding of knowledge and information needs of engineers and designers. Heisig et al. (2010) concludes that while previous studies looked at problem solving in design tasks the author’s study captured information and knowledge over the product life cycle, but cannot answer whether the findings were affected by role or years of experience.

Renaud et al. (2004) identify that the earlier a decision is made in the design process the more it mobilises knowledge. Having expert knowledge on hand at all times in the design process and tracking and reuse of acquired knowledge are key to capitalising on knowledge existing in an organisation. Robinsons et al. (2006) also states that knowledge management is “central to the sustainability debate” and that knowledge management helps to promote innovation from people, improves stakeholder’s involvement and promotes improvement. Dermaid and Quintas (2006) identify that critical design decisions are made throughout the process. Decisions take place in meetings, workshops and corridors, including how the project deals with risk which has a strong organisational cultural element. Lessons learnt from risk can be used to understand sustainability and concluded that if formal procedures for risk and value management can be built into management processes for major projects then sustainability procedures can also be integrated. Dermaid and Quintas (2006) also identify the complexity of the construction industry and how design and management processes differ significantly from models, as shown in the flow diagram Figure 3:3. The authors identify that through all the stages knowledge and its constituents of data, rules and procedures are made to work by people and are therefore highly complex.

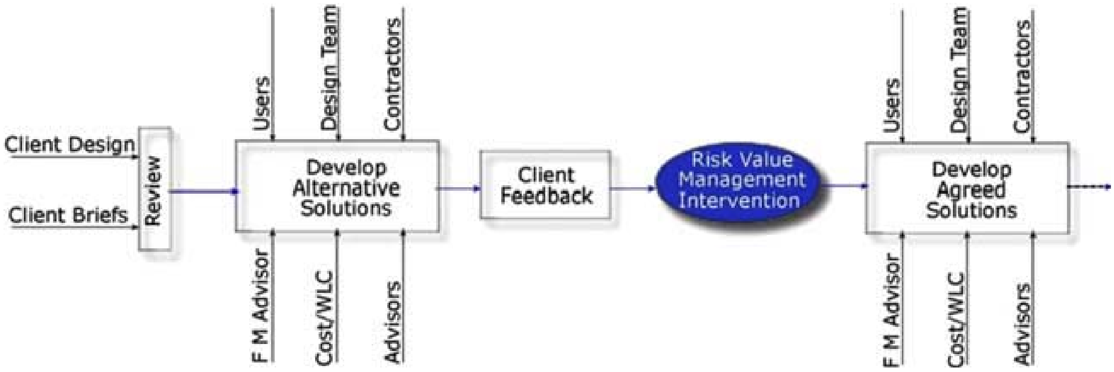

Figure 3:3 A formal portrayal of the design and bidding processes in the construction industry (Dermaid and Quintal 2006)

3.3 Knowledge management

Girard (2006) recognises common use of three related but discrete terms of data, information and knowledge. In a hierarchical structure, the basic building block of knowledge is data where processing of data results in information (Davenport and Prusak 1998; Newman 1999; Frickie 2008). Davenport and Prusak (1998) illustrate this hierarchy as a pyramid shown in Figure 3:4.

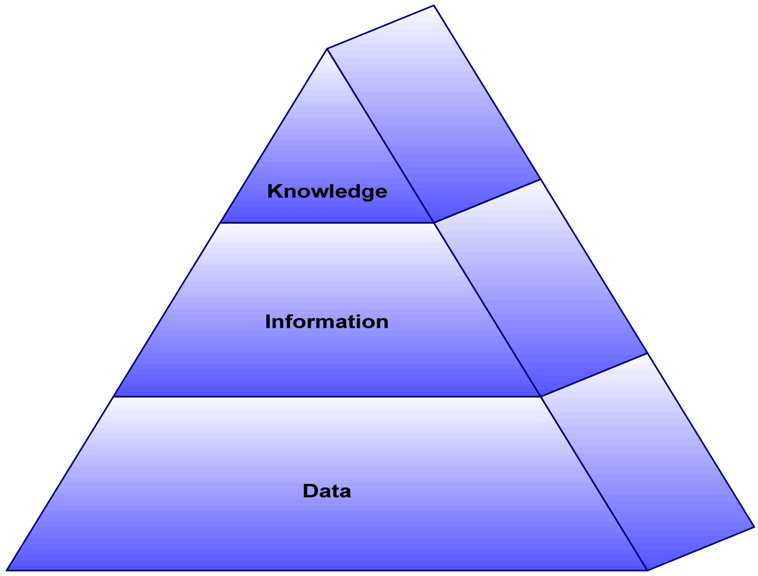

Figure 3:4 Knowledge hierarchy (Davenport and Prusak 1998)

Newman presents a model of how data is transferred to knowledge (Newman 1999) in Figure 3:5.

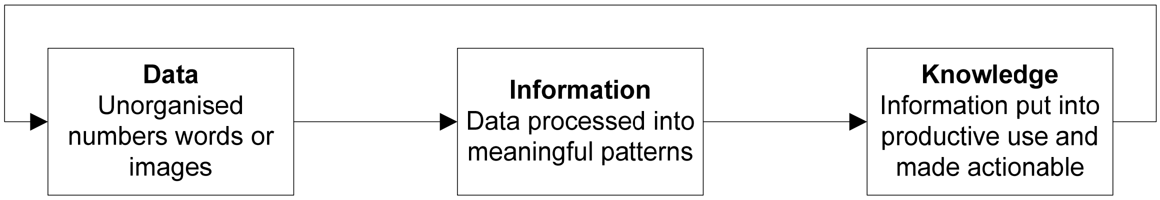

Figure 3:5 Process of data to knowledge Source: Newman (1999) p.2

To enable a discussion about data, information and knowledge, a definition of terminology is required and a starting point in this review is Davenport and Prusak's (1998) definition.

- Data - Davenport and Prusak (1998) define data as " a set of discreet, objective facts about events" (p.2) this could exist in the form of structured records within an organisation. Girard (2006) suggests this is the most straightforward definition and the least contentious within literature.

- Information - A way of defining Information is suggested by Davenport and Prusak (1998) as follows " information is meant to change the way the receiver perceives something, to have an impact on his judgement and behaviour" (p.3) This is complimented by Drucker (1998) "information is data endowed with relevance of purpose" (p.5).

- Knowledge – Davenport and Prusack (1998) define knowledge as "a fluid mix of framed experiences, values, contextual information, expert insight that provides a framework for evaluation and incorporating new experiences and information" (P.5) Kakabadse et al. (2003) presents a more simplified view that knowledge 'can be conceived as information put to productive use'.

Davenport and Prusak (1998) provide a useful starting point for defining knowledge and there is common ground in that authors agree that Knowledge is above Data and Information in the value chain (Girard 2006). This knowledge hierarchy is illustrated in Figure 3:6 together with the addition of 'wisdom' (Akoff 1989). Authors such as Allee (1997) have offered further additions including 'Meaning', 'Philosophy' and 'Union' but as Girard (2006) concluded, the name of the three components of most relevance remained the same in most models.

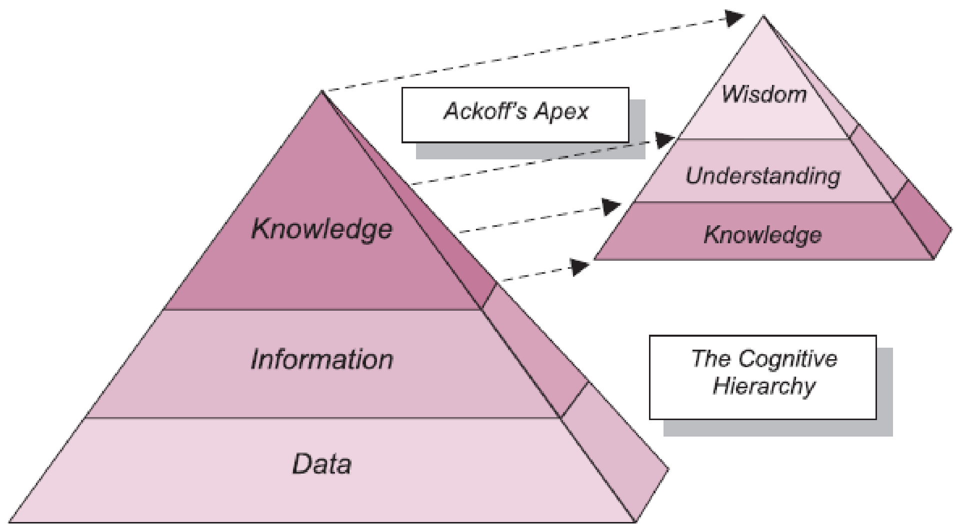

Figure 3:6 Knowledge hierarchy based on Davenport and Prusak (1998) and Akoff (1989) (source: Girard 2006 p. 23).

Rowley (2007) reviewed 'Knowledge hierarchy' literature and proposes that although it is fundamental and widely recognised it is perhaps a taken for granted model when discussing knowledge management. It is often quoted or used implicitly in definitions of Data, Information and Knowledge with the implicit assumption that data can be used to create information, information can be used to create knowledge, and knowledge can be used to create wisdom. Rowley (2007) identifies the range of theoretical debates in this area that has two major branches: information philosophy, focusing on the nature of information, and knowledge management, which contributes to notions of knowledge.

Rowley (2007) concludes that both the information philosophy and knowledge management literature are long standing and offer multiple perspectives on the definition of information and knowledge. However, Rowley identifies a consensus in literature that data, information and knowledge can be defined in terms of one another, although data and information can both act as inputs to knowledge. Finally, Rowley (2007) concludes, similarly to Girard (2006), that the consensus reaffirms the concept of a knowledge hierarchy that links the concepts of data, information and knowledge. A number of authors identify that knowledge is not just data or information alone and is a combination of experience, context and intuitions. Davenport et al. (1998) defines knowledge as "information combined with experience, context interpretation and reflection. It is high value of information that is ready to apply to decisions and actions" (Davenport et al. P.43). Zack (1999) identifies knowledge as what we come to believe and value, based in meaningful accumulation of experience, communication or inference. Knowledge is often embedded in routines, structures, cultures (Walsh and Urgson 1991), not a homogeneous mass.

Newman (1998) suggests managing knowledge means finding a way to create identify capture and distribute organisational knowledge to the people who need this information. Bender and Fish (2000) identify that knowledge can be captured and transferred in many ways, meeting, training, internal reports, job rotation and transfer and mentoring. Heisig's (2001) core process of knowledge management diagram as shown in Figure 3.7 illustrates the knowledge management cycle where knowledge is created, stored, distributed and applied.

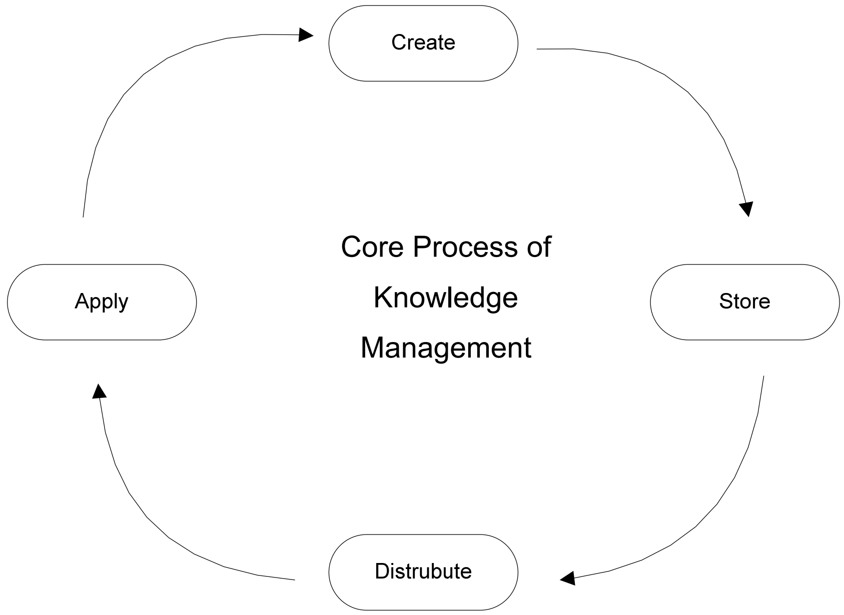

Figure 3:7 Core process of knowledge management (Heisig 2001 p. 28)

3.4 Explicit and tacit knowledge

Michael Polanyi wrote in The Tacit Dimension, “we can know more than we can tell” (Polanyi 1967, p4). Egbu (2006a) proposes that a great deal of knowledge for addressing sustainability challenges within the urban environment is tacit in nature. Anumba, Egbu and Carillo (2005) identify the opportunity for knowledge production, transmission and transfer between different professionals in the construction industry.

Explicit and Tacit knowledge are widely used in terms in knowledge management. Work by Nonaka (Nonaka and Takeuchi 1995; Nonaka 1998) stated that there are two types of knowledge, Tacit and Explicit. Nonaka and Takeuchi (1995) and Nonaka (1998) are considered to have instigated the use of these terms, together with number of other authors (Hubert 1996; Snowden 2000) and these are now widely used in knowledge management. Explicit knowledge is “formal and specific…it can be communicated and shared” (Nonaka 1998, P.27) Zack (1999) defines explicit knowledge as knowledge which can be precisely and formally articulated, easily codified, documented, transferred and shared. Zack (1999) categorises explicit knowledge into three types drawing on cognitive science literature of Schank (1975) and Anderson (1985).

- Declarative Knowledge – a shared explicit understanding of concepts, categories and descriptors that lay the foundation for effective communications and knowledge sharing
- Procedural knowledge – how something occurs or activity is performed laying the foundation for efficient coordinated activity
- Casual knowledge – why something occurs, often in the form of organisation stories

Tacit Knowledge is defined by Nonaka and Takeuchi (1995) as: “highly personal and hard to formalise, making it difficult to communicate and share with others”. Subjective insights, intuitions, hunches all fall into this category of knowledge. Furthermore, tacit knowledge is “deeply rooted in an individual’s action and experience, as well as the ideals, values, or emotion he or she embraces” (Nonaka and Takeuchi 1995, P.8). Nonaka and Takeuchi (1995) further split tacit knowledge down into two parts, a technical dimension and a cognitive dimension. Technical dimension encompasses the knowledge gained through experience, whereas the cognitive dimension is based on the individual’s belief and how they perceive the world. The spiral of knowledge and knowledge creation concepts are illustrated in Figure 3:8.

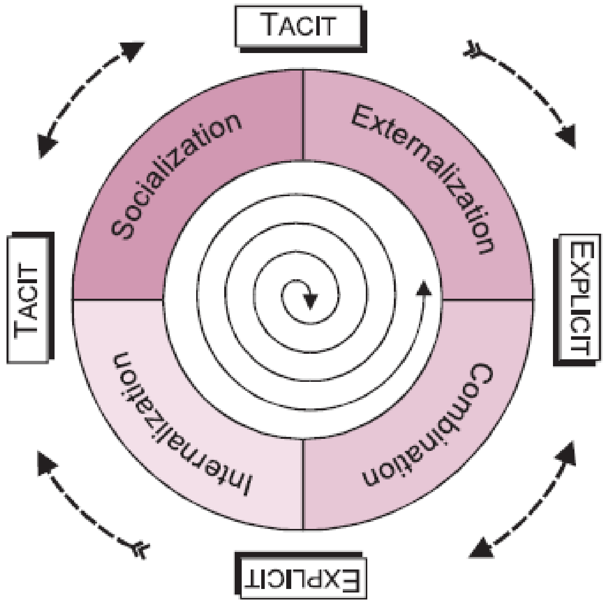

Figure 3:8 Spiral of knowledge (Nonaka and Takeuchi 1995)

Blackwood et al. (2004) state Knowledge Management is the way that organisations create, capture, distribute and re-use formal 'explicit' and informal 'tacit' knowledge. Explicit knowledge in an organisation is represented by some artefact, for example, by words, drawings, equations or numbers. Tacit knowledge is "what the knower knows which is derived from experience and embodies beliefs and values" (Marwick 2001). Organisational learning requires the transformation of knowledge from its tacit to explicit forms and Nonaka and Takueshi (1995) have identified four interrelated processes by which knowledge flows and is transformed within an organisation. Tacit knowledge is created and exchanged by "socialisation", a process of sharing experiences e.g. in meetings and in informal discussions and "externalisation" is the conversion of tacit knowledge to explicit, through conceptualisation, elicitation and articulation in the form of an artefact. "Combination" is the sharing of explicit knowledge through, for example, the dissemination of documents and reports or by formal training. Finally this explicit knowledge is converted to tacit again in the process of "internalisation" by individuals creating their own tacit knowledge in the process of acting on the explicit knowledge.

3.5 Knowledge mapping tools and techniques

NHS ABC of Knowledge management (2005) outlines common tools and techniques used in knowledge management:

- After action review - used to capture lessons learnt both during and after a project
- Communities of practice - link people together to develop and share knowledge around specific themes
- Knowledge Audits- systematic process to identify organisations' knowledge needs
- Exit interviews- to capture knowledge of departing individuals
- Best practices – capturing best practices in one part of an organising and sharing them for the benefit of wider organisation
- Knowledge centres – similar to libraries with a remit to connect individuals, resources, documents and databases
- Peer assists – to learn from the experience of others, before embarking on activity or project
- Social network analysis – mapping the relationship between people
- Storytelling – to share knowledge in an interesting and more meaningful way
- White pages – staff directory that allows people to find colleague with specific knowledge or skills

McElroy (2000) proposes there are now two generations of approaches to developing knowledge management strategies. First strategies were designed to improve knowledge sharing within organisations through using technical tools to collect and codify knowledge, whereas second generation focuses more on organisational processes. Hovland (2003) reviews a number of the most frequently cited authors of knowledge management and identifies that the authors draw on their experience as management consultants. Many similar recommendations are made by authors (Senge 1990; Argris 1992; Nokana 1995) as they all focus on the importance of thinking about process and connections within organisations (Hovland 2003).

Table 3:1 Binney (2001) sets out a framework for knowledge management options and presents the spectrum of knowledge management applications and technologies in six categories. The first 3 categories are mostly used for systemisation of existing information by technologists. The second 3 categories are for knowledge management consultants looking at organisational management (Hovland 2003).

Table 3:1 Knowledge management applications mapped to the knowledge management spectrum (source: Binney 2001, p 35)

	Transactional	**Analytical**	**Asset Management**	**Process**	**Development**	**Innovation and Creation**
Knowledge Management Applications	Case based reasoning Help desk applications Customer service applications Order entry applications Service agent support	Data warehousing Data mining Business intelligence Management information systems Decision support systems Customer relationship manager Competitive intelligence	Intellectual property Document Management Knowledge valuation Knowledge repositories Content management	TQM Benchmarking Best Practices Quality Management Business process reengineering Process improvement Process automation Lessons learnt Methodology SEI/CMM, ISP9xxx, Six Sigma	Skill development Staff competencies Learning Teaching training	Communities Collaboration Discussion forums Networking Virtual teams R&D Multi-disciplined teams

The effectiveness and significant importance of Knowledge mapping is recognised by a number of authors (Grey 1999; Vail 1999; Wexler 2001; Folkes 2004; van de Berg and Popescu 2005; Driessen et al. 2007). Egbu (2006a) states that identifying sets of knowledge which will make the greatest difference, how knowledge resides, is accessed and exploited, is integral to the issue of knowledge mapping. Egbu (2006a) also states that the clearest benefit and principal purpose of a knowledge map is to identify where to go when you need to access expertise, for example, knowledge of sustainability.

Speel et al. (1999) defined knowledge mapping as the process, methods, tools for analysing knowledge areas in order to consider features and visualise them in a meaningful and transparent form. Vail (1999), Folkes (2004), Berg and Popescu (2005) describe knowledge mapping as the technique and tools for visualising knowledge relationships, where relevant features are highlighted and mapping itself may create additional knowledge. Liebowitz (2005) states a knowledge map portrays the sources, flows, constraints and knowledge sinks (losses or stopping points) of knowledge within and organisation. Driessen (2007) identifies the information gathering benefits of knowledge mapping and its usefulness for making the knowledge available within an organisation transparent. Ebner (2006) proposes that visualising the result of mapping makes it easier to share information and allows a more integrated analysis of large amounts of data that could be easily captured in another form such as a table or text.

Yasin and Egbu (2010) make an important distinction between mapping tools and mapping techniques. In the field of Information technology, knowledge mapping tools are related software which help conveying, sharing, linking information and data such as online databases and intranet. Knowledge mapping techniques are specific protocols or modus operandi to map the knowledge (Yasin and Egbu 2010).

Mapping can be used to review an existing situation before improvements are made. It lets organisations control large amounts of information and display it in a pictorial form (Klotz et al. 2008). It also can help improve the transparency of a company's decision as every decision is clearly mapped out and the consequences shown. It is also a way of measuring a current situation and then as a basis for improvements (Klotz et al. 2008). Robinson et al. (2006) states that the main motivation for knowledge mapping is to share knowledge between employees, communicate best practice and to reduce workloads.

Wexler et al. (2001) emphasises several key people in the process: the map maker, map users, map innovators and map champions. The map maker in this process would be the person(s) involved with the creation of the decision making process. Kumar et al. (2005) makes it clear that a baseline has to be established to enable an effective valuation of any improvements. Yoo et al. (2007) also states that an "as is" should be established before process optimization takes place. The point is also made that the wider implications of the process should be considered.

Kumar et al. (2006) states that "Documenting processes can lead to insights and changes that can help improve operations." While Kumar is mainly concerned with manufacturing processes several points are still applicable to design. Decision mapping enables uncertain factors to be examined, enables the existing and proposed processes to be visualised and helps with the early elimination of any processes that will obviously fail. A final point made is that all gains can be seen which helps with any final decision making. Khoo et al. (2000) also states that there are three points to the investigation for process mapping. These are processes, decision making and environment in which the decision is made.

Driessen et al. (2007) states that there are three sources of knowledge; these are other employees, various documents and the various information systems used by an organisation. The problem with these sources of information is that other employees, outside an individual's circle of knowledge, are rarely asked which can lead to missed opportunities. There is usually a large amount of documents which are poorly organised and maintained. Also there may be several information systems and each one may be operated differently. A good process map would help point to important sources of knowledge and enable the correct stakeholders to be involved at the appropriate stage of any project. It would also assist both established and new staff to follow a consistent process (Driessen 2007).

Yoo et al. (2007) states that knowledge mapping and business practices are indistinguishable as knowledge is often derived as a result of business processes. He then states that a buffering procedure should take place periodically so that knowledge can be updated. Yoo et al. (2007) also states that as part of an optimization process multiple knowledge flows should be eliminated as part of a simplification process. In the knowledge mapping process shown by Yoo, knowledge becomes a node in any network and the processes become the links. This is due to the knowledge in a business process being made up of a series of inputs and outputs.

Folkes (2004) and Egbu et al. (2006b) have developed a comprehensive list of knowledge mapping tools and techniques. Jafari et al. (2009) also presents a number of different mapping methods as shown in Table 3:2.

Table 3:2 Knowledge mapping tools and techniques

Techniques	Use in organisation.
Yellow paging	Yellow paging is a structural collection of data and documents which facilitates communication and knowledge sharing between individuals. Iske (2005) identifies some limitations with this system, namely little integration in business process, no connection with entering information and context of information use, requires pro-active updating of system.
Information flow analysis	Through analysing organisations functional process and informal networks information flow analysis identifies what resources, how often resources are being accessed and by who within and organisation
Social network analysis	Social network analysis (Cross 2002) maps the relationships and flows between nodes (people, groups, computers). Flows are recorded and show the relationship between the nodes. Social network analysis identifies how information flows in an organisation and channels of communication of tacit knowledge.
Process knowledge mapping	Process knowledge mapping defines the knowledge needed and available to support a business process. Mapping business process identifies where decisions are made, where knowledge is needed, knowledge requirements, gaps between measured and current skills (USIDA 2003)
Functional knowledge management	Jafari et al (2009) describes Functional knowledge mapping approach which identifies the individual's knowledge and social contacts which are related to their specific position. The approach aids the identification of skills, experiences, training and other resources applicable to in other areas of the business

Folkes (2004) identifies a very wide range of map form and their various uses. These can be seen in Figure 3:9.

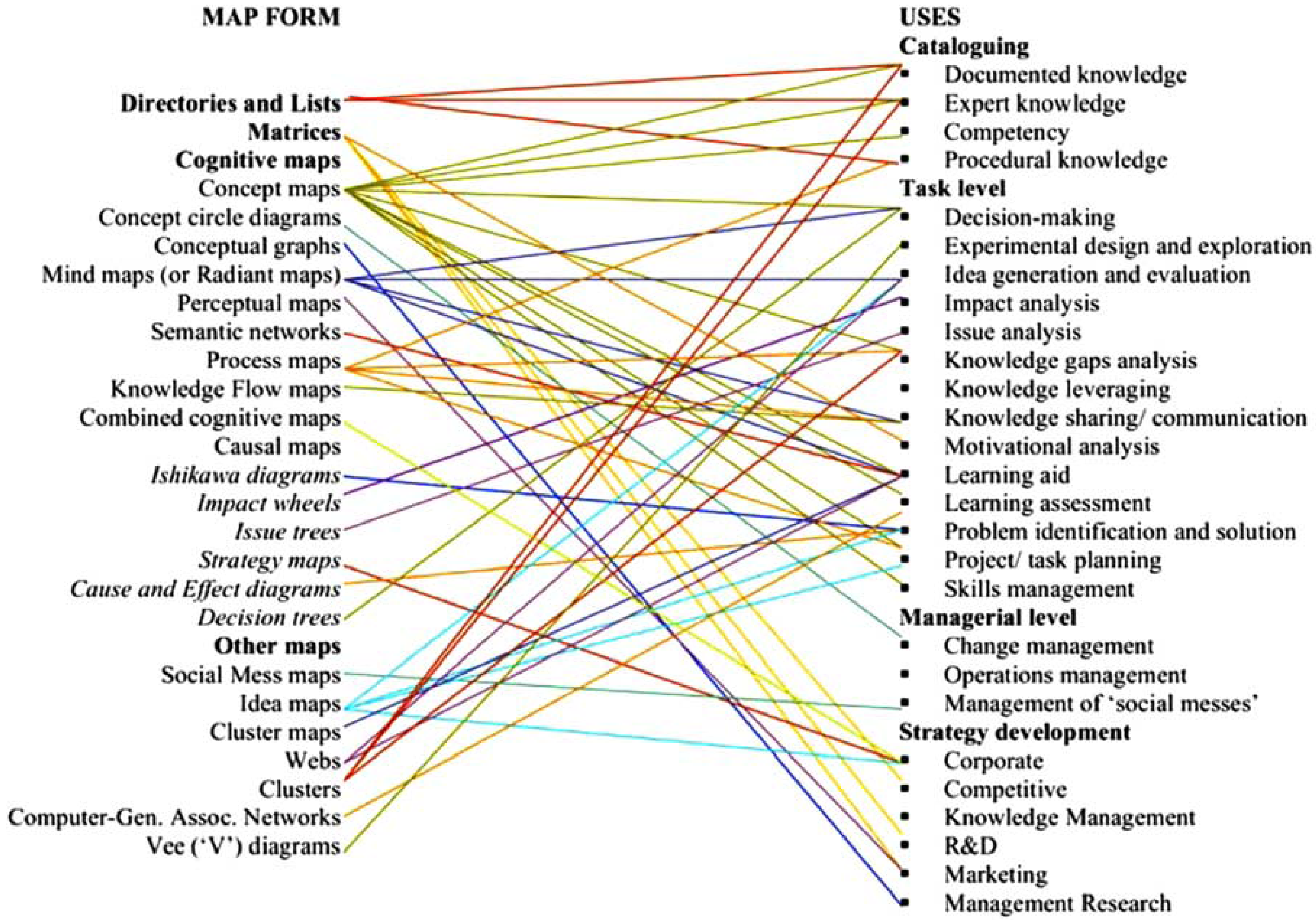

Figure 3:9 Knowledge mapping: map types, contexts and uses (Source: Folkes 2004)

Egbu's (2005) study revealed that many of these tools and techniques were not widely used in the construction industry and proposed a list of nine tools or techniques relevant for construction industry as shown in Table 3:3.

Table 3:3 Mapping tools and techniques relevant for construction industry (Egbu 2006a)

	Knowledge mapping Tools / Techniques	Construction Industry Actors	Software Developer
1	Casual Map	√	√
2	Cognitive Map	√	
3	Concept Map	√	√
4	Knowledge Flow Map	√	
5	Mind Map	√	√
6	Perceptual Map	√	
7	Process Map	√	√
8	Semantic Map	√	
9	Social Mess Map	√	

3.6 Criteria for evaluation

Knowledge mapping helps to increase the visibility of knowledge sources and hence facilitate the process of locating relevant expertise or experience (Egbu 2006a). Egbu (2006a) identifies a number of additional benefits of knowledge mapping.

- Helps find critical information quickly
- Improves awareness of organisational cultural issues and their values
- Improves decision making and problem solving
- Provides insights into corporate knowledge
- Increases the ease of access to relevant knowledge
- Shows the flow of knowledge within and across the organisations
- Provides an inventory of knowledge assets

As previously noted authors such as Wexler (2001), Vestal (2005), Driessen (2007) have identified the importance of mapping techniques, but only a few papers have discussed how researchers identify the most appropriate techniques to map knowledge. Egbu (2006a) assesses the efficacy of knowledge mapping tools and techniques and presents the key factors considered by users of mapping tools in the construction industry. These are presented as evaluation criteria in Table 3:4.

Table 3:4 Criteria for structured assessment of knowledge mapping tools (Source: Egbu 2006a)

Evaluation Criteria	Knowledge Mapping Tools/Techniques							
	Casual Map	Cognitive map	Concept Map	Know-ledge Map	Mind Map	Process Map	Semantic Map	Social Mess Map
Robustness	Med	Low	High	High	High	Med	High	High
Cost	Low	Med	Low	Low	Med	Low	High	High
User Friendliness	High	Med	Med	High	Med	High	High	High
Dynamism	Med	Med	Med	Med	Med	Med	Med	Med
Training	Low	Low	Med	Low	Med	Low	Low	Low
Impact	Med	Med	Low	Med	High	Med	Med	High
Adaptability	Med	Med	Low	Low	Low	Med	Med	Low

Jafari et al. (2009) presents a framework for the selection of knowledge mapping techniques and suggests criteria for comparing mapping techniques which are drawn from literature and ranked by 50 experts.

1. Used tools for data gathering (Vestal 2005)
2. Used tools for knowledge map evaluation (Vestal 2005)
3. Mapping objectives (Lecocq 2006)
4. Knowledge map characteristics and capabilities (Lecocq 2006)

5. Users (Lecocq 2006)
6. Determination of Knowledge map elements (Lecocq 2006)
7. Knowledge map approaches (Jenning 2006)
8. Top down or bottom up (Wexler 2001)
9. Static or Dynamic Knowledge map (Woo 2004)
10. Strategic or Tactical View (Hornett 2006)
11. Support individual group (Driessen 2007)
12. Support tacit or explicit knowledge (Martensson 2000)

The top 6 criteria were then validated and used by the author to compare knowledge mapping techniques as shown in Table 3:5.

Table 3:5 Knowledge mapping techniques comparison (source: Jafari et al. 2009, p.9)

	Yellow Page	Information Flow	Social Network Analysis	Process Knowledge Mapping	Functional Knowledge Mapping
Used tools for data gathering	Question and answer systems, skills dictionary and reports	Interviews skills inventories and extensive surveys, Information Flow Diagrams (IFD)	Questionnaire Sociogram graph theory	Brainstorming or conduct interviews with the process owners	Surveys and interviews
Used tools for knowledge map evaluation	Skills delivery	Questionnaire interviews and sign out sheets	Inflow, Krackpot and NetMiner	-	Observations, interviews, internal reports

Table 3.5 Knowledge mapping techniques comparison (continued)

Objectives	Create transparency as to the location of knowledge in the organisation by registering individual competencies in a database or similar	Determining who is accessing what information, resources and how often	Discover interaction patterns between members	Define knowledge needed, decision milestones, the knowledge available to support business process, routes for access retrieval of knowledge	Locate knowledge sensitive areas, identifies and characterises areas of process related critical knowledge spots
Knowledge mapping approach	Project based	Relationship based	Relationship based	Process based	Process based
Create static or dynamic map	Static	Static	Dynamic	Dynamic	Dynamic
Support tacit or explicit	Explicit	Tacit	Tacit	Explicit, Tacit	Explicit, Tacit

Egbu (2006a) reports on the development test and refines a generic knowledge mapping model for sustainable development. Drawing on stakeholder interviews four main issues were identified as being important.

1. Simplicity
2. Pragmatism
3. Dynamism
4. The ability to consider the why who what and where of Knowledge mapping

From this starting point Egbu (2006a) developed a five stage model to address the main issues of sustainability and knowledge mapping. Figure 3:10 shows the generic model of knowledge mapping for sustainability developed. Egbu (2005) recognises a key factor in the effectiveness of knowledge mapping is involving the right people who understand the process or knowledge domain. Egbu comments that the map can be as simple or as complicated as required, and states that at the commencement of a mapping process a clear articulation of the goal of knowledge mapping should be made together with a high level map of process area or organisation.

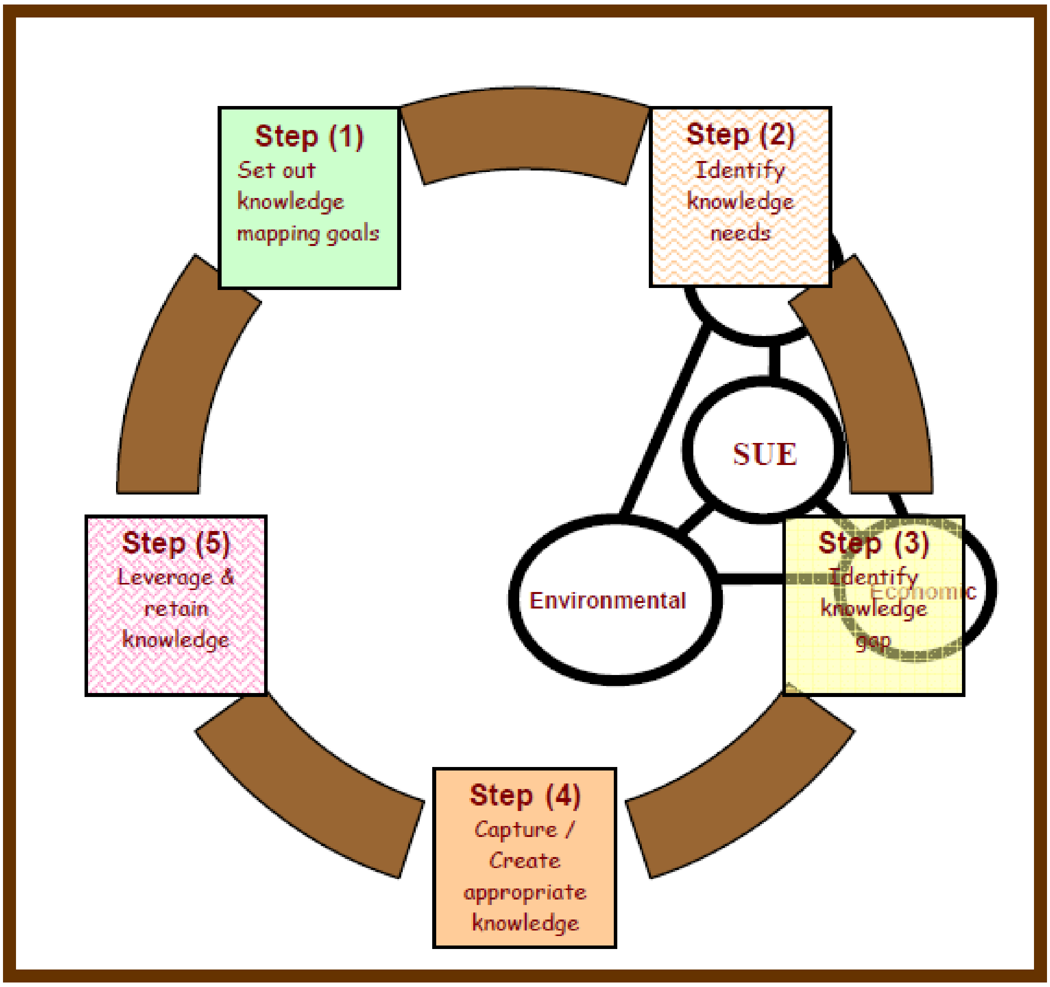

Figure 3:10 Generic model of knowledge mapping for sustainability (Egbu 2006a)

Egbu et al. (2006b) appraised the options to modelling and mapping knowledge which considered the flow of knowledge for sustainability, how it is created, distributed and accessed. The report presented recommendations with regard to strengths, weaknesses and suitability of mapping techniques, and concluded that if chosen effectively, knowledge mapping techniques are useful for decision makers working in the sustainable urban environment (Egbu et al. 2006b). The dynamic mapping of knowledge requires the identification of temporal aspects of time, duration behaviour and a way to map them in a dynamic manner (Egbu 2006a). Egbu (2006a) proposes that the mapping tool has to identify three needs to achieve a satisfactory dynamism.

1. Need to depict over time the relations that are most representative or central
2. Need to make relative assumption over the richness of the social interactions
3. Need to evaluate the capabilities that are most relevant to the organisation

Yoo (2007) presents a way of applying a knowledge map to redesign business processes. The authors used a knowledge map as an influence diagram showing the information or knowledge the person possessed when they took the action. Using this approach the relationships are sequenced logically to solve a given problem. Yoo (2007) outlines that to build the knowledge map the business process should be identified and analysed, and states knowledge flows and business flows cannot be separated (Yoo 2007). Yoo (2007) identified the following stages in mapping 1) map the process, 2) based on process map the knowledge, 3) profile the knowledge based on the processes, 4) knowledge flow identification based on the sub goal.

Yasin and Egbu (2010) identify that it is important to understand the perspective of the knowledge map and the form of the map (virtual or physical) before the benefits of using a knowledge mapping technique can be exploited. Ebner et al. (2006) suggest that a knowledge map should be created with reference to the following four stage visual framework as outlined in Table 3:6 and the success of the process depends to a great extent on the people who apply it and their ability to engage their participants in the exercise. Ebner (2006) also suggest for success of the map there is a need to ensure that stakeholders can understand and interpret map and integrate all four perspectives of the visual framework outlined below.

Table 3:6 Visual framework for knowledge mapping

The function of the map	Coordination, motivation and the elaboration
The knowledge types	Know what, know how, know why, know where and know who
The recipients	Individual, group, organisation, network
The visualisation type	sketch, diagram, image or map

3.7 Author's previous knowledge mapping and decision mapping work

The author first used knowledge management and decision mapping approaches as part of a sustainable decision making project (Butler et al. 2003). Blackwood et al. (2004) further developed mapping work with the development and application of a knowledge representation methodology. In this study a knowledge mapping methodology was devised that built upon the author's experience of the application of decision mapping (Bouchart, Blackwood, and Jowitt 2002) and data flow diagrams (Blackwood et al. 2000). These proved effective in identifying decision criteria and showing how decisions were taken. The author's previous studies of the decision making processes have shown that the large number of stakeholders involved and the nature of their interaction results in a much less rational and less structured approach to decision making than had been previously assumed (Ashley 2004). The research also demonstrated the non-linear iterative nature of the decision making process as identified in literature reviewed in Section 3.1 and the complexity of the pattern of communications during decision making. The methodology identified the sources of knowledge of the decision maker.

This previous work by the author demonstrated that knowledge mapping techniques were useful for decision makers working in the sustainable urban environment. The author's conceptualisation of the decision process, experience of the application of techniques such as decision mapping and knowledge categorisation were considered to be successful in previous studies. However, one key finding from previous work was the large amount of information generated through data flow diagrams and associated knowledge categorisation approaches. From this it was concluded that an alternative approach was required for mapping process and knowledge across infrastructure provision. Another key issue when considering an approach was the appropriateness of Knowledge Management to the organisation. Therefore, some transparent and communicable method of knowledge elicitation and evaluation was required.

3.8 Conclusion

The extent to which sustainability issues can be incorporated into the built environment is influenced by the degree of rationality of the decision making process. Rational decisions are desirable and could lead to optimal choices being made but require a highly specified and clearly defined environment. The review identified that decision making in practice is seldom structured and that often "satisfactory" solutions are reached in an ad-hoc basis and concludes that most human decision making is concerned with the discovery and selection of satisfactory rather than optimal alternatives. It describes this process as "satisficing". The concept of "satisficing" is particularly relevant to the design and planning stage of urban developments.

The review identified the types of knowledge that are used in decision making and the terms and techniques widely recognised in knowledge management. The literature concluded that it is important that mapping should recognise the current organisational process and needs to be simple or as complicated as required. Previous methods adopted by the researcher only used selected key information flows that were identified by interview. A method is therefore required that maps both the whole process involved and the knowledge supporting the process in order to effectively understand decision making which will influence sustainability across the life of a project.

The literature concluded knowledge mapping techniques were found to be useful for decision makers working in sustainable urban environments. The method chosen required the ability to map knowledge dynamically including the temporal aspects. The following key methods have been taken forward for application in the case study:

- To identify key points in the decision process and elicit knowledge used to make decisions. Techniques for knowledge elicitation - Snowden 2000 offers a linguistic framework which will be used in data collection to identify knowledge disclosure points (decisions) and analysis to categorise knowledge.
- To be dynamic and represent relationship between knowledge and process flows. Techniques for mapping knowledge – authors reviewed identified process mapping as an appropriate techniques (Biazzo 2022: McCormack

and Rauseo 2005). Process maps will be used in the data collection given the need to understand the context of the decision and understanding that the process and knowledge are inseparable.

- To be simple, transparent, pragmatic and illustrate the why, who, what and where of knowledge mapping. Techniques for developing a knowledge map – a number of authors who have effectively used decision mapping or knowledge mapping to document, understand organisation knowledge management and decision making (Wexler 2001; Vestal 2005; Driessen 2007; Yasin and Egbu 2010).

The combination of literature review focussing on mapping techniques and past experience of applying decision mapping approaches has led to the identification and development of a process mapping approach. This approach is described and implemented in Chapter 6 with methods used identified in Table 6:1.

4 Chapter 4 Research Strategy

4.1 Introduction

The aim of the research was to develop and apply knowledge mapping techniques to effectively assess and enhance sustainability within a major urban redevelopment project. The need for to the application of these techniques to real life decision making practices to operationalise sustainability has been outlined in Chapter 1. To achieve this aim, the research programme was undertaken in collaboration with Dundee City Council to support the sustainable development of Dundee Waterfront urban redevelopment.

This chapter describes the theoretical framework developed as a result of the literature review chapters and justifies the research strategy undertaken in the thesis. The justification of the research strategy draws out the choices made in relation to selecting the application of qualitative techniques to a case study and the philosophical position taken by the researcher.

The case study approach is explored, examining the use of a case study in organisational research and the limitations of the approach centring on issues of validity, bias and representativeness of case study research. The choice of the case study is presented together with a reflection on the appropriateness of the case study chosen. Steps taken by the researcher to ensure research quality by addressing issues around validity of case study findings are described. Finally, the Dundee Waterfront case study is presented to provide the context for the research undertaken. The data collection methods are outlined and forward referenced to Chapters 5 and 6 where data collection for each component of the framework is fully described.

4.2 Theoretical Monitoring and Enhancement Framework

The literature reviewed in Chapter 2 identified three key conclusions to inform the approach undertaken in the thesis.

- Firstly, sustainable development for urban development projects requires an integrated approach delivered across different scales namely policy, programmes and projects.
- Secondly, indicators play a key role in the assessment of sustainable development on a European, national and regional level. They have the ability to monitor performance, assist decision making and link impacts across spatial and temporal scales.
- Thirdly, the review of assessment and decision support tools for sustainable development suggests that tools are currently used in isolation and no tool supports sustainability across the project life.

A theoretical framework was therefore proposed to address these conclusions. The framework comprised of two parts, a monitoring framework which links policy and programme level objectives with project level outcomes, and an enhancement framework to influence sustainability through the project life.

The high level relationship between the conclusions from Chapter 2 and Chapter 3 and the Sustainable Development Monitoring and Enhancement Framework are shown in Figure 4:1. Methodological components drawn out of the literature review are summarised in Table 4:5 at the end of Chapter 4 and fully described in relevant sections of Chapters 5 and 6.

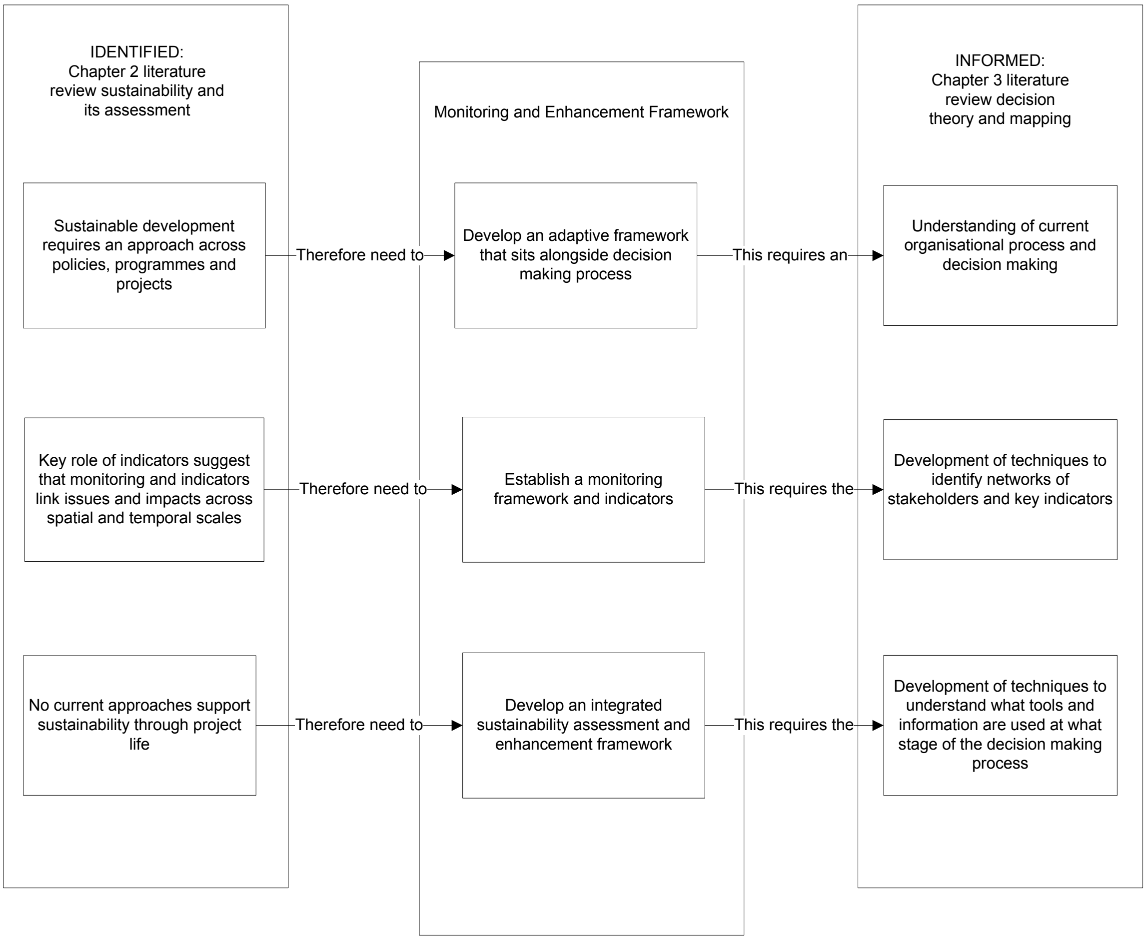

Figure 4:1 Relationship between literature review and Monitoring and Enhancement Framework

4.2.1 Assessment and Monitoring Component

The Assessment and Monitoring Component provides the data that are necessary for sustainability assessment and monitoring throughout the life of an infrastructure project. A sustainability benchmark is established at the visioning stage of the development and continuously monitored through the design, construction and occupancy stages. This will ensure that adequate consideration is given to sustainability issues throughout the process and that the impact on sustainability of key decisions at these four stages is assessed and understood. The initial outcome from the assessment component is a sustainability indicator set. The initial measured or modelled values of these indicators define the pre-development baseline of sustainability. These are published in a Baseline Sustainability Assessment Report. Subsequent Sustainability Monitoring Reports will then be published which provide an update of the indicator values. This will enable the assessment and reporting of changes and trends in the sustainability of a project. The direction of the indicators will inform the Enhancement Component. The Assessment and Monitoring component of the framework is presented in Chapter 5.

4.2.2 Enhancement Component

The Enhancement Component is concerned primarily with ensuring that due consideration is given to the potential impact of decisions and actions at key decision points throughout the project development stages on the direction of the sustainability assessment indicators. The purpose of the Enhancement Component is to identify opportunities to positively influence the sustainability of the development and to devise and implement appropriate activities and actions. This requires the application of a combination of techniques drawn from the information technology, knowledge management and business process mapping fields.

The Enhancement Component provides an understanding of the ways in which decisions are made throughout the project and enables the information needs of key decision makers to be determined. Key decision points in the process, the stakeholders involved in these decisions, their functions and their information needs are all identified at this stage. This ensures that information on the potential impact of decisions or actions that will influence the overall sustainability of the project can be provided to the right stakeholders, at the right time and in the right form. The Enhancement Component is presented in Chapter 6.

4.3 Justification of the research strategy

Bryman and Bell (2003) defines research design as the way data is collected and analysed based on the research question in order to provide a framework for understanding the research. Yin (2003) states that research design requires a choice of research strategy which is determined by three factors;

1. Type of research question to be addressed
2. Degree of investigator control
3. Degree of focus on contemporary events

Gorse (2005) proposes that the reasons for conducting the research, the key issues and methods used, the problems encountered during the research and the limitations of the research should all be clearly stated. Gorse notes that there are limitations within each study and research method.

Edmonds and Kennedy (2012) recognised the variety of terminology used in literature when discussing research methods and developed a research terminology hierarchy as shown in Table 4:1. An example of this is the current debate on qualitative research in the organization and management field around the use of methods and methodology (Bryman 2008). The Edmonds and Kennedy (2012) hierarchy was used to frame the justification of the research strategy in this thesis to ensure clarity in terminology.

Table 4:1 Research terminology hierarchy (Edmonds and Kennedy 2012, p xix)

Level	Explanation
Method	The method is the theoretical, philosophical and data analytic perspective. The method can be quantitative, qualitative or mixed (e.g. quantitative *method*)
Research	Research refers to the systematic process of control (e.g. group assignment, selection and data collection techniques). Research can be experimental, quasi-experimental or non-experimental (e.g. a quantitative method and experimental *research*)
Approach	The approach is the first step to adding structure to the design. It details (a) a theoretical model of how the data will be collected (b) if one case, one group, or multi groups will be associated with the process (e.g. a quantitative method, experimental research, with a between subjects *approach*)
Design	The design is the actual structure of the framework that indicates (a) the time frame that the data will be collected or how and when the data will be analysed (b) when the treatment will be, or not be, implemented (c) the exact number of groups that will be involved (e.g. a quantitative method, experimental research, with a between subjects approach, and a pre-test and post-test control group *design*)

4.3.1 Method

Methods can be classified according to whether they are qualitative or quantitative, where qualitative methods are distinguished by their collection and synthesis of information in a mainly non quantitative way. Quantitative methods tend to involve defining variables and quantifying observations on those variables (Edmonds and Kennedy 2012).

- Quantitative - traditional experimental design, defining and changing variables
- Qualitative - often uses different sources of data, transcripts, participant observation, interviews

Salkind (2012) states that qualitative research examines individuals, institutions and phenomena in the context in which they occur. Salkind also comments “It is not so much the sources of information that are important, but how they are used to answer the research question” (Salkind 2012 p. 11).

Graham and Thomas (2008) consider the importance of the researcher’s philosophical position and definition of a research paradigm. Two main concepts to be considered are Ontology, the form and nature of reality, what exist and how, and Epistemology concerned with nature of knowledge between the knower and what can be known (Schwandt 2001; McCalin 2003; Dainty 2007).

Knight and Ruddock (2008) discuss the methodological positions and the research methods used by construction management researchers. They recognise construction management as a relatively new field which draws on the natural and social sciences, based upon the theoretical and philosophical foundations of these methods. Dainty (2008) reviewed methodological positions and research methods adopted by construction management researchers. From this work Dainty developed four broad classifications as shown in Table 4:2.

The aim of the qualitative methods is to understand or interpret phenomena within the context or meaning of which it is expressed (Edmonds and Kennedy 2012). Qualitative research method has a focus on understanding and an emphasis on meaning. It often answers the how and why of systems and human behaviour. The type of analysis is mostly inductive involving the identification of patterns and relationships (Wersz et al. 2011).

Table 4:2 Classification of research methods adopted by construction management researchers

Method	Methodological position
Quantitative	Quantitative methods rooted in positivist research paradigm
Qualitative	Qualitative methods rooted in an interpretive research paradigm
Mixed Methods	Combination of both inductive and deductive research methods
Review	Not utilising empirical research methods.

It is therefore concluded that methods that gain an in depth understanding of culture and behaviour, institutions and phenomena, within the context they occur are particularly appropriate for answering the research question as outlined in Section 1.3. In this undertaking an interpretive constructivist philosophical position has been taken in line with other construction management researchers undertaking qualitative research as outlined in Dainty's work.

4.3.2 Research

There are two categories of research models, experimental and non-experimental. Experimental models are where there is active manipulation of variable or conditions and non-experimental are those in which no active manipulation takes place. Salkind (2012) provides examples of non-experimental and experimental methods as shown in Table 4:3.

The Non experimental research model allows the researcher to explore experiences, phenomena and social processes as they evolve. Therefore a non-experimental qualitative research model is considered appropriate to address the research question in this thesis.

Table 4:3 Categories of research models experimental and non-experimental (adapted from: Salkin 2012, p10)

	Model	Example
Non experimental	Historical	Examining the occurrence of practices in 1850 and comparing them with current practices
	Descriptive	Survey to find if x has an impact on university performance
	Correlational	Looking at the relationship between social media involvement and number of friends
	Qualitative	Investigating the success of a school and its impact on urban and rural families
Experimental	Quasi-Experimental	Examining the difference in compliance levels among diabetic and non diabetic adults in a weight reduction.
	Experimental	Examining the differences among three different types of balance programs that enrol older senior citizens.

4.3.3 Approach

Edmonds and Kennedy (2012) identifies four main categories of approach when considering qualitative research, Grounded Theory, Ethnographic, Narrative, Phenomenological research. Creswell (2008) adds a fifth category to this list, Case Studies as described below:

1. Grounded theory - a way to generate theory based on data that are systematically gathered and analysed.

2. Ethnographic - research designed to describe and analyse the culture of a particular social system or organisation based on detailed observation of what people do.
3. Narrative - involves gathering information in the form of storytelling to understand phenomena.
4. Phenomenology - description of an individual experience with the goal of understanding how individuals construct reality.
5. Case Studies – research explores in depth a programme, event, an activity or a process. The cases are bounded by time and activity and researchers collect detailed information using a variety of data collection procedures over a sustained period of time.

An approach that gained an in depth understanding of organisational process, culture and behaviour within the context it occurs, was required to develop the adaptive framework as set out in Section 4.1. A case study approach was considered appropriate to address the research question and fits well with the interpretive constructivist philosophical position established in Method Section 4.3.1. The use of a case study in organisational research was supported by Yin (2012) who presents a series of case studies, with case study applications of institutions and organisations the dominant genre. Yin concludes that case study research and evaluation are very effective in investigating multifaceted phenomena present in organisations.

Case studies can be used to examine a phenomenon within a specified context. Yin (2009) defined a case study as an empirical enquiry that investigates phenomena in a real world context where boundaries and context are not clearly evident, and can be investigated using multiple data sources. Schell (1992) identified that case studies have strength through their ability to deal with a full range of evidence such as documentation, artefacts, interviews and observations.

Limitations of case study approach are identified in literature (e.g. Collier and Mahoney 1996; Flyvbjerg 2006) centring on potential issues of validity, researcher bias and inability to generalise the case study findings. Validity is defined as the extent the outcome accurately answers the stated research question, is relevant in qualitative research in terms of the trustworthiness of the data and the rigour and quality of data collection methods (Williams and Morrow 2009). Four types of validity are commonly identified in research methods as outlined by Edmonds and Kennedy (2012):

- Internal validity is the extent to which the outcome was based on the independent variable.
- External validity is the extent to which results can be generalised to relevant settings or outcome.
- Construct validity is the extent to which measurement can be linked back to the conceptual basis for the outcome.
- Statistical conclusion validity is the extent to which the statistical relationship between treatment and outcome is accurate.

George and Bennett (2004) review trade-offs and potential pitfalls of case studies. Inherent limitations include relative inability to render judgements on the frequency of representativeness of particular case studies. The authors identify two main issues:

- Case selection bias - choosing cases to compare that have particular outcomes or fore knowledge of values in a case study, cognitive biases in favour of a hypothesis may bias the selection of a case study. The alternative viewpoint is, understanding a case allows much stronger research design.

- Lack of representativeness - case studies are often criticised for not being representative in the statistical terms and therefore have a perceived inability to generalise the case study findings. However trade-off between broad applicability and richness are often made in case study research.

Yin (2009) argues that case studies should meet challenges outlined above by using systematic approach to case study research. Bryman and Bell (2003) identifies that biases are accepted as part the process of qualitative research. The authors state that reflections in qualitative enquiry, where researchers openly question effectiveness of research methods on the robustness of their research and the effect their enquiry has had on the phenomena that they have observed, is common (Bryman and Bell 2003).

Yin (2012) identified 3 steps in defining the case study and in turn demonstrating the systematic procedures in undertaking case study research.

1. Defining a case: A case is generally bound by an entity such as a person or organisation event. Yin suggests identifying a significant case, which can be distinctive if not unique, such as organisation change or dramatic neighbourhood change.
2. Select a case study design: A single or multiple case study can consist of holistic case or have an embedded sub case within a holistic case. These are shown diagrammatically in Figure 4:2.

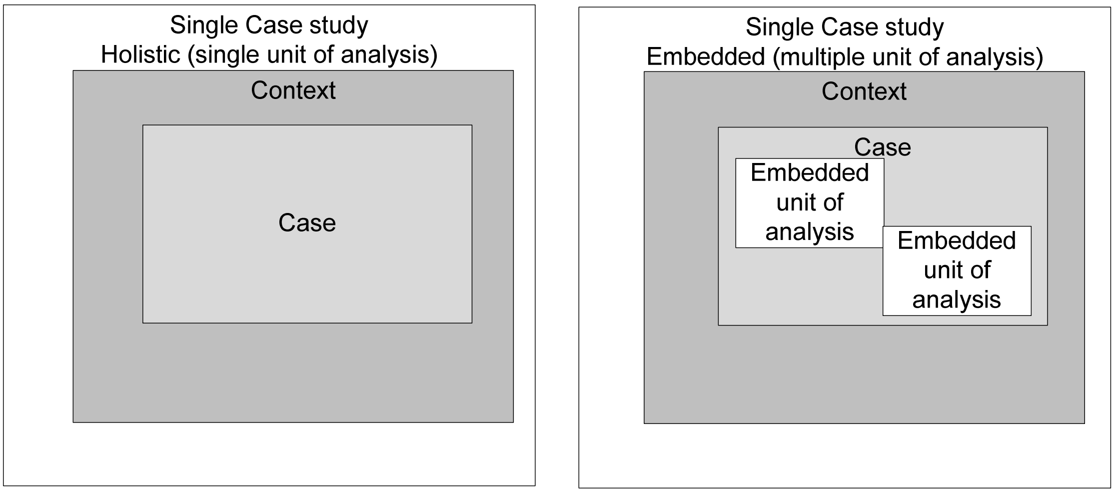

Figure 4:2 Basic types of design for case studies Yin (2012)

3. Theory in design: A theoretical perspective is required to develop research questions and to define relevant data to be collected. Yin (2012) identified how the use of theoretical frameworks can assist in generalising findings from the case study by establishing logic that may be applicable to other situations. This conceptual claim of how the study has informed the theoretical construct then can be related to other situations where similar theoretical constructs apply.

Yin (2003) proposes criteria for the validation of research quality in case studies as shown in Table 4.4. The criteria to ensure research quality respond to issues around validity as outlined in Section 4.3.3.

Table 4:4 Criteria for the validation of research quality in case studies

Construct validity	Establishing correct operational measures for the concepts being studied Case study based on theoretically founded criteria with a clear and logical link between literature review, data collection and analysis.
Reliability	Provided by case study protocols described in sufficient detail to replicate approach.
External validity	Criteria for interpreting findings have to be established to enable data to be referred back to objectives. Result provides a differentiation between finding based on structure and processes within and organisation and findings which can be exported to other organisations

4.3.3.1 Choice of the case

The opportunity arose to work with Dundee City Council to test the framework concept on a large scale infrastructure project. Maxwell 2005 states purposive sampling should be undertaken to guarantee the right choice of case (Maxwell 2005). This was not undertaken in the selection of case study. However the appropriateness of the case was reflected upon prior to starting the research project. Suitability of the case study was established on following the three steps in defining a case study as identified by Yin (2012):

1. Defining a case: Yin recommends identifying a significant case when selecting a case study. The scale and importance of the Dundee Waterfront redevelopment fitted this requirement.
2. Select a case study design: a single case was selected with the opportunity to incorporate sustainability assessment and enhancement practices within the planning and design process. This requires the consideration of a wide range

of environmental, economic and social issues and introduces a need to maximise input from a wide range of stakeholders. The case study involves multi agency work, the elicitation and communication of information in wide range of forms both from and to a wide range of stakeholders. These aspects were identified as important challenges in literature review Section 2.4.

3. Theory in design: A theoretical perspective was required to develop research question and define relevant data to be collected. The case matched the requirements of the theoretical framework as defined in section 4.2. The case study was selected to test the both parts of the theoretical framework through the identification and provision of meaningful information on the various aspects of sustainability to the right stakeholders, in the right form and at the right stage of the process.

The research quality was ensured by using Yin’s (2003) criteria to respond to issues around validity. Construct validly was maintained by ensuring a clear link between literature, data collection and analysis as described in relevant method sections of Chapters 5 and 6. The reliability of case study was ensured by describing the case study methods in detail in in relevant sections of Chapters 5 and 6. This provided the details to replicate the approach in future work.

External validity of the case study was achieved by using the theoretical framework as a basis to interpret the findings of the case study. The theoretical framework assisted in generalising findings from the case study by establishing logic that may be applicable to other situations. However, exportability of findings to other organisations may be limited due to the case study organisation operating in Scotland within the National Performance Framework and Single Outcome Agreement structure. The issues around exportability of findings will be fully discussed in Section 7.

4.3.3.2 Dundee Waterfront

The Dundee Waterfront redevelopment is a one billion pounds project to reconnect the city to the waterfront. This 30 year redevelopment encompasses 240 hectares of land stretching 8km along the River Tay and is expected to lead to the creation of over 7,000 jobs as well as enhancing the city landscape.

The Waterfront project is being led by Dundee City Council and Scottish Enterprise. Maxwell (2005) recognises the importance of the relationship with study participants and states that the relationships you create with the participant in your study are an essential part of your methods. ‘How you initiate and negotiate these relationships is a key design decision’ (Maxwell, 2005 p 82.). The organisation showed motivation in participating in the study by allowing the researcher to operate as part of the Waterfront Team delivering the project.

The project master plan was published in 2001 following a large consultation to develop a vision for Dundee. The Dundee Waterfront stretches from Invergowrie Bay in the West to Stannergate in the East of Dundee and consists of five linked areas; Nature Park, Riverside, Seabraes, Dundee Central Waterfront, City Quay and Port of Dundee. These areas have an integrated programme of sector investment financed through public and private sector partners. The development of Dundee Waterfront will comprise of a number of projects led by Scottish Enterprise, Dundee City Council or private developers. The Central Waterfront is the focal point of the project with a new street layout extending from the city centre down to the waterfront. The rail station will be modernised and a new civic space will stretch from the Caird Hall (marked with ▲) down to the river as shown in Figure 4:3.

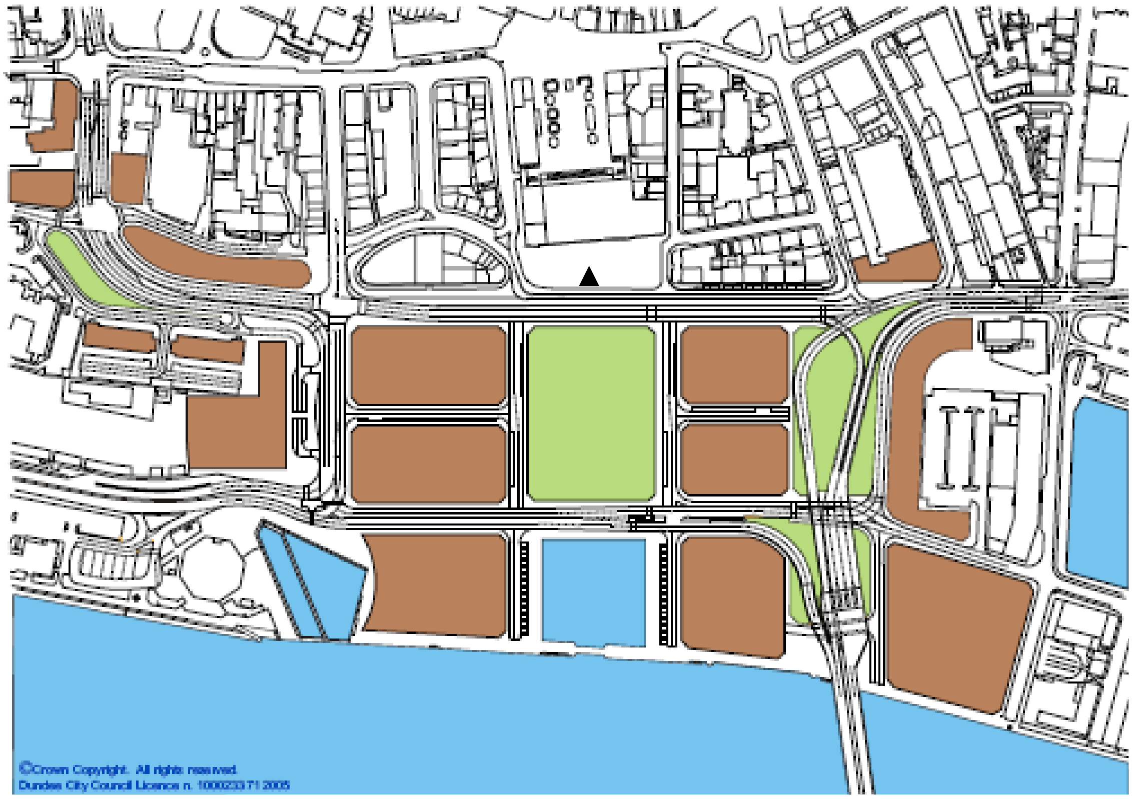

Figure 4:3 Central Waterfront grid pattern

The Development Masterplan for the Central Waterfront area includes certain key components;

- the extension of the city centre's built form down to the waterfront
- the creation of a new grid iron street pattern based on the historical routes to the north
- improved provision of facilities for walking, cycling & buses
- the reduction of the existing environmental effect of cars & parking
- the removal and replacement of some of the Tay Road Bridge vehicle ramps
- the creation of a pair of east/west tree lined boulevards to replace the existing inner ring road
- the formation of attractive sites for a variety of new mixed use developments
- the provision of a new rail station & arrival space at the western edge of the area

4.3.4 Pragmatic enhancement activities

Yin (2012) considers when working with an organisation researcher bias is unavoidable as cultural and personal perspectives affect how field conditions are observed. The researcher's presence may inadvertently affect participants being observed. In addition working with a team may only give a snapshot of an organisation.

The researcher operated as part of the Waterfront Team during the currency of the research project and, during this time, drew upon the range of tools to enhance sustainability in isolation as identified in Chapter 2. These pragmatic enhancement activities emerged whilst working with the Waterfront Project Team. Enhancement activities were identified through the researcher's knowledge of sustainability best practice. A summary of pragmatic enhancement activities together with their influence on the Knowledge Elicitation and Mapping method applied in Chapter 6 is given in Appendix A.

Working within the Waterfront Project Team provided an opportunity to reflect on the effectiveness of the mapping methodology in comparison with isolated pragmatic enhancement activities. Consideration of this is given when drawing conclusions of the application of Knowledge Elicitation and Mapping to the Dundee Waterfront Case Study in Chapter 7.

4.3.5 Design

The fourth and final part of the research hierarchy is research Design. Edmonds and Kennedy (2012) identify 'Design' as the actual structure of the framework that indicates how the data will be collected.

Several data collection methods were used to develop and test the Monitoring and Enhancement Framework as described in section 4.2. These are outlined in Table 4.5 and fully described in the relevant chapter relating to each component of the framework.

Table 4:5 Data collection methods

Chapter	Data collection method	Number of interviews
Chapter 5 Monitoring Framework	The process of indicator development consisted of three main activities, literature review, semi structured interviews (Blackwood et al. 2004; Dilley 2004; Kvale 2006; Edmonds and Kennedy 2012) and document analysis (Bryman 2001; Bowen 2009). This set of procedures is fully described in Chapter 5.	3 semi structured interviews 25 indicator finalisation interviews
Chapter 6 Mapping Process and Knowledge	Development and application of knowledge elicitation (Snowden 2002) and mapping techniques (Biazzo 2002; McCormack and Rauseo 2005) consisted of interviews (Snowden 2002; Edmonds and Kennedy 2012) and workshops (Snowden 2000). This set of procedures is fully described in Chapter 6.	8 process owner interviews 1 workshop 3 Verification interviews

5 Chapter 5 Monitoring Framework

5.1 Indicators

Indicators have been widely used by both policy makers and academics in sustainability assessment (Ashley et al. 2003; Walton et al. 2005; Hak, 2007; Pulitz and Ramstiner 2009) with well-chosen indicators considered as an effective technique for assessing sustainability (Reed et al. 2006; UN 2007; Singh 2009). Indicators help to break down the sustainable development concept, to give it a clearer definition (Porta and Renne 2005), and hence, to make it more comprehensible. Simply put, an indicator is something that helps us understand "where we are, which way we are going and how far we are from where we want to be" (Simon 2003, P2.).

Indicators can provide crucial guidance for decision-making in a variety of ways. They can translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process. They can help to measure and calibrate progress towards sustainable development goals (UN 2001). However, Dahl (2012) states that perhaps the most significant effect of an indicator, particularly during its early adoption, can simply be to make a problem visible therefore sensitising decision makers and the public to expand the basis for decision making. Development of indicators of sustainability can be seen as the first step towards the operationalisation of the concept of sustainability.

Indicators serve as pointers that can be easily identified and recognised as describing sustainability and help in monitoring the progress towards sustainability. Indicators can condense the enormous complexity of a dynamic environment to a manageable amount of meaningful information to monitor changes on different time space and scales and, if undertaken in a transparent way, to illustrate connectivity across ranging levels of complexity and scale (Hak 2007).

The most commonly cited reason for developing sustainability indicators is that they help policy and decision makers to make decisions that promote sustainability (White 2006). These policy and decision makers include politicians, high level public officials, heads of local government, chief executives and other strategic decision makers. Through the impetus of Agenda 21 the Rio summit in 1992 gave the United Nations the mandate to formulate a set of indicators that would help gauge the progress of sustainable development. Following the United Nations Commission on Sustainable Development's work programme deliberating indicators many countries have adopted indicators as one tool in providing information for decision making (Dahl 2012).

The enhancement concept, to be discussed later in this thesis, recognises a need to ensure that sustainability is considered in decision making at all stages of major projects to ensure a more sustainable outcome overall. This is because decisions made determine the processes, resources and outputs of subsequent actions. In order to achieve this, decision makers must have the appropriate level of information, and as such indicators can help improve the decision making process.

Great care needs to be taken when developing indicators. Reed et al. (2006) identify the particular problem of scale in relation to the efficacy of indicators. This can be due to the top down nature of national level data which can miss the critical issues that are important at a local level. The Environment Sustainability Index is an example which has been criticised for this (Morse and Fraser 2005). Another potential limitation of indicators are the lack of the relevant data which could lead to the omission of vital information. A consequence of this could lead to measuring what is measurable rather than what is important (Meadows 1998).

Reed et al. (2006) recognises that communities are unlikely to invest in collecting data unless the monitoring activity is related to action at the local scale. This is particularly important where most of the decision-making frameworks are decentralised which means decisions will have to be made at several levels within an organisation. Each person involved at the different levels must be well aware of the indicators. Hardi and Barg (1997) believe that indicators are planning tools that offer support in policy making. In addition they are performance assessment tools which help evaluate the success or failure of policy decisions and help in sustainability reporting.

This chapter presents the development and reporting of benchmark indicators and discusses the issues around developing and embedding sustainability indicators into existing process for urban infrastructure development.

5.2 Methodology

The development of the sustainability monitoring framework, which includes the development and reporting of indicators, is structured into five sections which represent the five main stages as identified by Brown (2009).

1. Establishing the purpose of the indicators
2. Designing the conceptual framework
3. Selecting and designing the indicators
4. Interpreting and reporting the indicators
5. Maintaining and reviewing the indicators

5.2.1 Establishing the purpose of the indicators

The concept of Monitoring Component of the framework and the Dundee Waterfront Case Study were presented in Chapter 4. The concept required a set of Dundee Waterfront Sustainable Development Benchmark Indicators to be developed and embedded in Dundee City Council (DCC) management process to, not only monitor, but also enhance sustainability.

These Sustainable Development Benchmark Indicators will, over time, provide a baseline for monitoring the whole development, to inform the Dundee Waterfront Partnership Project Board, the Scottish Government and funding bodies of the changes in the overall sustainability of the project. The monitoring framework has the ability to monitor performance and link impacts across spatial and temporal scales such as in the National Performance Framework and Single Outcome Agreements.

This approach is in line with Hak (2007) who states the purpose of indicator framework is to provide comprehensive information driven architecture that is policy relevant and understandable to all stakeholders. Brown (2009) identified that a critical step in defining a suite of indicators is to identify clearly the target audience and purpose for the indicators. This will help determine the scope of the indicator set and assist in keeping the project focused. In particular it is important to focus on how, when and by whom indicators are actually used (Lyytimäki et al. 2011).

The Local Government in Scotland Act 2003 (Scottish Executive 2004) established sustainable development as one of three cross-cutting themes sitting alongside equal opportunities and joint working. The guidance also identified specific activities that should be undertaken, including, that 'quality of life' indicators are identified to measure performance in contributing to the achievement of sustainable development, and that these are reported to the public. It is stated that review activities should take account of sustainability issues and assess the impact of policy proposals on sustainable development.

In addition the Audit Commission identified that there was a need for a strategic framework for sustainable development. Dundee City Council's (DCC) corporate response to sustainability will be fully integrated through the updated Sustainable Development Governance Framework (Dundee City Council 2010). The Sustainable Development Monitoring and Enhancement Framework work process compliments the existing sustainable development actions across Dundee City Council. There is strong emphasis on local authorities' ability to demonstrate Best Value. This is achieved through its contribution to the achievement of sustainable development in consideration of social, economic and environmental impacts of activities and decisions, both in the shorter and longer term.

The framework for the assessment and monitoring of sustainability of the Dundee Waterfront will use benchmark indicators to operationalise sustainability for urban design and construction, to aid decision making and demonstrate decisions leading to outcomes that are relatively more sustainable. The benchmark indicators can be used to report at a corporate level on Dundee City Council's performance in relation to delivering best value and sustainable development. The indicators can also be used at a project and departmental level, providing the link across policies, programmes and projects.

The indicators will therefore have a number of purposes:

- Project team decision making - Project team, infrastructure group and departmental level

- Project Board Monitoring - Part of Waterfront Performance Management Framework
- Public Reporting - Report sustainable development to wider stakeholders, funders and investors
- Council corporate policy - Inform Sustainable Development Governance Framework

5.2.2 Designing the conceptual framework

Lyytimäki* and Rosenström (2007), Holden (2008), Brown (2009) stress the importance of a conceptual framework to guide the development of a set of indicators. Conceptual frameworks for sustainable development indicators help to focus and clarify what to measure, what to expect from measurement, and define the kind of indicators to use (Segnestam 2002). A conceptual framework also provides a useful device for organising and reporting on indicators in a structured and meaningful way. The absence of a framework can result in the generation of an eclectic mix of indicators, with no clear rationale for their selection (Brown 2009).

The concepts underlying the framework in which the indicators are organised largely determines the selection of the types of indicators used (Pinter et al. 2005). Two types of frameworks are prevalent in literature, environmentally focussed Causal Chain Frameworks (Hammond et al. 1995; Smeets and Weterings 1999; OECD 2001; World Resources Institute 2005) and Thematic or Goal Orientated Frameworks (UNCSD 1996; IAEA 2005) such as the influential goal-oriented Millennium Development Goal Indicators (UNSD 2005). The main differences amongst frameworks are the way in which the main dimensions of sustainable development, as reviewed in Chapter 2 are conceptualised. The frameworks set out the interlinkages between these dimensions and the concepts that justify the selection of indicators (Ayers 2010).

5.2.2.1 Causal chain frameworks

The Pressure-State-Response (PSR) framework was developed in Canada for environmental statistics, and then further developed and adapted to be used in assessing sustainability internationally (Pinter et al. 2005). The framework was adopted by OECD for use in environmental indicator reports, starting in 1991 (OECD 1991).

Three variations of the PSR framework are evident (Niemeyer 2008) and shown in Figure 5:1. The original PSR framework divides the indicators into pressure state response. OECD (1999) describes the logic as the pressure on the environment from human activities lead to changes in the state of the environment that may provoke responses by society (OECD 1999). The second variation replaces the pressure indicator category with a category of driving force indicators (creating a DSR framework). The initial set of 134 UNCSD indicators, (UNCSD 1996), was organised in a driving force, state and response (DSR) framework. The last version reintroduces ‘Pressure’, and includes ‘Impact’ to present five indicator categories creating a DPSIR framework which provides a further detailed breakdown of the original PSR framework (Segnestam 2002).

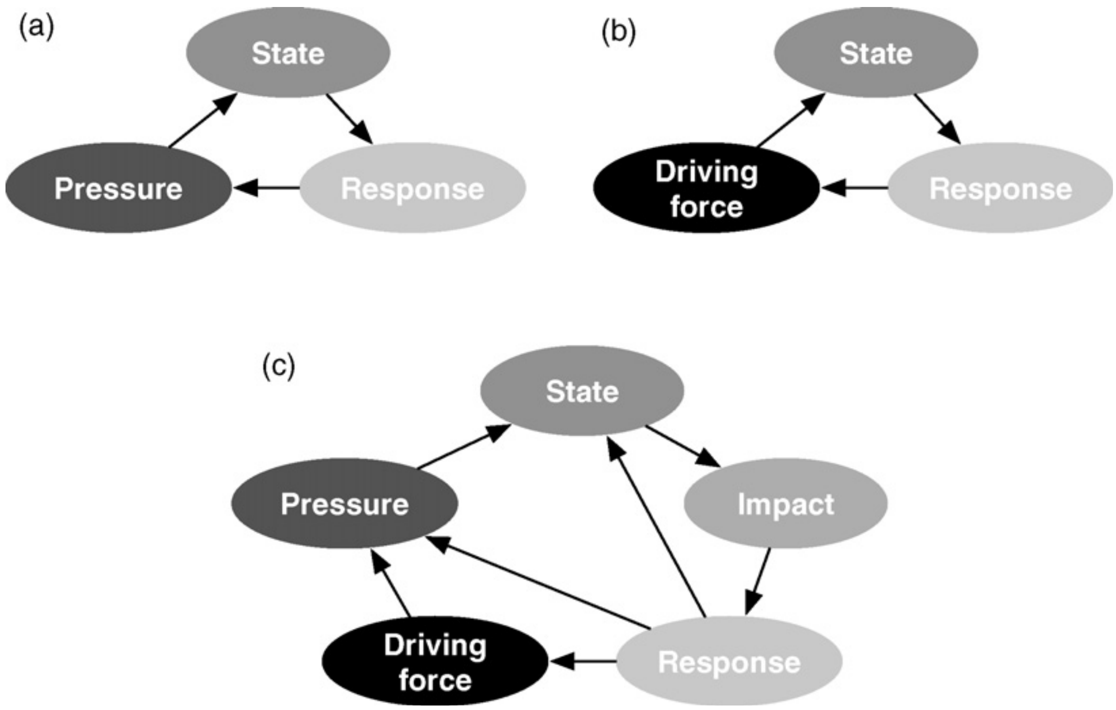

Figure 5:1 The (a) PSR, (b) DSR and (C) DPSIR frameworks (source: Niemeyer and de Groot 2008, P 16)

There are a number of limitations to Causal Frameworks. Central to these is that the PSR model and its variants do not work if evidence for causal links is missing and, when links are established, they may suffer from oversimplification (Pinter 2005). There are also multiple pressures for most states and multiple states arising from most pressures, creating difficulties in identifying indicators (Niemiejer 2008). UN (2007) reports that variations of the pressure-state-response framework continue to be used in more environmentally oriented indicator sets, however the revision of the UNCSD indicators in 2001 discontinued the DSR framework mainly "because it was not suited to addressing the complex interlinkages among issues; the classification of indictors into driving force, state or response was often ambiguous; there were uncertainties over causal linkages; and it did not adequately highlight the relationship between the indicators and policy issues" (UN 2007 p40).

5.2.2.2 Themes and policy goal orientated frameworks.

Issue or theme based frameworks are the most widely used type of frameworks, especially in official national indicator sets (UN 2007). In these frameworks the indicators are distinguished on the basis of different themes and issues. The issues or themes are typically determined on the basis of policy relevance. Most national sustainable development indicators are based on a thematic framework (UN 2007). United Nations Commission for Sustainable Development (2000) moved to indicators selected and organised according to major areas, themes and sub-themes as illustrated in Figure 5:2. The theme base indicators presented were developed from Agenda 21 themes and sub themes namely, social environmental economic and institutional.

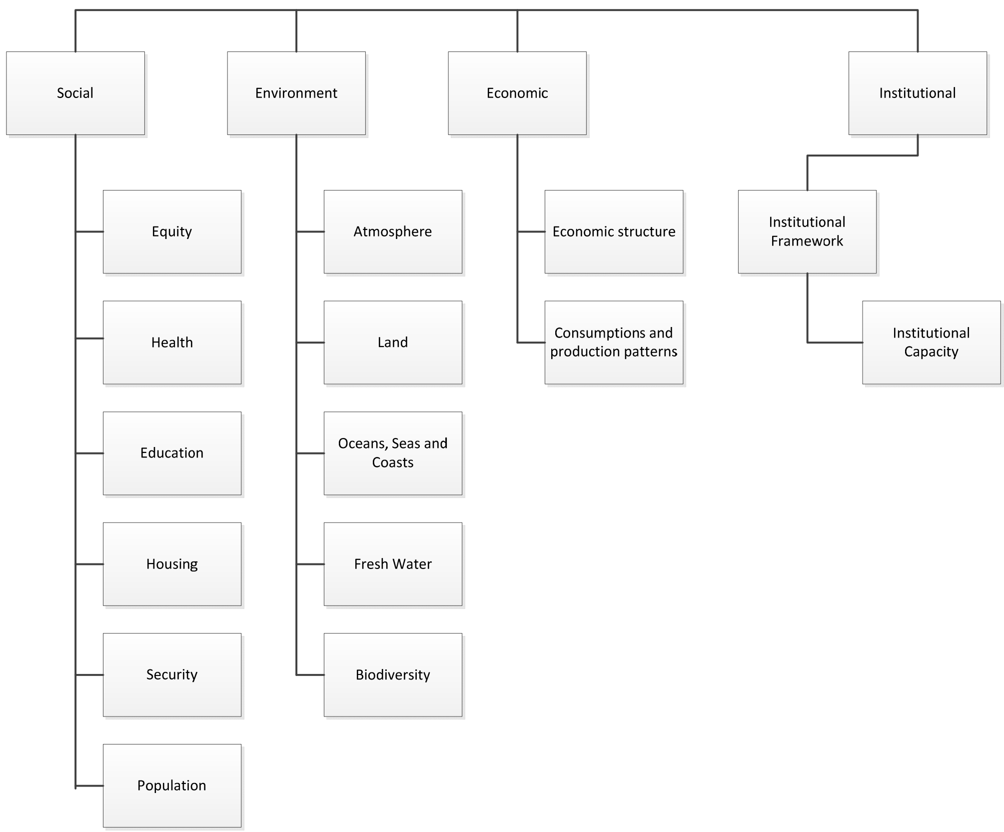

Figure 5:2 United Nations Commission for Sustainable Development (UNCSD) theme indicator framework. (Adapted from: Singh et al. 2008)

Theme and goal orientated frameworks usually emerge as a consequence of particular concerns at local, national and global levels (UNESCO 2005; DEFRA 2005), are goal-driven and have direct link to sustainable development policy to support policy makers in their decision making (UNCSD 2000). UN (2007) identified that the main reason for the prominence of thematic frameworks is their ability to link indicators to policy, processes and targets. This provides a clear and direct message to decision makers and is often more easily understood by the wider community (Segnestam 2002). A thematic framework for indicators is also well suited to monitor progress in attaining the objectives and goals as stipulated in national sustainable development strategies, and is, over time, flexible enough to adjust to new priorities and policy targets over time (UN 2007). Pinter et al. (2005) identified that decision-makers demand indicators for sustainable development that can be integrated into the relevant level of policy making namely regional, national, sub-national and local level.

5.2.2.3 Conceptual framework for Dundee Waterfront Monitoring Framework

The framework for the Sustainable Development Benchmark Indicators for the Dundee Waterfront follows the principles of the theme orientated framework as discussed in section 5.2.2.2. The reason for following this framework principle is because of the purpose of the indicators, to support decision making as outlined in 5.2.1, in line with the UK Government sustainable development strategy indicators (DEFRA 2005) and the Scottish (Scottish Executive 2006) thematic conceptual framework approach.

The UK framework is theme goal-based, reflecting priority areas and objectives mentioned in the UK Strategy document for Sustainable Development. There are four shared priorities i) Sustainable consumption and production ii) Climate change

iii) Natural Resource Protection iv) Sustainable Communities (DEFRA 2005). The Scottish Government strategy (Scottish Government 2007) adheres to the theme based principles of sustainable development matched against the objectives of a "wealthier", "fairer" (economic and social), "smarter", "healthier", "safer and stronger" (social) and "greener" (environmental) Scotland. These objectives are delivered through Framework and Single Outcome Agreement indicators that can be integrated into the relevant level of policy-making namely, national and local government level.

5.2.3 Selecting and designing the indicators

The process of selecting the indicators is generally iterative, undertaken in consultation with interested stakeholders. Care is needed in selecting indicators which resonate with the target audience and yet are technically sound (Brown 2009). Remetsteiner (2011) argues that the nature of sustainability indicators is to embed both knowledge and political social norms and therefore developing indicators is not a scientific task alone but involves political negotiation. Bell (2011) suggests that indicators are popular tools for sustainable development policy makers, planners and managers, largely because they do the hard work of condensing complexity into single values that can be more easily digested and acted upon. However, there is a significant amount of power resting with those who select the indicators that are deemed to be important. Rametsteiner (2011) contends that those who decide what to include in an indicator set will have used not only technical knowledge, but also a philosophical and political intentions. Those who are participating in the process of indicator development are "not only acting in their technical expert capacity, but also as political citizens taking normative decision about what to uphold" (Rametsteiner et al. 2011, p62.) Lehtonen (2008) emphasises the importance of the process of indicator selection otherwise one cannot develop indicators that are perceived to be sufficiently salient, credible and legitimate to key stakeholders.

Lundin (2003) identifies two ways to develop indicators with varying roles for stakeholders. 'Top down' approach where experts and researchers define the framework and indicators or 'Bottom up' which feature the participation of different stakeholders in the design of the framework and the indicators reflection process (Mickwitz & Melanen 2009). Van Zeijl-Rozema & Martens (2010) attempt to conceptualise the role of stakeholders from policy and science at various stages of monitoring sustainable development. Figure 5:3 illustrates these conceptualised roles where policy, science, steps in the process and roles of actors are shown. The decision on who participates in the development of indicators is evidently crucial to achieve an informed but balanced process. In this thesis the bottom up approach was chosen to ensure the credibility and legitimacy of the indicators as outlined above. The identification of key stakeholders to participate in the indicator development was a key part of the indicator selection. Relevant stakeholders were identified as part of the Information Flow Diagram exercise described in section 5.2.3.3. The participants in the indicator development were:

- Dundee City Council and Scottish Enterprise
- Dundee Waterfront Project Boards
- Waterfront Team decision makers,
- Stakeholders, e.g. members of Dundee Partnership

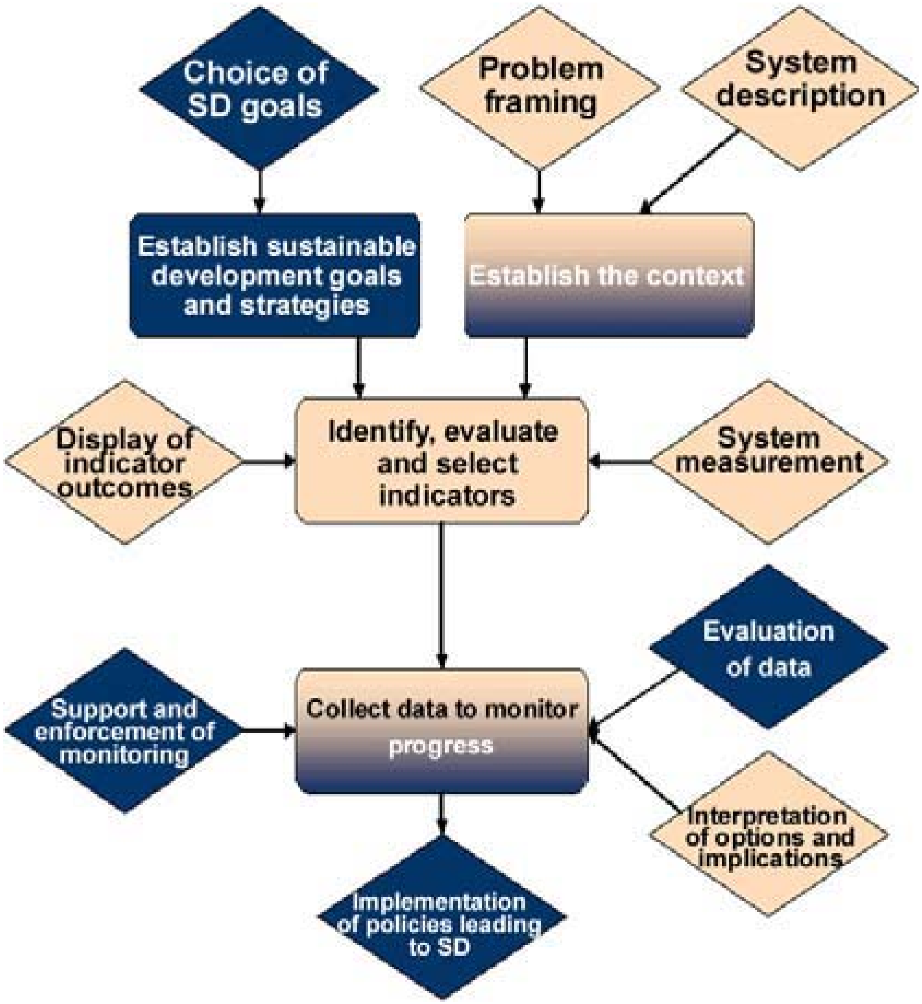

Figure 5:3 The role of policy and science in the various stages of monitoring sustainable development. (Adapted from: van Zeijl-Rozema & Martens 2010 p. 9)

Key: policy - dark, science - light, steps - rectangles, roles - diamonds.

5.2.3.1 Process of indicator development

The indicators were selected and designed using a set of procedures, developed by the author and drawn from IT and knowledge management fields (Butler et al. 2003; Blackwood 2004; Gilmour and Blackwood 2006), to identify appropriate indicators and ensure the effective incorporation of sustainability issues throughout the Dundee Waterfront project decision-making processes. The procedures include the production of information flow diagrams (Baldwin et al. 1999; Winch and Carr 2001; Gilmour 2005) to identify the wide range of stakeholders involved in the project and their means of interaction and to categorise the use of the information by the stakeholders.

The initial process of indicator development is shown in Figure 5:4. This consisted of three main activities: firstly a literature review to identify possible indicators and to understand the policy drivers that would influence their selection, secondly interviews and thirdly document analysis to validate the applicability of the potential indicators in the context of the Waterfront development. The process began with a review of current sustainability indicators related to infrastructure provision in the UK and Europe, emerging indicators from Scottish government, EU commission, United Nations, industry bodies and research.

A period of refining and testing indicators followed the initial indicator development. This coincided with the establishment of new governance regimes for both the Dundee Waterfront and Local Government. The refining of benchmark indicators continued in the Monitoring and Review stage of indicator development. This illustrated the iterative and cyclic nature of indicator development and refinement, and is similar to the adaptive learning process for sustainability indicator development and application proposed by Reed et al. (2006), as shown in Figure 5:5.

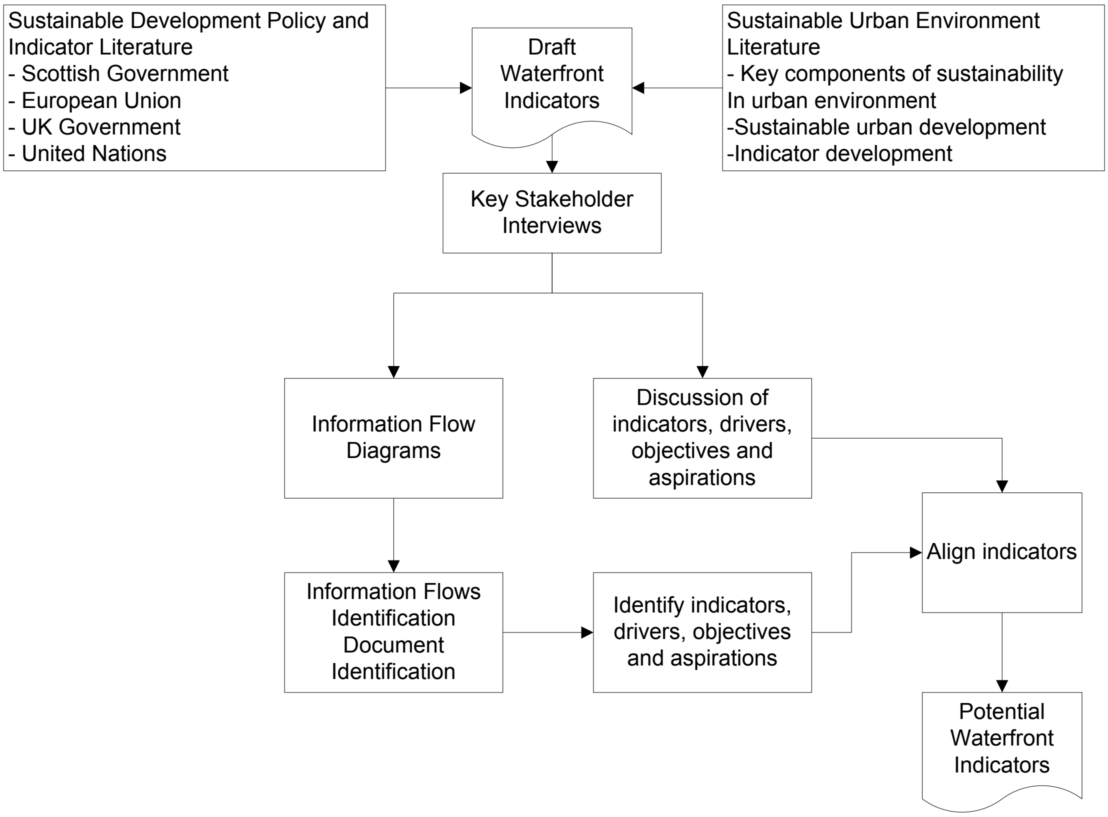

Figure 5:4 Initial process of indicator development

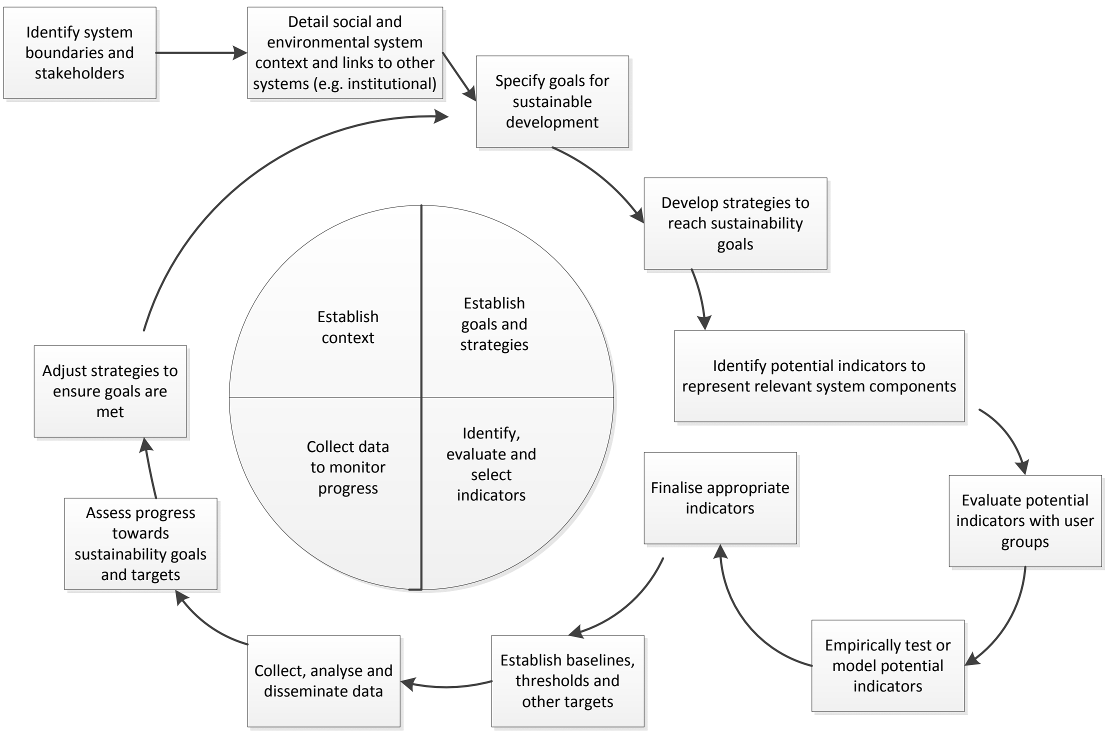

Figure 5:5 Adaptive learning process for sustainability indicator development and application (Adapted from: Reed et al. 2006, p. 414)

5.2.3.2 Review of published Indicators

The Benchmark indicators for Dundee Waterfront have been developed from the concept and theory of sustainable development as reviewed in Chapter 2. The indicators have been defined based on the purpose of indicators and conceptual framework described in Sections 5.2.1 and 5.2.2. The indicators were developed to reflect the UK Government Sustainable Development Strategy and the Scottish Government Sustainable Strategy. They were designed to align as closely as possible with Scottish Government indicators to provide a basis for tangible reporting to the Scottish Government whilst providing clear and easily understandable indicators for internal monitoring at the strategic level.

Each relevant indicator document and policy document was reviewed (DEFRA 1999; UNCSD 2000; GRI 2003; DEFRA 2005; UNSD 2005; Scottish Executive 2006; UN 2007; Scottish Government 2007; DEFRA 2010). The key indicator themes identified during policy literature review are illustrated in Table 5:1. A very large number of indicators are used across government to monitor the outcomes of policies. UK Government Strategy has established a set of 68 indicators consisting of 20 UK Framework Indicators and a further 48 indicators to monitor progress (DEFRA 2005). The framework indicators are relevant for Scotland and will be collected and reported by UK Government. The Scottish Executive have developed a set of indicators based on the policy in 'Choosing the future' (Scottish Executive 2006), their previous indicator set "Meeting the needs" was reported from 2003-2006 (Scottish Executive 2002). Table 5:2 presents the three indicator sets most relevant to developing Waterfront sustainability indicators to reflect the UK Government Sustainable Development Strategy and the Scottish Executive Sustainable Strategy. All three sets of indicators have been used to develop Waterfront Development Benchmark Indicators. Relevant indicators from sustainability policy were shortlisted based on their relevance to urban redevelopment and then grouped into three categories, Economic, Environmental and Social as shown in Table 5:3.

Additional indicators were developed where relevant policy indicators did not exist at the appropriate scope or scale to monitor Dundee Waterfront urban redevelopment. This process was supported by the a conceptual understanding of the urban environment and identified key components of sustainability (Urban Task Force 1999; Eagan 2004; Walton 2005; McAllister 2005; Boyko, Cooper and Davey 2005; Holden 2008; Davidson et al. 2012). The authors' experience of sustainable indicator development (Foxon et al. 2002, Butler et al. 2003, Ashley et al. 2008) and on a range of relevant sustainable urban development research papers (Maclaren 1996; Innes and Booher 2000; Deakin 2002; Hemphill, McGreal, Berry 2002; Bartlett and Guthrie 2005; Holden 2006; El-Haram et al. 2007; Hakkinen 2007; Xing et al. 2009). These key components were developed into indicators, which balanced Economic, Environmental and Social aspects of sustainable development. A definition for each draft indicator was then assigned together with draft units as shown in Table 5:4.

Proposed indicators were evaluated during the selection phase to ensure they are relevant, analytically sound and measurable. Olsen (2004) identify that well-chosen indicators should focus on materiality and accessibility. Materiality concerns the information stakeholders require. Accessibility refers to ability of stakeholders to acquire and understand the information contained in indicators. Winston and Eastaway (2008) state that indicators must be integrating across economic social and environmental dimensions, forward looking to target or goals, distributional in relation to inter and intra generational equity and developed with input from multiple stakeholders.

Table 5:1 Summary of sustainable development policy literature themes

Sustainable Development Policy Literature	**Key indicator themes and indicator approaches**
DEFRA 1999	Sustainable development strategy for the UK 'A better quality of life' identified a set of headline and core indicators to be used to report on progress. The 1999 Strategy consisted of 147 indicators, 15 headline indicators. These were used in the reporting process but could only provide an overview. The indicators are structured within six themes and 18 families were, in practice, too difficult to use to determine an overall progress system of traffic lights to show the baseline assessments for each indicator.
UNCSD 2000	Indicator framework focused on emphasising policy issues or main themes related to sustainable development following considerations: future risks; correlation between themes; sustainability goals; and basic societal needs, 15 themes and 38 sub-themes covers issues generally common to all regions and countries of the world. The organization of themes and sub-themes within the four dimensions of sustainable development.
Scottish Executive 2002	Meeting the Needs…Priorities, Actions and Targets for sustainable development in Scotland. Consists of 24 indicators around priority areas of Resource use, Energy and Travel, combining economic progress with environmental and social justice. Mainly environmentally focussed indicators, although social and economic indicators cover three pillars of sustainable development. To be taken forward with programmes on social justice and economic development to provide an integrated approach.

Table 5:1 Summary of sustainable development policy literature themes (continued)

Sustainable Development Policy Literature	Key indicator themes and indicator approaches
GRI 2003	The Sustainability Reporting Guidelines consist of principles for defining report content and ensuring the quality of reported information. It also includes Standard Disclosures made up of Performance Indicators and other disclosure items as well as guidance on specific technical topics in reporting, Economic, Environmental and Social Performance Indicators identify key Performance Aspects surrounding labour practices, human rights, society, and product responsibility.
DEFRA 2005	UK Framework indicators intended to cover key impacts and outcomes that reflect the priority areas shared across the UK. These will underpin the shared framework priorities whilst reflecting the respective priorities of each administration. Indicators for the UK Government Strategy include 20 UK Framework Indicators and 48 indicators related to the priority areas. The 68 indicators cover social, economic and environmental themes. This programme committed to developing appropriate wellbeing indicators although many of the indicators already covered issues that affect people's wellbeing, for example employment, community participation, education, housing conditions, health, income, and the environment.

Table 5:1 Summary of sustainable development policy literature themes (continued)

Sustainable Development Policy Literature	**Key indicator themes and indicator approaches**
UNSD 2005	United Nations Division for Sustainable Development (UNDSD) on sustainable development indicators (SDIs) provided a review of progress on SDIs over the last decade on national and international level, review key achievements and SDI trends in how SDIs are approached in theory and practice. Among emerging trends the paper highlighted Interest in core sets of 'headline indicators'; Emergence of goal-oriented indicators such as Millennium Goal indicators; measurement of sustainability by capital ('green') accounting systems; and emphasis on making better use of indicators in performance measurement.
Scottish Executive 2006	Sustainable development indicator set to measure progress on Scotland's Sustainable Development Strategy set out in Choosing our future. This includes measuring progress against a wide set of indicators that reflect social and environmental as well as economic goals, more closely aligning the indicators to the outcomes in DEFRA 2005. These indicators took account developments in international sets including the EU and UN to move away from the original focus on three priority areas of waste, energy and transport to give a fuller coverage of sustainable developments concerns. 18 indicators plus 3 indicators in development; social justice, environmental equality and well-being.

Table 5:1 Summary of sustainable development policy literature themes (continued)

Sustainable Development Policy Literature	Key indicator themes and indicator approaches
UN 2007	Third edition of Indicators of Sustainable Development: Guidelines and Methodologies based on experience with sustainable development indicators has the emphasis on measuring progress on achieving sustainable development, including the Millennium Development Goals (MDGs). The newly revised CSD indicators contain a core set of 50 indicators. These core indicators are part of a larger set of 96 indicators of sustainable development retaining the thematic/sub-thematic framework and remaining consistent with the practice of most countries. However, the division of indicators along the lines of four 'pillars' (social, economic, environmental and institutional) is no longer explicit, relying on cross cutting theme framework.
Scottish Government 2007	Scottish Government strategy on sustainable economic growth to make Scotland through 5 Strategic Objectives, wealthier and fairer; smarter; healthier; safer and stronger; and greener. It presents 9 indicators related to strategic economic targets not sustainability indicators
DEFRA 2010	Report progress on DEFRA 2005 UK government 68 indicators across the four themes; sustainable consumption, and production, climate change and energy, protecting natural resources and enhancing the environment, creating sustainable communities. The indicators are assessed on whether there has been improvement, deterioration or no change compared to 2003. Wellbeing is treated as a suit of 12 indicators.

Table 5:2 Relevant policy indicator sets based on alignment to Scottish Government reporting structure

A) Choosing our future (Scottish Executive 2006)		B) Meeting the needs (Scottish Executive 2002)		C) UK Framework (DEFRA 2005)					
1. Health inequality	13. Sustainable energy	1. Sustainable prosperity	13. Energy renewable	1. Greenhouse gas emissions*: Kyoto	13. Resource use*	25. Land recycling	37. Active community participation*:	51. Mortality rates	62. Housing conditions
2. Air quality	14. Resource use	2. Work people as a resource	14. Travel industry	2. CO2	14. Energy supply	26. Dwelling density	38. Crime*	50. Healthy life expectancy	63. Households living in fuel poverty
3. Economic opportunity	15. Transport	3. Population structure	15. Travel distance	3. Aviation and shipping emissions:	15. Water resource use	27. Fish stocks*	39. Fear of crime	52. Smoking	64. Homelessness
4. Economic opportunity	16. Learning	4. Waste production	16. Travel mode	4. Renewable electricity:	16. Domestic water consumption:	28. Ecological impacts of air pollution*	40. Employment*	53. Childhood obesity	65. Local environment quality

Table 5:2 Relevant policy indicator sets based on alignment to Scottish Government reporting structure (Continued)

A) Choosing our future (Scottish Executive 2006)		B) Meeting the needs (Scottish Executive 2002)		C) UK Framework (DEFRA 2005)					
5. Community	17. Economy	5. Waste recycling	17. Travel accessibility	5. Electricity generation	17. Water stress	29. Emissions of air pollutants	41. Workless households* population	54. Diet	66. Satisfaction in local area
6. Crime	18.Demography	6. Waste landfilled	18. Home life	6. Household energy use: domestic CO_2	18. Waste*	30. River quality*	42. Economic inactive	55. Mobility*	67. UK International assistance
7. Households		7. Climate change	19. Preparing for life	7. Road transport: CO_2	19. Household waste	31. Flooding	43. Childhood poverty*	56. Getting to school	68. Wellbeing*
8. Waste		8. Air	20. Fuel poverty	8. Private vehicles: CO_2	20. Bird populations*	32. Economic output*	44. Young adults	57. Accessibility	
9. Biodiversity		9. Water quality	21. Social concern	9. Road freight: CO_2	21. Biodiversity conservation	33. Productivity	45. Pensioner poverty*	58. Road accidents	

Table 5:2 Relevant policy indicator sets based on alignment to Scottish Government reporting structure (Continued)

A) Choosing our future (Scottish Executive 2006)		B) Meeting the needs (Scottish Executive 2002)		C) UK Framework (DEFRA 2005)					
10. Marine		10. Biodiversity	22. Crime	10.Manufacture sector: CO2	22. Agriculture sector:	34. Investment	46. Pension provision	59. Social justice*	
11. River quality		11. Sea fisheries	23. Volunteering	11. Service sector: CO2	23. Farming	35. Demography	47. Education*	60.Environmental equality*	
12. Climate change		12. Energy consumed	24. Health	12. Public sector: CO2	24. Land use	36.Household and dwellings:	48.Sustainable development education	61. Air quality and health	

Table 5:3 Indicators drawn from sustainable development policy documents

Economic	Environmental	Social
Demographics (A.1, B.3, C.35) Capacity to stimulate investment (C.34) Economic Output (A3,B1, C.33)	Biodiversity (A.9, B.10, C.21) Waste (A.8, B.4/5/6, C.18/19) Air (A. 2, B.8, C.29) Water (A.11, B.9, C.15/16/17) Energy (A.12/13, B.12/13, C.1/6-14) Travel (A.15, B.14-17) Land recycling (A.14, C. 25) Dwelling density (C.26)	Housing provision (A.7, C.62) Employment (A4, B.2, C.40) Social Inclusion (A.5, B 2.1, C.57) Participation and responsibility (A.5,B.23, C.37)

Table 5:4 Draft literature based benchmark indicators

Category	Benchmark indicators	Definition of indicator	Units
Economic	Demographics*	Population retention	Population number
	Retention of skills base	Graduate retention rate	% student staying
	Capacity to stimulate investment*	Total investment	£ inward investment
	Tourism	Number of tourist visiting Dundee	Number of visits
	Property Value	Increased property value	% Increase
	Job creation	Number of jobs created	Number
	Whole life cost of infrastructure	Capital and recurrent cost of infrastructure	£ over life of infrastructure
	Economic output*	Growth over economic cycle	£

Table 5:4 Draft literature based benchmark indicators (continued)

Category	Benchmark indicators	Definition of indicator	Units
Environmental	Biodiversity*	Priority Habitats	Number of habitats
		Priority Species	Number of species supported by habitat
	Green space/public space	Local environmental quality	Quality
		Design of safer places	Quality
	Waste*	Waste recycling	% of waste reused/recycled
		Waste arising by sector	Volume
	Air*	Air emissions	Emissions of CO2, NOx
	Water*	Loads to receiving water	In line with best practice
		Domestic water consumption	In line with best practice
	Noise	Noise level impact	unit
	Energy*	Energy consumption	unit
		Renewable energy	%
		Embedded energy	unit
	Travel*	Public transport use	% journeys
	Land recycling*	Brownfield development	%
	Dwelling density*	Dwellings pre hectare	Number per hectare

Table 5:4 Draft literature based benchmark indicators (continued)

Category	Benchmark indicators	Definition of indicator	Units
Social	Housing provision*	In relation to housing quality standard	% of houses of high quality
	Health & Well being	(?)	
	Employment*	Employment rates	% population
	Social cohesion	Community spirit	Qualitative
	Social Inclusion*	Accessibility of waterfront services	% accessible services
	Participation and responsibility*	Participation in sustainable decision making	% population involved in decision
		City centre action groups	% population involved in decision
	Active community participation	Informal and formal volunteering	% taking action
	Acceptability	Acceptability to stakeholders	Qualitative
	Confidence	Public perception of confidence	Qualitative
	Amenity value	Public perception of amenity	Qualitative

* Indicates indicator drawn from sustainable development indicator policy document

Brown (2009) provides further criteria as a basis for indicator selection as outlined in Table 5:5. In addition, Foxon et al. (2002) stated indicators should also have the following four characteristics. This has been subsequently confirmed by other authors (Neimejer and de Groot 2008):

- Comprehensiveness

  The indicators should cover the three categories economic, environmental, and social in order to ensure that account is being taken of progress towards sustainable development objectives. The indicators chosen need to have the ability to demonstrate movement towards, or away from, sustainable development according to these objectives.

- Tractability

  Sufficient reliable numerical or qualitative data should be available to enable the estimation of spatial and temporal trends.

- Transparency

  The indicators should be chosen in a transparent way so as to help stakeholders to identify why indicators are being considered.

- Practicability

  The indicators must be practical in terms of time and resources available for any analysis and assessment.

Table 5:5 Basis for indicator selection (Brown 2009)

Valid and meaningful	Indicator should adequately reflect the phenomenon it is intended to measure and should be appropriate to the needs of the user.
Sensitive and specific	Sensitivity relates to how significantly an indicator varies according to changes in the underlying phenomenon.
Grounded in research	Awareness of the key influences and factors affecting outcomes.
Statistically sound	Indicator measurement needs to be methodologically sound and fit for the purpose to which it is being applied.
Intelligible and easily interpreted	Indicators should be sufficiently simple to be interpreted in practice and intuitive in the sense that it is obvious what the indicator is measuring.
Relate where appropriate to other indicators	A single indicator often tends to show part of a phenomenon and is best interpreted alongside other similar indicators.
Ability to be disaggregated over time	Indicators should be able to be broken down into population sub-groups or areas of particular interest, such as ethnic groups or regional areas.
Consistency over time	The usefulness of the indicators is directly related to the ability to track trends over time so, as far as possible, indicators should be consistent.
Timeliness	There should be minimal time lag between the collection and reporting of data to ensure that indicators are reporting current information.
Linked to policy or emerging issues	Indicators should be selected to reflect important issues as closely as possible. Where there is an emerging issue indicators should be developed to monitor it.

5.2.3.3 Interviews

The draft literature based benchmark indicators were then refined through the process of interviews with key stakeholders with reference to the specific drivers, aspirations and objectives of the Dundee Waterfront. Interviews were held with members of staff to discuss the indicators and seek their views on their relevance. Each indicator was addressed in turn to verify relevance and improve their definition.

The interviews began to identify stakeholders' involvement in the Waterfront Development. Selection of interviewees was based on their key role within the Waterfront Team. Interviews were held with the Dundee Waterfront Project Coordinator, the Assistant Principal Engineer at Dundee City Council and the Strategy & Partnerships Manager at Scottish Enterprise. The participants' positions represented the three strands of the Waterfront Partnership delivery team namely, urban planner, engineer and enterprise agency.

Semi structured interviews were undertaken at the participants' place of work and were structured around Information Flow Diagram development (Blackwood et al. 2004; Gilmour and Blackwood 2006. A semi structured interview technique was selected to collect qualitative data as the method allowed the respondent the time and scope to talk about their opinions on a particular subject (Edmonds and Kennedy 2012).

Semi structured questions were developed prior to the interview (Dilley, 2004, Kvale 2006):

- Can you tell me about your role within your organisation?
- Who do you communicate with whilst undertaking you role?
- What kind of information do you share?
- What form does the information take?
- Can you tell me about the drivers for the undertaking of the waterfront?
- Can you tell me about the aspirations and objectives of the waterfront?

Semi structured interviews required a method of recording interviewee responses. This was by digital recording or note taking with the informed consent of the interviewee. In either case the interview process was a flexible one, with the emphasis on the answers given by the interviewee (Silverman 2010).

An example of the interview outputs is shown in Figure 5:6 and Table 5:6. In this example interviews were undertaken with the Project Coordinator for the Dundee Waterfront to refine the draft benchmark indicators, establish his network of stakeholders and the type of interaction he has with them. The Project Coordinator has responsibility for all facets of the project as can be seen in the Information Flow Diagram. The interview identified the information flows and their nature (e.g. verbal communication, letter, meeting minutes, reports) and, where appropriate, documents relevant to refining the indicators. Of particular relevance was the Dundee City Council Community Plan (Dundee Partnership 2005) which was used in the document analysis phase. Other potential key flows were identified with the Urban Design Group, Development Quality and Architect and Developers.

Each of the numbered information flows had a number of associated documents e.g. data, reports, meeting minutes. The Information Flow Diagram process was used to identify documents within the information flows for analysis to enable further refinement of the indicators as described in Section 5.2.3.4.

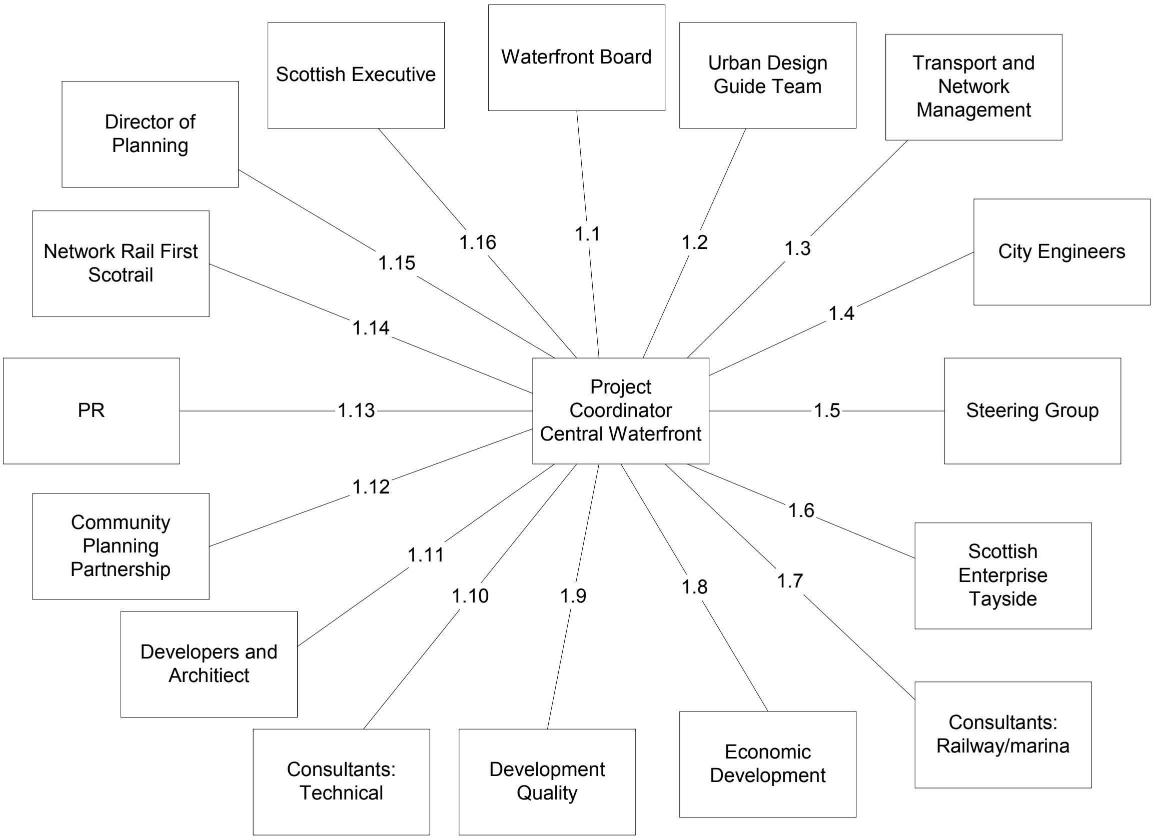

Figure 5:6 Information Flow Diagram - Project Coordinator Dundee Waterfront

Information Flow Diagrams were developed collaboratively by hand during the interviews and then drawn up supported by notes taken at each meeting. Follow up verification interviews were undertaken with the participants where the draft Information Flow Diagrams were reviewed for accuracy and agreed as representative of the participant’s network of stakeholders and information flows between them.

Table 5:6 Information Flows Project Coordinator

Ref Number	Information flow	Ref Number	Information flow
1.1	Waterfront Board	1.10	Consultants: Technical
1.11	Report progress	1.101	Consultants' report
1.12	Grant fund review	1.102	Data
1.13	Marketing update	1.11	Developers and Architect
1.2	Urban Design Group	1.111	Development quality
1.21	Guidelines	1.112	Brief from urban design guidance
1.22	Principles	1.113	Bid
1.23	Workshop results	1.114	Development control process
1.24	Urban design guide	1.12	Community Planning Partnership
1.25	Website sections	1.121	Reports
1.3	Transport and Network Management	1.122	Presentation
1.31	Departmental process	1.123	Updates
1.32	Capital plans	1.13	PR & Marketing
1.33	Marketing	1.131	Current economic development and marketing
1.34	Advice notes	1.132	PR department update
1.35	Public transport	1.133	Community council meeting
1.4	City Engineers	1.134	Briefing meetings
1.41	Copy emails	1.14	Network Rail Scotrail
1.42	Feedback	1.141	Property business development report
1.43	Updates	1.142	Briefing
1.44	Feasibility Report	1.143	Urban design guidance
1.45	Consultants reports	1.144	Negotiable
1.5	Steering Group		
1.51	Operational issues		
1.52	Progress reports		
1.53	Land transfer		

Table 5:6 Information Flows Project Coordinator (continued)

Ref Number	Information flow	Ref Number	Information flow
1.6	SET	1.15	Director of Planning
1.61	Economic appraisal reports	1.151	Briefing notes
1.62	Partnership arrangements	1.152	Cities growth fund annual report
1.63	Property use	1.153	Potential development
1.64	Land receipts	1.154	Updating sharing information
1.7	Consultants: Marina	1.155	Urban design guide
1.71	Consultants reports	1.156	Workshop results
1.8	Economic Development	1.157	Meetings with developers
1.81	Economic Reports	1.158	Development plan/proposals
1.9	Development Quality	1.16	Scottish Executive
1.91	Developer proposals	1.161	Annual reports-city growth fund
1.92	Design manual		
1.93	Meetings		

5.2.3.4 Document Analysis

Three key working documents were identified in the interviews with Dundee City Council and Scottish Enterprise personnel (see also Section 5.2.3.3) and used to refine potential indicators. Whilst several documents were identified for each information flow only one key document was selected for further analysis from each participant interview. This selection was undertaken during the verification, in collaboration with the interviewees, and was based on identifying the most strategic document containing vision, rather than day to day operational issues. The documents used in document analysis were as follows:

- Dundee Central Waterfront Market Appraisal and Economic Impact Assessment, (Scottish Enterprise 2006)
- Dundee Partnership Dundee Community Plan (Dundee Partnership 2005)

- Dundee Central Waterfront Infrastructure Feasibility Report (Dundee City Council 2004)

Documents were reviewed through qualitative analysis to identify potential indicators already in use and associated data availability (Bryman 2001; Bowen 2009). They were also used to develop indicators, which matched the objectives and aspirations stated in the documents, and verified the potential relevance of indicators under development.

5.2.3.5 Finalising Indicators

The document analysis above was used to align the benchmark indicators with regional policy and partnership documents so that their wider relevance was assured. Further to this an interview was undertaken with a member of Sustainable Development Indicator Development Team at the Scottish Government. The interview concentrated on the current and future development of the Scottish Government indicators and future EU and UK indicator reporting. The source and concept of the indicators was discussed, and how the indicators related and would relate in future, to Scottish Government policy. The interviewee could not give an opinion of the relevance of the Waterfront indicators in relation to the Waterfront Development but discussed the general robustness of the indicators. Scottish Government Sustainable Development Indicators were also discussed but no additional indicators or changes to Scottish Government indicators were foreseen for 10 years. Sources of data for Waterfront indicators were reviewed and potential national data source were identified. Overall the indicators were confirmed as being appropriate for monitoring the sustainable development of Dundee Waterfront.

The benchmark indicators were further developed and refined through close working with Dundee City Council, Scottish Enterprise and Dundee Partnership stakeholders. The indicators were reviewed through a further set of over 20 indicator meetings with stakeholders. This sometimes involved more than 1 session, where the indicators were tested against the four tests of an indicator, namely Comprehensiveness, Tractability, Transparency and Practicability. Particular attention was paid to scope and scale, data availability and methods of data collection with a focus on the establishment of a long term indicator collection mechanism. The full list of stakeholders involved in the selection process is shown in Table 5:7 together with a summary of their area of interest. The stakeholders were selected based on their understanding of the waterfront e.g. the waterfront delivery team, their area of speciality related to specific indicators e.g. green space quality assessment or, based on their understanding of data availability, Dundee Partnership Meta Data and the Single Outcome Agreement process.

Table 5:7 Stakeholder Engagement in Indicator Selection

Dundee Partnership Stakeholder	Feedback on indicators
City Engineer, Dundee City Council	Governance of Indicators
Waterfront Team Leader, Dundee City Council	Infrastructure delivery, management systems, reporting structures
Partnership Coordinator, Scottish Enterprise	Governance of Indicators, scope and scale
Business Infrastructure Manager, Scottish Enterprise	Economic, social indicators, scope and scale, data availability and methods of data collection, Dundee Waterfront Performance Management Framework, Marketing Group

Table 5:7 Stakeholder engagement in indicator selection (continued)

Team Leader Policy and Funding, Corporate Service , Dundee City Council	Economic, scope and scale, data availability and methods of data collection, Single Outcome Agreements,
Head of Sustainable Development and Environment, Corporate Planning, Dundee City Council	Environment indicators, scope and scale, data availability and methods of data collection
Waterfront Coordinator, Dundee City Council	Governance of Indicators, scope and scale, Dundee Waterfront Performance Management Framework
Greenspace Development, Dundee City Council	Environment and biodiversity indicators, scope and scale, data availability and methods of data collection
Monitoring Group Member, Scottish Enterprise	Monitoring Group indicators, Dundee Waterfront Performance Management Framework, Economic indicators, scope and scale, data availability and methods of data collection
Infrastructure Group Chair, Scottish Enterprise	Infrastructure delivery, Monitoring, Governance
Senior Community Planning Officer Corporate Planning, Dundee City Council	Social indicators, Single Outcome agreements, scope and scale, data availability and methods of data collection
Waterfront Team Senior Engineer, Dundee City Council	Infrastructure delivery and monitoring KPI
Team Leader, City Development, Dundee City Council	Infrastructure delivery and monitoring KPI
Planning Officer, Information and research, Dundee City Council.	Local Outcome Indicators, scope and scale, data availability and methods of automated data collection

Single Outcome Agreements were introduced in Scotland during the indicator refinement. Single Outcome Agreements require local authorities to have a strategic focus and to develop a manageable number of measurable indicators to report on the national outcomes. DCC published its first Single Outcome Agreement for Dundee in 2008 (Dundee City Council 2008). Single outcome agreements (SOA) were a step change in how local authorities are externally scrutinised. The agreement represented a new relationship between the Scottish Government and local government with a significant reduction in the level of funding that is ring fenced. Dundee City Council therefore had to effectively demonstrate how they contributed to national outcomes through identifying local outcomes and relevant indicators.

The SOA is a key strategic document which will influence the structure and content of other documents. The agreement covers all local authority services and strategic priorities and directions set in the Dundee Partnership community plan for Dundee 2005-2010 (Dundee Partnership 2005) and embraces all the themes in these documents. Indicators have been established for SOA to enable each of the Scottish Governments National Outcomes to be assigned to a partnership group. Indicators will provide an evidence base for analysis of performance against priorities for Dundee as set out in Single Outcome Agreement for Dundee 2009-2012 (Dundee City Council 2009).

The Scottish Government National Outcomes fairer, smarter, healthier, safer and greener (Scottish Government 2007) reference well the three pillars of sustainability. Single Outcome Agreement indicators for Dundee can provide data for Dundee Waterfront Sustainability Benchmark Indicators either through SOA Outcome indicators or SOA Delivery Plan intermediate outcome indicators. SOA indicators can provide information for Dundee Waterfront Sustainability Benchmark Indicators either directly (i.e. using the same units) or indirectly by measuring similar aspects.

The successful alignment of the SOA and Dundee Waterfront indicators has given additional confidence to the long term applicability of the Dundee Waterfront sustainability indicators. The Dundee Waterfront Monitoring and Evaluation Group have developed a Dundee Waterfront Performance Management Framework (PMF) to monitor the performance of Waterfront projects. The Sustainable Development Benchmark Indicators were then reviewed to align with existing data collection activities of Dundee Waterfront Performance Management Framework.

The indicators shown in Tables 5:8 - 5:10 are the benchmark indicators for monitoring the Dundee Waterfront. The * denotes that the indicator is based on the UK Government Framework Indicator or Scottish Government Sustainable Development Indicator Set, but in most cases the definition has been adjusted to be more relevant to Dundee Waterfront. The final two columns on the table provide reference to the Single Outcome Agreement indicators for Dundee and the lead officer for each indicator. The indicator can either be part of the SOA strategic context such as ‘demographics’; directly relevant to a specific outcome, for example ‘retention of skill base’ or a national outcome indicator such as ‘knowledge based economy’. In the case of the latter, terminology and units would be the same in both the Dundee Waterfront and SOA reporting. The term “City Wide” or “Direct” is also used with reference to each Benchmark Indicator. This identifies whether the indicator and data is relevant to the whole of Dundee (City Wide), or Dundee Waterfront specific data (Direct). One of three forms of baseline data exist for each indicator:

1) An initial baseline value for 2010, e.g. population 142,170,

2) A value of 0 as a datum for 2010, e.g. Number of jobs created since 2010,

3) Not yet available, where the indicator is not measurable at this time e.g. Per capita water consumption of new buildings as the area has not yet been developed.

Table 5:8 Sustainable Development Benchmark Indicators - Economic

Category		Benchmark indicators	Definition of indicator	Units	Baseline Data	Desired direction/ Target	Source of Data	Lead Officer
Economic	1a	Demographics* (City Wide)	Population retention	Population number	142, 170	UP	SOA context, GROS Mid Year Population Estimates	Rory Young, Dundee City Council
	1b	Retention of skills base (City Wide)	Graduate retention rate	Graduate population	33 %	Up	Annual Population Survey	Rory Young, Dundee City Council
	1c	Knowledge based employment (City Wide)	Knowledge economy sector jobs	Percentage share of jobs in knowledge industries	28.8 % (09/10)	Up	SOA Delivery Plan intermediate outcome 2a Dundee city council company survey	Stan Ure Dundee City Council
	1d	Employment* (City Wide)	Employment rates	% of resident working age population	72.2%	Up	SOA Outcome 1 Indicator Annual population survey data from NOMIS	Stan Ure Dundee City Council
	1e	Capacity to stimulate investment* (Direct)	Total inward investment to waterfront	£ Inward investment	0	Up	Scottish Enterprise	Angela Crabb Scottish Enterprise

Table 5:8 Sustainable Development Benchmark Indicators – Economic (continued)

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Economic	1f	Tourism numbers (City Wide)	Tourists visiting city centre locations	Number	53,535 (-9.5%) 72,061 (+16.8%) 2008	Up	Discovery /Sensation /McManus V&A visitor numbers annual survey	Visit Scotland Visitor attraction Monitor
	1g	Tourism (City Wide)	Level of tourism expenditure Dundee	Expenditure	£130.79 million	Up	SOA Delivery Plan Intermediate outcome 1h	Stan Ure Dundee City Council
	1h	Regeneration (Direct)	Increased property value	% Increase	0	Up	Scottish Enterprise	Angela Crabb Scottish Enterprise
	1i	Job creation (Direct)	Number of jobs created	Number	0	UP	Scottish Enterprise	Angela Crabb Scottish Enterprise
	1j	Economic output* (City Wide)	Economic output	GDP per capita	£17 335	Up	Scottish Enterprise	Peter Noad Scottish Enterprise

Table 5:9 Sustainable Development Benchmark Indicators - Environmental

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Environmental	2a	Green space/public space* (Direct)	Local environmental quality	Green space quality standard	Not yet available	Excellent	SOA Delivery Plan Intermediate outcome 11 f Dundee Open Space Strategy	Peter Sandwell Dundee City Council
	2b	Waste* (Direct)	Construction waste recycling	% of projects where waste re used/ recycled in line with best practice	100	Target - to match national best practice	DCC City Engineers Recycling Group Report	Roger Grace, Dundee City Council
	2c	Air* (Direct)	Air emissions continually monitored at Union Street and Seagate	Emissions of , NO_2 average µg/m^3	36.6/59.9	Down	SOA Delivery Plan Intermediate outcome 11e National Air Quality Standards and objectives for NO_2	Iris Coghill, Dundee City Council

Table 5:9 Sustainable Development Benchmark Indicators – Environmental (continued)

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Environmental	2d	Water* (Direct)	Per capita water use	l/head/day P.E.	Not yet available	Target - to match national best practice	Design specification	Allan Watt Dundee City Council
	2e	Noise * (Direct)	Noise level impact	Number of complaints related to DCW construction	0	Down	DCC	Allan Watt Dundee City Council
	2f	Energy* (Direct)	Energy consumption	Energy use/CO_2 per M2 of property	N/A	Target - to match national best practice	Design specification	Allan Watt Dundee City Council
	2g	Travel* (City Wide)	Journeys to work and school made by pubic or active transport	% Journeys	15%	Up	SOA Delivery plan intermediate outcome 11c Scottish Household Survey /Waterfront travel Plan	John Berry Dundee City Council

Table 5:10 Sustainable Development Benchmark Indicators - Social

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Social	3a	Housing provision (Direct)	Residential development	% of residential development	21%	21%	Urban Design Guide	Allan Watt, Dundee City Council
	3b	Health & Well being* (City Wide)	Positive and sustained destinations (education, higher education, employment or training)	% of school leavers in positive and sustained destinations	85% (2007)	increase	SOA Outcome 1 Indicator School Leavers Destination Survey	Allan Millar Dundee City Council
	3c	Community* (City Wide)	Neighbourhood satisfaction	% Resident satisfaction with the quality of and access to local services, facilities and environment	Quality 83% Access 93% City Wide	Up	SOA Outcome 10 Indicator Annual Dundee Partnership Social Survey	John Hosie, Dundee City Council

Table 5:10 Sustainable Development Benchmark Indicators – Social (continued)

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction / Target	Source	Lead Officer
	3d	Social Inclusion* (City Wide)	Accessibility of cultural and learning opportunities	Uptake of cultural opportunities by people from under represented areas of the city e.g V &A	Survey in October 2013	Up	SOA Outcome 2 Intermediate Outcome 2f	Marie Dailly Dundee City Council
Social	3e	Participation and responsibility (Direct)	Participation in sustainable decision making	Number of people involved in marketing and stakeholder engagement activities	0	Up	Marketing Officer, Dundee City Council	Gaynor Sullivan, Dundee City Council

Table 5:10 Sustainable Development Benchmark Indicators – Social (continued)

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction / Target	Source	Lead Officer
	3f	Active community participation* (City Wide)	Informal and formal volunteering	% adults who volunteer regularly	17%	UP	SOA Delivery Plan Intermediate outcome 9d Greater Community Spirit and wellbeing, Scottish household Survey DCC	John Hosie, Dundee City Council
	3g	Acceptability (Direct)	Acceptability to stakeholders	%	96%	Up	DCW consultation and communication, City Centre Action Group	Allan Watt Dundee City Council
Social	3h	Confidence (City Wide)	Public perception of Dundee	Qualitative: Very good Good Neither Poor Very poor	 18 49 24 7 2	UP	SOA Delivery plan intermediate outcomes 1g Improved image and perception of the city	Stan Ure Dundee City Council
	3i	Amenity value* (City Wide)	Public perception of amenity of Waterfront area	Qualitative	Not yet available	Excellent	SOA Delivery Plan Intermediate Outcome 11f An attractive and sustainable natural environment	Peter Sandwell Dundee City Council

5.2.4 Interpreting and reporting indicators

The interpretation and reporting of indicators is a critical stage in the development process as it bridges the gap between measurement and understanding (Brown 2009). Transparency is essential in providing a credible reporting of indicators (DEFRA 2006; Hak 2007). The Sustainable Development Monitoring Framework provided the Dundee Waterfront Monitoring and Evaluation Group with the mechanism to monitor and demonstrate the sustainable development of the Dundee Waterfront. The indicator report forms part of the Dundee Waterfront Performance Management Framework reporting to the Governance structure as illustrated in Figure 5:7 Dundee Waterfront Partnership Governance. The Indicator report as provided the Dundee Waterfront Monitoring and Evaluation Group is shown in Appendix B.

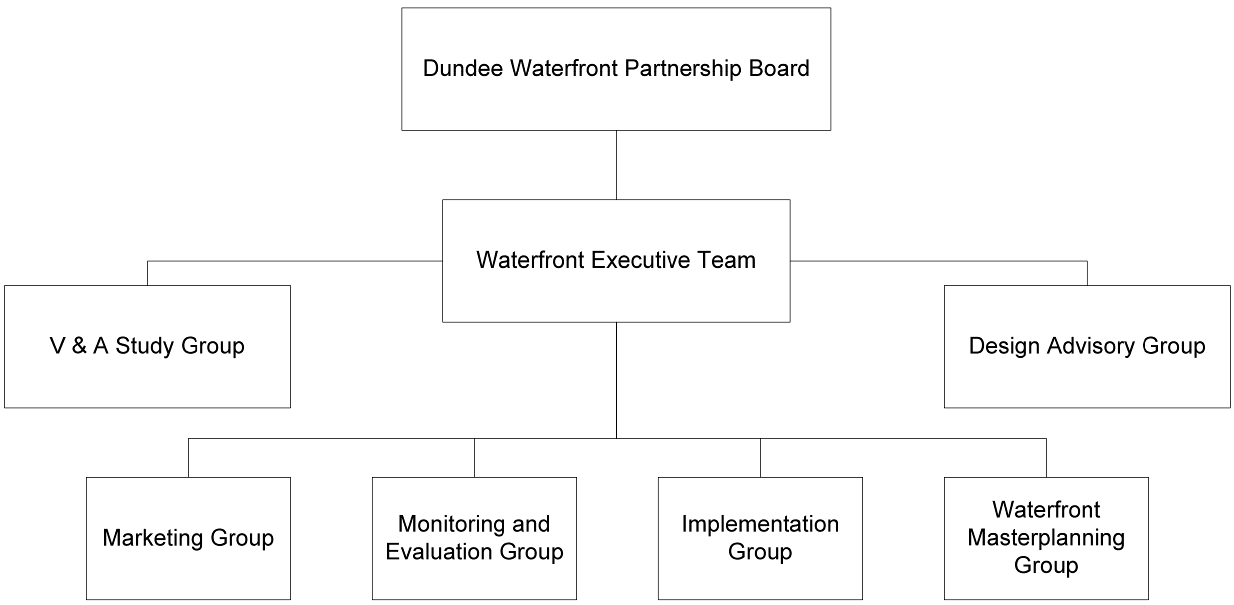

Figure 5:7 Dundee Waterfront Partnership Governance

Dundee Waterfront Performance Management Framework will report data on the baseline annually with major reviews in 2015 and 2020. The Dundee Waterfront Sustainable Development Benchmark indicators will follow the same reporting regime. The Dundee City Council Single Outcome Agreement database and data from the Performance Management Framework will populate the data for Sustainable Development Benchmark indicators.

5.2.5 Maintaining and reviewing the indicators

Indicators should be subject to regular maintenance and assessment (UN 2007). They should be open to modification to reflect changing objectives, the emergence of new issues and improvement in measurement techniques and data availability (Reed 2006; Brown 2009). In addition, reporting requirements may vary over time with changes in the popularity of different types of information (Sustainable Development Commission Scotland 2007). Consideration of these issues is integral to the establishment of viable benchmark indicators for the Dundee Waterfront.

The refining and testing of indicators ensured there was enough scope in the data collected to future proof the indicators regardless of reporting styles. The wide scope of the indicators should prevent them from being superseded and allows additional data to be collected, if required by the Partnership, to measure topical aspects of sustainable development. Continuous monitoring of the Scottish Government and UK Framework for any developments will ensure that the monitoring indicators reflect any changes in sustainable development reporting practice. Particular attention will be given to the Menu of Local Outcome Indicators (Improving Local Outcome Indicators Project 2012) that provides the basis for Community Planning Partnerships to report to Scottish Government through Single Outcome Agreements.

5.2.5.1 Currency of indicators

The currency of the indicator set was reviewed in February 2013. This was undertaken through two workshops with Improvement Service Scotland. This organisation works with councils and their partners to help improve the efficiency, quality and accountability of local public services in Scotland. The first workshop at Scottish Government explored different indicator best practice approaches. The Dundee Waterfront Sustainable Benchmark Indicators were presented alongside Menu of Local Outcome Indicators (Improving Local Outcome Indicators Project 2012) developed by SOLACE Scotland (Society of Local Authority Chief Executives) with input from Scottish Government, Audit Scotland and Improvement Service. The Menu was developed to assist those involved in Community Planning Partnerships to identify and access the most relevant suite of outcome indicators for use in their Single Outcome Agreements (SOA).

A good practice note has been developed as part of the project Indicators Menu of Local Outcome Indicators (Improvement Service 2010). The guidance note provides the criteria on which indicators should be assessed for local authority Single Outcome Agreement (Improvement Service 2010). The text of the guidance summarised in Table 5:14 relates well to the criteria used in section 5.2.3.2 to develop Waterfront Benchmark Indicators.

The second workshop at TAYplan Strategic Planning Authority was facilitated by Improvement Service and looked at developing a set of indicators for TAYplan. The workshop discussion regarded indicators' development, the guidance note, Menu of Local Outcome Indicators, developing indicators of regional impact and drew reference to the benchmark indicators developed for Dundee Waterfront.

These two workshops provided confidence in the method of development and the currency of the indicators. This confidence was based on the best practice workshops which invited the researcher to present the indicators and their method of development. Particular reference was made to the Waterfront Indicators by the Improvement Service and TAYplan when they considered the criteria for indicator selection and encouraged the use of Menu of Local Outcome Indicators to be utilised.

Table 5:11 Improvement Service indicator selection guidance (Improvement Service 2010)

Criteria	Description
Relevant and unambiguous	The indicator should be clearly and directly related to outcomes that are being sought, should be a clear and unambiguous indicator of progress toward that outcome. The definition should allow for non-experts to understand the indicator and there should be no possibility of misinterpretation.
Harmonised with other frameworks and concepts	The definition of the indicator should be harmonised with any similar measures being used in other frameworks, performance management systems, legislation or national or international conventions.
Timely and accessible	The data should be published regularly enough to tie in with the SOA reporting arrangements, the time-lag between recording and reporting of data should be minimal and the data should be easily accessible to all (i.e. available publicly).
Statistically robust and consistent	The data should be precise enough to measure change. The data should be consistent across time and place in terms of both the survey questions asked and the survey design and analysis methodology.
Affordable	The cost of collecting the data to a sufficient quality standard should be outweighed by the usefulness and utility of the data.

5.3 Critical reflection on the uptake of the indicators

Sustainable Development Monitoring Framework Benchmark Indicators have successfully been established and agreed with Dundee City Council. They have been considered at policy, programme and project levels namely:

- Project Team decision making during design and construction of Waterfront infrastructure: To define sustainability issues at project level and as part of enhancement mechanisms to ensure indicators go in the right direction. E.g. Sustainability Risk Log and Development Design Guide.
- Project reporting: As part of Performance Management Framework reporting to the Waterfront Infrastructure Group to monitor progress.
- City Development Department reporting: Department Environment Management System reporting and Service Plan Key Performance Indicators.
- Dundee Waterfront website: Made publically available to investors, funders and wider stakeholders.

There is good awareness of the Benchmark Indicators within the Waterfront Team and City Engineers Division where indicators are reviewed at the Sustainability Group meetings. At the Infrastructure delivery phase the indicators are monitored by Key Performance Indicators. This is where activities to enhance sustainability are initially picked up. These feed into Environmental Management System, Quality Management System and Service Delivery Plans within City Development. These service delivery plans link to Single Outcome Agreement reporting. Indicator changes at project level feed into Waterfront Benchmark Indicators either through direct measurement and reporting e.g. % of project with Site Waste Management Plans or through Single Outcome Agreements. However, the indicators have not been embedded as strongly in Waterfront Governance as anticipated.

The need for indicators was apparent to key decision makers from the outset of the Waterfront project. Their commitment was demonstrated through funding the establishment of Sustainable Development Benchmark indicators. The process of indicator development was iterative and undertaken over a three year period working closely with the project team and wider stakeholders. However, institutional and governance challenges lay around those who will be responsible for the final publication of the indicators and how the indicators will be sustained and funded over time. A large proportion of the refining and testing of the indicators surrounded the alignment to existing data collection. The Scottish Government Framework and Single Outcome Agreement provided a data collection mechanism that would enable the indicators to be sustainable over time. If this had not existed the Council would have had to commission an external party to collect these indicators making it less likely that the indicators would have been successfully accepted within Council.

The establishment of a Waterfront Governance Structure Partnership Board with remit for overseeing the Waterfront Development provided the reporting and governance framework for indicators. The existence of Single Outcome Agreement meta data to populate indicators will allow annual compilation and reporting. However, the interpretation of these indicators at their review in 2015 will require external expertise. Abertay will undertake the interpretation and report to the Waterfront Board in 2015 but there is still uncertainty beyond this.

To address this uncertainty an interview with the Dundee Waterfront Coordinator was undertaken in March 2013 to critically reflect on the use of the Indicators and whether they have been used as intended and are fully embedded in the Waterfront Board decision making. The interview explored changes in governance structure since the indicators were developed. It concluded there are no major changes in the management structure but the membership of each has reduced to a more streamlined set up, with the focus of all the groups on delivery. The indicator reporting structure was considered. The interviewee suggested the Monitoring and Reporting Group was the most appropriate to initially consider the Indicator Report. The Monitoring Group would then recommend the report be considered at the Executive Group. Following consideration at the Executive Group it would then recommend the report be passed to the Board for its consideration. The Coordinator commented that the style of the report would be particularly relevant when the Executive Group considered the report's relevance to the Board. A key point discussed was expressing sustainability threads clearly and engagingly for the Executive Group and Board. This was considered more appropriate than raw data which is most suitable for the Monitoring and Reporting Group.

The regularity of sustainability data collection was also reviewed as part of the interview. The coordinator considered the 5 year reviews at 2015 and 2020 as most important as this is where the interpretation of the indicator trends occurs. He considered annual data collection was not as necessary as these are presently collected in project level KPI. However, an update on indicators over the short term is considered useful, for example on a Biennial basis mid-way between indicator development and large scale review. It was suggested that the reason for this may be due to the current stage in the project, prior to plot development, where the majority of indicators may not have changed enough to make an important and exciting thread for the Board's interest. Most of the social and economic indicators will not change until plot development stage therefore main issues of interest for the board, (headline making issues) will not appear until the first review stage of 2015.

Indicator development was based on a participatory approach to tailor the indicator framework to the specific development project rather than use generic indicators, e.g., CIRIA. One particular challenge addressed during indicator development was achieving a balance between choosing indicators which are wide enough to capture the nature of the development and yet defined and narrow enough to be meaningful. This was overcome by the selection of both City Wide vs Direct development indicators. The careful balance between these seeks to address the challenge of how an indicator can be seen as reliable when so many other factors external to the project may affect its properties and change. This is recognised at the interpretation phase which will occur in 2015. This may also have had an impact on initial use of indicators by Waterfront Board.

Another interesting governance issue relating to this is at officer level. The sustainable development indicators present an additional data collation burden which does not exist currently within any of the officers' roles. This has led to a delay in handing over responsibility for the indicators and therefore truly embedding indicators into the management process. A lot of effort has gone into developing automated data collection. This has been continually reviewed with the ever evolving requirements of Single Outcome Agreement which is the main reporting focus of the statistic and analyst department. However, with the last round of SOA revision and data collection there is now a more aligned application linking closely with the Menu of Indicators as described in 5.2.6. This provides an opportunity to develop the automated collection of the SOA indicators related to Benchmark indicators. This will be trialled in November 2013.

5.4 Conclusion

This chapter presents the development and reporting of benchmark indicators and discusses the issues around developing and embedding sustainability monitoring indicators into existing governance within Dundee Waterfront.

A sustainability monitoring framework was successfully established for Dundee Waterfront in line with the assessment component of the theoretical framework. The indicators followed the principles of the theme orientated framework in line with UK and Scottish Government thematic conceptual approach. The process of indicator was iterative and consisted of three main activities, literature, interviews and document analysis. Indicators were finalised through close working with Dundee City Council, Scottish Enterprise and partnership stakeholders. The currency of the indicators was confirmed through a process of review and comparison with current best practice with the Improvement Service.

The indicators have been successfully established with a number of functions as set out in the Purpose of the Indicators Section 5.2.1. The indicators are now used in Dundee City Council at project and departmental level, providing the link across policies, programmes and projects.

- Project team decision making: Project team, infrastructure group and departmental level
- Project Board Monitoring: Part of Waterfront Performance Management Framework
- Public Reporting: Reporting sustainable development to wider stakeholders, funders and investors

- Council corporate policy: Inform Sustainable Development Governance Framework

The key challenge in developing the benchmark indicators has been establishing robust governance for the monitoring framework. The indicators have been successfully developed at the Project Team and Executive level but less firmly embedded at Board level. This raises issues of ownership in the long term. The stage of Waterfront project life may be relevant with most of the social and economic indicators not likely to change until plot development stage and therefore headline making issues will not appear until the first review stage of 2015.

The use of indicators in the case study supports the case presented in literature review in Chapter 2 for the potential for sustainable assessment to support sustainability management. The wider implications of the findings of indicator development can be related to the current work of sustainability assessment and management as seen in Thompson and El-Haram (2014). This improvement of sustainability practice within the case study through the development of indicators informs lessons for future practice. This is possible because of nature of the indicators as an operational framework is therefore applicable to other contexts. The pragmatic approach based on policy and practice can be used by other public sector organisations to develop a set of indicators based on the policy agenda. The use of theme orientated indicators provides the benchmark to measure progress provide an approach which can be used by other organisations.

6 Chapter 6 Mapping process and knowledge

6.1 Introduction

The second part of the theoretical framework proposed in Chapter 4.2 is the Enhancement Component. The Enhancement Component's role is to ensure that due consideration is given to the potential impact of decisions and actions at key decision points throughout the project development stages. The Enhancement Component identifies opportunities to positively influence the sustainability of the development and to devise and implement appropriate activities and actions.

The Enhancement Component requires an understanding of the ways in which decisions are made throughout the project to enable the information needs of key decision makers to be determined. Key decision points in the process, the stakeholders involved in these decisions, their functions and their information needs require to be identified at this stage. This is to ensure that information on the potential impact of decisions or actions that will influence the overall sustainability of the project can be provided to the right stakeholders, at the right time and in the right form.

Chapter 3 identified a number of authors who have effectively used decision mapping or knowledge mapping to document, understand organisation knowledge management and decision making (Snowden 2000; Wexler 2001; Vestal 2005; Driessen 2007; Yasin and Egbu 2010). The literature review concluded that an appropriate knowledge a mapping technique needed to do the following:

- To identify key points in the decision process and elicit knowledge used to make decisions

- To be dynamic and represent relationship between knowledge and process flows
- To be simple, transparent, pragmatic and illustrate the why, who, what and where of knowledge mapping

A knowledge elicitation and mapping methodology was therefore developed which addressed the above requirements. The methodology developed enhanced previous work by the researcher and extended the approach used in development of the Monitoring Framework presented in Chapter 5.

6.2 Methodology

The knowledge elicitation and mapping methodology utilised a combination of techniques drawn from the information technology, knowledge management and business process mapping fields. These were developed into a three stage process:

1. Knowledge Elicitation: Knowledge elicitation and process mapping to identify and classify knowledge and identify Knowledge Disclosure Points.

2. Knowledge Mapping for Sustainability: The creation, through stakeholder workshops, of a verified Knowledge Map for sustainable decision making on the Waterfront Development project.

3. Operationalisation of Sustainability: Interviews with key process owners to map existing management systems, identify opportunities to ensure the full integration of sustainability issues into project decision process.

The Knowledge Map of Sustainability draws together the output of the Stage 1 Process Owner Interviews and the Stage 2 Workshops. The resulting knowledge map presents the key Knowledge Objects, flows and process in relation to sustainability across infrastructure provision. Stage 3 operationalises sustainability using the Knowledge Map. The three stages are summarised in Table 6:1 and illustrated diagrammatically Figure 6:1. Each stage of the methodology is described in detail in the following Sections of 6.2.

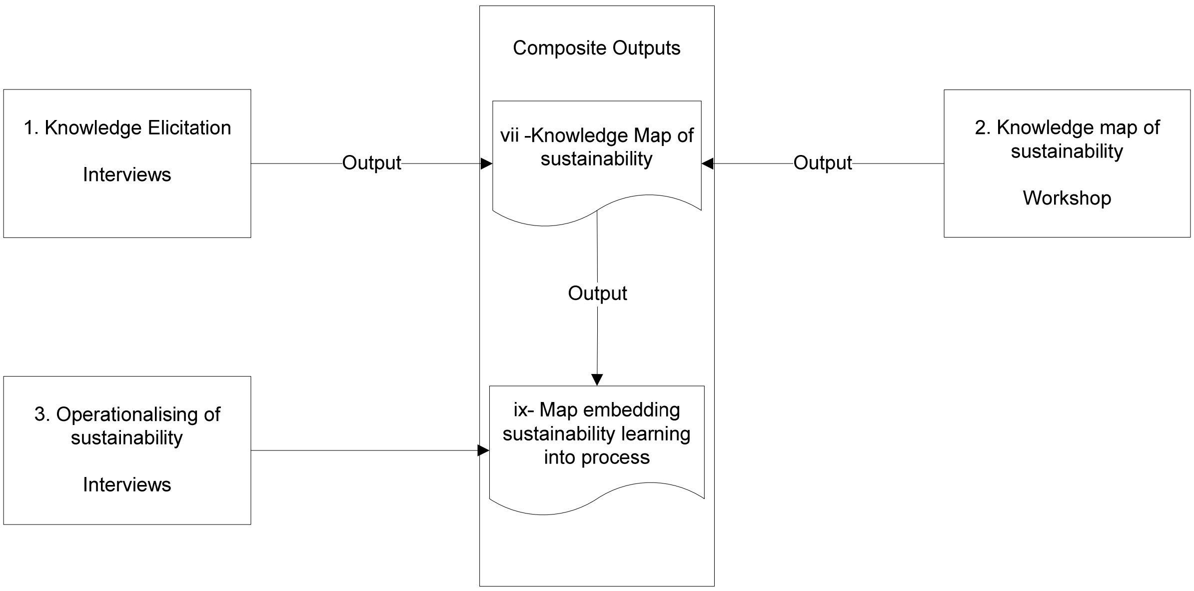

Figure 6:1 Knowledge Elicitation and Mapping methodology

Table 6:1 Three stage knowledge elicitation and mapping methodology

Stage in methodology		Activity (approach developed from)	Output	Figure and Tables reference
1. Knowledge Elicitation	Data Collection	Process Owner Interviews (Snowden 2000; Biazzo 2002; McCormack and Rauseo 2005)	i. Process Maps ii. Knowledge Disclosure Points iii. Knowledge Objects	Figures 6:8 - 6:13
	Analysis	Knowledge Categorisation (Snowden 2000)	iv. Knowledge Objects tabulated using ASHEN categorisation	Tables 6:4 - 6:7
2. Knowledge Map for Sustainability	Data Collection	Workshop (Snowden 2000)	v. Identified Sustainability Knowledge Objects	Figures 6:14 - 6:18
	Analysis	Draw together outputs of Stage 1 & 2 (Hunt et al 2008; Thompson et al. 2011)	vi. Confirmed Knowledge Objects arising from Stage 1 vii. Knowledge map for Sustainability	Figure 6:19
3. Operationalise Sustainability	Data Collection	Process owner Interviews (Snowden 2000; Biazzo 2002; McCormack and Rauseo 2005)	viii. Identify management and Approval Systems	Figure 6:20
	Analysis	Draw together outputs 1,2 & 3 (Nonaka and Takeuchi 1995)	ix. Map embedding sustainability learning into decision process	Figure 6:21

6.2.1 Stage 1 Knowledge Elicitation

Process mapping has been used effectively across many fields (Biazzo 2002; McCormack and Rauseo 2005; Greasley 2006; Wang, Zhao and Zhang 2009; Jallon, Imbeau and Marcellis-Warin 2011). Common to this wide application is that process mapping creates a diagrammatic understanding of the activity, people, data and objects involved in the process. Techniques of representation however vary between process mapping methods and what is represented, or captured, is bounded by the constructs of the language used for mapping (Curtis 1992; Biazzo 2002).

In this study an Organic Knowledge Management approach (Snowden 2000) was adopted to elicit and categorise knowledge. This approach recognises a key finding of the literature review that one cannot map knowledge without understanding of the process (Egbu 2006a; Yoo 2007). The premise to Snowden's approach is that knowledge is only known when it is needed to be known, triggered by events and need, therefore you cannot ask someone to list everything they know (Snowden 2000). The human mind needs to be stimulated and therefore recalling the points in which we use knowledge, is a method to recollect the use of knowledge. Snowden (2000) terms these as Knowledge Disclosure points (KPDs) such as decisions, judgements, problem resolution or learning.

The process mapping concepts have been used, together with Snowden's Organic Knowledge Management linguistic framework, to develop a technique which allows the Knowledge Disclosure Points to be identified during each process of all stages in infrastructure development.

6.2.1.1 Process Owner Interviews

Mapping was undertaken by interviewing key individuals responsible for a task or process. These individuals are termed 'process owners' and have a deep understanding of the phase of infrastructure or process under investigation. Process Maps were developed with the process owners during the interviews which were tape recorded for accuracy of the records. Maps were developed and subsequently verified through a series of interviews with each participant. Each of the interviews built up a set of process maps and associated Knowledge Objects based on Knowledge Disclosure Points.

The method used a 3 level hierarchy of diagrams which allows process to be mapped at appropriate level of detail:

- Level 1 which presents high level process and high level Knowledge Objects as shown in Figure 6:2.
- Level 2 which present activities within each process, Knowledge Disclosure Points and associated Knowledge Objects as shown in Figure 6:3.
- Level 3 which present the workflow within the Level 2 diagram processes, as shown in Figure 6:4. The workflow diagrams provide an additional level of detail to allow Knowledge Disclosure Points (decisions) and associated Knowledge Objects used in the process to emerge.

Knowledge Objects used in the process were then collated for categorisation and analysis as described in section 6.2.2.

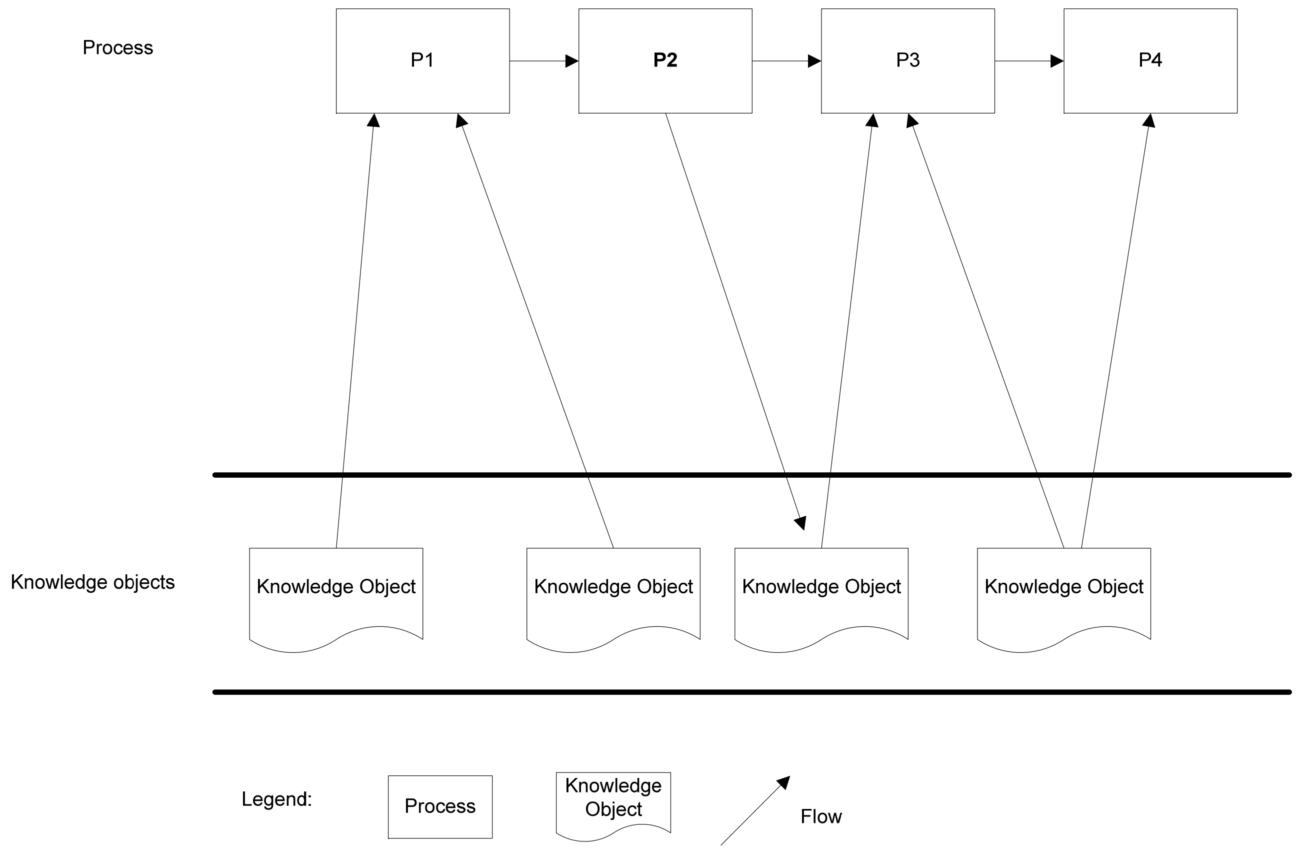

Figure 6:2 Level 1 Process Map

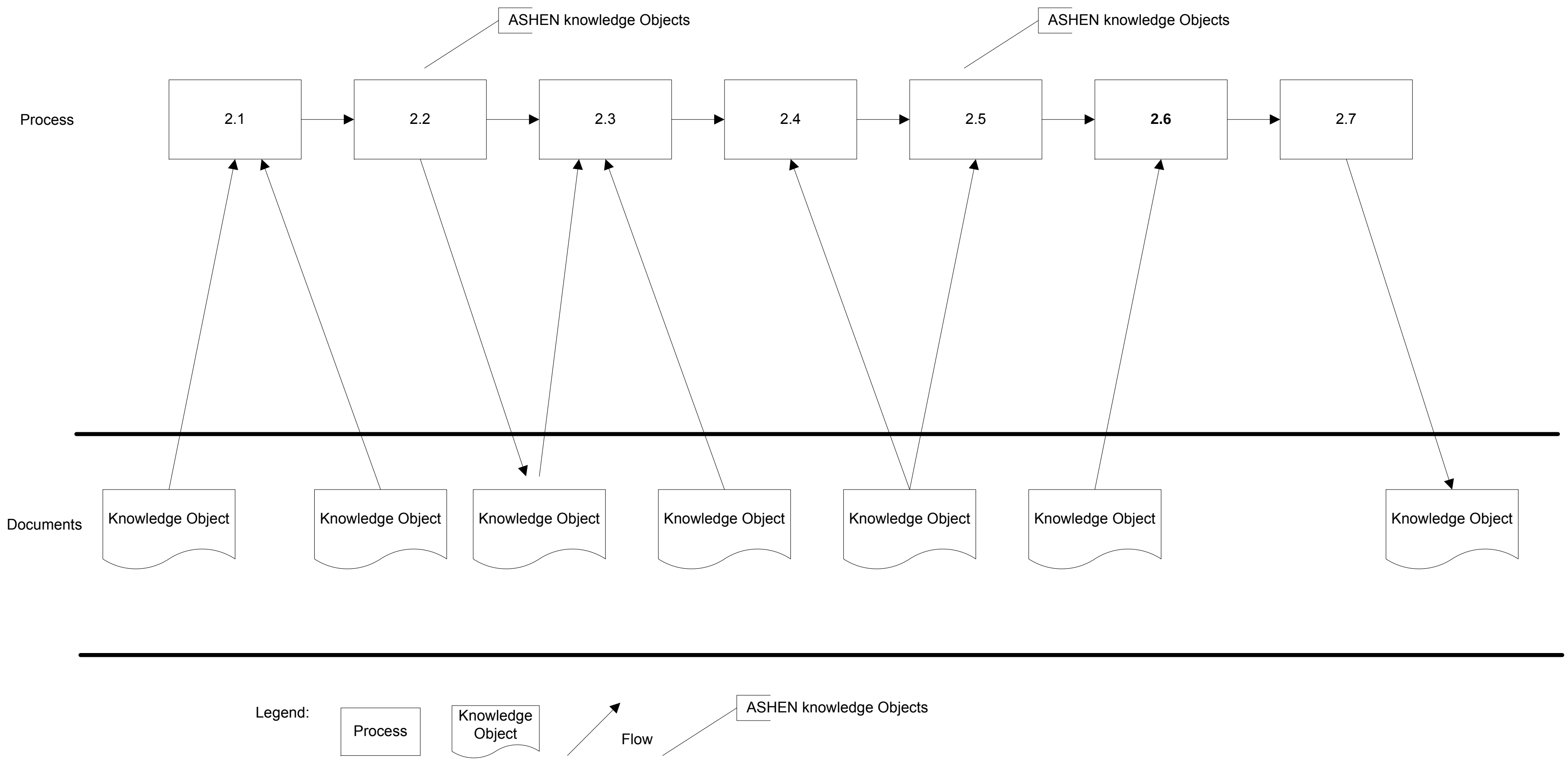

Figure 6:3 Level 2 Process Map

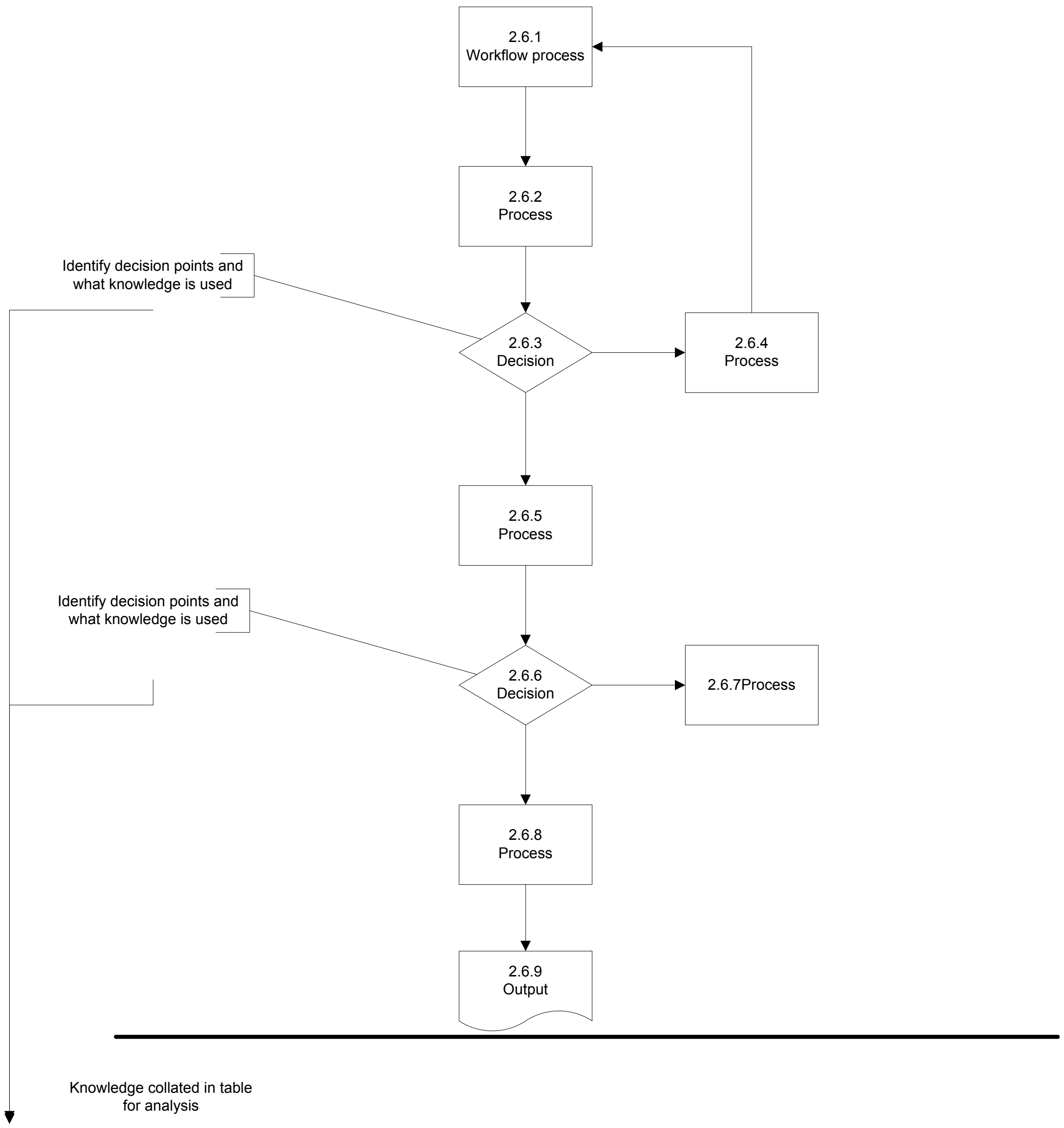

Figure 6:4 Level 3 Workflow Map

6.2.1.2 Knowledge Categorisation

Knowledge management and the concepts of Tacit and Explicit knowledge have been reviewed in Chapter 3. In the field of management literature two key groups of authors lead in the development of these concepts Nonaka and Takeuchi (1995) and Probst, Raub and Romhardt (2000). Nonaka and Takeuchi (1995) developed the influential knowledge creation and transfer SECI model, where the four transitions between tacit and explicit, namely socialisation externalisation, combination and internalisation are described. Probst, Raub and Romhardt (2000) in their work emphasise two types of knowledge, that which can be codified and that which cannot. Snowden (2000) argues that these authors reinforce the implicit assumption that tacit knowledge should be explicit and anything useful should be written down or embedded in a process.

Snowden (2000) contends that the manager's day to day desire in calm and rational moments is to want information written down, leading to an idealised rational decision making with access to all information required. This is contrasted with real life under pressure decision where the problem moves from structured explicit, pseudo rational decision making to simple rules and values, and tacit empowerment based on trust and experience (Snowden 2000). The Chapter 3 review identified that decision making in practice is seldom structured and that often "satisfactory" solutions are reached on an ad-hoc basis. It concludes that most human decision making is concerned with the discovery and selection of satisfactory rather than optimal alternatives. Snowden (2000) presents a method of categorising knowledge whilst maintaining a sense of what information is used in decision making. Knowledge Objects associated with the Knowledge Disclosure Points that were identified and mapped in the interviews during process mapping, (as described in section 6.2.1), were then collated in tables and categorised based on ASHEN categorisation (Snowden 2000) as follows:

- Artefact: the term encompasses all existing explicit knowledge and /or codified information within an organisation: documents, databases, processes.
- Skills are those things we can identify tangible measure of their successful acquisition: expertise, practised ability, dexterity, tact
- Heuristics are the effective way by which decisions are made when the full facts are not known: rules of thumb.
- Experience: actual observation or practical acquaintance with fact or events and the knowledge resulting from this.
- Natural talent: special aptitude, faculty, gift.

The nature of the knowledge objects associated which each process was used to inform mechanisms developed to embed sustainability within processes.

6.2.2 Knowledge Map for sustainability

6.2.2.1 ASHEN workshop

Process owners who had participated in the interviews described in 6.2.1 were invited to participate in a workshop. The workshop enabled the collective identification of Knowledge Objects based on a number of Knowledge Disclosure Points identified in process mapping. This had three purposes. Firstly to confirm Knowledge Objects identified during process mapping. Secondly to draw out as a workshop group any clusters of Knowledge Objects used during the Design & Phasing and Construction stages. Thirdly to draw from the participant's reflection of the sustainability issues relevant to, or contained within, the Knowledge Objects. The

ASHEN diagrams of sustainable development issues were then used to create a 'Portfolio of Sustainability Knowledge Objects' for the Knowledge Map for sustainability as described in the next section. The clusters are used in Stage 3 to operationalise sustainability, to link current and potential stages of influence for sustainability with clusters of knowledge objects currently used in the decision process.

The workshop, at City Development Offices, Dundee City Council was led by the researcher and lasted two and half hours. Following a brief introduction, the workshop was anchored around meaningful questions on the context of the Knowledge Disclosure Points:

- When you made that decision what **artefacts** did you use or have access to?
- What **skills** had you acquired that were necessary?
- What **heuristics** have you developed that enabled you to make that decision quickly on the basis on incomplete or unarticulated inputs?
- What **experience** have you had which are essential or just plain useful in making that decision?
- What **natural talent** is necessary and can you give examples of signs that such talent exists as potential in others?

The participants worked as a group to agree what Knowledge Objects were used at Knowledge Disclosure Points during Design and Phasing and Construction phases in the Dundee Waterfront project. The ASHEN Model was presented to workshop participants on a flip chart and knowledge objects were placed in the categories by the workshop participants. The workshop was tape recorded to give a complete overview of what had been said, the context of the knowledge disclosure and any discussion with the participants around this. The ASHEN model workshop template is shown in Figure 6:5 where the five types on Knowledge Object are laid out.

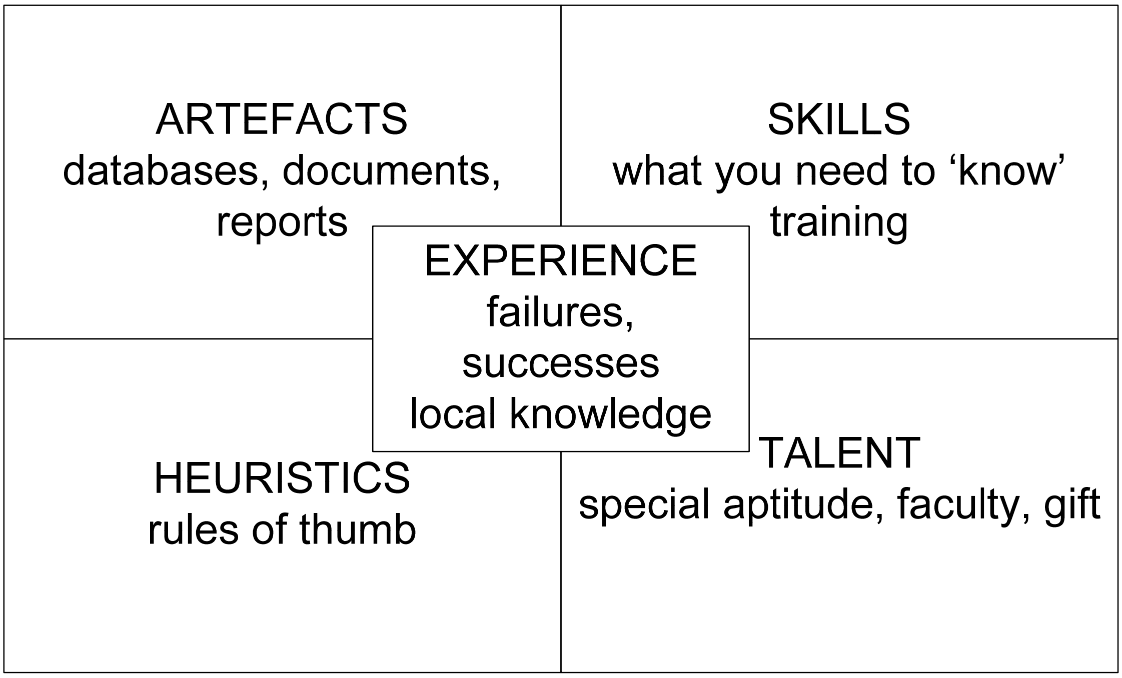

Figure 6:5 ASHEN model workshop template

6.2.2.2 Creation of a Knowledge Map for Sustainability

The Knowledge Map for Sustainability draws together the output of Stage 1 Process Owner Interviews and Stage 2 Workshops. The resulting knowledge map presents the key Knowledge Objects, flows and process in relation to sustainability across Design & Phasing and Construction of infrastructure for Dundee Waterfront. Chapter 3 reviewed mapping methods for sustainable urban environments with reference to authors such as Wextler (2001), Egbu (2006), Eppler (2008), and Thompson (2011). Through these studies a number of mapping techniques and mapping outputs were presented and evaluated. Authors concluded that the important aspect to any map was simplicity so that the stakeholders or users of these maps understand and can use these outputs. They also need to be able to show key documents, key flows and key knowledge and to be dynamic to depict information over time. In addition they need to show the why, who, what, where (Egbu 2006a).

The Stage 1 methodology required the production of process and workflow maps for each stage of infrastructure provision under investigation. It was evident simplification of outputs was required to enable the combination of these outputs onto one map. Methods from IT and information management fields such as Entity Relationships (Coad and Yourden 1991), Corporate Knowledge (Burk and Horton 1988) or Mind Mapping (Buzan and Abott 2005) were evaluated for use at this stage. Botha and Boon (2003) and Buchanan and Gibb (2008) provided comprehensive reviews of commonly cited methodologies, which they used to present a methodological baseline. Their work concluded that there is wide commonality with approaches, with no method distinguishing itself a preferred approach. Emphasis should be on usability of the outputs and organisational requirements (Buchanan and Gibb 2008).

Therefore, methods used in the mapping or assessment of sustainability in urban environment were of particular relevance. Hunt et al. (2008) and Thompson et al. (2011) undertook similar studies which aimed to track sustainability through project life. These studies produced outputs tied to stages in the project life cycle. Hunt et al (2008) uses a term Development Timeline Framework to describe development lifecycle and identifies the activities in relation to sustainable development within a number of stages. Thompson et al. (2011) look at the life cycle of a building and use the RIBA stages to conceptualise the criteria for sustainability assessment by life cycle stage. The researcher in Isaacs et al. (2011) shows a similar conceptual view of where sustainability influence on infrastructure project life cycle. Each of these studies has used the project life as the dynamic part of the output and this concept was continued in this study.

Vail (1999) presents quality criteria to inform the design of knowledge maps as follows:

- Participative- the map is created interactively involving key employees
- Shared - the map represents shared knowledge all can relate to
- Synergistic- experts contribute their different expertise to the map'
- Simple- the map can be viewed at one glance
- Visual- the map uses a visual framework
- Information rich- the map aggregates great amount of noteworthy references related to decision process.

A representation technique has therefore been developed using the project life cycle to integrate process, knowledge objects and knowledge flows. The map was then verified by process owners at Dundee City Council to ensure usefulness, simplicity of representation and effectiveness to represent a knowledge map for sustainability.

The following criteria were used in the verification process based on Eppler (2001) knowledge map quality criteria.

- Functional map quality - does the map serve its explicit purpose, is there a process to update the map periodically and feedback mechanism which users can suggest improvements?
- Cognitive map quality - can the map be grasped at one glance, does it offer various levels of detail, does it allow to compare elements visually?
- Aesthetic map quality – is it pleasing to the eye and has visual identity when new elements are added?

6.2.3 Operationalise sustainability

The framework proposed in Chapter 4 had two parts, a Monitoring Framework and a Sustainability Enhancement Framework. The Monitoring Framework as described in Chapter 5 was developed and established as part of Performance Management System for Dundee Waterfront. The principle of the Sustainability Enhancement Framework is to align the framework with the current organisational process to allow it to be effectively embedded in within the City Development Department. The final part of the methodology was therefore to combine outputs together from Stages 1 and Stage 2 of the methodology to develop a strategy to operationalise sustainability using the Knowledge Map. This involves 3 steps:

1. Establish how well current sustainability knowledge objects are embedded in process and what knowledge object clusters are used and at what stage.

2. Inform a future Knowledge Management Strategy by interviews, to understand the link between concepts of translation of sustainable development and DCC Quality Management System.

3. Gap Analysis to systematically identify Sustainable Development Knowledge Objects related to Knowledge Disclosure Points in order to establish opportunities for enhancement.

The method involved interviews with key process owners to link existing management systems to ensure the full integration of sustainability issues into the Waterfront project decision making process. Interviews were held with the Waterfront Team Leader who was responsible for management systems across the City Engineers Division. The Waterfront Team Leader also oversaw the processes which were mapped in stages 1 and 2 of the methodology. The interviews were semi structured, with the starting point for the interview being the Stage 1 Process Owner interviews and resulting process maps. The interview had two purposes firstly to verify the process maps produced by the process owner and then to identify the relationship between activities at the Waterfront Team level with Divisional Service Plans, Corporate Plans, Quality Management and Environmental Systems. A map of organisation structure was developed as a result of the interviews. The Knowledge Map of Sustainability was then integrated with the map of organisational structure to embed sustainable development learning in the process.

6.3 Results

The focus of this study is the Waterfront Team within City Engineers Division who are part of City Development Department Dundee City Council. The Waterfront Team is responsible for delivering the Dundee Waterfront Master Plan infrastructure which involves the creation of new bridge, road and service infrastructure to Dundee. The three stage process as described in 6.2 was:

1. Knowledge Elicitation: Knowledge elicitation and process mapping to identify and classify knowledge and identifying Knowledge Disclosure Points

2. Knowledge Mapping of Sustainability: The creation, through stakeholder workshops, of a verified Knowledge Map for sustainable decision making on the Waterfront Development project

3. Operationalisation of Sustainability: Interviews with key process owners to map existing management systems, identify opportunities to ensure the full integration of sustainability issues into project decision process.

6.3.1 Knowledge Elicitation

6.3.1.1 Process Owner interviews

The interviews focused on the Waterfront Team's processes during the design and phasing, appointment of contractors and construction activities of infrastructure provision for Dundee Waterfront.

Figure 6:6 shows the stages in infrastructure provision in relation to Royal Institute of British Architects Outline Plan of Work which organises the design, construction and administration of building into a number of key work stages (RIBA 2008).

The box identifies the RIBA Stages that occurred during the study and therefore were able to be mapped, namely RIBA Stages C,D E (Design & Phasing in the study), RIBA Stages F,G,H,J,K (Construction in the study).

Dundee Waterfront Infrastructure stages occurring during study

Preparation		Design			Pre-Construction			Construction		Use
A Appraisal	B Design Brief	C Concept	D Design	E Technical	F Production Information	G Tender Document	H Tender Action	J Mobilisation	K Construction	L Post completion

Figure 6:6 Dundee Waterfront Infrastructure provision stages occurring during the period of study

The initial step of the mapping work was to contextualise the boundaries and sphere of influence of the team. This was effective in previous work by Gilmour and Blackwood (2006). Egbu (2006a) also recommends a high level map of process or team under investigation be made.

Figure 6:7 illustrates the interactions between three tiers; Waterfront Team (Centre tier), providing the infrastructure for the new Dundee Waterfront. The second tier represents immediate client, communities served by the project, and the approvers of the infrastructure design. The outer tier represents the societal, geographical and political frameworks in which the customers and communities are located.

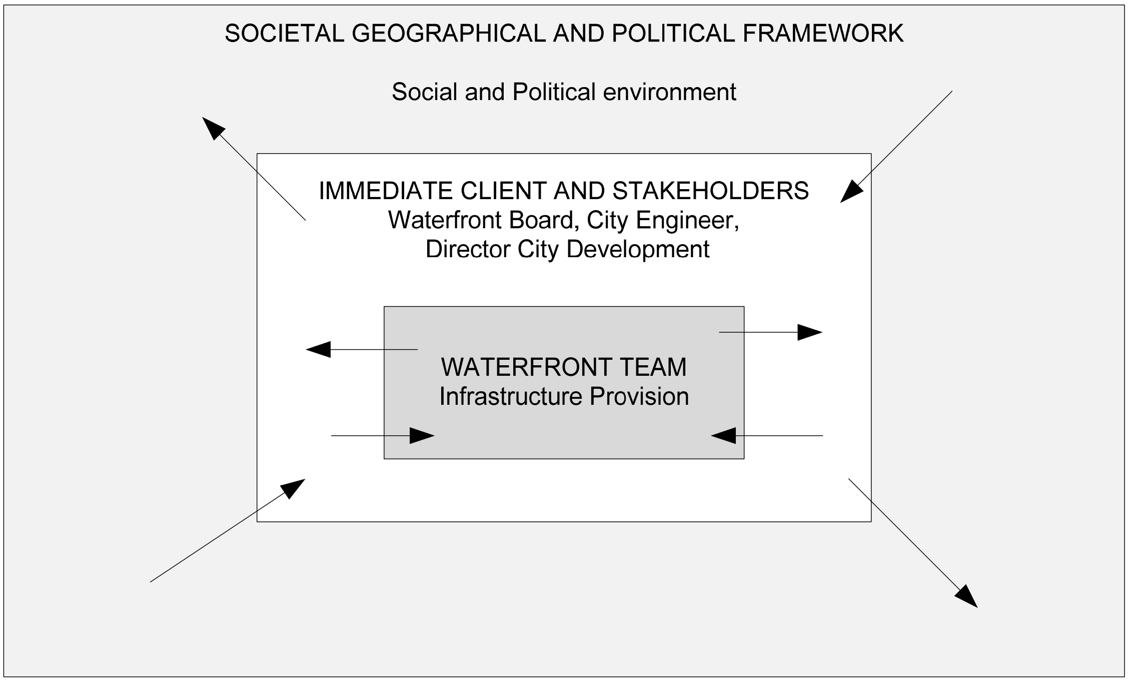

Figure 6:7 Interactions between waterfront team providing the infrastructure for the new Dundee Waterfront

6.3.1.2 Process Owner Design & Phasing

Interviews were undertaken with the process owner at Dundee City Council offices. A breakout meeting space was used so the interviewee could talk freely without interruption. The Interviewee was asked to talk about the Design & Phasing process for Dundee Waterfront and explain the process, information and knowledge which was essential in making a judgment or decision. Diagrams were drawn during the interview and these provided the structure of the interview. Notes were also taken to support the diagrams. Diagrams and notes produced during the interviews were followed up in the verification interviews. Two processes were covered through this series of interviews with the Design & Phasing Process Owner.

The first interview focused on Design & Phasing of infrastructure, the second interview discussed Pre-Construction stages which was also the responsibility of the process owner. Each of the interviews built up a set of process maps and associated Knowledge Objects based on Knowledge Disclosure Points. Table 6:2 shows the series of interviews with Design & Phasing Process Owner.

Table 6:2 Interviews with Design & Phasing Process Owner

Interview	Topic
Interview 1	Design and Phasing process
Interview 2	Pre-Construction process
Interview 3	Verification and further detail
Interview 4	Verification and further detail
Interview 5	Verification

Seven Process Diagrams were developed with the Process Owner to map Design & Phasing stage of infrastructure provision. One Level 1 process diagram presented an overview of all stages involved in design and phasing. A further six Level 2 and 3 diagrams captured the process, workflow and Key Decision Points as described in section 6.2.1.

Three examples of the Design and Phasing process maps are given in the body of the text. These provide an illustration of the scope of Design & Phasing and knowledge objects identified and used during Design & Phasing process. All process maps are shown in Appendix C.

Figure 6:8 provides an overview of the Design & Phasing process for Dundee Waterfront. The purpose of the map is to provide the context for the more detailed process and workflow maps but in itself provides a set of key information that the process owner identified for each stage of the process. Three key documents were identified which inform the client brief and the overall design process. These are the Master Plan for Dundee Waterfront, the Outline Design of the Waterfront and Concept Planning. These documents existed prior to the establishment of the Waterfront Team and the research study period as described in Figure 6:7. This illustrated the influence strategic documents had on the Client Brief and Outline Feasibility stages.

Figure 6:9 presents a Level 2 Outline Phasing process map which maps the Outline Phasing process. Each process has a document and other Knowledge Objects associated with it. Design drivers have been included within the Design & Phasing diagrams where the process owner identified the context of the design drivers as being particularly important to the Design & Phasing process. These serve to contextualise the overall design.

Figure 6:10 presents a Level 3 work flow map for Phasing Revision. This map identifies decision points alongside Knowledge Object identified in Level 2. In this case Clients' Requirements, Experience, Training and Engineering Judgement are used alongside Model Outputs and other documented Knowledge Objects in the decision process. This mapping process allows process and Knowledge Disclosure Points to be captured and Knowledge Objects to be identified. Knowledge Objects used in the process are then collated for categorisation and analysis as described in section 6.2.

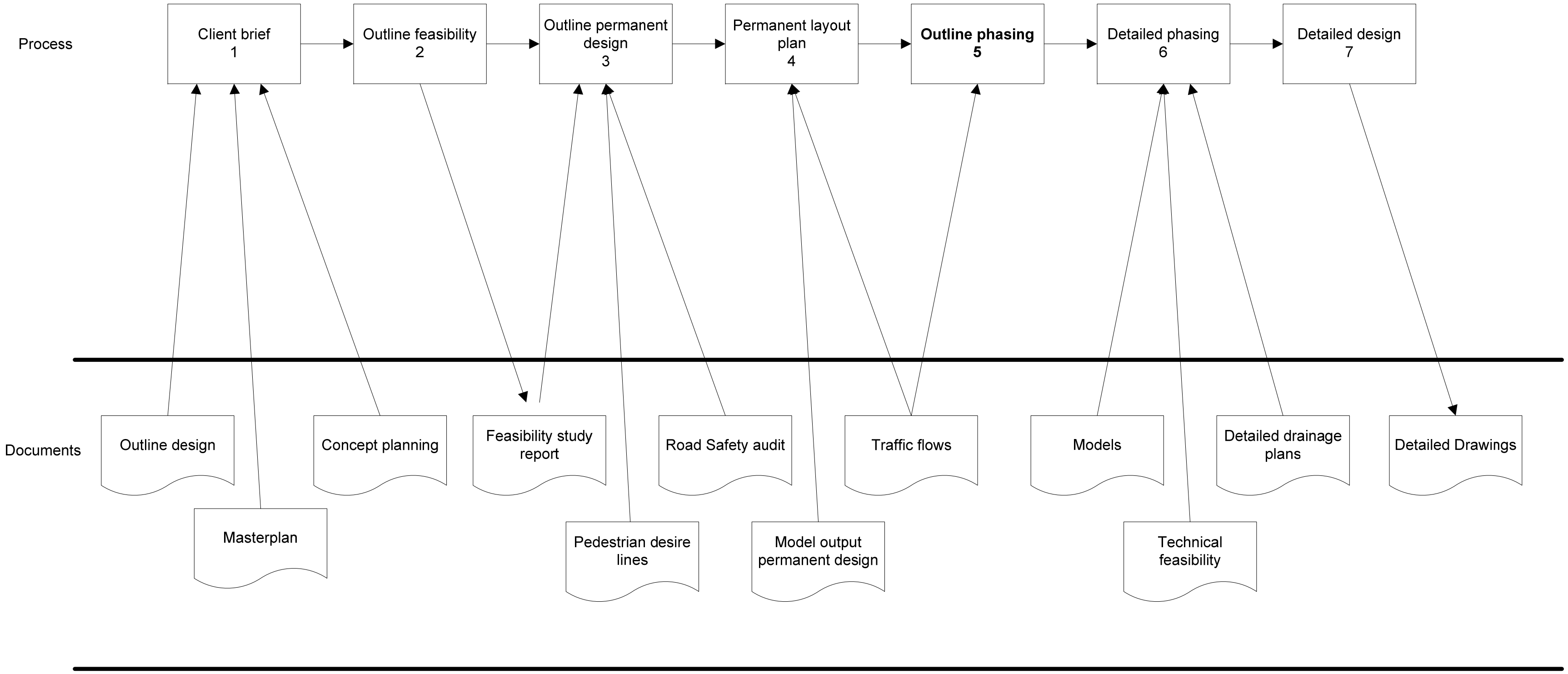

Figure 6:8 Level 1 Overview of Design and Phasing

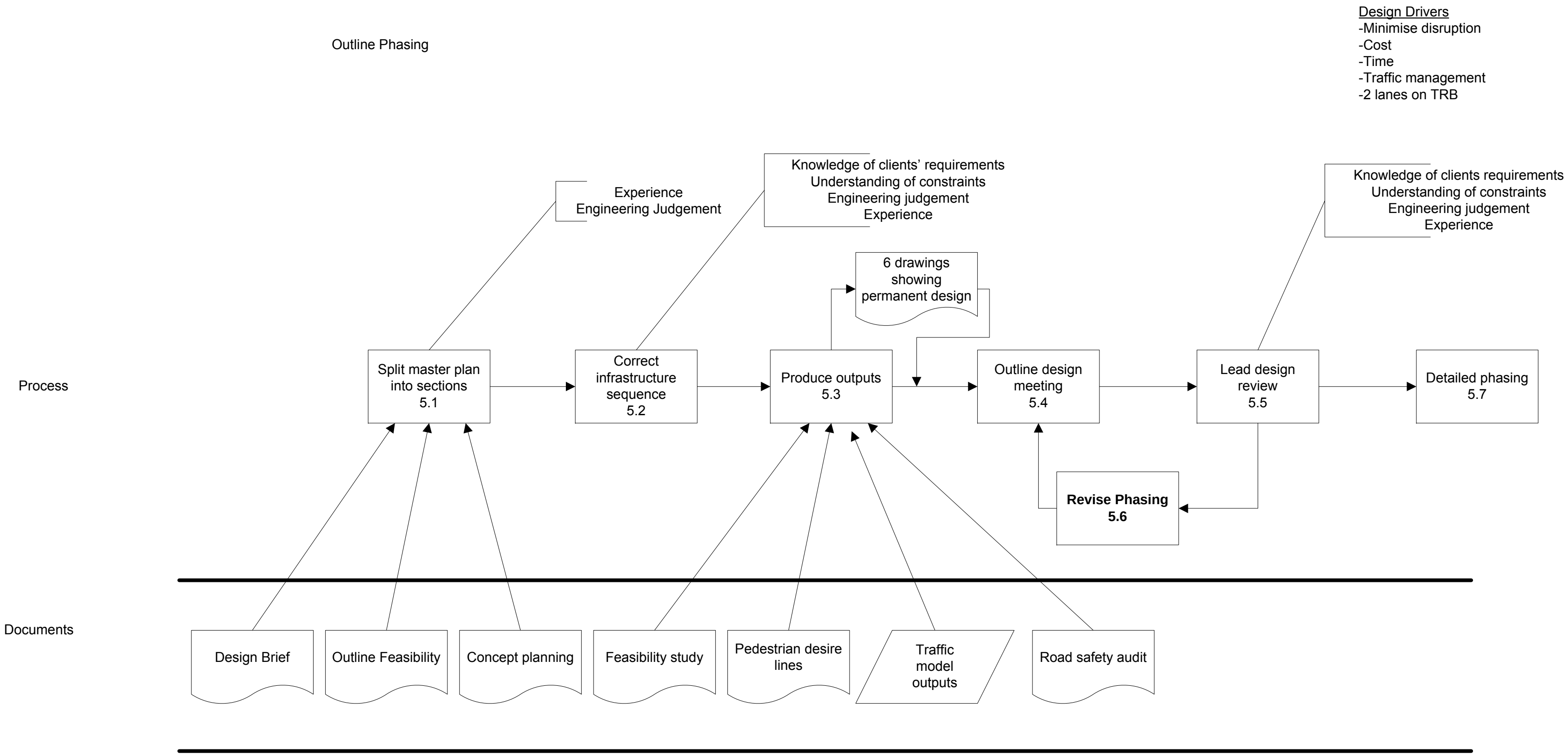

Figure 6:9 Level 2 Outline Phasing

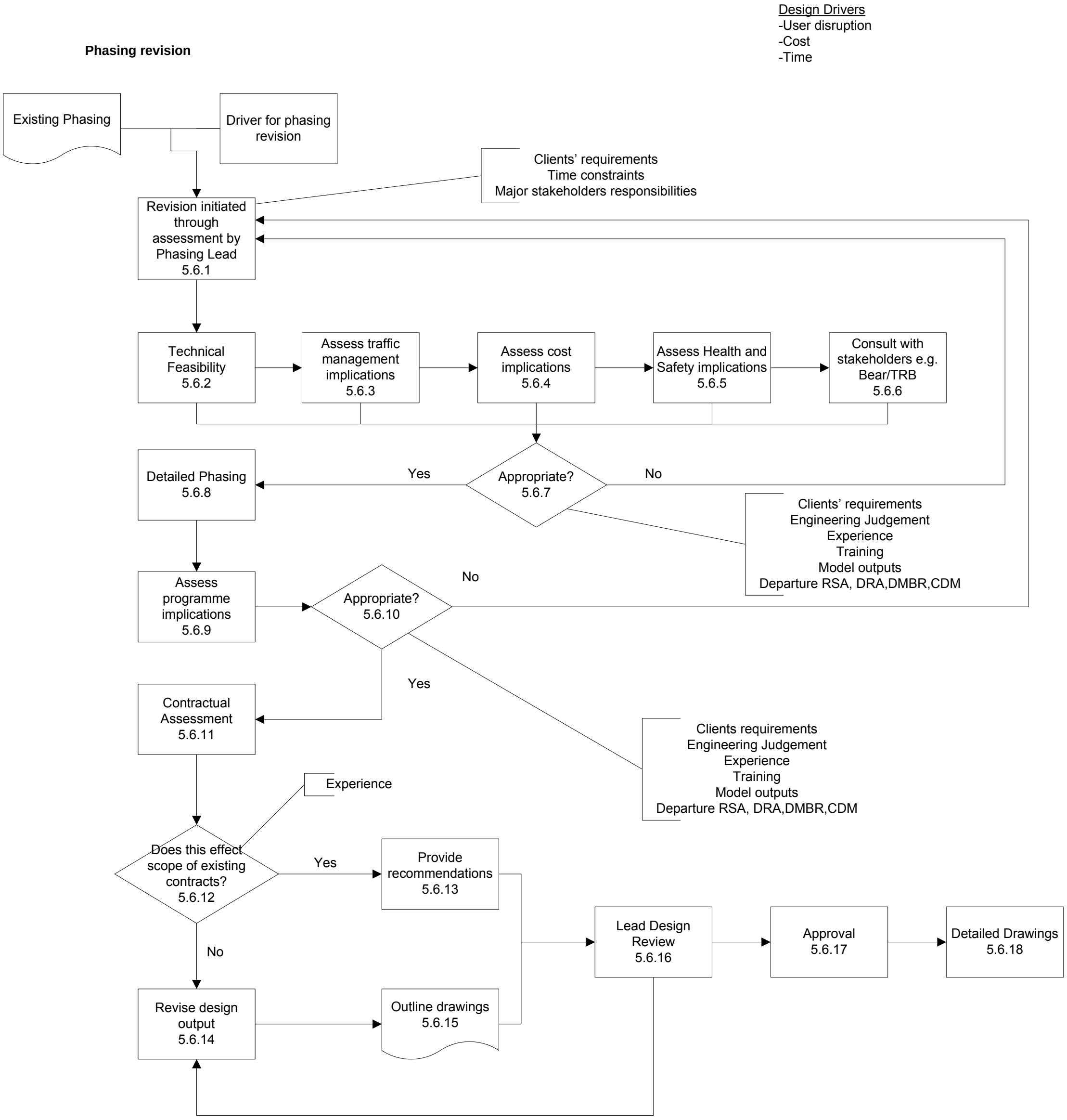

Figure 6:10 Level 3 Phasing Revision

6.3.1.3 Process Owner Construction

Interviews with the Construction Process Owner were undertaken as previously described in Section 6.1.3.2. The interview focused on construction of infrastructure and built up a set of process maps and associated Knowledge Objects, based on Knowledge Disclosure Points. Table 6:3 shows the series of interviews with Construction Process Owner.

Table 6:3 Interviews undertaken with the process owner.

Interview	Topic
Interview 1	Construction process
Interview 2	Verification and further detail
Interview 3	Verification

Figure 6:11 represents an overview of the Construction Process. This interview covered preparation of contract documentation, tendering and letting the contract and contract administration as part of the construction process. The main focus of the interview was on contact administration as guided by the process owner. Key documents were identified by the process owner at this stage and further explored in the Level 2 process and Level 3 workflow maps.

Figure 6:12 presents Level 2 Contract Administration process map which maps the contract administration process. Each process had a number of documents associated with it and also other Knowledge Objects which provided the decision making framework for administering the project. There were two key processes during contract administration, Technical Queries and Commercial Contract

Administration. These require different administration systems which are in use at Dundee City Council 4Project, for Technical Queries, and MPS, for Commercial Administration. There were common drivers across the project administration process as identified by the process owner. These were user disruption, cost management, time and quality.

Figure 6:13 presents Level 3 workflow diagram for prestart and establishment of administration systems. The map identified the Knowledge Disclosure Points alongside the Knowledge Objects as identified in Level 2 Contract Administration process map. Additional Knowledge Object may also emerge at Level 3 as Knowledge Disclosure Points are identified. The mapping allows Knowledge Disclosure Points to be captured and Knowledge Objects identified.

In this workflow the emphasis towards documented knowledge objects was evident supported by an understanding of clients' requirements, contract constraints, judgement and experience. Knowledge Objects used in the process were then collated for categorisation and analysis.

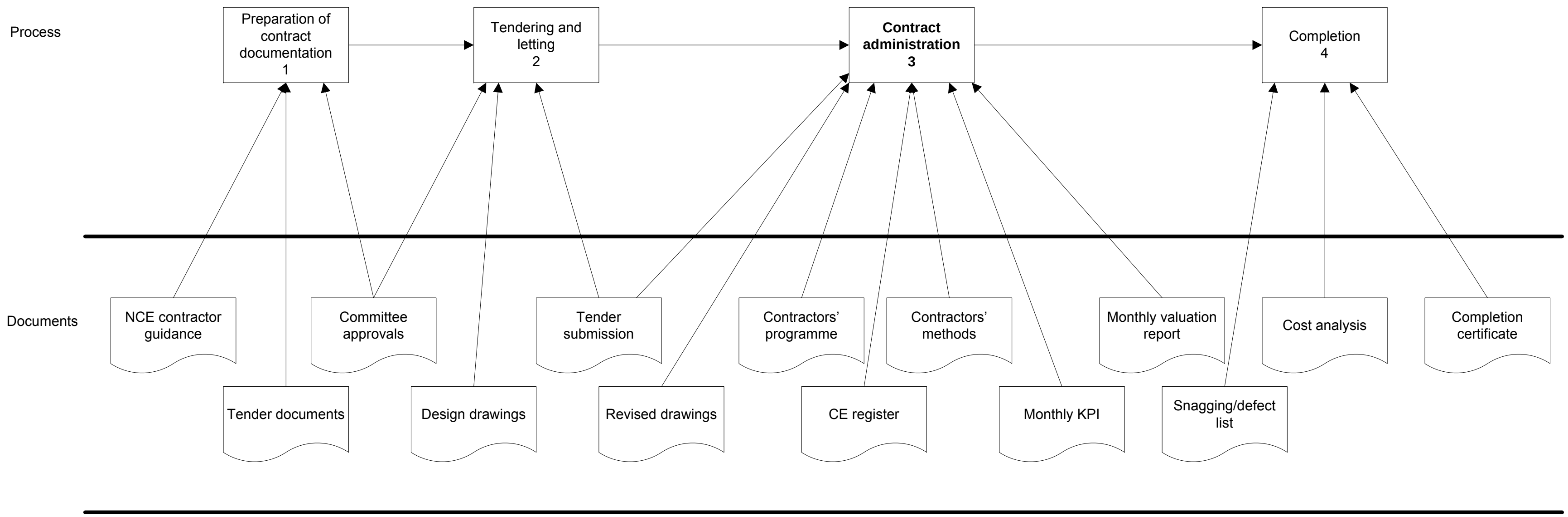

Figure 6:11Level 1 Overview of Construction

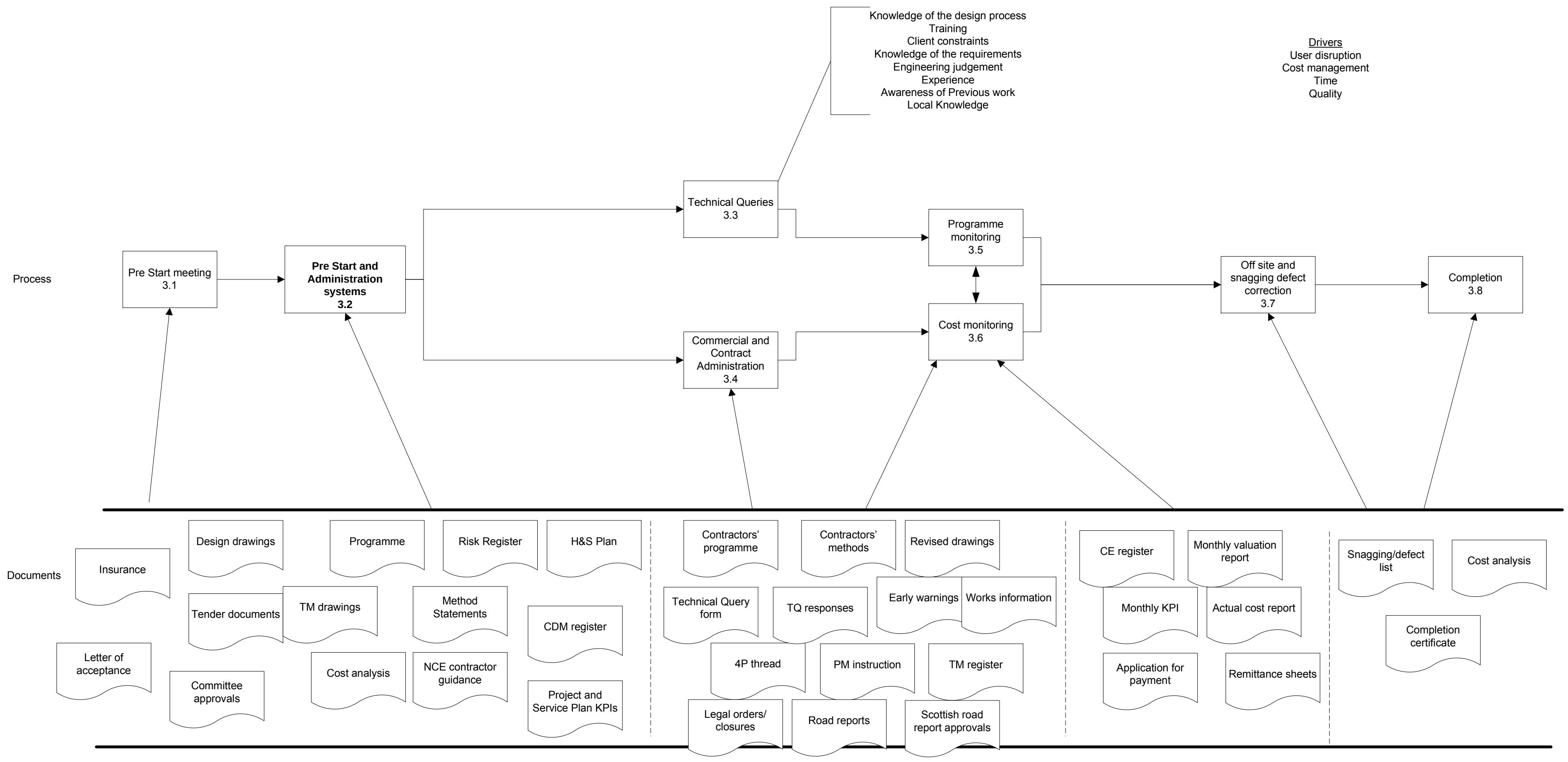

Figure 6:12 Level 2 Contract Administration

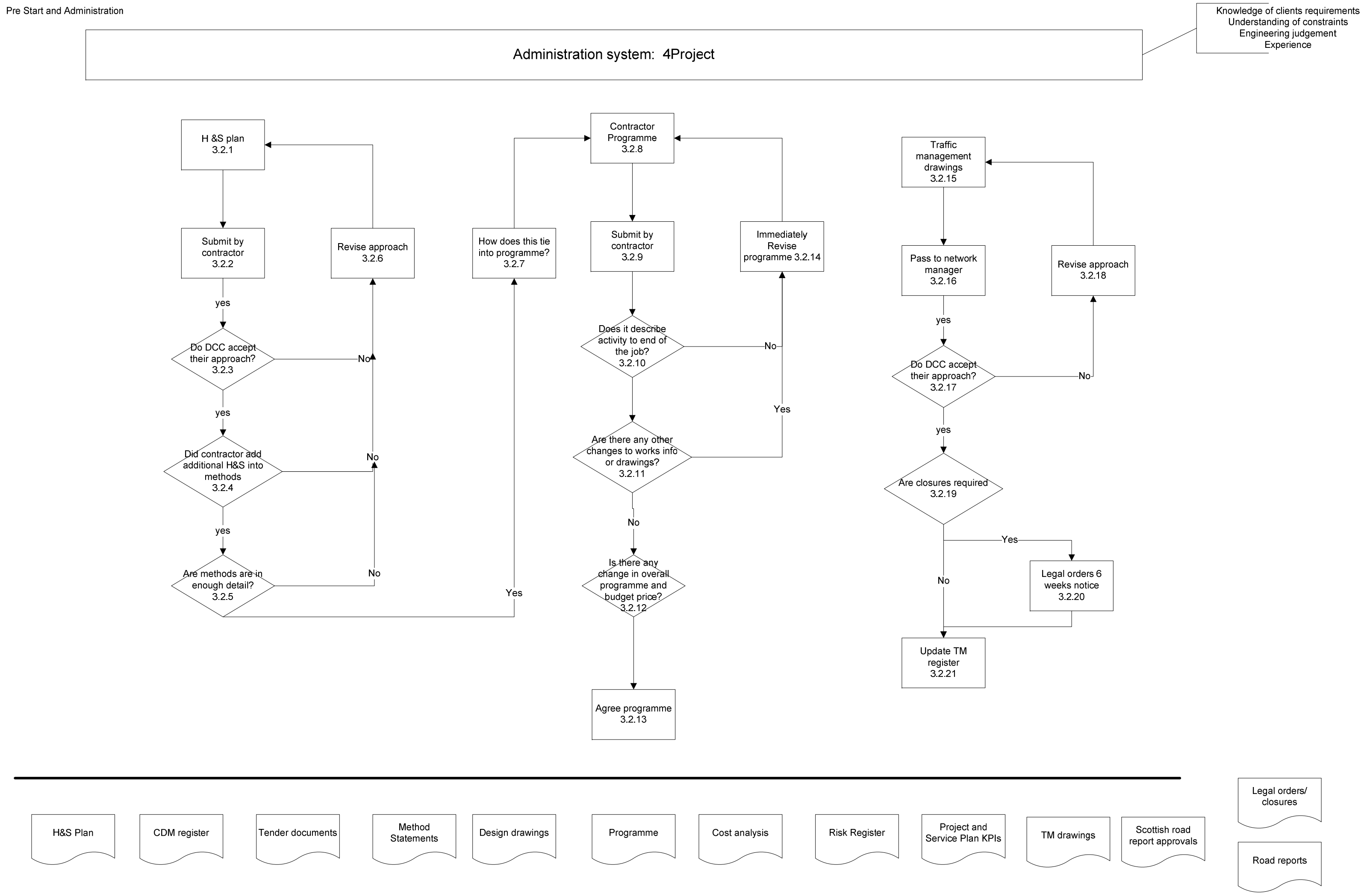

Figure 6:13 Level 3 Pre start and administration systems

6.3.1.4 Knowledge Categorisation

Knowledge Objects were identified as a result of the process owner interviews of Design & Phasing and Construction. These were then collated using ASHEN categorisation to identify the source and type of information.

Knowledge Objects for Design & Phasing were identified and collated as shown in Tables 6:4 and 6:5. The tables show the variety of Knowledge Objects used during the Design & Phasing process. Natural Talent was not identified during the categorisation and therefore not included in the tables. A full set of Knowledge Object tables is given in Appendix C.

Table 6:4 Knowledge Objects from Outline Phasing

Artefact	Skills	Heuristics	Experience
Design brief	Engineering judgement	Engineering judgement	Understanding of constraints
Outline feasibility	Knowledge of the requirements	Timings	Experience
Concept planning	Understanding of constraints	Cost implications	Knowledge of clients requirements
Feasibility study		Traffic management implications	
Pedestrian desire lines			
Traffic model outputs			
Road safety audit			

**Natural talent was not identified during categorisation*

Table 6:5 Knowledge Objects from Phasing Revision

Artefact	Skills	Heuristics	Experience
Design outputs	Training	Engineering judgement	Knowledge of the design process
Existing phasing	Engineering judgement	Technical feasibility	Client constraints
Model outputs	Knowledge of the requirements	Cost implications	Experience
Consultant output drainage	Understanding of constraints	Traffic management implications	Knowledge of clients requirements
Consultant output highways	Stakeholder information requirements	H&S implications	DCC traffic and transportation requirements
Departures-designers risk assessment	Contractual assessment		Drivers for phasing revision
Departures-construction design management			Traffic management implications
Departures-road safety audit			Existing contracts
Departures-design manual for bridges and roads			
Review recommendation			
Outline drawings			
Detailed drawings			

Natural talent was not identified during categorisation

Knowledge Objects for Construction were identified and collated as shown in Tables 6:6 and 6:7.

Table 6:6 Knowledge Objects from Contract Administration

Artefact	Skills	Heuristics	Experience
Insurance	Training	Engineering judgement	Knowledge of the design process
Design Drawings	Engineering judgement		Client constraints
Programme	Knowledge of the requirements		Experience
Risk Register			Awareness of Previous work
H& S Plan			Local Knowledge
Tender Documents			Knowledge of clients requirements
TM drawings			
Method Statements			
CDM register			
Letter of acceptance			
Committee approvals			
Cost analysis			
NCE contractor guidance			
Project and Service Plan KPI			

**Natural talent was not identified during categorisation*

Table 6:6 Knowledge Objects from Contract Administration (continued)

Artefact	Skills	Heuristics	Experience
Contractors Programme			
Contractors Method			
Revised Drawings			
Technical query form			
TQ responses			
Early Warnings			
Works information			
4P thread			
PM instructions			
TM register			
Legal orders/closures			
Road reports			
Scottish road approvals			
CE register			
Monthly valuation reports			
Monthly KPI			
Annual cost report			
Application for payment			
Remittance sheets			
Snagging list			
Cost analysis			
Completion certificate			

Table 6:7 Knowledge Objects from Pre Start and Administration Systems

Artefact	Skills	Heuristics	Experience
H&S plan	Engineering judgement	Engineering judgement	Knowledge of the design process
CDM Register	Knowledge of the requirements		Client constraints
Tender Document			Experience
Method Statements			Knowledge of clients requirements
Design Drawings			
Programme			
Cost analysis			
Risk Register			
Project KPI			
Service Plan KPI			
Traffic Management drawings			
Scottish Road report approvals			
Legal orders/closures			
Road reports			

**Natural talent was not identified during categorisation*

6.3.2 Knowledge Map for Sustainability

6.3.2.1 Ashen Workshop

The ASHEN workshop was held as described in methodology section 6.2.2.1. A number of questions were used to stimulate discussion between workshop participants. The ASHEN workshop material is shown in Appendix D. The ASHEN workshop outputs show how the participants categorised Knowledge Objects during the discussions on Design & Phasing and Construction process. The workshop outcomes verify the initial Knowledge Objects identified during the Process Mapping method used in Stage 1. Five ASHEN model diagrams were produced during the workshop:

1. Design & Phasing
2. Construction
3. Sustainability in Design & Phasing
4. Sustainability in Construction and appointment of contractors
5. Sustainability opportunities

The ASHEN model diagrams above follow the sequence of discussion. The first part of the workshop reviewed the Design & Phasing and Construction processes as discussed in knowledge elicitation and process mapping. This provided an opportunity to cross check ASHEN Knowledge Objects identified at the workshop with types of Knowledge Objects identified during knowledge elicitation and process mapping.

The second part of the workshop focussed on sustainability knowledge objects. Design & Phasing and Construction and appointment of contractors were discussed, and sustainability knowledge objects were identified and categorised as described in the methodology. The final part of the workshop looked at future opportunities for sustainability. The ASHEN layouts are shown in Figures 6:14 – 6:18. In each diagram a cluster of knowledge objects have been identified and illustrated with a circle over the cluster. The purpose of the cluster was to illustrate any predominant groups of knowledge objects used related to the phase of infrastructure provision. For the purpose of distinguishing a pattern of knowledge use clusters of 5 knowledge objects or more were identified. This number was chosen at the researcher's discretion. The knowledge objects have been listed in order of number of objects entries. These are summarised in Table 6:8 as follows.

Table 6:8 ASHEN workshop object clusters

	Knowledge object	Knowledge objects for Sustainability
Design and Phasing	Experience (17) , Artefacts (12) , Skills (10)	Artefacts (16), Skills (8), Experience (6)
Construction	Artefacts (23), Experience (14), Heuristics (9)	Artefacts (13), Experience (11)
Future opportunities		Experience (17), Artefacts (15) Skills (8)

The clustering of the workshop knowledge objects identified that during Design & Phasing 'Experience' was most frequently evident followed by 'Artefacts'. The opposite position was found for Construction with 'Artefacts' most present followed by 'Experience'. When the discussion moved to identifying Knowledge Objects for sustainability, 'Artefacts' were most frequently evident, followed by 'Skills' and 'Experience' in both Design & Phasing and Construction respectively.

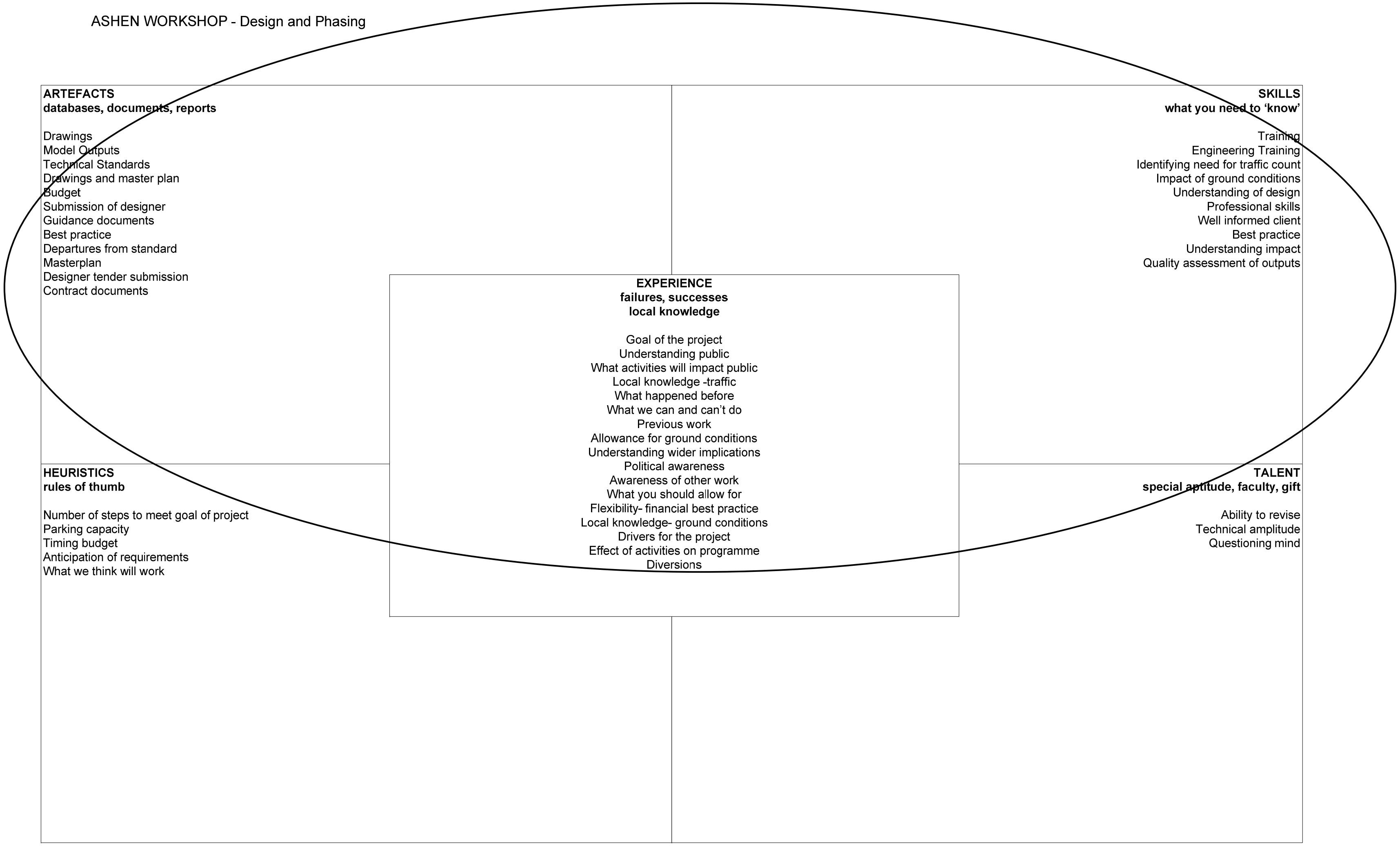

Figure 6:14 ASHEN workshop design and phasing

ASHEN WORKSHOP - Construction

ARTEFACTS
databases, documents, reports
Documents highlight need for change-utility provider
Drawings- sketch/ make a change
Early warnings
Quotation on MPS
Contract-share saving
Tender total-Target price
Contractor notification
Target Price
PM instruction
Type of contract
Method of site investigations
Design and designers available
Rates-labour, plant, material
Previous bill quantity
CE
Method statements
Standards
Ground conditions
Site investigations
Monthly reviews using 4 project and risk register

SKILLS
what you need to 'know'

Review quote methods
Engineering training
Understanding Contract
Engineering judgement
Overseeing project
Good Practice
Design Philosophy
Methods

EXPERIENCE
failures, successes
local knowledge

Knowledge of design
Alternatives
Review quote
What's required
Questioning
Understanding of contract implications
Understanding of cost implications
Linking of contracts
What's happening on site
Design philosophy
Methods too standardised
Methods more specific to local environment

HEURISTICS
rules of thumb

Know how long certain construction tasks take
What's the best way
Review quote
Previous rates
Scope
Methods
Standards
Understanding different approaches
Question if higher than rule

TALENT
special aptitude, faculty, gift

Maintain good relationships
Negotiation skills
Encourage culture of good practise

Figure 6:15 ASHEN workshop construction

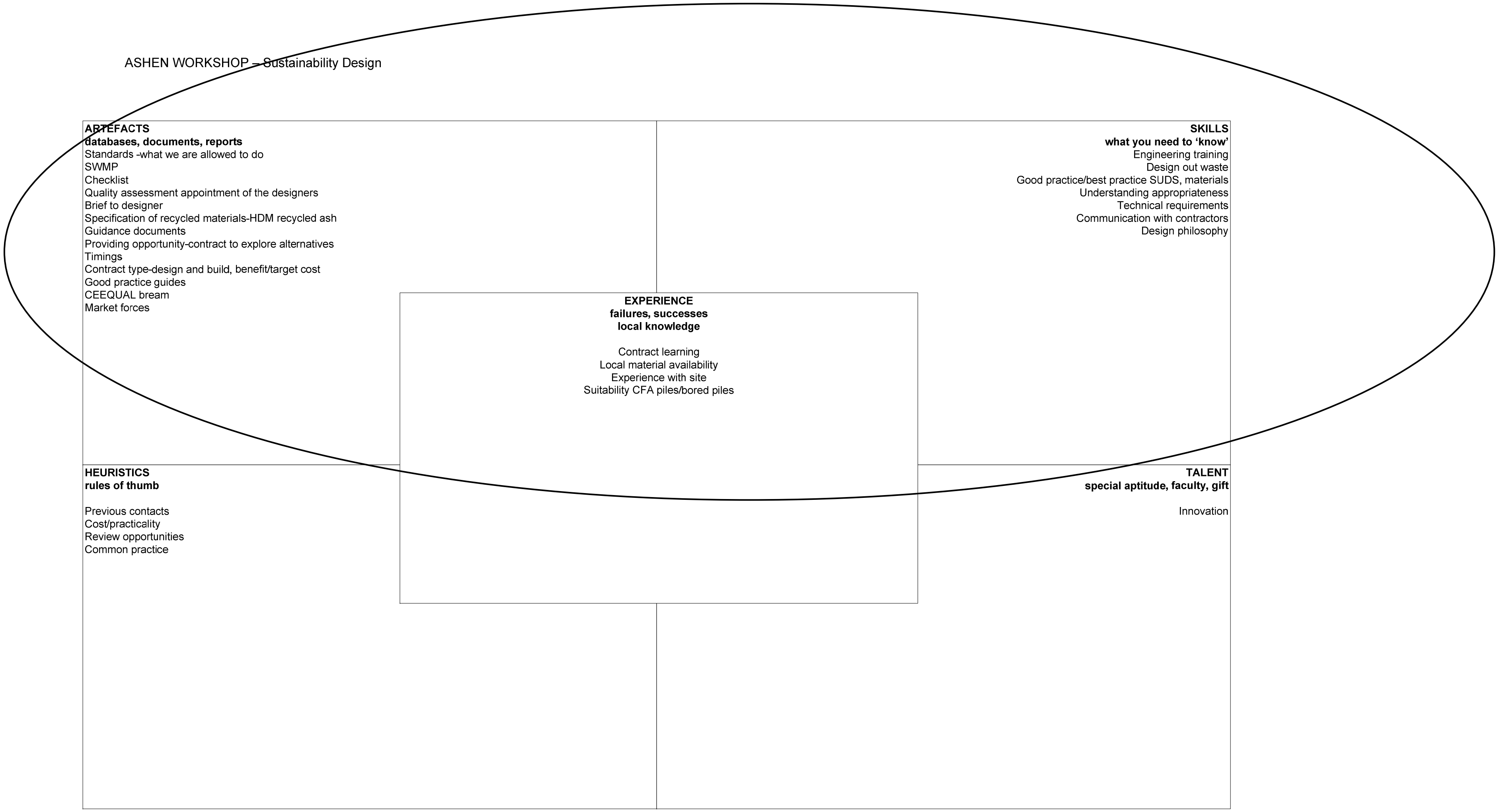

Figure 6:16 ASHEN workshop sustainability in design

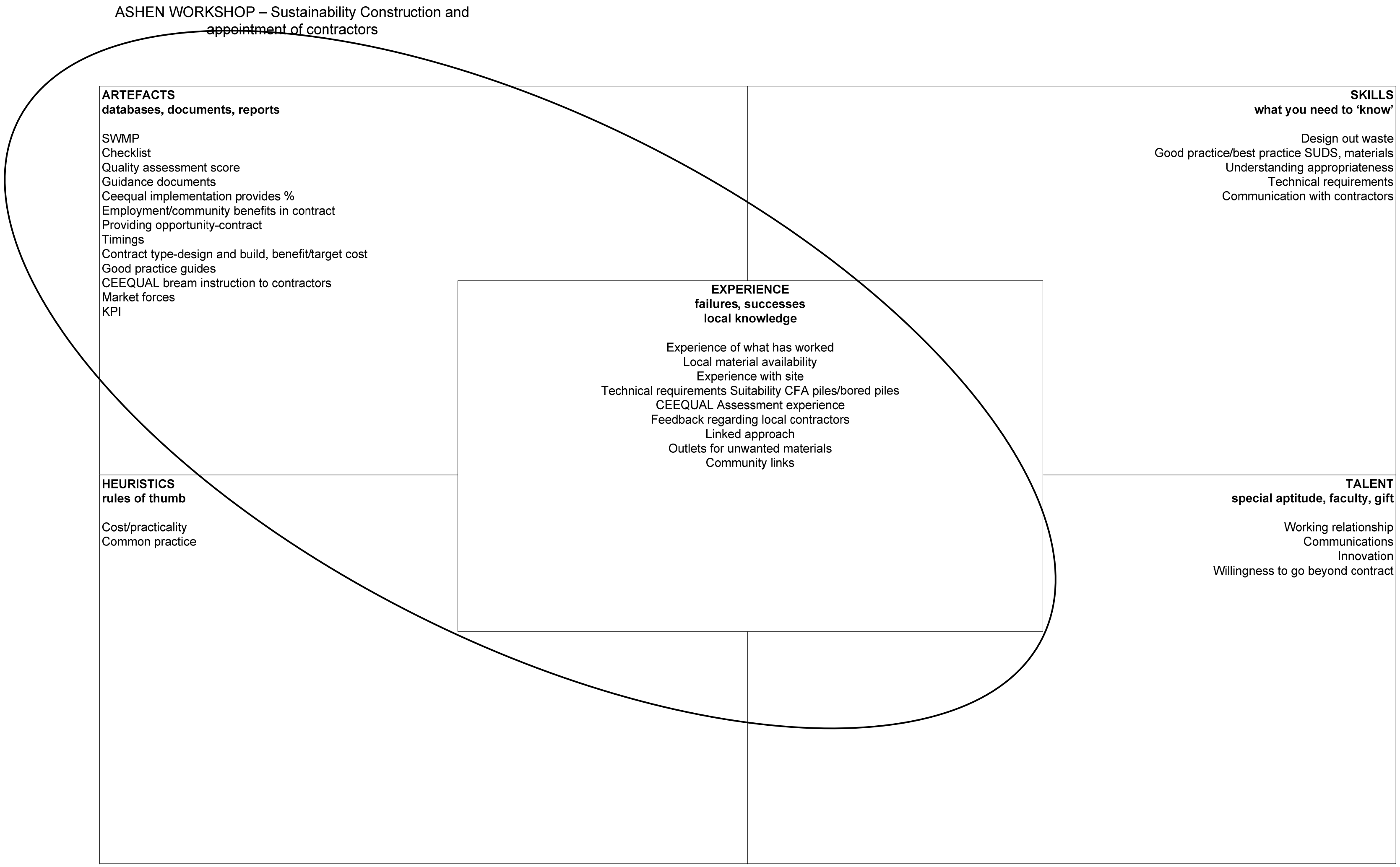

Figure 6:17 ASHEN workshop sustainability construction and appointment of contractors

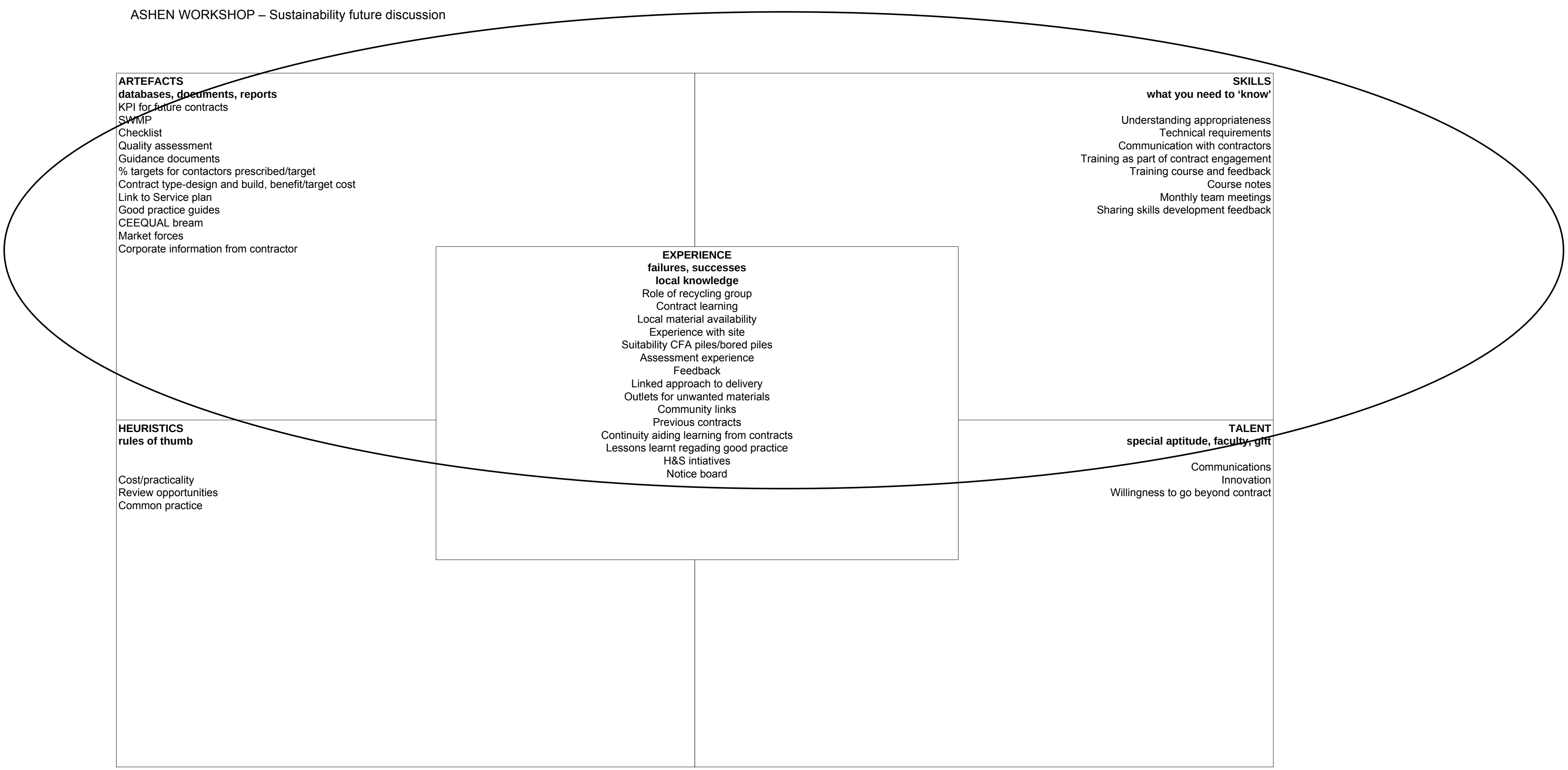

Figure 6:18 ASHEN workshop sustainability opportunities

Based on ASHEN principles the Clusters form the basis of the strategy presented in 6.3.3 to operationalise sustainability into processes by specifying actions that will enhance knowledge transfer. As described by Nonaka and Takeuchi (1995), transformation process encompasses personalisation of knowledge sharing through experience, socialisation or codefining knowledge and a transformation from tacit knowledge to explicit knowledge in the form of artefacts.

The ASHEN workshop has also provided an opportunity for group discussion and knowledge sharing between workshop participants. In particular the workshop provided a platform to identify opportunities to enhance sustainability as a group. It also enabled the group to look at opportunities across the whole infrastructure provision process. Future opportunities to incorporate sustainability were identified by the workshop participants. The clustering of Knowledge Objects in Figure 6:18 illustrate that Knowledge Objects under ‘Experience’ were deemed important by the group alongside ‘Artefacts’ and ‘Skills’.

The ASHEN workshop knowledge elicitation and clustering results served to inform the embedding of sustainability into the process in Stage 3 of the method. It also provided an opportunity to share knowledge between the Waterfront Team workshop participants.

6.3.2.2 Knowledge Map for Sustainability

The Knowledge Map for Sustainability is shown in Figure 6:19 and presents a distillation of output from Process Owner interviews and ASHEN workshops across Design & Phasing and Construction. In addition the map has been extended to illustrate the Feasibility and Use to present the flow of sustainability knowledge across the project life.

The map describes how the sustainability vision flows and transforms through **translation** of the vision in the design stage, by **specification** of the vision in tender documents and appointment of contractors and the **delivery** of the vision during construction. Finally the delivery of the sustainability vision is monitored through the **monitoring and reporting** of sustainable development benchmark indicators. The map also identifies where the knowledge resides within each of the project stages. Knowledge Objects (key artefacts, skill and experience) and a portfolio of specific sustainable development knowledge objects which influence sustainable development are identified.

Once the elicitation process is complete, as in section 6.2, the next stage is to relate Knowledge Objects back to process. The Knowledge Map for Sustainability (Figure 6:19) has linked the Portfolio of Sustainability Knowledge Objects with process identified through Process Owner interviews. The Knowledge Map shows for the first time the aspects of sustainability in infrastructure provision for Dundee Waterfront. The map is built from each of the outputs from the Knowledge Elicitation Stages as listed below and described in Figure 6:19:

1. Stages in infrastructure process,
2. Flow of sustainability across project life,
3. Key artefacts from process mapping
4. Non artefact knowledge objects from process mapping
5. Portfolio of Sustainable development Knowledge Objects from ASHEN workshop

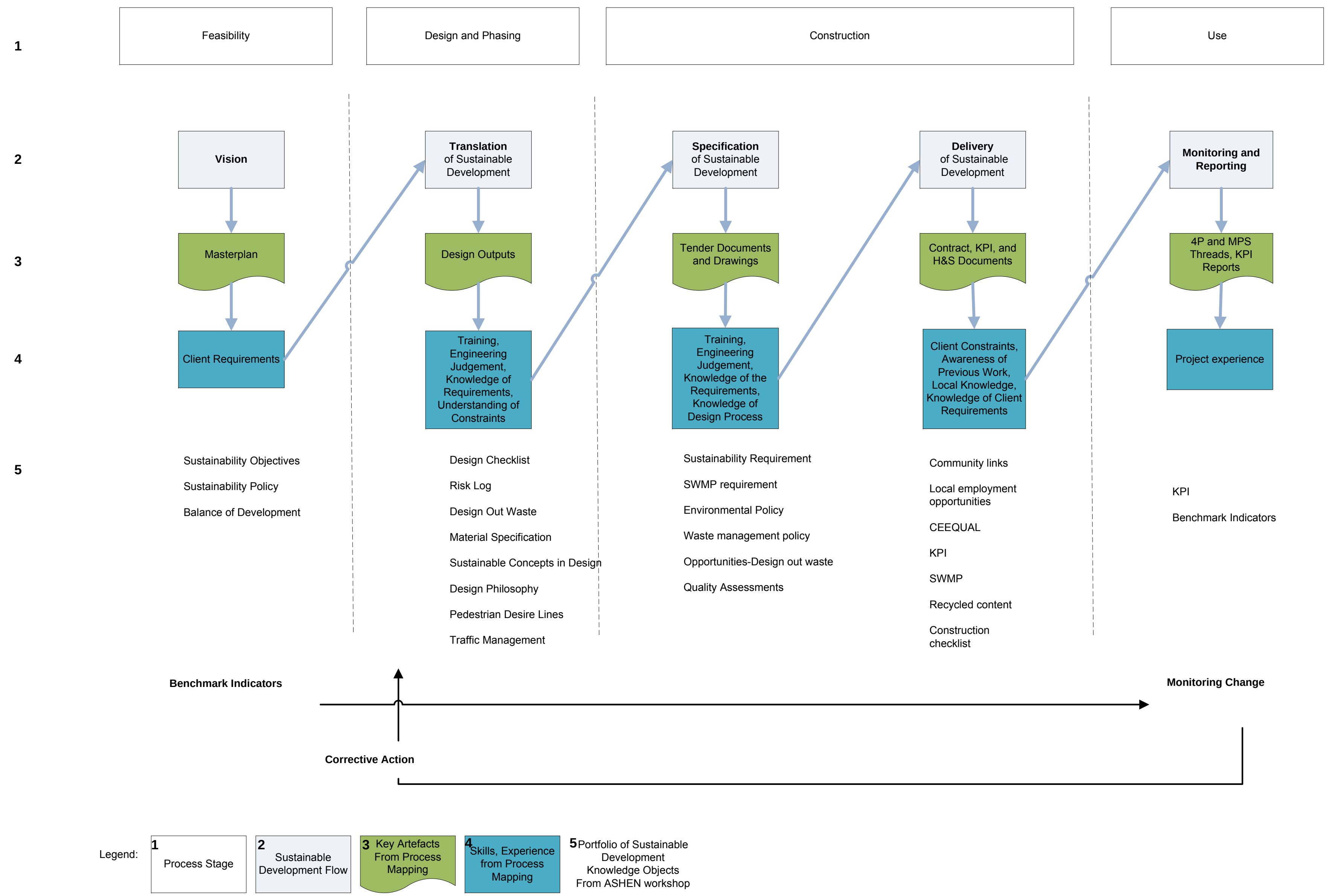

Figure 6:19 Knowledge Map for Sustainability

One of the key challenges of the map presentation was to capture the dynamism and complexity of the real life process while keeping the simplicity and transparency desirable in knowledge maps. To this end, the iterative nature of the process has been concealed through categorising knowledge objects into phases. It is acknowledged by the researcher that in reality these may be quite indistinct or overlapping.

In the case study Infrastructure provision for the Dundee Waterfront was let as a series of independent contracts following the phasing plan. In Figure 6:19 no attempt has been given to show how the knowledge is created, distributed, transferred or disseminated through project learning between contracts. This concept is articulated in Figure 6:21 where embedding sustainability learning into process is considered. The Knowledge Map illustrates one contract as part of overall infrastructure provision. However, the monitoring and reporting of KPIs arising from the contract and monitoring change of benchmark indicators illustrates the principle of monitoring, reporting and taking corrective action to ensure indicators are moving in the desired direction.

The Knowledge Map was verified by 3 Process Owners at Dundee City Council to ensure usefulness, simplicity of representation and effectiveness to represent a knowledge map for sustainability. This verification interview comprised of a number of structured questions based on Eppler's (2001) knowledge map quality criteria. The map user comments in relation to each of the criteria are quoted in Table 6:9. The users concluded that the Knowledge Map for Sustainability met these requirements.

Table 6:9 Knowledge Map verification

Criteria	Verification question	User comments quotes
Functional map quality	Does the map serve its explicit purpose?	"Yes that makes sense to me reading that through" "shows vision, master plan, agree clients requirement, consolidate that into sustainable development, design outputs, requiring engineering judgement, specification then leads to tender, delivery contracts, KPI then review requirements, monitoring and use" "Show the flow of sustainability from vision"
Cognitive map quality	Can map be grasped at one glance, does it offer various levels of detail, does it allow user to compare elements visually?	"lots of information" "Makes sense to me" "Shows overarching objectives, policies of the client, as the design process you are looking at more detail, as you get to tender more detail again, until you are at construction stage and you're at KPI –yes that makes sense" "not sure is monitoring and corrective action works that well, could feedback into different stages"

Aesthetic map quality	Pleasing to the eye, visual identity when new elements are added?	"Yes" (but made following suggestions regarding presentation which were incorporated in final version). "Not sure about the key on the side, put it at the bottom" "Lines could be bigger or stronger to highlight flows more" "Remove process owners"

The Knowledge Map provides a resource for the Waterfront Team to identify current practice with regard to infrastructure provision and where and how sustainability information is used in the process. It can be also used as the cornerstone for Operationalising Sustainability.

6.3.3 Operationalise sustainability

This section presents a strategy to operationalise sustainability using the Knowledge Map. This involves 3 elements:

1. Establish how well current sustainability Knowledge Objects are embedded in process and what Knowledge Object clusters are used and at what stage

2. Inform a future Knowledge Management Strategy by interviews to understand the link between the concepts of translation of sustainable development and the City Engineers' Quality Management System

3. Gap Analysis to systematically identify Sustainable Development Knowledge Objects related to Knowledge Disclosure Points to establish opportunities for enhancement

6.3.3.1 Sustainability knowledge objects embedded in process

The purpose of this first stage in operationalising sustainability was to establish how well Sustainability Knowledge Objects were embedded in the processes involved in infrastructure provision. The Knowledge Map for Sustainability presented a Portfolio of Sustainable Development Knowledge Objects. The map relates each of these objects to stages in infrastructure provision and to the flow of sustainability from Vision to Monitoring and Reporting. The map recognised that the Portfolio Knowledge Objects are used at different frequencies within the infrastructure process and embedded in existing process to varying degrees of 'Security' (Snowden, 2000). In this context 'Secure' means that the process is not vulnerable to Sustainable Knowledge Objects not being used in the decision process. How secure knowledge objects were in City Engineers' Quality Management System or other processes in the process was evaluated through an interview with the Waterfront Team Leader and Construction Process Owner. A five point scale was used is used to evaluate Security where 1 was low and 5 was high.

In addition to 'Security' some assessment of the 'Dependency' of the Knowledge Object on sustainability was required. 'Dependency 'was regarded as the importance of the Knowledge Object to address sustainability. This was also evaluated through an interview with the Waterfront Team Leader and Construction Process Owner. A five point scale was used is used to evaluate Dependency where 1 was low and 5 was high.

The results of the interview were tabulated as shown in Table 6:10 and a simple 'IF' Statement was applied.

Table 6:10 Sustainable Development Knowledge Object Dependence and Security

Stage	Knowledge Object	Dependence 1 -5		Security 1- 5	
Feasibility	Sustainability Objectives	5	True	5	False
	Sustainability Policy	5	True	5	False
	Balance of development	4	True	5	False
Design and Phasing	Design Checklist	5	True	3	True
	Risk Log	5	True	2	True
	Design out waste	4	True	3	True
	Material Specification	4	True	4	False
	Sustainable concepts in design	4	True	3	True
	Design philosophy	4	True	3	True
	Pedestrian Desire Lines	3	False	5	False
	Traffic Management	3	False	5	False
Construction	Community Links	4	True	5	False
	Local Employment Opportunities	4	True	5	False
	CEEQUAL	4	True	3	True
	KPI	4	True	5	False
	SWMP	5	True	5	False
	Recycled Content	4	True	3	True
	Construction Checklist	5	True	3	True
Use	KPI	4	True	5	False
	Benchmark Indicators	5	True	3	True

The simple 'IF' Statement approach was undertaken based on a logical test as follows, a value for the test if true and a value for the test if false (Chapman, 2001). In this case, if Dependency was greater than equal to 4 the 'IF' Statement reads

‘True’. If Security was less than or equal to 3 the ‘IF’ Statement reads ‘True’. Knowledge Objects with ‘True’ for both Dependency and Security (shaded cells in Table 6:10) were therefore targeted for a strategy to operationalise sustainability interventions outlined in section 6.3.3.2.

6.3.3.2 Inform a future Knowledge Management Strategy

The Knowledge Map, literature in Chapter 3 and interviews suggested that Knowledge Objects such as Experience can be shared between members of the Waterfront Team through socialisation, anecdotes or in a formal setting during Team training sessions and Sustainability Group meetings. The open plan office environment and current close team work also present opportunities to share experience. Team work prevalent across the group allows project learning to be shared effectively across the Waterfront Project Team over a number of contracts. There is a procedure for evaluating development training needs as part of the Divisional QMS. The use of these training opportunities to develop appropriate skill for sustainable development such as Site Waste Management Plan training has already taken place.

Chapter 3 outlines common tools and techniques used in knowledge management strategies such as; After Action Review used to capture lessons learnt both during and after a project; Best Practices to capture best practices in one part of an organising and sharing them for the benefit of wider organisation; Peer Assists learning from the experience of others before embarking on activity or project. These Knowledge Management techniques can be used to develop knowledge sharing to operationalise sustainability in QMS and other management systems.

The knowledge management techniques explored here do not focus on transforming tacit to explicit unlike a number of knowledge management texts (Nonaka and Von Krogh 2009; Anand, Ward and Tatikonda 2010) but rather to increase the sharing of knowledge through knowledge interventions. This sharing can be achieved through the use of a combination of ASHEN objects, including the use of existing systems to document and share best practice through the City Engineers Division.

An interview with the Waterfront Team Leader established the influence of existing Quality management System (ISO 9001), Environmental Management System (ISO 14001) and other management structures at the Dundee City Council City Engineer Division level. The Quality Management System (QMS) provides engineers with procedures for each part of Design, Pre-construction, Construction and Use. The Environmental Management System sits alongside the QMS with associated Environmental Key Performance Indicators (KPI). The City Engineers Division Service Plan contains associated KPI which are then reported within Departmental reports by City Development Department.   The management structure for approvals and reporting is shown in Figure 6:20.

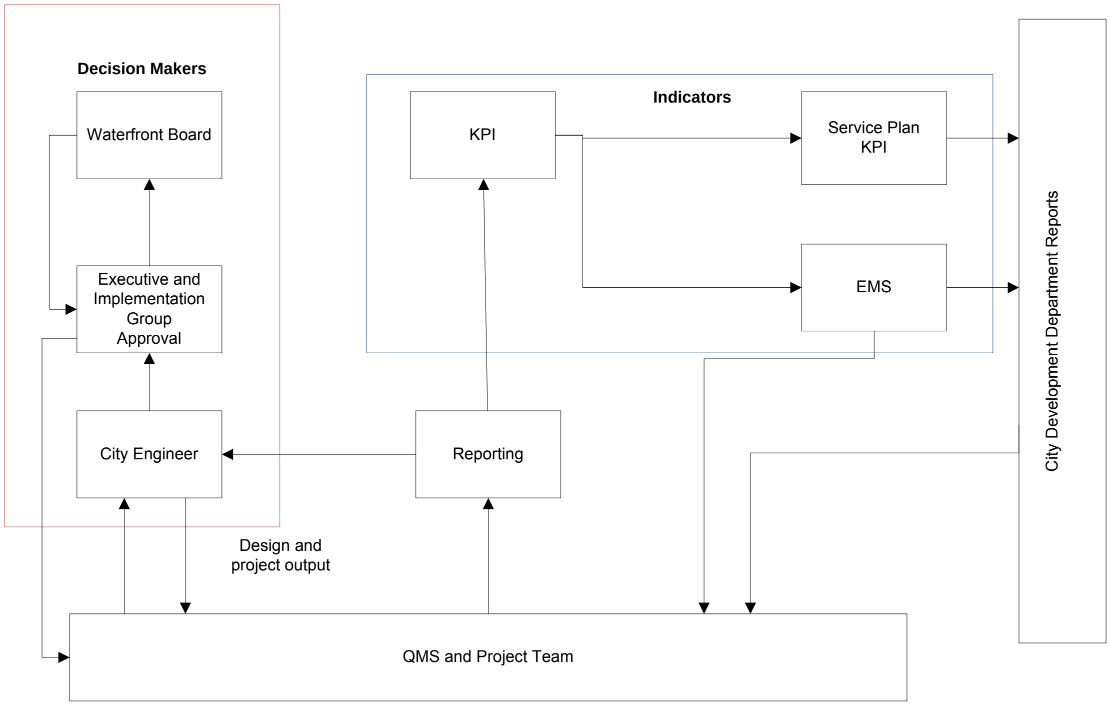

Figure 6:20 Management structures, reporting process and approvals

The management structure for the Dundee Waterfront Team consists of the City Engineer who is responsible for all DCC engineering projects across the City including Dundee Waterfront. It also contains the Dundee Waterfront Executive and Implementation Group which has members from Dundee City Council and Scottish Enterprise who are responsible for monitoring provision of infrastructure and the Waterfront Management Board who oversee all aspects of Dundee Waterfront project. The Project Team provide design output, project management and contract requirements that are managed and approved by the City Engineer. There is a two way flow of information between the Waterfront Team and the City Engineer which is not only important in reporting and approvals but also for sharing knowledge of sustainability and project learning.

Reporting and monitoring instruments are also represented in Figure 6:20. These consist of Key Performance Indicators (KPI) which are monitored and reported through each contract. KPIs inform relevant Service Plan indicators on a divisional level and are use as indicators as part of the Division's Environmental Management System. The Service Plan and Environmental Management System are reported to the City Development Department in which the City Engineers Division sits.

The interview identified that project feedback, design reviews and experience sharing are ways where project learning is activated. The monitoring and reporting of sustainability provides the mechanism for project learning through KPI and Benchmark Indicators. These indicators feed into contract KPI and Service plan KPI at divisional level. They also feed into the Environmental Management System for the division. Experience is shared between team members but also with the City Engineer who has an understanding across all contracts and activities at the divisional level.

The focus of Figure 6:21 is the use of knowledge identified in the Knowledge Map for Sustainability, and how this knowledge is shared through contract learning. The project learning process is illustrated together with the sustainability knowledge flow through project and management and reporting structure in Figure 6:21.

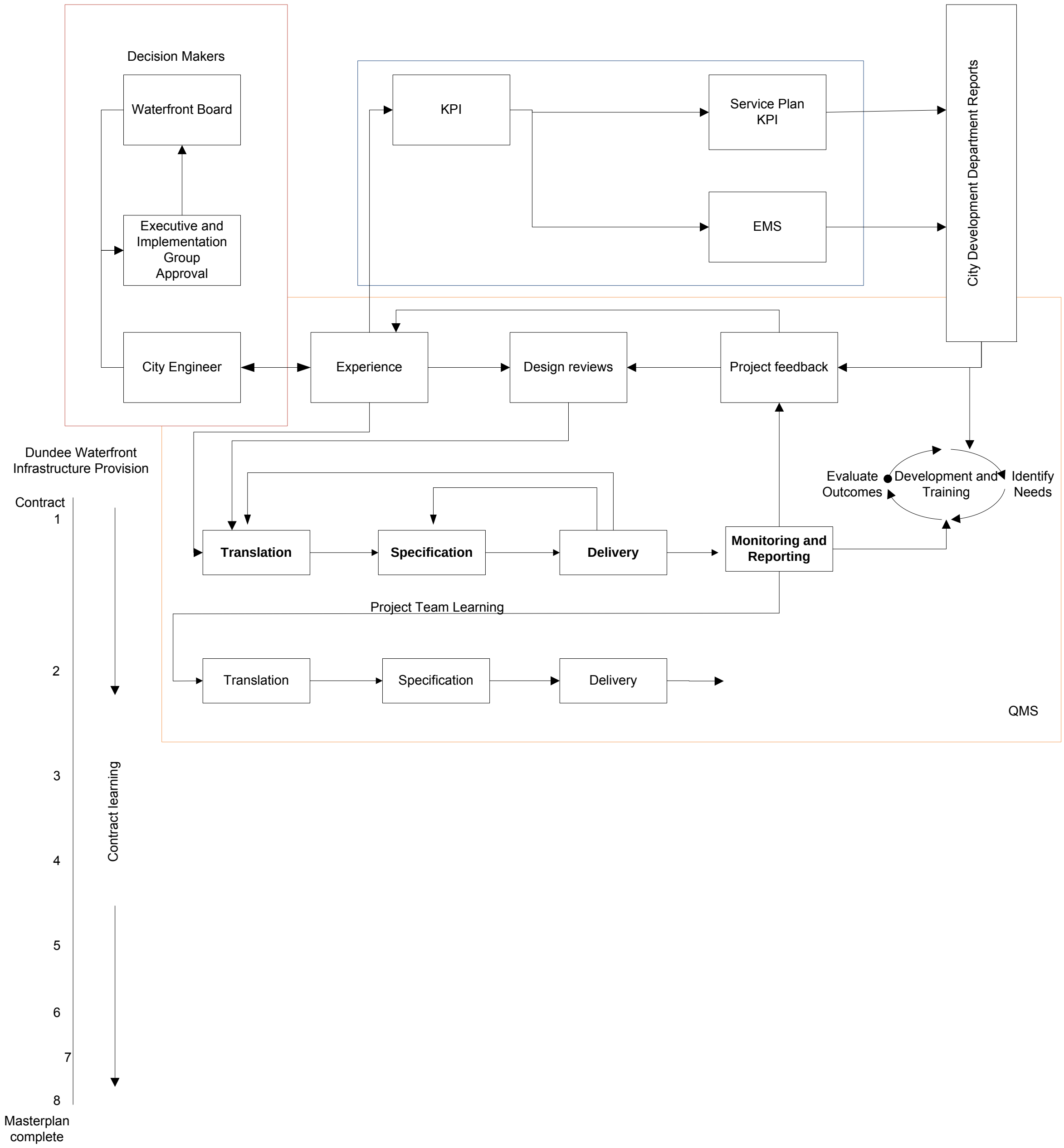

Figure 6:21 Embed Sustainable Development learning into process

In Figure 6:21 the QMS and team box has been expanded to illustrate the Dundee Waterfront Infrastructure Provision contract process through Translation, Specification, and Delivery of the vision, and Monitoring and Reporting of sustainable development benchmark indicators within the QMS. Each of these steps is shown with a feedback loop to illustrate sustainability knowledge flow through the contract. As the team deliver parts of the infrastructure, the Knowledge Objects are shared and experience gained (shown in the centre of the Figure). This concept builds on Markus (1972) model of the iterative nature of the design process where in this case, more knowledge is gained and learning activated in each cycle of Translation, Specification, and Delivery.

The interview identified aspects of learning between Waterfront Team members such as skills development. This practice is documented in the QMS and illustrated by the development and training cycle which evaluates and identifies training needs. This is shown in Figure 6:21 as occurring at the end of a contract whereas in fact this can occur at any point through the contract process. One important part of training is sharing this with the team following training programme or skills development.

A verification interview was undertaken with members of the Waterfront Team to review the validity and usefulness of Figures 6:20 and 6:21. The Waterfront Team reviewed were asked to verify the accuracy of Figure 6:20 depicting the management, reporting and approvals structure. The Waterfront Team members provided some comments on detail within the diagram (which were integrated following the interview) and confirmed it was representative of the management, reporting and approvals structure within City Engineers Division. The conceptualisation of the learning process through Dundee Waterfront Infrastructure Provision was also reviewed with the Waterfront Team. The Waterfront Team were asked to give their opinion on the representativeness of the diagram to reflect current practice. The team identified the diagram represented the learning cycle, “the learning cycle is what you are showing” and recognised the learning process of “translation, specification, delivery, monitoring and then establish what we could have done better”. The Waterfront Team confirmed that Figure 6:21 was a valid representation of the project learning process through Waterfront infrastructure provision and identified that the conceptualisation was accurate and appropriately represents existing procedures. However, the concept to embed sustainability into learning process has not been verified by practice in the currency of the thesis.

6.3.3.3 Gap analysis to systematically enhance sustainability

The use of artefacts is widespread within the infrastructure provision process and QMS. The ASHEN workshop identified artefacts currently heavily used in both Design & Phasing and Construction. Making sure that sustainability information is integral to these core documents will strongly embed sustainable development into process. This concept is taken forward in the this section with emphasis on operationalising the Portfolio of Sustainability of Knowledge Objects within the Knowledge Disclosure Points identified during the Knowledge Elicitation Stage.

The Sustainability Knowledge Map can be used together with the Knowledge Disclosure Points drawn from the process maps, to systematically identify opportunities to enhance sustainability. The analysis table developed by the researcher draws together each Knowledge Disclosure Point, establishes whether there is an opportunity to use Sustainable Development Knowledge Objects within the process and identifies benchmark indicators which will be influenced by interventions. Table 6:11 presents a gap analysis for Design & Phasing process and Table 6:12 presents gap analysis for Construction process.

Table 6:11 Design & Phasing gap analysis

Process ref	Knowledge disclosure point	Opportunity	Relevant SD Portfolio objects	Benchmark indicators
3.3	Outline feasibility	Y	Design checklist, sustainable concepts in design	Acceptability, Waste
3.4	Explore alternatives	Y	Design philosophy	Waste, Noise, Acceptability
3.7.1	Design meeting requirements of other DCC units	Y	Risk log, design checklist	Acceptability, Noise, Air, Travel
3.7.4	All technical and CDM issues addressed	Y	Risk log,	Acceptability, Noise, Air, Travel, Waste
5.1	Split master plan into section	Y	Design philosophy	Acceptability, Noise, Air, Travel, Waste
5.2	Correct infrastructure sequence	Y	Design philosophy	Acceptability, Waste, Travel
5.3	Produce outputs	Y	Design checklist, sustainable concepts	Waste, Acceptability
5.5	Lead design review	Y	Design checklist, sustainable concepts, Risk log	Acceptability

Table 6:11 Design & Phasing gap analysis (continued)

Process ref	Knowledge disclosure point	Opportunity	Relevant SD Portfolio objects	Benchmark indicators
5.6.1	revision initiated by phasing lead	Y	Risk log	Acceptability
5.6.2	Technical feasibility	N		
5.6.3	Traffic management implications	Y	Risk log, design checklist	Acceptability, Air, Travel
5.6.4	Cost implications	Y	Risk log, design checklist	(Project KPI)
5.6.5	H&S implications	Y	Risk log, design checklist	Noise, Acceptability
5.6.10	Programme implications	Y	Risk log, design checklist	Acceptability
5.6.12	Scope of existing contracts	Y	Design philosophy	Waste, Acceptability
6.2	Detailed phasing	Y	Sustainable Concepts in design, Design philosophy	Waste, Acceptability
6.3	Detailed design option appraisal	Y	Design philosophy, Sustainable Concepts in design	Waste, Acceptability, Noise, Air, Travel

Table 6:11 Design & Phasing gap analysis (continued)

Process ref	Knowledge disclosure point	Opportunity	Relevant SD Portfolio objects	Benchmark indicators
6.4	Technical feasibility	N		
6.8.1	Design meeting requirements of other DCC units	Y	Risk log, design checklist	Acceptability, Noise, Air, Travel
6.8.5	All technical and CDM issues addressed	Y	Risk log,	Acceptability, Noise, Air, Travel, Waste
6.8.6	Road safety audit	N		

Table 6:11 shows there is opportunity to use the Sustainability Knowledge Objects at the majority of knowledge disclosure points in Design & Phasing. In most cases there is an opportunity to introduce Sustainability Knowledge Object to enhance sustainability and positively influence the related Benchmark Indicators.

Table 6:12 Construction gap analysis

Process ref	Knowledge disclosure point	Opportunity	Relevant SD Portfolio objects	Benchmark indicators
3.1	Pre start	N		
3.2	Pre start administration systems	Y	CEEQUAL, KPI, SWMP	Acceptability, Air, Waste, Noise
3.3	Technical queries	N		

Table 6:12 Construction gap analysis (continued)

Process ref	Knowledge disclosure point	Opportunity	Relevant SD Portfolio objects	Benchmark indicators
3.4	Commercial and contract administration	Y	CEEQUAL, KPI, SWMP, Recycled Content	(Project KPI)
3.5	Programme monitoring	Y	CEEQUAL, SWMP, Recycled content, Construction Checklist	Acceptability, Air, Waste, Noise
3.6	Cost monitoring	Y	KPI	(Project KPI)
3.7	Off site snagging and defect correction	N		
3.8	Completion	N		
3.2.3	Do DCC accept H&S approach	Y	KPI	Acceptability, Air, Noise
3.2.4	Additional H&S methods	Y	KPI	Acceptability, Air, Noise
3.2.5	Enough details in method	Y	CEEQUAL, SWMP, Recycled content, Construction Checklist	Acceptability, Air, Waste, Noise

Table 6:12 Construction gap analysis (continued)

Process ref	Knowledge disclosure point	Opportunity	Relevant SD Portfolio objects	Benchmark indicators
3.2.10	activity to end of the job	Y	CEEQUAL, SWMP, Construction Checklist	Acceptability, Air, Waste, Noise
3.2.11	Changes to works drawing	Y	CEEQUAL, SWMP, Recycled content, Construction Checklist	Acceptability, Air, Waste, Noise
3.2.12	Change in overall programme and budget	Y	KPI	Acceptability, Waste,
3.2.17	Traffic management approach acceptable	Y	Construction Checklist	Acceptability, Air, Noise
3.2.19	Are closures required	N		
3.3.3	activity to end of the job	N		
3.3.4	Changes to works drawing	Y	CEEQUAL, SWMP, Recycled content, Construction Checklist	Acceptability, Air, Waste, Noise, Travel
3.3.11	Can we answer the query	N		

Table 6:12 Construction gap analysis (continued)

Process ref	Knowledge disclosure point	Opportunity	Relevant SD Portfolio objects	Benchmark indicators
3.3.12	Additional work or consultant's defect	N		
3.3.21	Are contractors adhering to programme	Y	KPI	Acceptability,
3.3.22	Adhering to drawings	Y	CEEQUAL, SWMP, Recycled content	Acceptability, Air, Waste, Noise, Travel
3.3.24	Early warnings	Y	KPI	(Project KPI)
3.4.7	has work been done	N		
3.4.10	Contractor adhering to programme	Y	KPI	(Project KPI)
3.4.11	Any early warnings	Y	KPI	(Project KPI)

Table 6:12 shows there is opportunity to use the Knowledge Objects at the Knowledge Disclosure Points in Construction. In 75% of cases there is an opportunity to introduce Sustainability Knowledge Object to enhance sustainability and positively influence the related Benchmark indicators or project KPI. The integrated approach is demonstrated by the identification of 5 out of 6 Benchmark Indicators affected by infrastructure provision in the gap analysis for both Design & Phasing and Construction.

6.4 Discussion

The knowledge elicitation and mapping methodology utilised a combination of techniques drawn from the information technology, knowledge management and business process mapping fields. These have been extended or applied in different ways in the three stage process as described in Section 6.2 Methodology. The knowledge elicitation and process mapping to identify and classify knowledge and identify Knowledge Disclosure Points combined Snowden Organic Knowledge Management linguistic framework with process mapping approaches. Process Owner Interviews used Snowden's technique to elicit Knowledge Disclosure Points. These were combined with process maps (Biazzo 2002; McCormack and Rauseo 2005) which extended Snowden's approach.

An ASHEN Workshop approach was used to identify sustainability knowledge objects used in infrastructure development to develop the Knowledge Map for Sustainability. These were based on the Snowden Organic Knowledge Management linguistic framework (Snowden 2000) and elicitation techniques. The results of the workshop were drawn together with the outputs of the process maps to create a Knowledge Map for Sustainability. The map concept was inspired by techniques from IT and information management fields such as Entity Relationships (Coad and Yourden 1991). The simplification of outputs was required to enable the displaying of the combination of these outputs onto one map. Hunt et al. (2008) and Thompson et al. (2011) were used as a guide to develop the dynamic part of the knowledge map representation.

The operationalisation of sustainability required interviews with key process owners to map existing management systems and the identification of opportunities to ensure the full integration of sustainability issues into project decision process.

Snowden's Organic Management theory was adapted to establish how well sustainability knowledge objects were embedded in the process and to establish enhancement interventions. Snowden's theory of Organic Knowledge Management was added to in order to develop knowledge interventions that fit into current practice rather than to impose an engineered solution.

Process mapping successfully identified the processes involved in infrastructure provision. The resulting process maps showed Knowledge Disclosure Points and associated Knowledge Objects used in making decision, judgements or problem resolution. The process maps illustrated what information was needed during the process under investigation, what time in the process and to whom the information was needed. This addressed key issues in the literature review Chapter 3.

The process mapping method was not however exhaustive, and only mapped a snapshot of process as identified by the process owner. The mapping process resulted in a collection of maps at different levels for each process under investigation. This led to the challenge of how to compile and communicate these maps to the user, as key issue identified in Chapter 3. Process mapping allowed Knowledge Objects to be categorised using ASHEN categorisation. This informed an understanding of the prevalent Knowledge types used in infrastructure stages under investigation, but did not discretely identify Sustainability Knowledge Objects.

The ASHEN knowledge elicitation workshop successfully identified Knowledge Objects used in Design & Phasing and Construction stages. This provided a cross check of Knowledge Objects identified by the Process Mapping. The ASHEN workshop identified Sustainability Knowledge Objects used in Design & Phasing and Construction stages addressing the shortcoming of the process mapping. The

Portfolio of Sustainability Knowledge Objects was then used in the Knowledge Map for Sustainability.

The Knowledge Map for Sustainability drew together the understanding of process, a requirement arising from the literature in Chapter 3, and the Portfolio of Sustainability Knowledge Objects. This drawing together of process mapping outputs into one map addressed a key challenge identified in the literature, to create a map which was dynamic, showing the complexity of real life process, combined with simplicity and transparency required by the map user. The Knowledge Map for Sustainability was successful in meeting these aspirations. The map was verified by users who tested the map against Eppler's (2001) knowledge map quality criteria namely functional, cognitive and aesthetic map quality. The users concluded that the Knowledge Map for Sustainability met these requirements. The Map showed for the first time the aspects of sustainability in infrastructure provision for Dundee Waterfront. This enabled the Waterfront Project Team to understand current practice and where sustainable development information is presently used within the process.

The Map was used to systematically operationalise sustainable development in three ways:

Firstly, to establish how well current Sustainability Knowledge Objects were embedded in the processes. The map was used to identify Sustainability Knowledge Objects related to process and an assessment was made on the object's security in the process. The systematic approach allowed the user to assess the level of embedding of the Sustainability Knowledge Object. This provided appropriate Knowledge to allow a knowledge management strategy to be planned to ensure decisions or actions to enhance sustainability were embedded in the process.

Secondly, it was used to inform future options for a knowledge management strategy. The Knowledge Map was used to conceptualise the process of embedding sustainability learning into process. The process of Transition, Specification, Delivery and Monitoring, which illustrated sustainability knowledge flow throughout the contract, was central to this process. This enabled the Waterfront Project Team to understand current practice, who possesses sustainability knowledge and where sustainable development information is used in the process, in order to plan a knowledge management strategy and provide learning opportunities.

Thirdly, it was used together with the Knowledge Disclosure Points drawn from the Process Map to systematically identify opportunities to enhance sustainability. The gap analysis showed where there were opportunities to use the Knowledge Objects through the Knowledge Disclosure Points in both Design & Phasing and Construction. This ensured that opportunities to enhance sustainability, and information on the potential impact of decisions or actions that will influence the sustainability, are provided to the project team at the correct point through the process.

It can therefore be concluded that the Knowledge Map for Sustainability provides the tools and techniques to operationalise sustainability within infrastructure provision. In addition to user verification that the mapping processes were successful, the knowledge elicitation and mapping responded to the needs as identified in the literature. The success of the knowledge elicitation and mapping can also be assessed by critical reflection of the pragmatic enhancement activities as described in Section 4.3.4 and Appendix A, with systematic Knowledge Elicitation and Mapping described in this chapter.

From this comparison it can be concluded that the knowledge mapping and elicitation was successful. The knowledge elicitation and mapping process successfully identified the pragmatic enhancements undertaken whilst working with the project team on indicator development. The pragmatic sustainability enhancement activities were responsive to the need of the Waterfront Team at the time of action. However, activities were undertaken in isolation as it was not possible to assess whether activities should be repeated somewhere else, or if there was an opportunity to use them further at different stages of infrastructure delivery. This was the key limitation of pragmatic enhancement activities and a main criticism of previous approaches using tools and techniques in isolation as shown in Chapter 2. The main reason for the success of the knowledge mapping and elicitation approach was the focus on embedding sustainability within process and procedures thus ensuring the long term uptake of enhancement activities to positively influence monitoring indicators and enhance sustainability. This is significantly different from the pragmatic enhancement activities which use tools and techniques in isolation.

It can be concluded that systematic knowledge mapping and elicitation is more effective than pragmatic enhancement activities. Knowledge mapping and elicitation has been used to enhance sustainability systematically, to avoid using tools and techniques in isolation and embed enhancement activities into process to effectively operationalise sustainability in infrastructure provision.

The exportability of the findings of the case study link to case study methods as described in Chapter 4. Although the primary reason to choose the case was the opportunity to validate the framework concept on a large scale infrastructure in Dundee, the appropriateness of the case was determined prior to starting the research project. The external validity of the case study provided the differentiation between findings based on structure and processes within and organisation and findings which can be exported to other organisations. The theoretical framework assisted in generalising findings from the case study as it established logic that may be applicable to other infrastructure development projects.

The mapping techniques can be exported to understand current practice, where sustainable development information is presently used within the process, to plan a knowledge management strategy and provide learning opportunities. Part of the success of the case study was the mapping aligning itself with the QMS in organisation studied. Exportability of findings to other organisations may be limited to organisations that have a Quality Management system in place. It would be argued that most organisations have an approvals system or alternative structure which would incorporate the learning part of the operationalisation of sustainability. Additionally the knowledge elicitation and mapping is an adaptive framework designed to respond to other organisational structures. Therefore the findings are exportable due to the nature of the methodology.

6.5 Conclusion

Decision mapping and knowledge elicitation techniques have been successfully developed and applied to Dundee Waterfront to identify Knowledge Disclosure Points, information decision makers need and which Knowledge Objects are being used to make decisions. The techniques have mapped the infrastructure provision process to identify knowledge supporting the process. This in turn has allowed a Knowledge Map for Sustainability to be developed to identify information which is currently used to influence sustainability and identify future opportunities to enhance practice.

The Knowledge Map for Sustainability has been verified by users to ensure usefulness, simplicity of representation and effectiveness. It can therefore be concluded that the map has been effective in capturing the role of each stage in process to translating the sustainability vision. This understanding provides an insight into how to operationalise sustainability, a key concept arising from Chapter 2.

The Knowledge Map for Sustainability was effective in assessing how well Sustainability Knowledge Objects were embedded in the process, developing a Knowledge Management strategy for embedding knowledge objects and systematically identifying opportunities to enhance sustainability. This provided the Project Team with the tools and techniques to identify opportunities to inculcate sustainability knowledge into Dundee Waterfront infrastructure development.

The mapping techniques can be exported to other case studies to understand current practice, where sustainable development information is presently used within the process, to plan a knowledge management strategy and provide learning opportunities. A potential limitation of the exportability of the case study findings is the reliance on the existence of a QMS, however the adaptability of the mapping approach should overcome this.

The theoretical framework should be equally applicable to other infrastructure projects which require an integrated approach to sustainability monitoring and enhancement. Additionally, infrastructure projects which comprise of the stages of Translation, Specification, and Delivery will be suited to the approach. It is therefore concluded that the approach should be applicable to any project which has infrastructure work stages and a QMS.

The case study application has proved that the Knowledge Elicitation and Mapping techniques work to produce a map, and verification through users proved that the map is effective in demonstrating current practice. The use of the map to embed sustainability into learning process has not been verified by practice in the currency of the thesis. However, interviews with members of the Waterfront Team identified that the conceptualisation was accurate and fits into existing procedures.

The findings of the case study supports the literature presented in in Chapter 3 in relation to the potential for knowledge management to demonstrate current practice, improve decision making and support sustainability enhancement. The wider implications of the findings of knowledge map can be related to the current work that emphasises the requirement for an effective mechanism to manage and reuse the knowledge created in projects such as discussed in Tan et al. (2012) and Leblanc and Thompson (2012). The case study has also illustrated the use of knowledge management in accelerating learning to develop expertise and improve processes affecting planning and design development, construction and operational aspects as discussed in work by Robinson et al. (2011).

7 Chapter 7 Conclusions

7.1 Introduction

The conclusions were developed by the critical review of the extent to which the aim and objectives had been achieved and therefore how well the study has addressed the research question. Objectives are reviewed in Sections 7.2 to 7.5. to determine the extent to which the research question was answered within the programme of work. Section 7.6 provides general conclusions derived from the study and Section 7.7 presents recommendations for further work.

The research aim was:

To develop, test and apply knowledge mapping techniques to effectively assess and enhance sustainability within a major urban redevelopment project.

The objectives were:

1. To establish the current state of the art in sustainability and it's assessment for major urban redevelopment
2. To establish the current state of the art in understanding decision making process and knowledge management for major urban redevelopment
3. To develop appropriate procedures for sustainability assessment of major urban redevelopment
4. To develop appropriate procedures for knowledge elicitation and mapping to enhance sustainability in major urban redevelopment
5. To apply procedures to a case study

The overall research question was:
Can knowledge mapping approaches be applied to enhance sustainability of a major urban redevelopment project?

7.2 Establish the current state of the art in sustainability and it's assessment

The work undertaken to achieve the first project objective was presented in Chapter 2. The literature review demonstrated that sustainable development is a complex, multifaceted concept with interrelated environmental, social, and economic dimensions. Commonality in interpretation in UK and Scottish government policy has established the sustainability agenda and shaped the political environment. Defining how these concepts and ideas can be adapted into policy can be considered the first step towards operationalising sustainability. It can however be concluded that sustainability requires a form of multi-disciplinary thinking that encourages integration between policies, programmes and projects.

The review outlined how sustainable development has been adopted and interpreted into policy from European context to a national and regional level. The key role of indicators in the Scottish National Performance Framework and Single Outcome Agreement suggest that monitoring and indicators, clearly linked to Single Outcome Agreement, can play a crucial role in linking issues and impacts across spatial and temporal scales in a way that is compatible with the decision-making process for infrastructure projects. The literature reviewed in Chapter 2 identified three key conclusions to inform the approach undertaken in the thesis.

- Sustainable development for urban development projects requires an integrated approach delivered across different scales namely policy, programmes and projects.
- Indicators play a key role in the assessment of sustainable development on a European, national and regional level. They have the ability to monitor performance and link impacts across spatial and temporal scales.

- The review of assessment and decision support tools for sustainable development suggests that tools are currently used in isolation and no tool supports sustainability across the project life.

An adaptive framework was therefore proposed to address these conclusions. The framework comprised of two parts, a monitoring framework, which links policy and programme level objectives with project level outcomes, and an enhancement framework to influence sustainability through the project life.

It can be concluded that the first research objective has been achieved and conclusions from this objective informed the development of the theoretical framework presented in Chapter 4.

7.3 Establish the current state of the art in understanding decision making process and knowledge management

The work undertaken to achieve the second project objective was presented in Chapter 3. The literature review identified that the extent to which sustainability issues can be incorporated into the built environment is influenced by the degree of rationality of the decision making process. The review identified that decision making in practice is seldom structured and that often "satisfactory" solutions are reached in an ad-hoc basis. It was concluded that most human decision making is concerned with the discovery and selection of satisfactory, rather than optimal, alternatives and describe this process as "satisficing". The concept of "satisficing" was found to be particularly relevant to the design and planning stage of urban developments. The review identified the types of knowledge used in decision making, and the terms and techniques widely recognised in knowledge management. It was concluded from the literature that there was a potential for knowledge mapping techniques to be used to aid decision makers working in the sustainable urban environment. The review identified a number of authors who have effectively used decision mapping or knowledge mapping to document or understand organisation knowledge management and decision making. The literature review concluded that an appropriate knowledge mapping technique needed to do the following:

- To identify key points in the decision process and elicit knowledge used to make decisions
- To be dynamic and represent relationship between knowledge and process flows
- To be simple, transparent, pragmatic and illustrate the why, who, what and where of knowledge mapping

A knowledge elicitation and mapping methodology was therefore developed which addressed the above requirements.

It can be concluded that the second research objective has been achieved. Achieving this objective informed the development of the theoretical framework presented in Chapter 4, and led to the identification and development of an appropriate knowledge elicitation and mapping approach described and implemented in Chapter 6.

7.4 Develop and apply appropriate procedures for sustainability assessment

The work undertaken to achieve the third project objective was presented in Chapter 5. This work also contributed to the achievement of the fifth objective, to apply procedures to a case study. The conclusion from this part of the research was that the case study demonstrated it was possible to establish procedures for assessment and enhancement for major infrastructure projects. A sustainability monitoring framework was successfully established for Dundee Waterfront in line with the assessment component of the theoretical framework. Indicators were successfully established with a number of functions, as set out in the Purpose of the Indicators. The indicators are now used by Dundee City Council at project and departmental level, providing the link across policies, programmes and projects.

In this respect the third and fifth project objectives have been partially achieved. In partially achieving this objective the following overall conclusion can be drawn. The key challenge in developing the benchmark indicators was establishing robust governance for the monitoring framework. However, an uncertainty related to governance and long term use of the framework exists. The indicators were successfully developed at the Project Team and Executive level but less firmly embedded at Board level. This raises issues of ownership in the long term. To address this a longitudinal study to track the effectiveness proposed in Section 7.7.

The ability to conclude on the exportability of the procedures for sustainability assessment was restricted by the policy context of the case study, in particular, the existence of the Single Outcome Agreement reporting structure within the case study organisation. Single Outcome Agreements are Scotland specific, however outcome based approaches are present in England in the form of Local Public Service Agreements and in Wales in the form of Outcome Agreements. The limitation of exportability based on outcome agreements may therefore not be an issue in the UK but as is proposed, requires exploration in future work. In addition, the application of techniques to private companies or organisations which do not have outcome indicators as part of their reporting structures is recommended.

It is concluded that this objective was partially achieved because of uncertainty relating to governance.

7.5 Develop and apply appropriate procedures for knowledge elicitation and mapping

The work undertaken to achieve the fourth project objective was presented in Chapter 6. This work also aimed to achieve the fifth objective, to apply procedures to a case study. From this part of the research it was concluded that the case study demonstrated it was possible to develop appropriate procedures for knowledge elicitation and mapping to enhance sustainability for major infrastructure projects.

In this respect the fourth and fifth project objectives have been partially achieved. Decision mapping and knowledge elicitation techniques were successfully developed as a result of achieving Objective 2. These were applied to the case study to identify key points in decision process, information decision makers need and knowledge objects that were being used to make decisions. It is concluded that the knowledge elicitation and mapping approaches applied were effective at identifying the existing processes and knowledge objects used in infrastructure provision. The case study application has proved that the knowledge and elicitation mapping techniques work to produce a map.

In order to identify knowledge supporting the infrastructure provision process the mapping techniques were applied. This allowed a Knowledge Map for Sustainability to be developed to identify what information is currently used to influence sustainability and identify future opportunities to enhance practice. The map was effective in capturing the role of each stage in process and to translating the sustainability vision as proved by user verification. The Knowledge Map for

Sustainability has linked the Portfolio of Sustainability Knowledge Objects with processes identified through Process Owner interviews. This enables the case study project team to understand current practice and where sustainable development information is used in the process. The Map showed for the first time the aspects of sustainability in infrastructure provision and can be used to systematically operationalise sustainable development. This has been shown through mapping onto existing processes and organisational systems.

This understanding provides an insight into how to operationalise sustainability, a key concept arising from Chapter 2. Through verification with case study participants it was concluded that techniques were effective in identifying Sustainability Knowledge Objects. This provided the project team with the information needed to identify knowledge management opportunities to inculcate sustainable development knowledge into Dundee Waterfront Infrastructure Provision. The use of the map to embed sustainability into learning process could not be verified by practice in the currency of the thesis. It is therefore concluded that this objective was partially achieved because of limits of verification.

Weighing up the fully achieved objectives against the limitations of the case study it can be concluded that the overall research question: Can knowledge mapping approaches be applied to enhance sustainability of a major urban redevelopment project has been addressed.

7.6 General conclusions

The three interconnected concepts of sustainability assessment, decision making and knowledge management have been explored through a case study within the thesis. The investigation has developed knowledge elicitation and mapping techniques to improve sustainability assessment practice and, in turn, provided closer integration of assessment and decision making. The study has identified that organisational learning can be greatly facilitated by Knowledge Management, which can be used to understand and then enable greater participation amongst stakeholders. The findings of the work add to current knowledge, in relation to the potential for knowledge management, to demonstrate current practice, to improve decision making and support sustainability enhancement.

The following can be derived from the study:

- Developing theme orientated indicators based on policy and practice is an effective mechanism to improve sustainability practices. The use of sustainability indicators provides the benchmark to measure progress and presents an approach which can be used by other organisations. These findings provide the basis to inform future approaches applied by organisations who are planning to develop an operational framework set of indicators based on the policy agenda.

- The knowledge elicitation and mapping approaches applied are effective in identifying existing processes and knowledge objects. Knowledge Maps for Sustainability identify what information is currently used to influence sustainability, identify future opportunities to enhance practice and can be used to systematically operationalise sustainable development. The findings of the study supplements current knowledge in relation to the potential for knowledge management to demonstrate current practice, to improve decision making and support sustainability enhancement. These approaches can be used by other organisations to identify what information is currently used to influence sustainability and identify future opportunities to enhance practice.

- Knowledge mapping and elicitation approaches are effective in embedding sustainability within process and procedures, to positively influence monitoring indicators and to enhance sustainability. The use of sustainability assessment is also effective in promoting learning and informing decision making. The mapping techniques can be exported to other contexts in order to understand current practice, to plan a knowledge management strategy and provide learning opportunities. The study adds to current knowledge on the potential for sustainable assessment to enable sustainability management through knowledge management.

A limitation of the use of a case study within the thesis application is as follows: The integrated sustainability assessment and enhancement framework has been applied in a Scottish local authority context, to an organisation that already has a Quality Management System and outcome based indicators. These have been identified as contributing factors to the effectiveness of the sustainability assessment and enhancement framework and, as such, have the potential to limit the exportability of any findings. There are also questions that have emerged following the study which need to be explored further. These include uncertainty related to governance and long term use of the framework, testing how the Knowledge Map for Sustainability is used in practice and the exportability of findings from the case study. These questions form the basis of the recommendations for future work as outlined in Section 7.7.

7.7 Recommendations for future work

The general robustness of the findings of the thesis is supported by the theoretical framework introduced in Chapter 4. The theoretical framework assists in the generalisation of findings where the same logic is applicable elsewhere. However to deal with the exportability of findings, future work is recommended to reapply knowledge elicitation and enhancement techniques to another case study. Wider application of the techniques would address limitations of case study research as outlined below:

- The role management systems: The role of the Quality Management System on case study findings and whether the method would be as effective within a different organisational set up.
- The role of the policy framework: The role of Single Outcome Agreements and whether the monitoring framework would be as effective out with the Scottish Single Outcome Agreement framework.
- The type of organisation: The application of the integrated sustainability assessment and enhancement framework to private organisations rather than a public sector organisation.

Practical limitations of undertaking the research meant Sustainable Development Benchmark Indicators were developed first, followed by Knowledge Elicitation and Mapping to establish an integrated sustainability assessment and enhancement framework. Further work is recommended to investigate undertaking indicator development and knowledge elicitation and mapping simultaneously, to identify any potential benefits from adapting this approach.

In addition, future work is recommended in the case study organisation to address the uncertainty related to governance and long term use of the framework. The indicators were successfully developed at the Project Team and Executive level but less firmly embedded at Board level. A longitudinal study to track the effectiveness of benchmark indicators is therefore recommended to address the long term issues of ownership and governance. Future work is also recommended to monitor efficacy of both data collection and reporting in order to evaluate the success of the automated collection of the Single Outcome Agreement indicators related to benchmark indicators.

Future work is also recommended in the case study organisation to test the efficacy of the Knowledge Map for Sustainability in systematically operationalising sustainable development. The Knowledge Map for Sustainability was developed to identify what information is currently used to influence sustainability and identify future opportunities to enhance practice. The use of the map to embed sustainability into learning process has not been verified by practice in the currency of the thesis. Therefore to address the limitation of this part of the thesis it is recommended that a study is undertaken to monitor the use and effectiveness of the knowledge map to operationalise sustainability.

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APPENDICIES

Appendix A Pragmatic Enhancement Activities

1 Pragmatic Enhancement Activities

Opportunities exist to enhance sustainability across project stages, from specifying the vision in the Master Plan to operation and maintenance of infrastructure when complete. These opportunities are shown conceptually in Figure A:1.

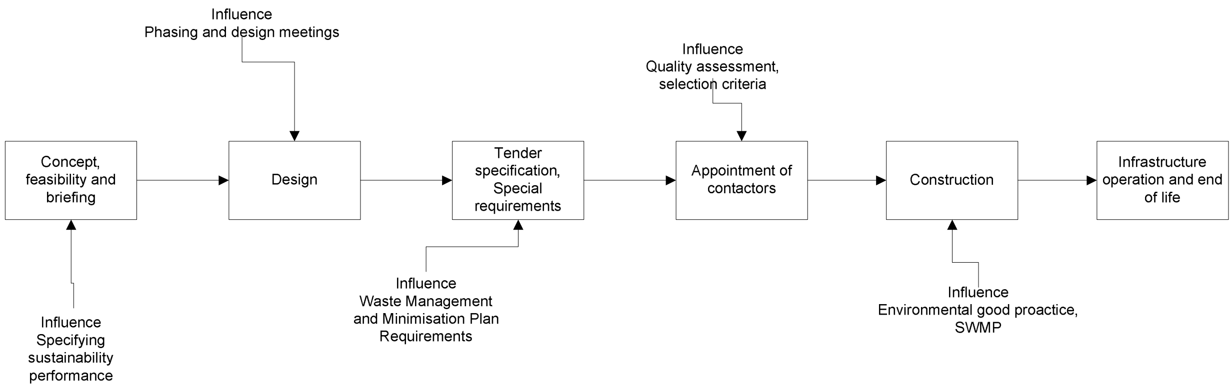

Figure A:1 Example of sustainability interventions in the project life

Pragmatic enhancement activities emerged while working with the project team during the currency of the research project and identified through the researcher's knowledge of sustainability best practice. Pragmatic enhancement activities were undertaken with the project team while working to develop and embed indicators within the project and positively influence sustainability as reported in Chapter 5.

The enhancement activities undertaken influenced Design & Phasing, Tender document preparation and Appointment of Contractors as briefly described below.

<u>Sustainable development issues register</u>

This activity involved identifying sustainable development issues arising during the design and phasing meetings which required further consideration. From January 2007 the researcher sat in on over twenty relevant phasing & design meetings with the consultants White Young Green, Fairhurst and Dundee City Council project team.

During these meeting the issues driving the design in relation to sustainable development were identified. These were then either raised and dealt with during the meeting if appropriate, or identified in the sustainable issues register to be fed back to design team through the 4project management system and CDM processes. An extract of the Sustainable Development Issues Register is shown in A:2.

Waste management

Waste management support was provided through the period of study to identify opportunities to recycle materials in the construction process. The aim of this activity was to link an understanding of the phasing of the project and the identification of opportunities for the specification of recycled materials during the design stage and to ensure best practice in recycling of materials. Assistance included developing a strategy to identify quantities and types of waste arising from the tunnel strengthening programme, identifying the management options with reference to the waste hierarchy and monitoring the waste arising and maximise recycling to inform future waste management approaches. An extract of the Waste management support is shown in A:3.

Sustainable design and construction checklist

A sustainable design and construction checklist was developed for use in the City Engineers Division based on the requirements for CEEQUAL (Civil Engineering Environmental Quality Award Scheme). In particular the checklist leads the user through each of the categories included in CEEQUAL assessment and provides a mechanism for documenting evidence. This is particularly valuable when applying for any future award through the scheme. The interaction with the other enhancement tools and other guidance currently being developed is encouraged through this process. An extract of the Sustainable design and construction checklist is shown in A:4.

Tender document preparation

Sustainability opportunities at tender preparation stage were reviewed for Contract 1 and Waste Management and Minimisation (WMM) was considered the most appropriate sustainability enhancement mechanism. The enhancement framework supported the development of tender documentation, particularly waste management policy wording and client expectations of contractors approach to environmental best practice. Questions for the quality assessment and interview process were also developed along with a SWMP template based on DTI guidance to be included in the tender documents. In Contract 2 there was an opportunity to increase the emphasis of sustainability through WMM and increase the weighting on environmental performance during the quality assessment scoring. Detailed work was undertaken on developing a more robust quality assessment scoring for SWMP template included in the tender documents. An extract from the relevant section in Dundee Waterfront tender document is shown in A:5.

SWMP development

Prior to appointment of the preferred contractor, a number of options were explored to increase the on-site recycling and reuse opportunities in Contract 1. Arisings and material requirements for Contracts 1, 2 and 3 were projected based on phasing drawings. To inform the appointment of contractor for Contract 1, these material volumes were considered alongside site constraints such as processing restrictions and the available space for storage. Once the preferred approach for recycling and reuse for Contract 1 was agreed with the contractor, support was provided to develop a template for a Site Waste Management Plan (SWMP). Available SWMP templates were reviewed and WRAP v 2 was selected as the most appropriate. A SWMP was then developed, administered and monitored for Contract 1. An extract of the SWMP is shown in A:6.

DUNDEE CENTRAL WATERFRONT DESIGN - PROJECT MANAGEMENT LOG - LAST UPDATED 02/11/07 (DD)

ID	Risk / Issue Group	Date Identified	Identified by	Issue Description	Impact Summary	Project Priority	Escalation Required?	Action Steps	NEC	Assigned To Owner	Expected Resolution Date	Current Status
1	Sustainability	13/02/2007	DG	Footway study -street furniture	Loss of public "buy in" if not allowed to consult on street furniture.	High	LB	Should engage public regarding street furniture		LB	Spring 2008	Work In Progress
2	Sustainability	13/02/2007	DG	Street lighting -historical columns	Loss of public "buy in" if not allowed to consult on historical column placement.	High	LB	LB to engage public regarding historical columns		LB/AU	Spring 2008	Work In Progress
3	Sustainability	13/02/2007	DG	Bridge Lighting-light pollution	Possible lost opportunity for SD if TRB lighting causes detriment to existing/proposed residences.	High	LB	DD to meet with AU/LB and discuss.		LB/AU	Mid December 2007	Work In Progress
4	Sustainability	13/02/2007	DG	Ramp Options-lift removal	Possible lost opportunity for SD if disabled access not considered.	High	No	Access for disable users, ferry people back and forward			Spring 2008	Work In Progress
5	Sustainability	13/02/2007	DG	Footway Study	Footway study encompasses incorporate SD topics - access, public desires, aesthetics, acceptability	High	LB	DD to discuss at next meeting with LB/RG.		DD/LB/RG	Mid December 2007	Work In Progress
6	Sustainability	13/02/2007	DG	Park and ride	Loss / delay to sustainable transport/public transport provision.	High	LB	DD to liaise with Park and Ride providers, minimise impact by adjusting phasing if reasonably possible.		DD/WYG	Mid December 2007	Work In Progress
7	Sustainability	13/02/2007	DG	Bridge ramps -material used in facing material	Loss of public "buy in" if not allowed to consult on TRB facing materials.	High	LB	Bridge decisions based on performance, maintenance, aesthetics, opportunity to seek public input on aesthetics - LB/DD to build public consultation into master programme.		LB/DD	Spring 2008	Work In Progress
8	Sustainability	13/02/2007	DG	Road design-transfer station	If not put in place may result in lost opportunity to recycle demolition material	High	No	Transfer station (or arrangement with contractors) to allow demolition material from sites in Dundee to be recycled in DCW. WAF/WYG to consider this as part of the phasing design. DD/WYG to liaise and add envisaged multi demolition programme key dates to DCW phasing programme to inform. DG to monitor and advise.		DG/DD/WAF/WYG		Work In Progress
12	Sustainability	19/03/2007	DG	Drainage excavations - backfill using demolition material	Possible lost opportunity for SD if not explored.	High	No	WAF to consider this as part of their design. DD/WYG to liaise and add envisaged multi demolition programme key dates to DCW phasing programme to inform. DG to monitor and advise.		DG/DD/WAF	Mid December 2007	Work In Progress
13	Sustainability	19/03/2007	DG	Stiffen foundation/bed material using demolition material.	Possible lost opportunity for SD if not explored.	High	No	WAF/WYG to consider this as part of their design. DD/WYG to liaise and add envisaged multi demolition programme key dates to DCW phasing programme to inform. DG to monitor and advise.		DG/DD/WAF/WYG	Spring 2008	Work In Progress
22	Sustainability	19/06/2007	DG	Increase likelihood of maintaining access to Port, by bringing up level of drainage under main ramp.	Potential "showstopper" as to whether an "in" to the Port under the main ramp can be provided at all times during the phasing.	High	No	WYG/WAF/DD have collaborated to reroute drainage under approach ramps. SW approval still required.		DD/WAF	Late November 2007	Work In Progress
23	Sustainability	19/06/2007	DG	Reduce sacrificial drainage systems where possible.	Possible lost opportunity for SD if sacrificial systems are used when they could have been avoided.	High	No	RM seeking to minimise sacrificial systems in collboration with MW.		DD/WAF/WYG	Late November 2007	Work In Progress
24	Sustainability	19/06/2007	DG	Opportunity to re-use piling under TRB.	Possible lost opportunity for SD if existing piles are not used when they could have been.	High	No	DD to ask MG to utilise existing structure where possible, and advise on 4P to DG.		DD/WYG	Late November 2007	Work In Progress
25	Sustainability	19/06/2007	DG	Loss of car parking provision - impact upon businesses.	Possible lost opportunity for SD if public disruption could have been minimised by phasing things slightly differently to allow car parking and reduce impact city centre businesses.	High	LB	DD to instruct MW to consider this as part of current phasing review.		DD/WYG	Late November 2007	Work In Progress
26	Sustainability	19/06/2007	DG	Impact of piling upon traffic management.	Possible lost opportunity for SD if piling could have been avoided so as reducing construction periods and length of traffic management periods.	High	No	WYG/WAF/DD have collaborated to reroute drainage under approach ramps. SW approval still required. WAF piling appraisal carried out to review need for piling.		DD/WAF	Mid December 2007	Work In Progress
28	Sustainability	03/07/2007	DG	Health and safety hazard reduction.	Possible lost opportunity for SD if H&S risks not reduced to acceptable degree due to poor CDM co-ordination.	High	No	DD to set up regular CDM meetings. Three CDM meetings held to date, monthly CDM meetings commencing 5/11/7.		DD/design team.	05/11/2007	Work In Progress
41	Sustainability	17/07/2007	DG	Risk of damage to Telford Beacon	Possible lost opportunity for SD if risk of damage to Telford Beacon not reduced.	High	LB	DCC structures team to look into safe removal, storage and final location of Telford Beacon, trying to minimise no. of moves, and avoid storage.		DD/TVA	Late January 2008	Work In Progress
42	Sustainability	17/07/2007	DG	Continuation of Leisure provision to Dundee	Possible lost opportunity for SD if provision of leisure services to Dundee not maintained as part of DCW.	High	LB	DCC in process of developing alternative leisure provision adjacent to Port / DCW areas.		LB	Due 2011	Work In Progress
121	Sustainability	01/11/2007	DD	DG involvement in DCW design	DG must be actively engaged in design process to maximise SD opportunities, otherwise difficult to demonstrate SD approach.	High	No	DD to track SD issues and actions at monthly meeting with DG.		DD	05/11/2007	Work In Progress

A:3 Extract of the Waste management and WRAP support

Dundee City Council
Planning and Transportation

DUNDEE CENTRAL WATERFRONT

Waste Minimisation and Management Plan

April 2008

UNIVERSITY of ABERTAY DUNDEE

Macleod Consulting (UK) Ltd
Civil Structural and Environmental Engineering
11 Castle Street, Dundee DD1 3AA
Telephone: 01382 221999
Facsimile: 01382 203383
Mobile: 07932 683191
E Mail: office@macleodconsulting.co.uk

CONTENTS

APPENDICES

4.0 PHASING REVIEW

4.1 Timing and Volume of Waste Generation

A review of the Central Waterfront phasing was undertaken to establish the main excavation, demolition and construction activities for each of the phases. Drawings were used to estimate types and volumes of material that may be produced from each activity. All main activities were included in the review and an assessment was made of the likely associated waste management issues. Table 1 shows the approximate volumes produced during the review of the phasing drawings. The activities that are likely to require excavations below the water table which will give rise to water treatment were identified and the time period between these assessed to establish the need of permanent water treatment facility. Table 2 shows the requirement for water treatment.

The gap between contracts where treatment of groundwater from excavations is likely to be generated is considerable. In addition the storm water tank constructed within Contract 1 will create a large below ground retention tank which could with some modification be used to provide retention for settlement of groundwater generated in future contracts. There is, therefore, considered to be no merit in creating common water treatment infrastructure to serve all waterfront contracts.

4.2 Type of Waste and Opportunity for Re-use

Five key waste streams were identified using this process:

1. Concrete
2. Macadam and road base aggregates
3. Excavated soils including gravels, sands, silt, demolition wastes used as dock infill.
4. Dressed stone arising from dock wall removal or demolition wastes as dock infill.
5. Water

Waste Stream 1 & 2: It is expected that best practice for re-use and recycling of materials is implemented for concrete, aggregates and macadam. Without on site crushing and screening there is limited scope for re-use of aggregates on site. Therefore best practice may constitute ensuring, through on site segregation and duty of care, that the maximum % of the two waste streams are recycled by the waste service providers.

Waste Stream 3: It is expected that best practice for re-use and recycling of materials is implemented for excavation material, silt and fill. The quality of material removed from the excavation, in particular the fill, may be of poor quality and silt may be odorous. Best practice may constitute ensuring, through on site segregation and duty of care, that the maximum % materials are recycled by the waste service providers.

Waste Stream 4: It is expected that any large dressed stone can be easily identified and segregated for general excavation and that best practice would see the material stockpiled on site prior to removal by traders for processing and re-sale.

Waste Stream 5: Provision for suitable treatment of water arising from below the water table excavations will be required throughout the waterfront project. It is expected that environmental best practice for water treatment prior to discharge to the Tay will be implemented. A particular issue to consider will be the volume of water requiring treatment and the adequate provision for sediment removal through settlement.

6.0 CONTRACT 1

6.1 Background

The phasing review identified that whilst there may be significant benefit in establishing partnership arrangements with existing local waste processing and macadam and concrete manufacturers, retention of any physical infrastructure established to manage solid or liquid waste for future contracts is unlikely to be practical.

The significant specific issues for Contract 1 which were identified during the phasing review process were treatment and disposal of water and material produced during surface water tank excavation and processing and disposal of the refined concrete (540m^3) arising from the demolition of ramp D and excavated material from various small excavations and the storm water tank (totalling approximately 5600m^3).

6.2 Water Treatment and Disposal

Water removed from the ground to allow excavation and construction must be treated to achieve environmental standards.

Water removed from the ground during construction will require treatment prior to disposal back to the environment. The treatment is likely to comprise settlement and possibly hydrocarbon separation. The proximity to the Tay and heterogeneous nature of the made ground make management of the water arising during excavation essential particularly if the extent of the infrastructure required such as pumps and associated settlement tanks is to be minimised.

The most significant excavation below the water table is the storm water tank. The storm water tank (SWT) is located close to the Tay and the Hilton Hotel. Continuous pumping of the excavation is anticipated to be required with control of the noise generated, particularly overnight, understood to be a requirement of the contract.

The measures identified which would assist in reducing the need for pumping of the SWT excavation are:

- Extension of any temporary works piling towards or into rock head to achieve an extended flow path/seal.
- Reduce extent of excavation by ensuring that tank design permitted staged construction.

The extent of settlement and hydrocarbon removal required will also depend on the “source” water and the environmental limits to be achieved at the discharge point. The source water has been characterised by analysis of groundwater extracted from monitoring boreholes as summarised in Appendix D.

Returning groundwater to the ground is considered unlikely with discharge to the Tay directly or via an existing outfall considered the most likely option. Consent for such a discharge will be regulated by SEPA who have advised:

- A CAR licence is not required for the anticipated water quality at flow rates up to 0.6 m^3/hour.
- The discharge will be required to comply with the Water Environment (Controlled Activities) (Scotland) Regulations 2005 and the current version of Schedule 3 (General Binding Rules) as set out in Scottish Statutory Instruments 2007 No. 219.

- The works should comply with General Binding Rule 15, see Appendix E.
- In relation to Rule 15(e) compliance should be achieved by retention of abstracted water at settlement structures for a period of between one and two hours depending on the sediment content of the abstracted water.
- In relation to Rule 15(f) there are no licensed discharges in the vicinity of Contract 1 and, therefore, any discharge would need to be arranged with the owner of the outfall .

6.3 Solid Waste Management

It is understood that there is a desire to limit the on site processing of solid waste arisings due to the adverse environmental effects of noise and dust for local residents and business. Careful segregation at source into potentially recyclable waste streams should, however, be possible if established as a site management practice with the respective materials removed by registered waste service providers for separation and recycling. The contractors should be encouraged through the development of the contract terms and the Waste Management Plan to ensure that source segregation takes place and a local waste service provider is identified that will recycle as high a proportion as possible.

There is also an expectation that the materials brought on site for construction will contain a stated % of recycled material. It is considered unrealistic to require that this material will be from on site sources recycled from the waterfront project but could be from other DCC managed construction sites or other sources of recycled materials.

Appendix C gives a Site Waste Management Plan template to allow contractors to identify waste arisings and recycled materials used on the project and whether this source is on or off site. It is intended that the contractors use the tender documents to estimate waste arisings for Contract 1 to complete this template. The template allows the contractor to forecast the waste to be produced, and demonstrate how it will be re-used, recycled and disposed.

Contract 1, therefore, gives DCC and the contractor an opportunity to develop strategic relationship with local waste management companies and this should be explored during the ECI process.

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Dundee City Council
City Development
City Engineer's Division

SUSTAINABLE DESIGN AND CONSTRUCTION CHECKLIST (1.1)

(ADAPTED FROM CEEQUAL MANUAL FOR PROJECTS. VERSION 3.1)

Project No:	
Project Title:	

Ref.	Requirement	Y	N	NA	Provide Evidence
1	**Basic Principles**				
1.1	Have environmental impacts been identified, prioritised and responsibility assigned, for each stage of the project?				
1.2	Are environmental management practices in place (e.g. Environmental Management Plan or Pollution Control Plan)?				
1.3	Are targets to be set and monitored for environmental performance during construction (e.g. air quality, water quality discharge)?				
1.4	Have social impacts been identified and prioritised (e.g. H&S, welfare)?				
1.5	Is project specific environmental training required for staff?				
2	**Land Use**				
2.1	Has past and current land use been considered and remediation requirements reported?				
2.2	Has the re use of material currently on site been considered?				
3	**Landscape Issues**				
3.1	Does the design take account of amenity, ecology and vegetation of existing landscape into design?				
4	**Ecology and Biodiversity**				
4.1	Has the conservation of existing ecology, biodiversity and new habitat creation opportunities been incorporated in design?				
5	**Archaeology and Cultural Heritage**				
5.1	Have appropriate archaeological surveys been carried out and in house experts assigned (e.g. role currently held by Gary …)?				
5.2	Does the design take account of existing archaeological sites within design?				
5.3	Will archaeological information collected be made available to public?				

Ref.	Requirement	Y	N	NA	Provide Evidence
11	**Nuisance: Noise, air quality and vibration**				
11.1	Will contractors be required to have a policy or code of practice regarding considerate behaviour (e.g. Considerate Constructors Scheme)?				
11.2	Are there any issues that require specific guidance from Environmental Health?				
11.3	Will there be any short of long term air quality issues?				
12	**Community Relations**				
12.1	Has a community consultation exercise been carried out and the results been passed to appropriate members of the project team?				
12.2	Have the results been fed back to consultees?				
12.3	Have responses from the community relations programme been incorporated into project decision making?				
12.4	Has a member of the project team been made responsible for ongoing community consultation?				
12.5	Does the design consider the needs of all user groups to an equal degree (for example, car drivers, cyclists, pedestrians etc)?				
12.6	How has the project been designed to be sympathetic to its users and complementary to its surrounding environment?				

Rev	Date	Description	Prepared	Reviewed	Approved

A:5 Extract Dundee Waterfront Tender Document

APPENDIX A

MARKING PLAN

		Max. Score	Actual Score
4	**TIME AND COST MANAGEMENT**	**50**	
4.1	Provide the following information for the last 3 completed similar types of projects exceeding £2M, utilising the NEC 3 Contract, that your proposed Site Agent has controlled. Completion Date (as per Clause 30.1) Actual Completion Date The final Price for Work Done to Date (state which main NEC3 Option was used)	**20**	
4.2	What procedures and/or systems do you use to monitor costs to ensure completion within the total of the Prices.	**15**	
4.3	What procedures and/or systems do you use to monitor progress so as to ensure completion on or before the *completion date*.	**15**	

		Max. Score	Actual Score
5	**ENVIRONMENTAL ISSUES**	**50**	
5.1	Give a brief description of the environmental issues you associate with this project	**10**	
5.2	Which good practice waste minimisation and management (WMM) processes do you think are applicable to this project	**10**	
5.3	Please outline your experience in setting waste recovery targets, measuring waste streams on site and implementing review processes.	**10**	
5.4	Give details of any contractual arrangements you have in place with local waste management recycling providers and indicate whether this a framework type agreement for call off contracts or if you negotiate on a contract by contract basis.	**10**	
5.5	Describe the specific measures you will undertake to minimise noise, dust and contaminated water emissions during construction, demolition, excavation, segregation, stockpiling and transport of waste materials.	**5**	
5.6	The proposed scheme may be subject to a CEEQUAL assessment {as developed by the Institute of Civil Engineers (ICE)}, aiming for an "Excellent" Award. Please provide details of relevant experience of working toward the highest levels of CEEQUAL.	**5**	

SITE WASTE MANAGEMENT PLAN - QUALITY SCORE CALCULATION – EXAMPLE

Types of waste arising											
	Quantities (m3)										
Column Ref.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Re-use of Materials		Where recycled Materials will be Used		Location/Type of Recycling to be Undertaken				Disposal of Materials unable to be Reused and/or Recycled		
Material (Tenderer to complete list)	Re-used within Boundaries of the Site	Re-used outwith Boundaries of the Site	Remediate/ process for use within Boundaries of the Site	Remediate/ process for use outwith Boundaries of the Site	Remediation within Boundaries of the Site	Processing within Boundaries of the Site	Remediation outwith Boundaries of the Site	Processing outwith Boundaries of the Site	Sent to WML exempt site	Disposal to land fill	Total quantity (cols 1 thro' 4, cols 9 & 10)
INERT											
ACTIVE											
HAZARDOUS											
TOTAL (m3)	**1170**	**4880**	**714**	**1314**	**714**	**0**	**0**	**1314**	**0**	**0**	**8078**
TOTAL (%) (A)	**14.5%**	**60.4%**	**8.8%**	**16.3%**	**8.8%**	**0.0%**	**0.0%**	**16.3%**	**0.0%**	**0.0%**	**100.0%**
Factor (B)	**10**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**-2**	**n/a**
Column Scoring (A) x (B) x 100	**145**	**483**	**62**	**98**	**44**	**0**	**0**	**33**	**0**	**0**	**865**
NB: Total volume for columns (3) + (4) must equal the total volume of columns (5)+(6)+(7)+(8)											

Total Column Scoring = 145 + 483 + 62 + 98 + 44 + 0 + 0 + 33 = **865**

Site Waste Management Plan Quality Score = (**865**/1000) x 50 (maximum possible score – see Appendix A) = **43**

A:6 Extract of the SWMP

wrap Material change for a better environment

? Tell me about this sheet

Dundee City Council
Sir Robert McAlpine
Dundee Central Waterfront
33909

Waste Totals

Display summary as:
Tonnes

Waste Stream	Total waste arising (Tonnes)	Total waste retained on site (Tonnes)	Total waste sent offsite (Tonnes)	Total waste to landfill (Tonnes)	Total waste recovered offsite (Tonnes)	Cost of waste disposal
Inert - Soil & stones	13,788		13,788		13,788	£60,588.00
Hazardous - Soil & stones						£0.00
Non Haz (Non Inert) - Dredgings						£0.00
Segregated Haz - Soil & stones						£0.00
Gypsum						£0.00
Metals						£0.00
Wood	16		16		16	£1,620.00
Packaging						£0.00
Inert - Building rubble						£0.00
Inert - Glass						£0.00
Mixed Hazardous - C&D waste						£0.00
Mixed C&D waste	45		45	11	34	£600.00
Segregated Haz Waste						£0.00
Other C&D segregated waste	144		144	2	142	£5,290.00
Total	**13,993**		**13,993**	**13**	**13,980**	**£68,098.00**

Actual Waste Movements

Movement Number	C, D or E Activity	Waste Stream	Material Type	Further description of waste - optional	LOW Code used	On or off-site destination	Off-site carrier	Off- site destination	Overide facility recovery rate for individual skip	Overall diversion from landfill / recovery (further detail on Sheet 4)	Date of Movement (dd/mm/yyyy)	Waste Totals (m^3)	(tonnes)	Actual Cost	£/m^3	£/t
1	Demolition	Other C&D segregated waste	biodegradable waste	Trees from site clearance	20 02 01	Off-site segregated	D Geddes (Contractors) Ltd	Geddes - Kellas Transfer Station (Construction Mixed C&D waste (17 09 04))	100.00%	100%	19/10/2011	40	13.62	£300.00	£7.50	£22.03
2	Demolition	Other C&D segregated waste	biodegradable waste	Trees from site clearance	20 02 01	Off-site segregated	D Geddes (Contractors) Ltd	Geddes - Kellas Transfer Station (Construction Mixed C&D waste (17 09 04))	100.00%	100%	20/10/2011	40	6.52	£300.00	£7.50	£46.01
3	Demolition	Other C&D segregated waste	biodegradable waste	Trees from site clearance	20 02 01	Off-site segregated	D Geddes (Contractors) Ltd	Geddes - Kellas Transfer Station (Construction Mixed C&D waste (17 09 04))	100.00%	100%	01/11/2011	40	13.88	£300.00	£7.50	£21.61
4	Demolition	Other C&D segregated waste	biodegradable waste	Trees from site clearance	20 02 01	Off-site segregated	D Geddes (Contractors) Ltd	Geddes - Kellas Transfer Station (Construction Mixed C&D waste (17 09 04))	100.00%	100%	02/11/2011	40	14.58	£300.00	£7.50	£20.58
5	Excavation	Other C&D segregated waste	biodegradable waste	Trees from site clearance	20 02 01	Off-site segregated	D Geddes (Contractors) Ltd	Geddes - Kellas Transfer Station (Construction Mixed C&D waste (17 09 04))	100.00%	100%	03/12/2011		19	£300.00		£15.79
6	Excavation	Inert - Soil & stones	soil and stones other than those mentioned in 17 05 03	Inert Drainage Arisings	17 05 04	Off-site segregated	D Geddes (Contractors) Ltd	Geddes - Ardownie (Excavation Inert - Soil & stones)	100.00%	100%	03/12/2011		260	£988.00		£3.80
7	Excavation	Inert - Soil & stones	soil and stones other than those mentioned in 17 05 03	Inert Drainage Arisings	17 05 04	Off-site segregated	D Geddes (Contractors) Ltd	Geddes - Ardownie (Excavation Inert - Soil & stones)	100.00%	100%	19/12/2011		50	£228.00		£4.56

A:7 Pragmatic activities identified in Knowledge Map

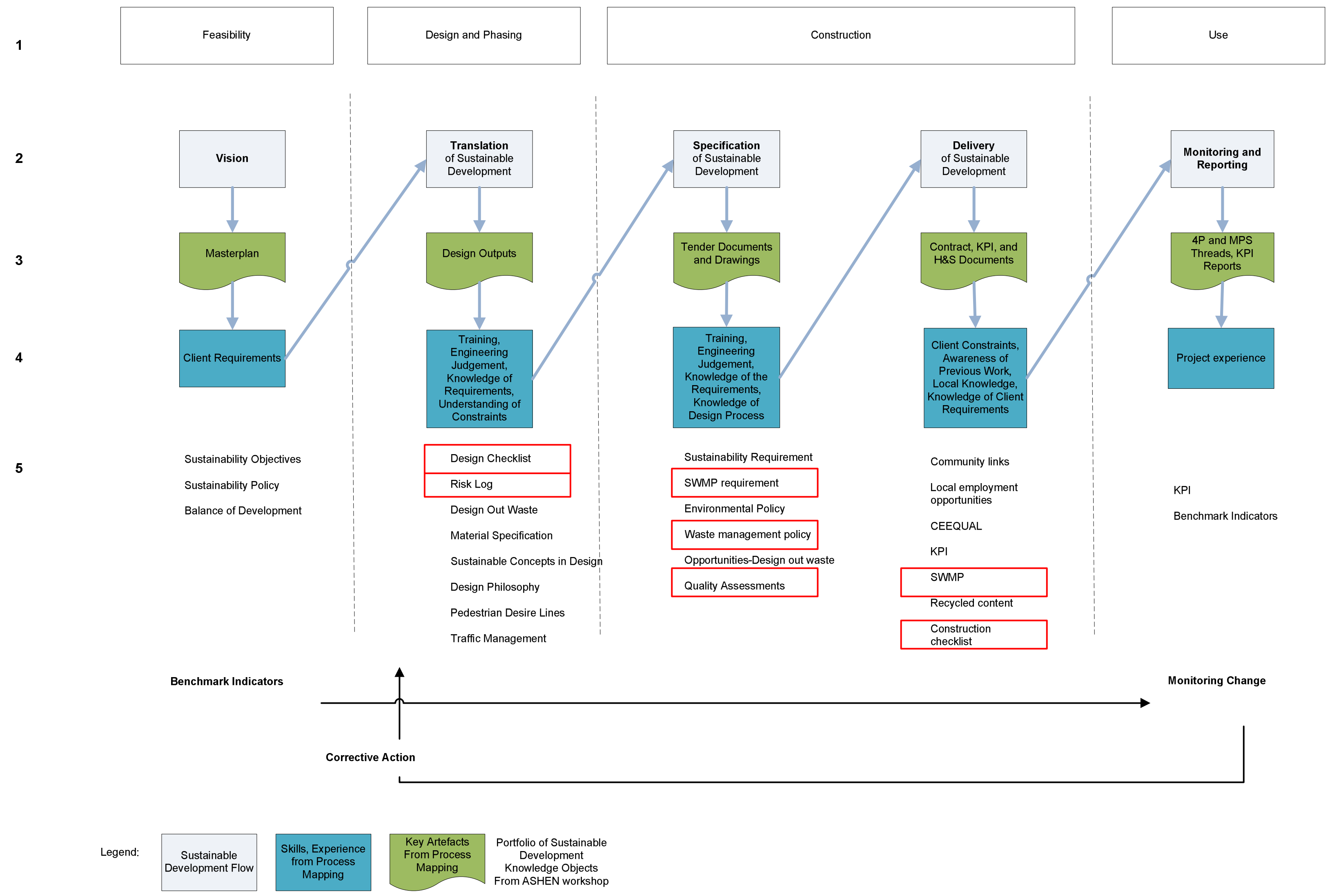
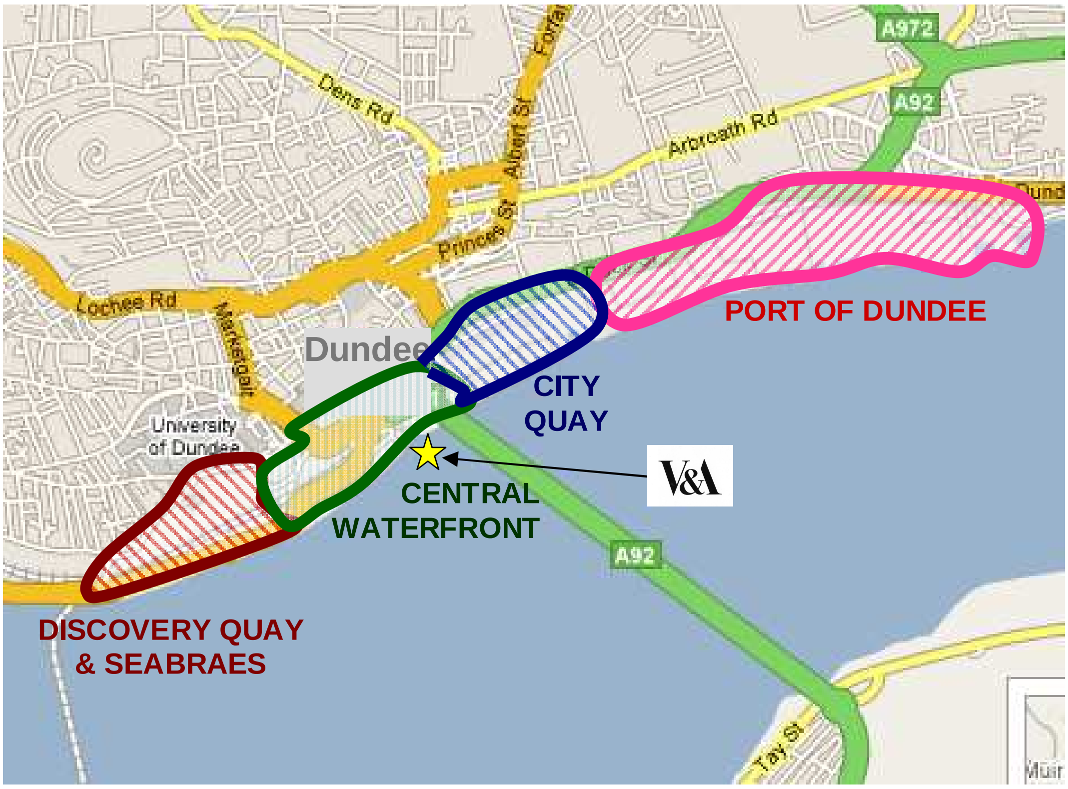


Figure A:7 Pragmatic activities identified in the Knowledge Map for Sustainability

Appendix B Dundee Waterfront Sustainable Benchmark Monitoring

Dundee Waterfront –

Sustainable Development Monitoring Framework



Prepared by: University of Abertay Dundee

October 2010

UNIVERSITY of ABERTAY DUNDEE

Executive Summary

This document presents the Dundee Waterfront Sustainable Development Benchmark Indicators and forms part of the Dundee Waterfront Performance Management Framework.

The benchmark indicators were developed by the University of Abertay Dundee over a period of three years as part of an ongoing Dundee Waterfront Sustainability Enhancement Commission.

The benchmark indicators were developed from literature, interviews with stakeholders and document analysis and have been aligned with existing data collected by the Dundee Waterfront Partnership.

The alignment of Benchmark Sustainable Development Indicators with partners existing reporting requirements will allow long term collation of sustainable Development Benchmark Indicator Data.

Dundee Waterfront Performance Management Framework proposes to collect data on the baseline annually with major reviews in 2015 and 2020. The Dundee Waterfront Sustainable Development Benchmark indicators will follow the same reporting regime.

The University of Abertay Dundee will collate indicators for Dundee Waterfront in 2011 and 2012 as part of their Sustainability Commission. The Dundee City Council database for the providing of SOA data and data from the Performance Management Framework will populate the data for Sustainable Development Benchmark indicators.

Contents

1 Introduction

1.1 Dundee Waterfront

The Dundee Waterfront consists four linked areas; Seabraes Yard, Dundee Central Waterfront, City Quay and Port of Dundee. These areas have an integrated programme of sector investment financed through public and private sector partners. The development of Dundee Waterfront will comprise a number of projects lead by different partners such as Scottish Enterprise, Dundee City Council or private developers.

The Dundee Central Waterfront Monitoring and Evaluation Group have developed a Dundee Waterfront Performance Management Framework (PMF)[i] to monitor the performance of these projects. The Sustainable Development Monitoring Framework is designed to provide the Dundee Waterfront Monitoring and Evaluation Group the mechanism to monitor and demonstrate the sustainable development of the Dundee Waterfront. This report forms part of the Dundee Waterfront Performance Management Framework reporting.

1.2 Sustainable Development

The Local Government in Scotland Act 2003[ii] establishes sustainable development as one of three cross-cutting themes, sitting alongside equal opportunities and joint working.

Section s1 (5) of the Act sets out this statutory duty and specifically states:

‘The local authority shall discharge its duties under this section in a way which contributes to the achievement of sustainable development.’

The Local Government in Scotland act’s (2003) definition of Sustainable Development provides starting point for the development of a sustainable development monitoring framework. “Sustainable Development is commonly defined as being development which secures a balance of social, economic and environmental well-being in the impact of activities and decisions; and which seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs”. [iii]

The guidance also identifies specific activities that should be undertaken:

1. That there is a commitment at both elected member and senior officer level to contribute to the achievement of sustainable development and to promote an integrated approach to improving economic, social and environmental well-being.

2. That contributing to the achievement of sustainable development is reflected in the authority's objectives and highlighted in all strategies and plans at corporate and services level.

3. That these plans, priorities and actions are informed by the views of its communities and key local partners.

4. That 'quality of life' indicators are identified to measure performance in contributing to the achievement of sustainable development and reported to the public.

5. That review activities take account of sustainability issues and assess the impact of policy proposals on sustainable development.

6. That sustainable development requirements are taken into account in the procurement strategy.

7. That there is a systematic approach to the management of resources which contributes to the achievement of sustainable development.

Dundee City Council's (DCC) corporate response to sustainability will be fully integrated through the updated Sustainable Development Governance Framework.[iv] The Sustainable Development Monitoring and Enhancement Framework work compliments the existing Sustainable Development actions across DCC. There is a strong emphasis on local authorities' ability to demonstrate Best Value through its contribution to the achievement of sustainable development in consideration of the social, economic and environmental impacts of activities and decisions both in the shorter and longer term [iii]. In light of the Local Government in Scotland Act (2003), it is recognised that the scale and regional importance of Dundee Waterfront requires adherence to the principles of sustainable development and this must be demonstrated to European funding bodies, private investors and the public as well as to the Scottish Government in a transparent way.

2 Reporting Frameworks

2.1 National Performance Framework

The Scottish Government's five Strategic Priorities are a:

1. Wealthier and Fairer Scotland
2. Healthier Scotland
3. Safe and Stronger Scotland
4. Smarter Scotland
5. Greener Scotland

These priorities sit comfortably within the three pillars of sustainability and therefore, a number of natural commonalities between the indicators to monitor sustainable development and strategic priorities are evident.

This Scottish Government strategy[v] has been developed "to focus the Government and public services on creating a more successful country, with opportunities for all to flourish, through increased sustainable growth". Adherence to the principles of sustainable development provides the opportunity to assess progress against the objective of a "wealthier", "fairer" (economic and social), "smarter", "healthier", "safer and stronger" (social) and "greener" (environmental) Scotland.

Scotland's National outcomes are [v]:

1. We live in a Scotland that is the most attractive place for doing business in Europe.
2. We realise our full economic potential with more and better employment opportunities for our people.
3. We are better educated, more skilled and more successful, renowned for our research and innovation.
4. Our young people are successful learners, confident individuals, effective contributors and responsible citizens.
5. Our children have the best start in life and are ready to succeed.
6. We live longer, healthier lives.
7. We have tackled the significant inequalities in Scottish society.
8. We have improved the life chances for children, young people and families at risk.
9. We live our lives safe from crime, disorder and danger.
10. We live in well-designed, sustainable places where we are able to access the amenities and services we need.
11. We have strong, resilient and supportive communities where people take responsibility for their own actions and how they affect others.
12. We value and enjoy our built and natural environment and protect it and enhance it for future generations.
13. We take pride in a strong, fair and inclusive national identity.
14. We reduce the local and global environmental impact of our consumption and production.
15. Our public services are high quality, continually improving, efficient and responsive to peoples needs.

2.2 Single Outcome Agreement for Dundee 2009-2012

Single Outcome Agreements require local authorities to have a strategic focus and to develop a manageable number of measurable indicators to report on the national outcomes. DCC published its first Single Outcome Agreement for Dundee in 2008[vi]. Single outcome agreements (SOA) were a step change in how local authorities are externally scrutinised. The agreement represented a new relationship between the Scottish Government and local government with a significant reduction in the level of funding that is ring fenced. Dundee City Council (DCC) therefore had to effectively demonstrate how they contributed to national outcomes through identifying local outcomes and relevant indicators.

The SOA is a key strategic document which will influence the structure and content of other documents. The agreement covers all local authority services and strategic priorities and directions set in the Dundee Partnership community plan for Dundee 2005 -2010[vii] and embraces all the themes in these documents. Indicators have been established for SOA to enable each of the Scottish Governments national outcomes to be assigned to a partnership group. Indicators will provide an evidence base for analysis of performance against priorities for Dundee as set out in Single Outcome Agreement for Dundee 2009-2012[viii]

A new governance structure has been established in DCC as part of the SOA implementation, with local priority outcomes contained within corporate plans. SOA require indicators to be set up for each national outcome and this new duty provides an opportunity to align sustainability monitoring of Dundee Waterfront with SOA reporting. DCC will publish an annual report on the performance of local indicators. This will detail a progress statement on the achievement of the projects and programmes referred to in the council plans and other strategic documents.

2.3 Dundee Waterfront Performance Management Framework

The Dundee Waterfront consists of four linked areas Seabraes Yard, Dundee Central Waterfront, City Quay and Port of Dundee:

- Seabraes yard forms the Digital Media District and Scottish Enterprise are in the process of developing a masterplan for this area. It will consist of housing and Digital Media premises.
- Dundee Central Waterfront involves the redevelopment of city centre waterfront area through realignment of roads and Tay Bridge Ramps, to reconnect the city centre with the river and create high quality development land for mixed use development.
- City Quay is private sector led housing offices and retail area, with potential redevelopment of the dock into marina space.
- Port of Dundee together with Dundee Renewables plan to develop parts of port based on renewable energy opportunities in the first instance from offshore wind manufacturing and maintenance.

The Dundee Central Waterfront Monitoring and Evaluation Group have developed a Dundee Waterfront PMF to monitor the performance of these projects. The Dundee Waterfront PMF will develop a set of baseline conditions to enable the Dundee Waterfront Partnership to monitor the impact of the linked projects.

The 11 Baseline Condition Measures (BCM) are economically focussed with the success of a project measure in terms of a positive change in these measures [i].

These are as follows:

Competitive advantage

BCM1: Employees in employment
BCM2: Business Stock
BCM3: Industry Structure
BCM4: GDP per capita
BCM5: Visitor numbers and spend
BCM6: Working age populations

Quality Places

BCM7: Land and property values

BCM8: House prices

BCM9: Vacant and derelict land

Community regeneration

BCM10: Economic activity rate

BCM11: Unemployment

Based on these indicators the Dundee Waterfront PMF will capture the planned and actual performance of each of the projects that comprise the Dundee Waterfront. The data required should be available as a result of project approval process and routine monitoring such as SOA data. Additional commissioned studies for specific data will be undertaken.

3 Dundee Waterfront Sustainable Development Monitoring Framework

The Sustainable Development Monitoring Framework is designed to strategically monitor the overall sustainability of the Dundee Waterfront through the use of indicators. These Sustainable Development Benchmark Indicators will provide a baseline for monitoring the whole development over time to inform the Dundee Waterfront Partnership Project Board, the Scottish Government and funding bodies.

3.1 Indicator Development

Sustainable Development Benchmark Indicators were developed to reflect the UK Government Sustainable Development Strategy[ix] and the Scottish Government Sustainable Strategy[x]. Indicator development consisted of three main activities, literature review, interviews and document analysis as illustrated in Figure 1.

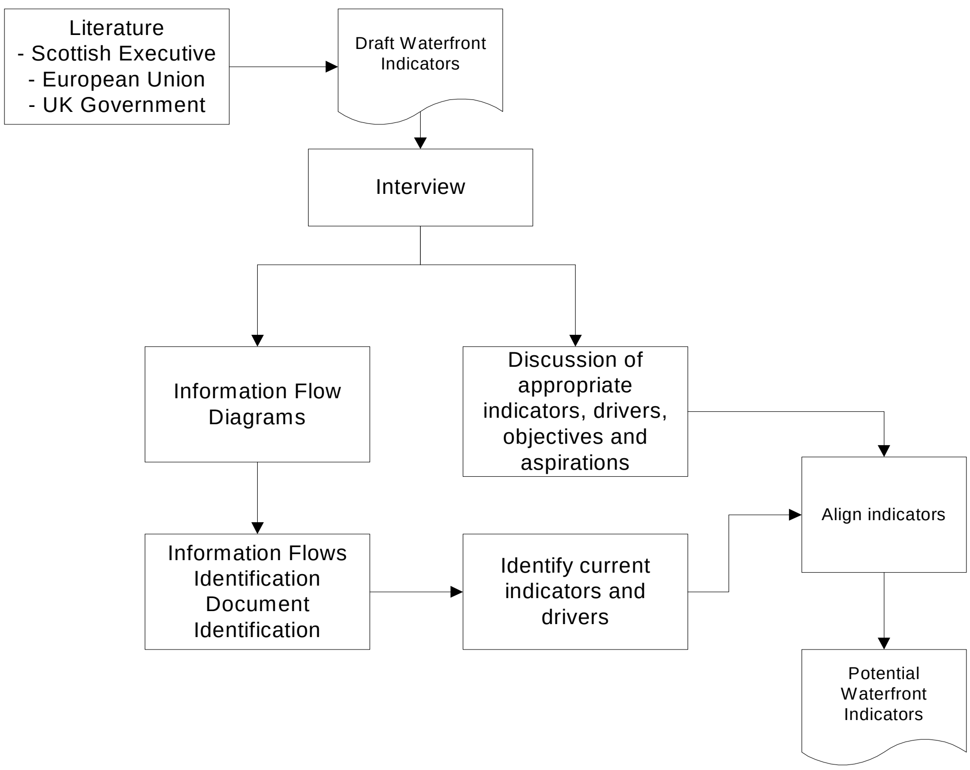


Figure 1 Sustainable Development Benchmark Indicator development

3.1.1 Literature Review

The Benchmark Indicators for the Dundee Waterfront have been developed from the literature to reflect the UK Government Sustainable Development Strategy and the Scottish Government Sustainable Strategy. A large number of indicators are used across government to monitor the outcomes of policies. Experience from the 1999 Strategy suggests that the 147 indicators were in practice too difficult to use to determine overall progress[xi]. The other approach tried at that time was to have 15 headline indicators. These were used in the reporting process but could only provide an overview. A balance between these approaches is therefore needed.

In response to this, the UK Government Strategy has established a set of 68 indicators consisting of 20 UK Framework Indicators and a further 48 indicators to monitor progress[xii]. The framework indicators are relevant for Scotland and will be collected and reported by UK Government. The Scottish Government have their own set of indicators 'Sustainable Development Indicator Set'[xiii] based on the policy in 'Choosing the future'[xiv], their previous indicator set "Meeting the needs"[xv] was reported from 2003-2006. All three sets of indicators have been used to develop Dundee Waterfront Benchmark Indicators.

As part of the literature review stage, indicator documents and policy documents were reviewed and the relevant indicators shortlisted. Each indicator on the shortlist was reviewed to identify its appropriateness to the Dundee Waterfront, in relation to its scale, geographical area, units of measurement, and focus and direction. Indicators were then grouped into three categories, Economic, Environmental and social.

During the literature based development stage, the indicators were designed to align as closely as possible with Scottish Government indicators to provide a basis for tangible reporting to the Scottish Government, whilst providing clear and easily understood indicators for internal monitoring at the strategic level.

Where Scottish Government/UK Government indicators did not exist, specific indicators were developed. These were based on the authors' experience of sustainable indicator development[xvi xvii,xviii] and on a range relevant sustainable urban development research papers. Unfortunately, most of the papers presented a conceptual understanding of the urban environment and identified key components of sustainability[xix,xx,xxi] rather than presenting indicators. However, these key components were developed into indicators, which balanced Economic, Environmental and Social aspects of sustainable development.

3.1.2 Interviews

The literature based Benchmark Indicators were then refined through the process of interviews with key stakeholders with reference to the specific drivers, aspirations and objectives of the Dundee Waterfront. Interviews were held with members of Scottish Enterprise, Dundee City Council and Scottish Government staff to discuss the indicators and seek their views on their relevance. Each indicator was addressed in turn to verify relevance and improve their definition.

In addition, the interviews began to identify stakeholders' involvement in the Dundee Waterfront. The interviews collected data to illustrate the network of stakeholders for each role holder through the development Information Flow Diagrams. Each of the numbered information flows had a number of documents associated with it e.g. data, reports, meeting minutes. The Information Flow Diagram process was thus used to identify documents within the information flows, for analysis to enable further refinement of the indicators.

3.1.3 Document Analysis

Three key working documents were used refine potential indicators in addition to the interviews. These were identified during interviews with Dundee City Council and SE personnel. Several documents were identified for each information flow. However, for the purposes of developing a potential set of indicators, one document was selected from each of the interviewee as follows:

- Dundee Central Waterfront Market Appraisal and Economic Impact Assessment, SE[xxii]
- Dundee Partnership Dundee Community Plan [xxiii]
- Dundee Central Waterfront Infrastructure Feasibility Report[xxiv].

The documents were reviewed to identify potential indicators already in use and associated data availability. They were also used to develop indicators, which match the objectives and aspirations stated in the documents, and verify the potential relevance of indicators under development.

As part of the development process it was important to establish that there was sufficient scope in the variety of indicators to be robust to changes in reporting. Following an extensive review as part of indicator development, checks made with the Scottish Government confirmed that they do not foresee any changes to their Sustainable Development indicators for 10 years.

Draft Sustainable Development Benchmark Indicators were reported in October 2007. This report provided values of the baseline indicator set for monitoring the sustainable development of the Central Waterfront prior to the commencement of the masterplan infrastructure provision.

3.2 Review 1 Single Outcome Agreement

A new governance structure was established in DCC as part of the SOA implementation, with local priority outcomes contained within corporate plans. SOA required indicators to be set up for each national outcome and this new duty provided an opportunity to align sustainability monitoring of DCW with SOA reporting.

Benchmarking indicators for DCW for 2007 were therefore reviewed in response to the SOA national outcomes indicators to identify where there are synergies. National outcomes map well onto the three pillars of sustainability and the DWC indicators therefore provide information on a large number of SOA indicators either directly (i.e. using the same units) or are indirectly by measuring similar aspects. The alignment of the SOA and DCW indicators gives additional confidence in the initial DCW sustainability indicators long term applicability.

3.3 Review 2 Dundee Waterfront Performance Management Framework

The Sustainable Development Benchmark Indicators were then reviewed to align well with existing data collection activities of Dundee Waterfront Performance Management Framework (economic indicators) and to the SOA national outcomes indicators where there were synergies. National outcomes map well onto the three pillars of sustainability and therefore the SOA indicators for Dundee provide data, either through SOA Outcome indicators or SOA Delivery Plan intermediate outcome indicators.

Dundee Waterfront Performance Management Framework proposes to collect data on the baseline annually with major reviews in 2015 and 2020. The Dundee Waterfront Sustainable Development Benchmark indicators will follow the same reporting regime.

It is proposed that University of Abertay Dundee Collate indicators for Dundee Waterfront in 2011 and 2012 as part of their Sustainability Commission. Dundee City Council database for the providing of SOA data and data from the Performance Management Framework will populate the data for Sustainable Development Benchmark indicators.

4 Benchmark Indicators

The indicators shown in Tables 1-3 are the benchmark indicators for monitoring the Dundee Waterfront. The * denotes that the indicator is based on the UK Government Framework Indicator or Scottish Government Sustainable Development Indicator Set, but in most case the definition has been adjusted to be more relevant to Dundee Waterfront. The final two columns on the table provide reference to the single outcome agreement indicators for Dundee and the lead officer for each indicator.

The indicator can either be part of the SOA strategic context, such as 'demographics'; directly relevant to a specific outcome, such as 'retention of skill base' or a national outcome indicator such as 'knowledge based economy'. In the case of the latter, terminology and units would be the same in the Dundee Waterfront and SOA reporting.

The term "City Wide" or "Direct" is also used with reference to each Benchmark Indicator. This identifies whether the indicator and data is relevant to the whole of Dundee (City Wide), or Dundee Waterfront specific data (Direct).

One of three forms of baseline data exist for each indicator:

1) An initial baseline value for 2007, e.g. population 142,170,
2) A value of 0 as a datum for 2007, e.g. Number of jobs created since 2007,
3) N/A (not available) where the indicator is not measurable at this time e.g. Per capita water consumption of new buildings as the area has not yet been developed.

Blanks are shown in the table in place of indicator data that is still being sourced.

Section 5 defines each indicator in detail and gives information regarding the purpose of the indicator, its origin and the expected influence of the stage of development on the indicator. It also identifies how indicators relate to UK Framework and Government indicators of sustainable development, SOA, Dundee Waterfront Performance Management Framework and comments on future proofing and data information sources. As part of the development process it was important to establish that there was sufficient scope in the variety of indicators to be robust to changes in reporting. Following an extensive review as part of indicator development, checks made with the Scottish Government confirmed that they do not foresee any changes to their Sustainable Development indicators for 10 years. The alignment of the SOA, Dundee Waterfront Performance Management Framework and Dundee Waterfront indicators gives additional confidence in the initial Dundee Waterfront sustainability indicators long term applicability.

Table 1 Sustainable Development Benchmark Indicators - Economic

Category		Benchmark indicators	Definition of indicator	Units	Baseline Data	Desired direction/ Target	Source of Data	Lead Officer
Economic	1a	Demographics* (City Wide)	Population retention	Population number	142, 170	UP	SOA context, GROS Mid Year Population Estimates	Rory Young, Dundee City Council
	1b	Retention of skills base (City Wide)	Graduate retention rate	Graduate population	33 %	Up	Annual Population Survey	Rory Young, Dundee City Council
	1c	Knowledge based employment (City Wide)	Knowledge economy sector jobs	Percentage share of jobs in knowledge industries	28.8 % (09/10)	Up	SOA Delivery Plan intermediate outcome 2a Dundee city council company survey	Stan Ure Dundee City Council
	1d	Employment* (City Wide)	Employment rates	% of resident working age population	72.2% (June 2008)	Up	SOA Outcome 1 Indicator Annual population survey data from NOMIS	Stan Ure Dundee City Council
	1e	Capacity to stimulate investment* (Direct)	Total inward investment to waterfront	£ Inward investment	0	Up	Scottish Enterprise	Angela Crabb Scottish Enterprise

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Economic	1f	Tourism numbers (City Wide)	Tourists visiting city centre locations	Number	53,535 (-9.5%) 72,061 (+16.8%) 2008	Up	Discovery /Sensation /McManus V&A visitor numbers annual survey	Visit Scotland Visitor attraction Monitor
	1g	Tourism (City Wide)	Level of tourism expenditure Dundee	Expenditure	£130.79 million	Up	SOA Delivery Plan Intermediate outcome 1h	Stan Ure Dundee City Council
	1h	Regeneration (Direct)	Increased property value	% Increase	0	Up	Scottish Enterprise	Angela Crabb Scottish Enterprise
	1i	Job creation (Direct)	Number of jobs created	Number	0	UP	Scottish Enterprise	Angela Crabb Scottish Enterprise
	1j	Economic output* (City Wide)	Economic output	GDP per capita	£17 335	Up	Scottish Enterprise	Peter Noad Scottish Enterprise

Table 2 Sustainable Development Benchmark Indicators - Environmental

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Environmental	2a	Green space/public space* (Direct)	Local environmental quality	Green space quality standard	N/A	Excellent	SOA Delivery Plan Intermediate outcome 11 f Dundee Open Space Strategy	Peter Sandwell Dundee City Council
	2b	Waste* (Direct)	Construction waste recycling	% of projects where waste re used/ recycled in line with best practice	N/A	Target - to match national best practice	DCC City Engineers Recycling Group Report	Roger Grace, Dundee City Council
	2c	Air* (Direct)	Air emissions continually monitored at Union Street and Seagate	Emissions of , NO_2 average µg/m^3	36.6/59.9	Down	SOA Delivery Plan Intermediate outcome 11e National Air Quality Standards and objectives for NO_2	Iris Coghill, Dundee City Council

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Environmental	2d	Water* (Direct)	Per capita water use	l/head/day P.E.	N/A	Target - to match national best practice	Design specification	Allan Watt Dundee City Council
	2e	Noise * (Direct)	Noise level impact	Number of complaints related to DCW construction	0	Down	DCC	Allan Watt Dundee City Council
	2f	Energy* (Direct)	Energy consumption	Energy use/CO_2 per M2 of property	N/A	Target - to match national best practice	Design specification	Allan Watt Dundee City Council
	2g	Travel* (City Wide)	Journeys to work and school made by pubic or active transport	% Journeys	15%	Up	SOA Delivery plan intermediate outcome 11c Scottish Household Survey /Waterfront travel Plan	John Berry Dundee City Council

Table 3 Sustainable Development Benchmark Indicators - Social

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Social	3a	Housing provision (Direct)	Residential development	% of residential development	21%	21%	Urban Design Guide	Allan Watt, Dundee City Council
	3b	Health & Well being* (City Wide)	Positive and sustained destinations (education, higher education, employment or training)	% of school leavers in positive and sustained destinations	85% (2007)	increase	SOA Outcome 1 Indicator School Leavers Destination Survey	Allan Millar Dundee City Council
	3c	Community* (City Wide)	Neighbourhood satisfaction	% Resident satisfaction with the quality of and access to local services, facilities and environment	Quality 83% Access 93% City Wide	Up	SOA Outcome 10 Indicator Annual Dundee Partnership Social Survey	John Hosie, Dundee City Council
	3d	Social Inclusion* (City Wide)	Accessibility of cultural and learning opportunities	Uptake of cultural opportunities by people from under represented areas of the city e.g V &A	To be provided by October 2012		SOA Outcome 2 Intermediate Outcome 2f	

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/ Target	Source	Lead Officer
Social	3e	Participation and responsibility (Direct)	Participation in sustainable decision making	Number of people involved in marketing and stakeholder engagement activities	0	Up	Marketing Officer, Dundee City Council	Gaynor Sullivan, Dundee City Council
	3f	Active community participation* (City Wide)	Informal and formal volunteering	% adults who volunteer regularly	17%	UP	SOA Delivery Plan Intermediate outcome 9d Greater Community Spirit and wellbeing, Scottish household Survey DCC	John Hosie, Dundee City Council
	3g	Acceptability (Direct)	Acceptability to stakeholders	%	96%	Up	DCW consultation and communication, City Centre Action Group	Allan Watt Dundee City Council

Appendix C Process Maps and Knowledge Categorisation

Process Maps Design and Phasing

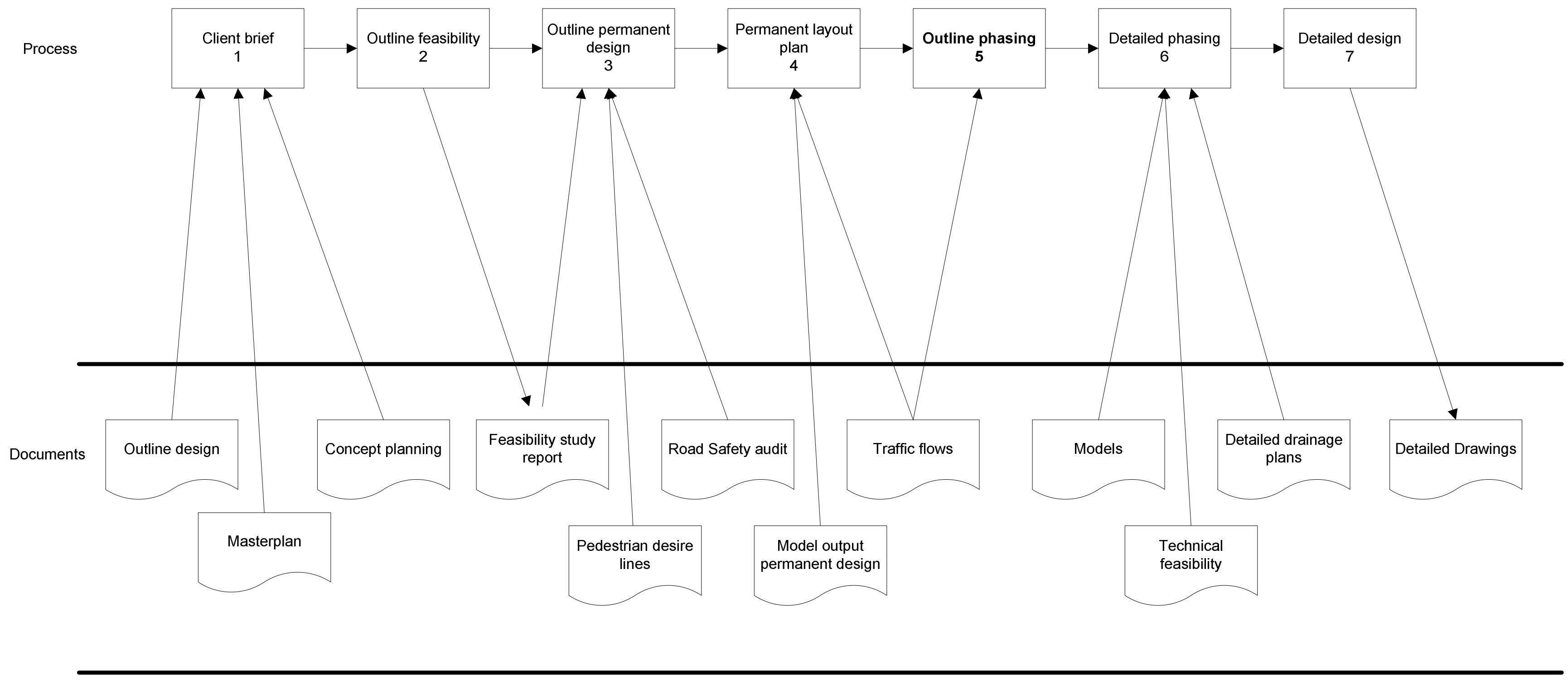


Figure C:1 Level 1 Overview of Design and Phasing

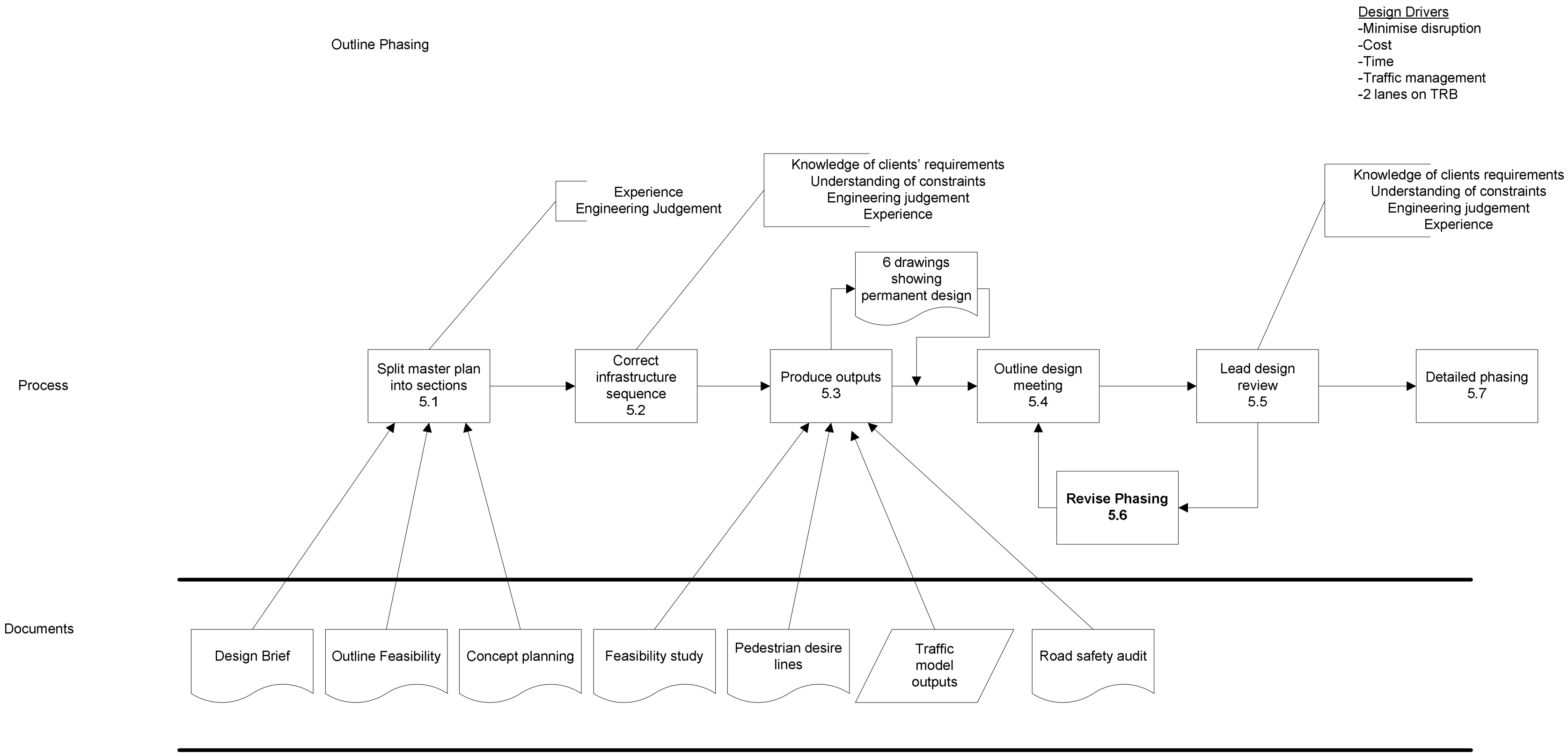


Figure C:2 Level 2 Outline Phasing

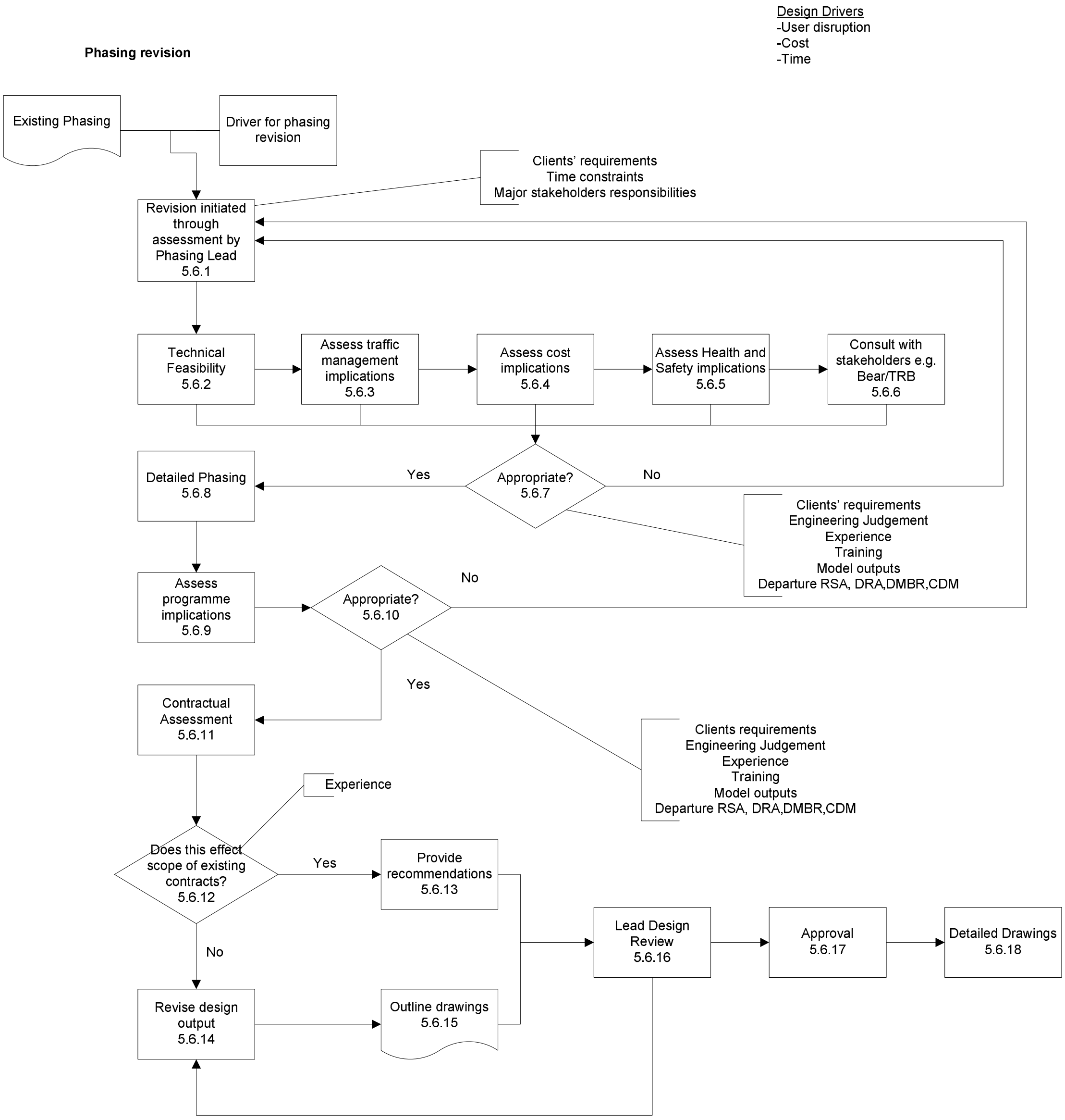


Figure C:3 Level 3 Phasing Revision

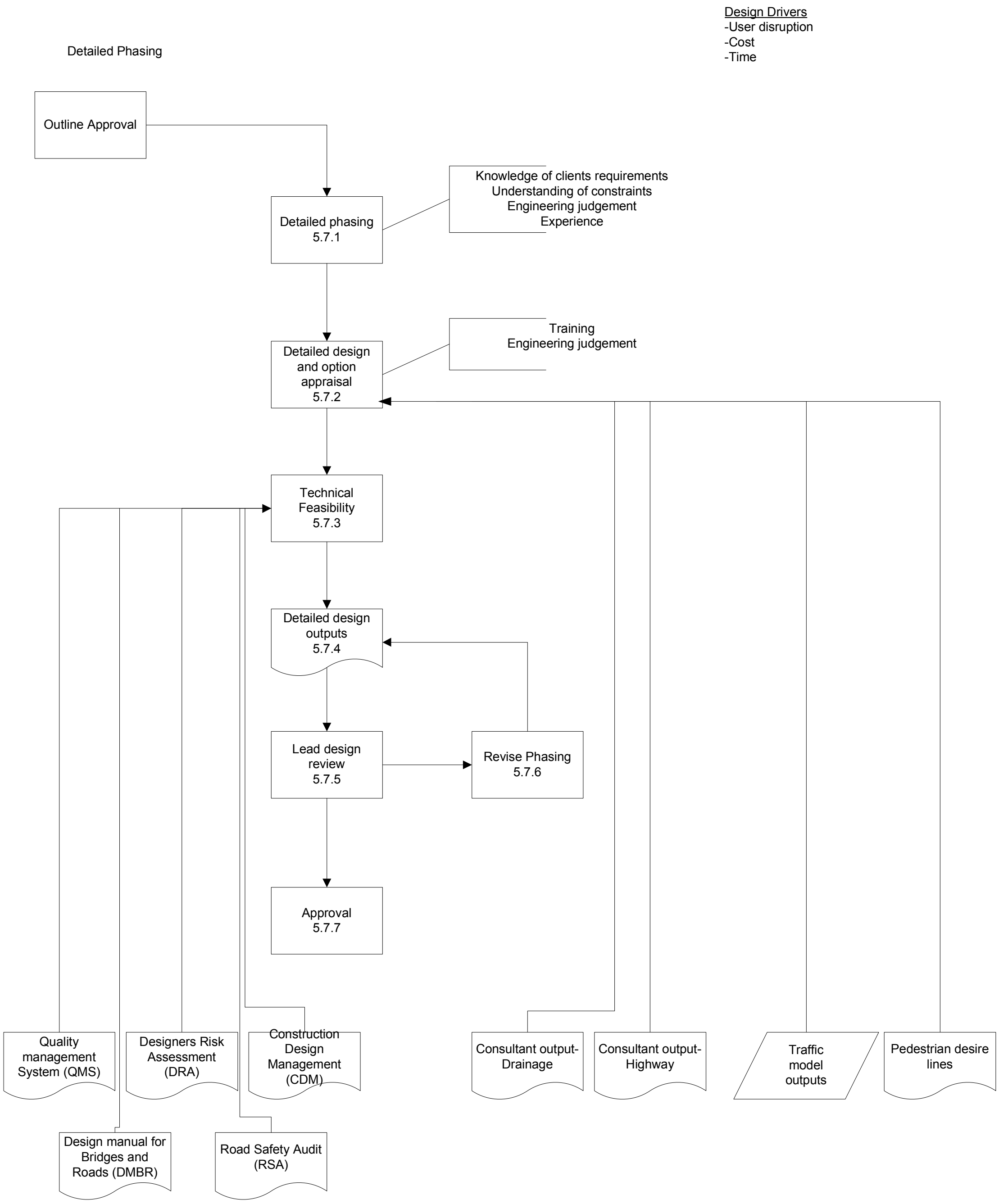


Figure C:4 Level 3 Detailed Phasing

Outline permanent design

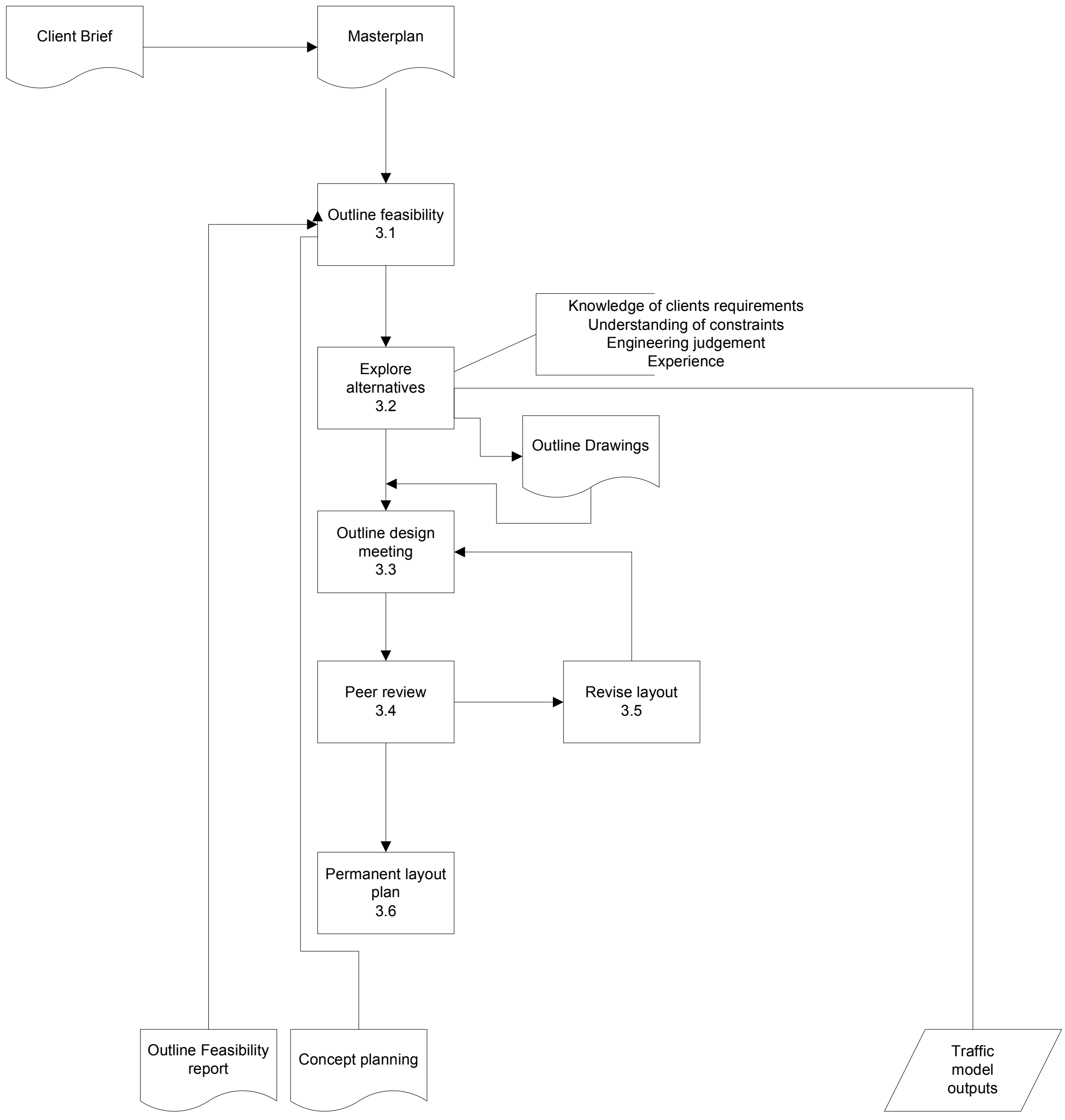


Figure C:5 Level 3 Outline Permanent Design

Explore Alternatives

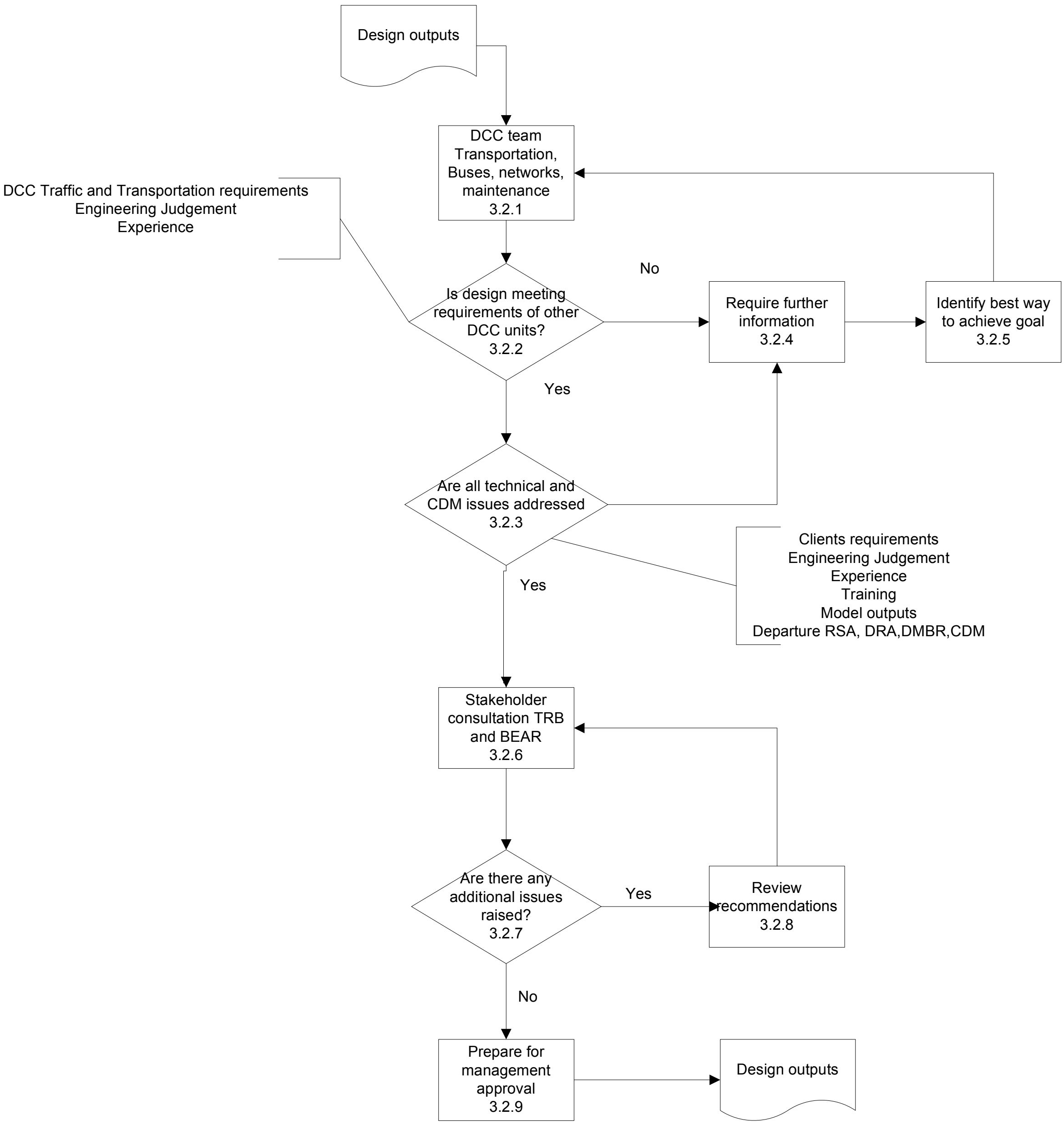


Figure C:6 Level 3 Explore Alternatives

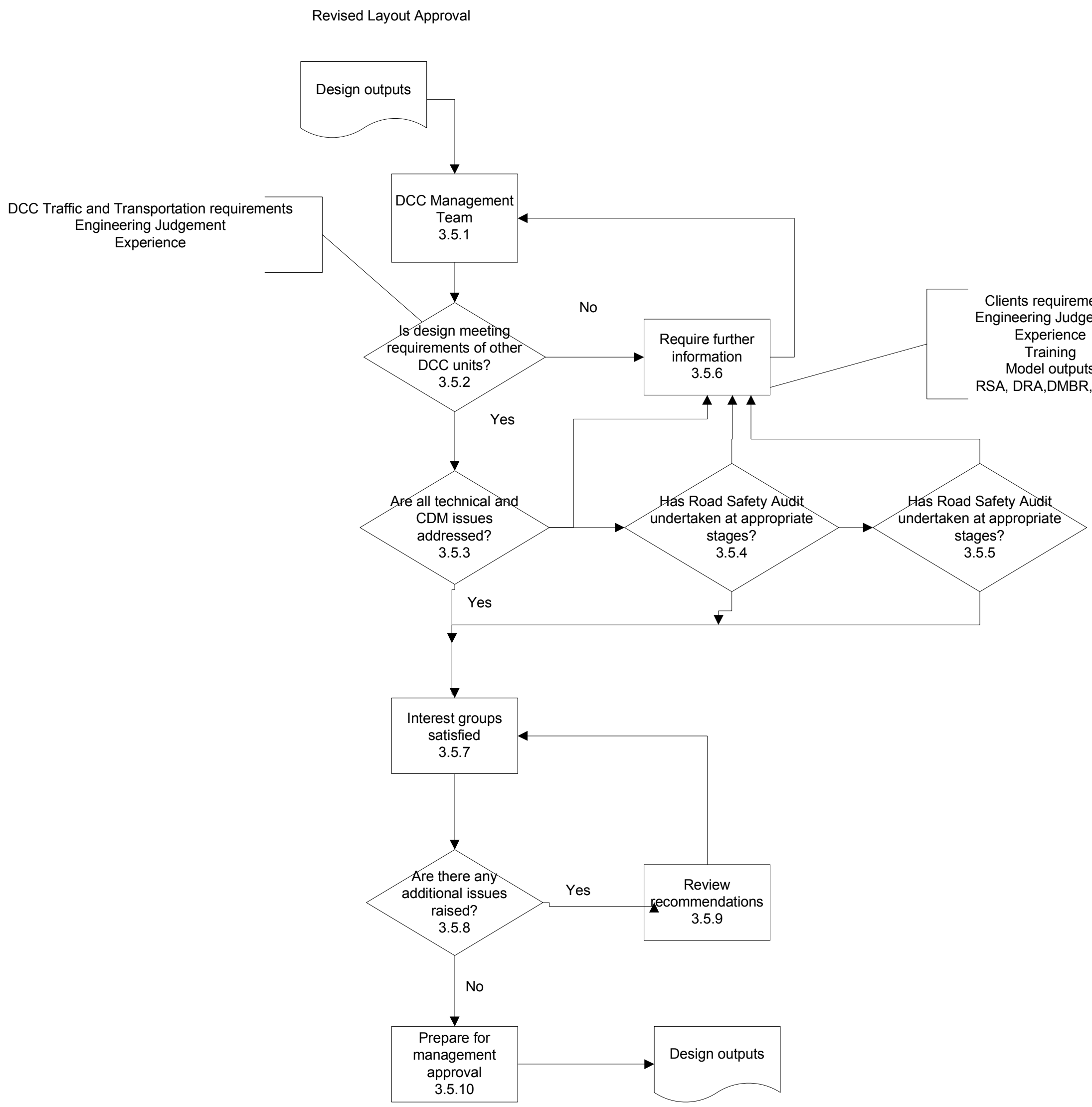


Figure C:7 Level 3 Revised Layout Approval

Process Maps Construction

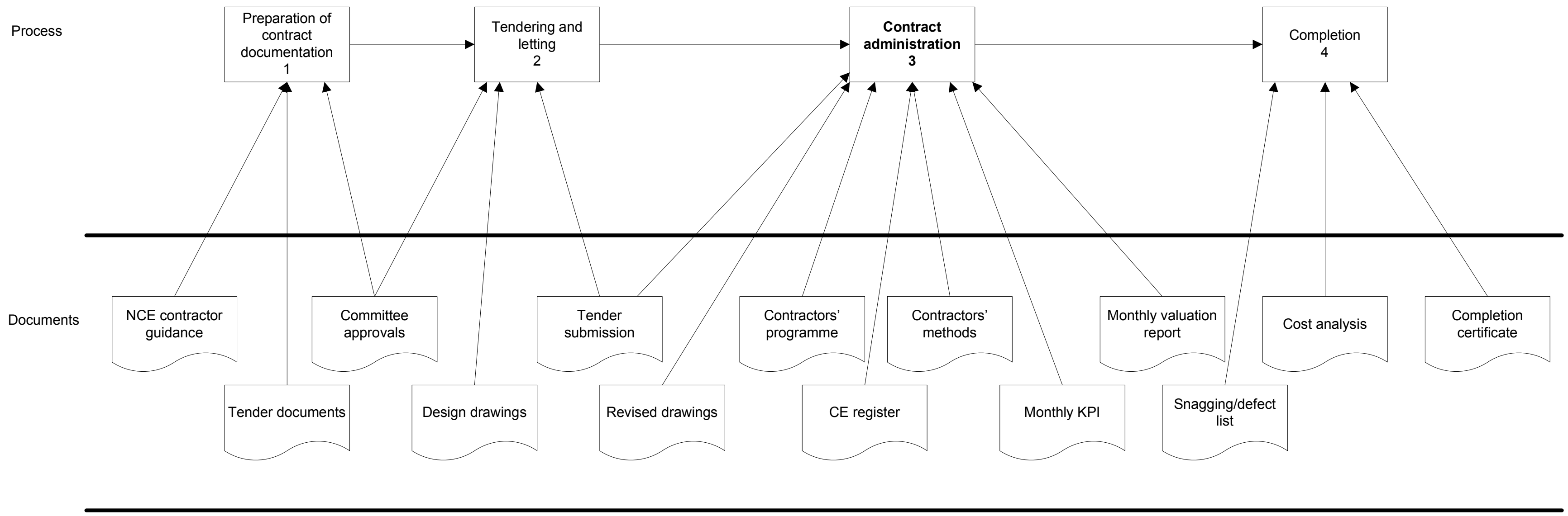


Figure C:8 Level 1 Overview of Construction

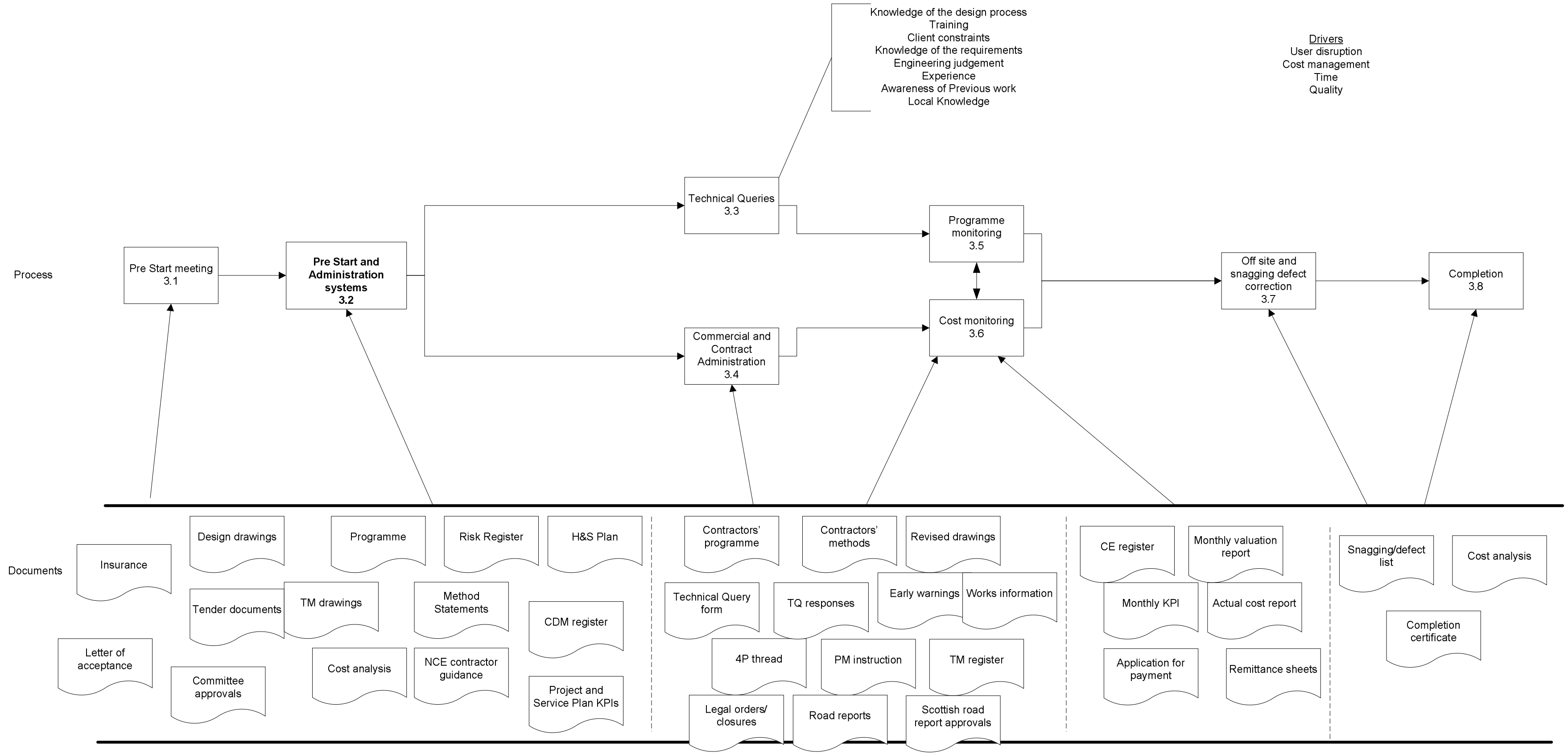


Figure C:9 Level 2 Contract Administration

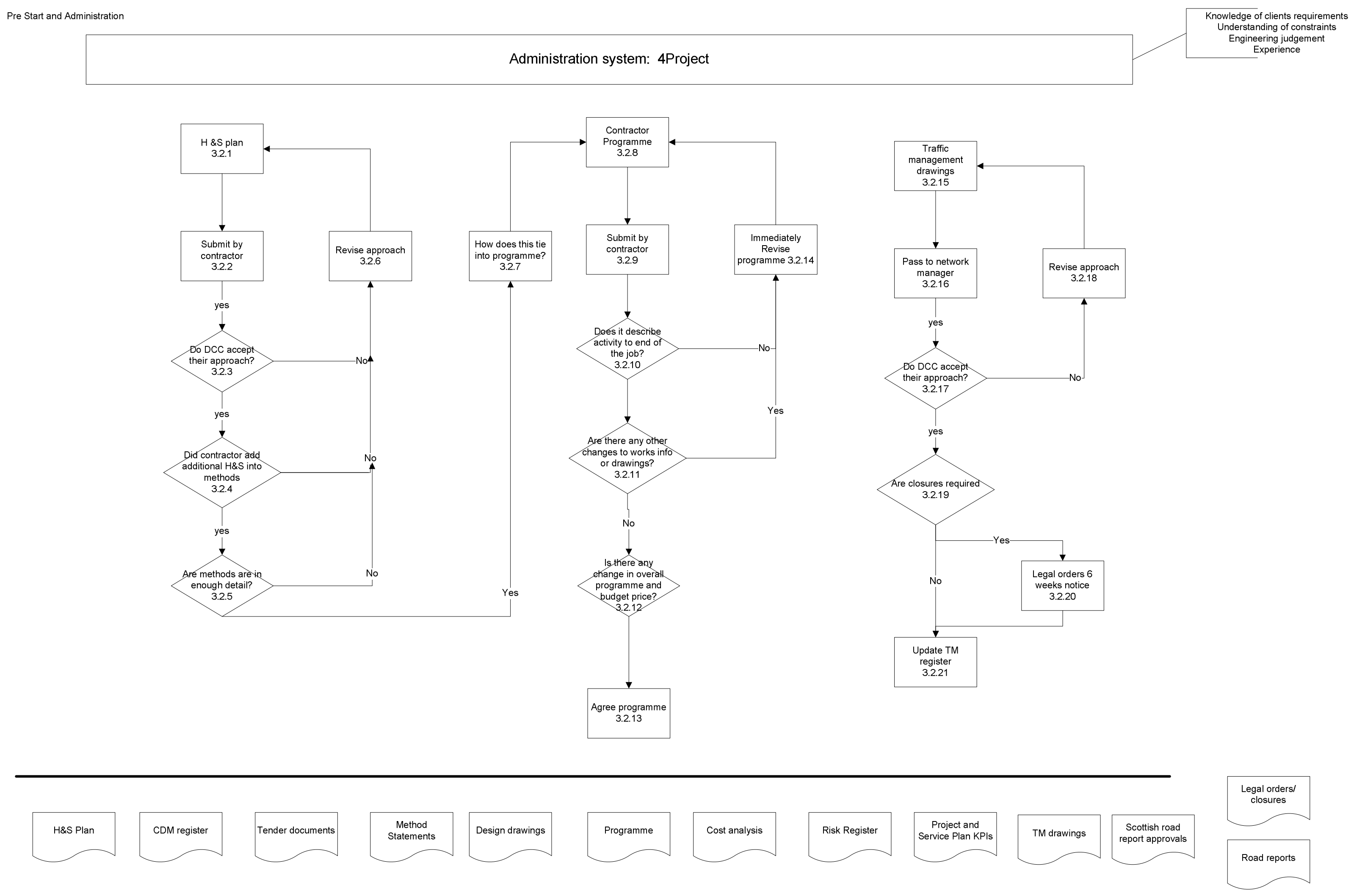


Figure C:10 Level 3 Pre start and administration systems

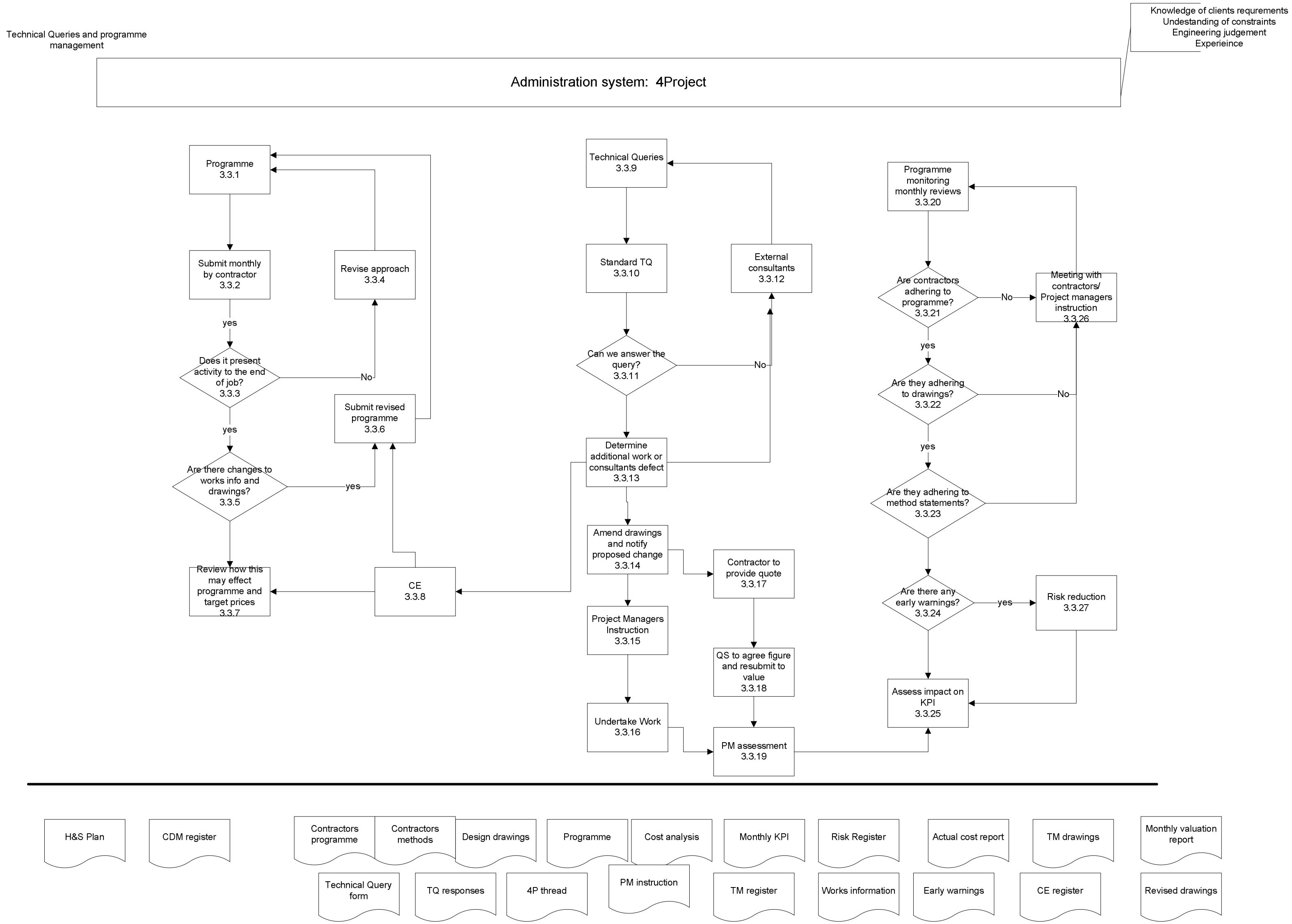


Figure C:11 Level 3 Technical Queries and Programme Management

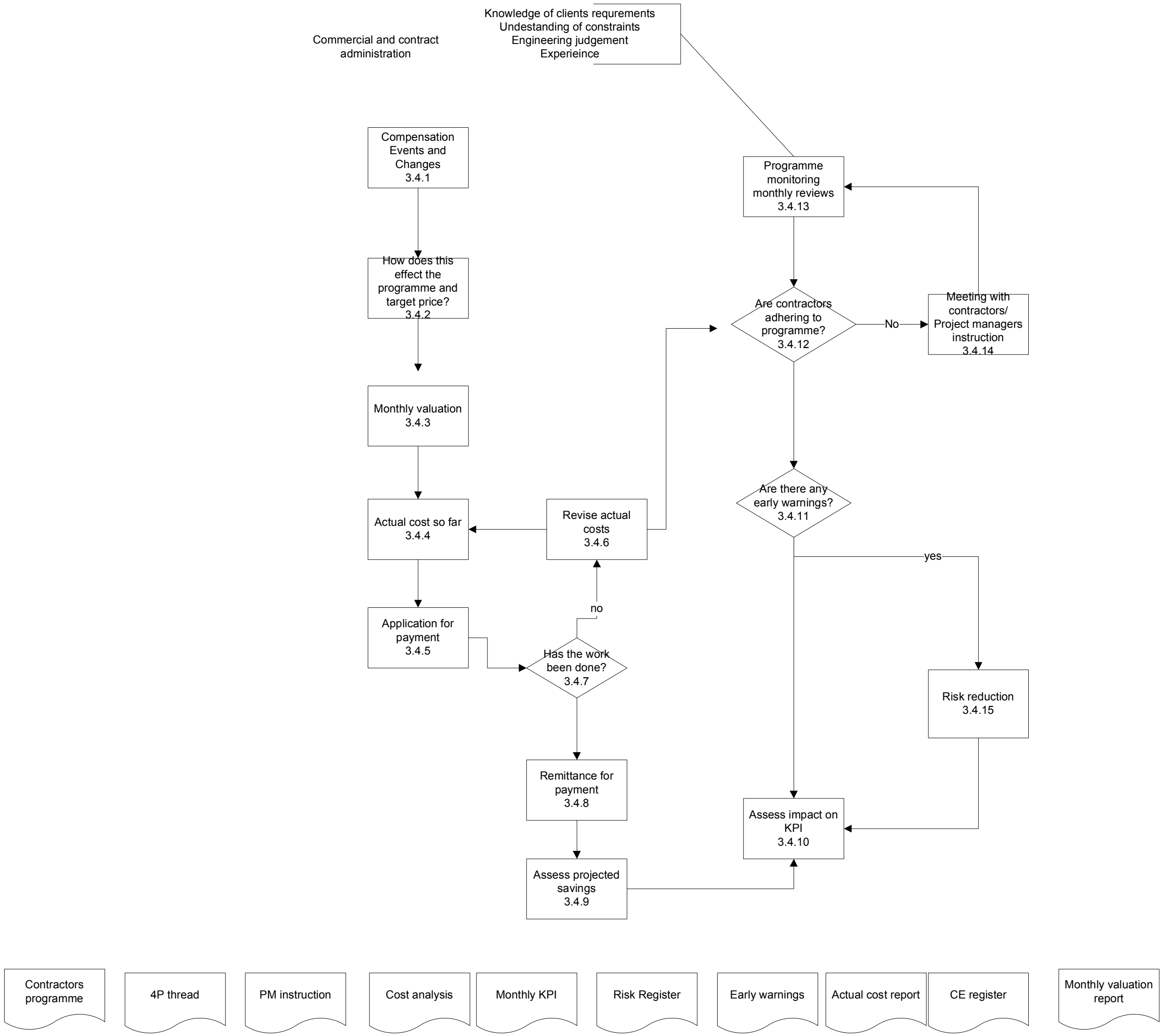


Figure C:12 Level 3 Commercial and Contract Administration

Table C:1 Knowledge Objects from Outline Phasing

Artefact	Skills	Heuristics	Experience
Design brief	Engineering judgement	Engineering judgement	Understanding of constraints
Outline feasibility	Knowledge of the requirements	Timings	Experience
Concept planning	Understanding of constraints	Cost implications	Knowledge of clients requirements
Feasibility study		Traffic management implications	
Pedestrian desire lines			
Traffic model outputs			
Road safety audit			

**Natural talent was not identified during categorisation*

Table C:2 Knowledge Objects from Phasing Revision

Artefact	Skills	Heuristics	Experience
Design outputs	Training	Engineering judgement	Knowledge of the design process
Existing phasing	Engineering judgement	Technical feasibility	Client constraints
Model outputs	Knowledge of the requirements	Cost implications	Experience
Consultant output drainage	Understanding of constraints	Traffic management implications	Knowledge of clients requirements
Consultant output highways	Stakeholder information requirements	H&S implications	DCC traffic and transportation requirements
Departures-designers risk assessment	Contractual assessment		Drivers for phasing revision
Departures-construction design management			Traffic management implications
Departures-road safety audit			Existing contracts
Departures-design manual for bridges and roads			
Review recommendation			
Outline drawings			
Detailed drawings			

**Natural talent was not identified during categorisation*

Table C:3 Knowledge Objects from Detailed Phasing

Artefact	Skills	Heuristics	Experience
Detailed design outputs	Engineering judgement	Engineering judgement	Understanding of constraints
Quality Management System	Knowledge of client requirements	Timings	Experience
Design manual for bridges and Roads	Understanding of constraints	Cost implications	Knowledge of clients requirements
Designers risk assessment	Training		
Road safety audit			
Construction design management			
Consultant output drainage			
Consultant output highway			
Traffic model outputs			
Pedestrian desire lines			

**Natural talent was not identified during categorisation*

Table C:4 Knowledge Objects from Outline Permanent Design

Artefact	Skills	Heuristics	Experience
Client brief	Engineering judgement	Engineering judgement	Understanding of constraints
Masterplan	Knowledge of client requirements		Experience
Outline drawings	Understanding of constraints		Knowledge of clients requirements
Outline feasibility			
Concept planning			
Traffic model outputs			

**Natural talent was not identified during categorisation*

Table C:5 Knowledge Objects from Explore Alternatives

Artefact	Skills	Heuristics	Experience
Design outputs	Engineering judgement	Engineering judgement	Understanding of constraints
Model outputs	Knowledge of client requirements	Traffic and transport judgement	Experience
Road safety audit	Understanding of constraints		Knowledge of clients requirements
Designers risk assessment			
Design manual for bridges and roads			
Construction design management			

**Natural talent was not identified during categorisation*

Table C:6 Knowledge Objects from revised Layout Approval

Artefact	Skills	Heuristics	Experience
Design outputs	Engineering judgement	Engineering judgement	Understanding of constraints
Model outputs	Knowledge of client requirements	Traffic and transport judgement	Experience
Road safety audit	Understanding of constraints		Knowledge of clients requirements
Designers risk assessment			
Design manual for bridges and roads			
Construction design management			

**Natural talent was not identified during categorisation*

Table C:7 Knowledge Objects from Contract Administration

Artefact	Skills	Heuristics	Experience
Insurance	Training	Engineering judgement	Knowledge of the design process
Design Drawings	Engineering judgement		Client constraints
Programme	Knowledge of the requirements		Experience
Risk Register			Awareness of Previous work
H& S Plan			Local Knowledge
Tender Documents			Knowledge of clients requirements
TM drawings			
Method Statements			
CDM register			
Letter of acceptance			
Committee approvals			
Cost analysis			
NCE contractor guidance			
Project and Service Plan KPI			

**Natural talent was not identified during categorisation*

Table C:8 Knowledge Objects from Contract Administration (continued)

Artefact	Skills	Heuristics	Experience
Contractors Programme			
Contractors Method			
Revised Drawings			
Technical query form			
TQ responses			
Early Warnings			
Works information			
4P thread			
PM instructions			
TM register			
Legal orders/closures			
Road reports			
Scottish road approvals			
CE register			
Monthly valuation reports			
Monthly KPI			
Annual cost report			
Application for payment			
Remittance sheets			
Snagging list			
Cost analysis			
Completion certificate			

Table C:9 Knowledge Objects from Pre Start and Administration Systems

Artefact	Skills	Heuristics	Experience
H&S plan	Engineering judgement	Engineering judgement	Knowledge of the design process
CDM Register	Knowledge of the requirements		Client constraints
Tender Document			Experience
Method Statements			Knowledge of clients requirements
Design Drawings			
Programme			
Cost analysis			
Risk Register			
Project KPI			
Service Plan KPI			
Traffic Management drawings			
Scottish Road report approvals			
Legal orders/closures			
Road reports			

**Natural talent was not identified during categorisation*

Table C:10 Knowledge Objects from Technical Queries and Programme Management

Artefact	Skills	Heuristics	Experience
H&S plan	Engineering judgement	Engineering judgement	Knowledge of the design process
CDM Register	Knowledge of the requirements		Client constraints
Contractors programme			Experience
Contractors methods			Knowledge of clients requirements
Technical query form			
Technical query responses			
Design drawings			
4pthread			
Programme			
Cost analysis			
PM instruction			
Monthly KPI			
TM register			
Risk register			
Works information			
Actual cost reporting			
Early warnings			
TM drawings			
CE register			
Monthly valuation			
Revised drawings			

**Natural talent was not identified during categorisation*

Appendix D ASHEN Workshop Material

ASHEN workshop material

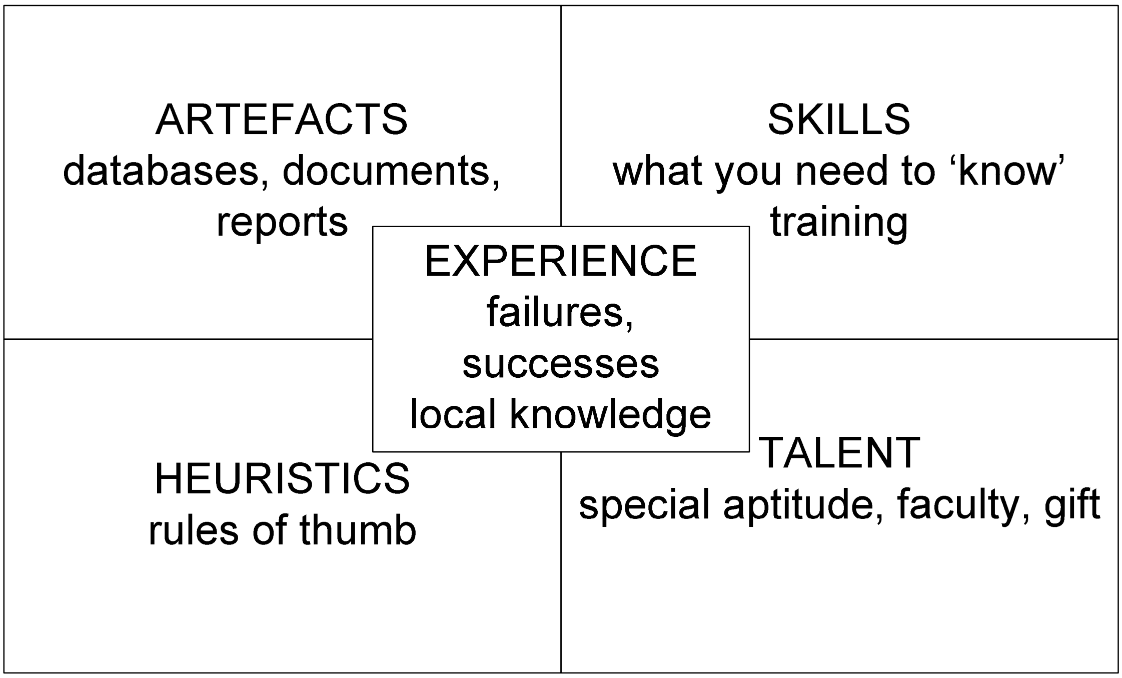
The workshop enabled the collective identification of Knowledge Objects based on a number of Knowledge Disclosure Points identified in process mapping. This had three purposes. Firstly to confirm Knowledge Objects identified during process mapping. Secondly to draw out as a workshop group any clusters of Knowledge Objects used during the Design & Phasing and Construction stages. Thirdly to draw from the participant's reflection of the sustainability issues relevant to, or contained within, the Knowledge Objects.

The workshop, at City Development Offices, Dundee City Council was led by the researcher and lasted two and half hours. Following a brief introduction, the workshop was anchored around meaningful questions on the context of the Knowledge Disclosure Points:

The participants worked as a group to agree what Knowledge Objects were used at Knowledge Disclosure Points during Design and Phasing and Construction phases in the Dundee Waterfront project. The ASHEN Model was presented to workshop participants on a flip chart and knowledge objects were placed in the categories by the workshop participants. The workshop was tape recorded to give a complete overview of what had been said, the context of the knowledge disclosure and any discussion with the participants around this.

ASHEN Model

When you made that decision what knowledge did you use?



- **Artefact:** all existing explicit knowledge and /or codified information within an organisation e.g. documents, databases.
- **Skills:** expertise, practised ability, dexterity, tact that we can identify, a tangible measure of their successful acquisition.
- **Heuristics:** rules of thumb, often used to make decisions.
- **Experience:** actual observation or practical acquaintance with fact or events and the knowledge resulting from this.
- **Natural talent:** special amplitude, faculty, gift

Knowledge Disclosure Points

When you made that decision what knowledge did you use?
When you made that judgement what knowledge did you use?
When you solved that problem what knowledge did you use?

Ask a meaningful question on the context of the Knowledge Disclosure Points:

When you made that decision what **artefacts** did you use or have access to?

What **skills** had you acquired that were necessary?

What **heuristics** have you developed that enabled you to make that decision quickly on the basis on incomplete or unarticulated inputs?

What **experience** have you had which are essential or just plain useful in making that decision?

What **natural talent** is necessary and can you give examples of signs that such talent exists as potential in others?

Appendix E Publications

The publications in Appendix E have been removed to comply with UK Copyright Law. The citations to the articles are given below.

Gilmour, D.J., Blackwood, D.J, Banks, L., and Wilson, F. 2011. Sustainable development indicators for major infrastructure projects. *Proceedings of the ICE -Municipal Engineer. 164*(1):pp. 15-24.

Isaacs, J. P., Falconer, R. E., Gilmour, D. J. and Blackwood, D. J. 2011. Enhancing urban sustainability using 3D visualisation. *Proceedings of the ICE - Urban Design and Planning. 164*(3):pp.163-173.