Stakeholder involvement in wastewater treatment design

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ABSTRACT
The design option appraisal stage of new water industry capital investment projects involve greater levels of complexity than those generally encountered in other stages of the design process. It is at this stage that the issues related to sustainable development will be introduced, as decisions are multi-stakeholder and therefore decision criteria that reflect the views of a wide range of stakeholders with a range of different viewpoints need to be incorporated. This paper describes a case study which maps information flows, identifies decision criteria and evaluates the extent of stakeholder involvement in the design stage of a major UK wastewater system project. A mapping technique was developed to document and represent the flow of information during the decision making process. An in-depth study of the information flows enabled the researchers to establish the extent to which sustainability criteria were actually used. This was compared with recognised sustainability criteria identified in previous research involving the authors to allow an assessment of the effectiveness of stakeholder representation. Recommendations are given regarding ways of improving stakeholder involvement in water industry asset investment decisions.

KEYWORDS
Information flows, Stakeholders, Sustainability, Wastewater treatment design

INTRODUCTION
There are over 200 definitions of "sustainable development" (Parkin et al 2003). The UK government defines sustainable development as "*ensuring a better quality of life for everyone, now and for generations to come*" (DETR, 1999a) and is currently reviewing the approach to sustainability (Defra, 2004). The principles that it sets out take the form of four objectives, to be met concurrently: social progress which recognises the needs of everyone; effective protection of the environment; prudent use of natural resources; and, maintenance of high and stable levels of growth. A common feature of all the definitions is the recognition that the concept of sustainable development has three overlapping dimensions: environmental, social, and economic, giving rise to the triple bottom line concept. Therefore, the assessment of sustainability clearly involves the systematic evaluation of a number of diverse indicators that will require input from a wide range of stakeholders to ensure that each dimension of the triple bottom line is fully evaluated.

Sustainability indicators
The UK government proposed a set of 15 headline indicators and 132 other core indicators that have been developed based on their original principles (DETR, 1999b). Water UK, the trade body for all UK water service providers, originally developed a set of 25 indicators to measure progress towards environmental sustainability (Water UK, 2000). These have been

extended to encompass a broader definition of sustainability to include social and economic facets (Water UK, 2004).

These and a number of other similar indictors, serve a useful purpose by presenting an aggregate national picture of trends towards, or away, from sustainability. However, they must be fully integrated in a systematic manner within the design process if they are to influence the development of wastewater improvement projects. The Sustainable Water industry Asset Resource Decisions (SWARD) project (Ashley et al, 2004) explored the difficulties that water service providers face when making asset investment decisions. The primary objective of the project was to provide a means whereby the providers of water services could more effectively include the principles of sustainability within the decision-making processes. This 'enhancement' of the inclusion of sustainability had to be as transparent as possible if it was to be accessible to each of the stakeholders in any development proposal. In addition it had to fit with contemporary decision-making processes in the water industry and be cognisant of the institutional and other constraints. The output was a procedural guide that incorporated a mechanism for selecting applicable criteria from an initial set of generic criteria (Foxon et al, 2002).

Stakeholder involvement

The basis of stakeholder involvement in the design of wastewater projects is illustrated in Figure 1. The centre of the figure (the first tier) represents the decision makers and project design teams for a wastewater project within a water service provider organisation. The second tier represents the immediate customers and the communities served by the wastewater project and the third tier represents the societal, geographical and political frameworks within which the customers and communities are located. The arrows represent the required information flows across the possible boundaries if all aspects of sustainable development are to be considered by the design team.

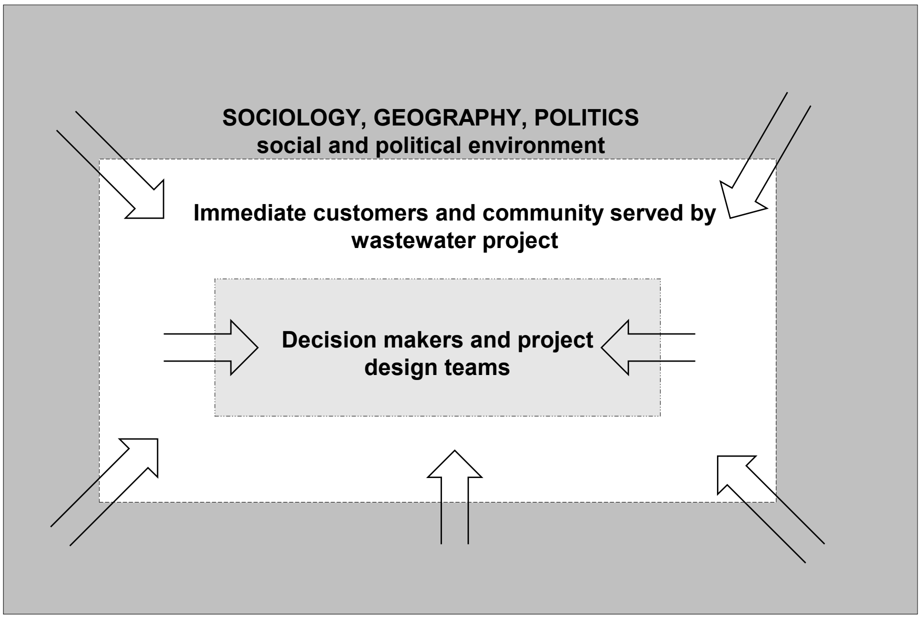

Figure 1. Wastewater project design – Stakeholder boundaries and information flows

The involvement of stakeholders in decisions on water services is of increasing importance in Europe. Wider stakeholder participation is specified in the Strategic Environmental Assessment (SEA) (e.g. Feldman et al, 2001) and the Water Framework Directive (WFD), which came into force in 2000, and deals with integrated water management based on river basins. This specifically requires member states to adopt public participation (Article 14) in water management. The Directive will have to be implemented over the next 15 years. The EU is also proposing a new Directive on 'Public Participation in Certain Plans and Programmes Relating to the Environment' - as a step towards the ratification of the June 1998 Aarhus Convention (EU, 2000).

It can be concluded that the concept of sustainability assessment provides a mechanism for expressing all the facets of a decision through its use of diverse social, economic and environmental criteria. Furthermore, the assessment of these criteria requires the involvement of a wide range of stakeholders, thereby contributing to the EU requirements on stakeholder participation in decision-making. However the extent to which this consultation and evaluation process will result in more sustainable design solutions for wastewater projects will be dependent on the use of the full range of criteria by the project designers. In order to begin to assess this, a case study project was identified and a decision process analysed to establish the extent of genuine stakeholder involvement in design decision-making. This involved an information mapping exercise to assess the interaction with stakeholders, to establish boundaries to their sphere of influence and to assess the extent of the use of pre-defined (SWARD) criteria to this process.

DEVELOPMENT OF THE INFORMATION MAPPING APPROACH

A process of decision mapping had been previous developed (Bouchart *et al.*, 2002) and applied to a water supply project. This technique utilised mainly fly-on-the–wall attendance at Value Management (VM) workshops as the source of data and the principle output was decision maps, which identified key decision points and then mapped the influence of the stakeholders on the key decision points. The focus of the Bouchart study was to provide an understanding of *how* decisions were taken. However, the purpose of the case study reported in this paper was to provide a clearer insight on the *sources and the nature of the information* that was used in reaching the decision and therefore a new approach was developed.

The approach in this study involved regarding the design and decision making process at the early stages of the design of a wastewater system as an Information System (IS). An IS can be defined as a way of using and organising information for a purpose (Checkland & Howell 1998). There are a myriad of analytical tools for the evaluation of information systems but a review of literature in this area identified the potential for the application of Data Flow Diagrams (DFD's). Data flow diagrams were initially developed by De Marco (1978) as part of his concept of structured systems analysis. He provided the following definition: "A DFD is a network representation of a system. The system may be automated, manual or mixed. The DFD portrays the system in terms of its component pieces, with all interfaces among the components indicated" *(De Marco 1978).*

The most useful characteristics of DFDs in the context of this study are that they are simple, using only a few symbols such as data flow, process, and data store and that they provide a graphic representation of the working of a process, which is a useful tool in communicating the results of a study. DFD's have been used successfully in earlier studies of construction industry processes (Baldwin et al, 1999, Winch & Carr 2001) and in a study by Roda at al (2000) who created a conceptual model of the design process for a wastewater treatment plant. However, consideration must be given to the contents of the information system, i.e. whether data or information is flowing through the process. Checkland & Howell (1998) provided definitions of data and information and a simple relationship linking them. Data are facts and figures, which can be measured, recorded and are the same irrespective of how they are looked at. Data are first transformed to 'capta' which is the data of importance to the person or group in the IS, finally capta becomes information when interpreted and used. As this study is concerned with the use of sustainability indicators the approach adopted can be best described as Information Flow Diagrams (IFDs).

CASE STUDY

The case study consisted of the initial design stages of a sewage transfer scheme for a UK town. Exiting outfalls and CSO's required to be collected by an interceptor sewer before being pumped, via pumping stations with screened CSO's, to the site of a wastewater treatment plant under construction. The method used a hierarchical set of diagrams to display the decisions, processes, files and information flows to enable these flows to be analysed for evidence of the use of sustainability criteria. At the first level, (Level 0) a context diagram was produced which represents the overall process. Each process identified at Level 0 can be studied in more detail and Level 1 IFDs produced. Sub-process at Level 1 can be similarly expanded to produce Level 2 IFDs. It was found that expansion to Level 2 enabled all the discrete items of information that might include sustainability criteria to be identified. Figure 2 shows an example of a process map for Level 1 scheme design and Table 1 explains the notation used.

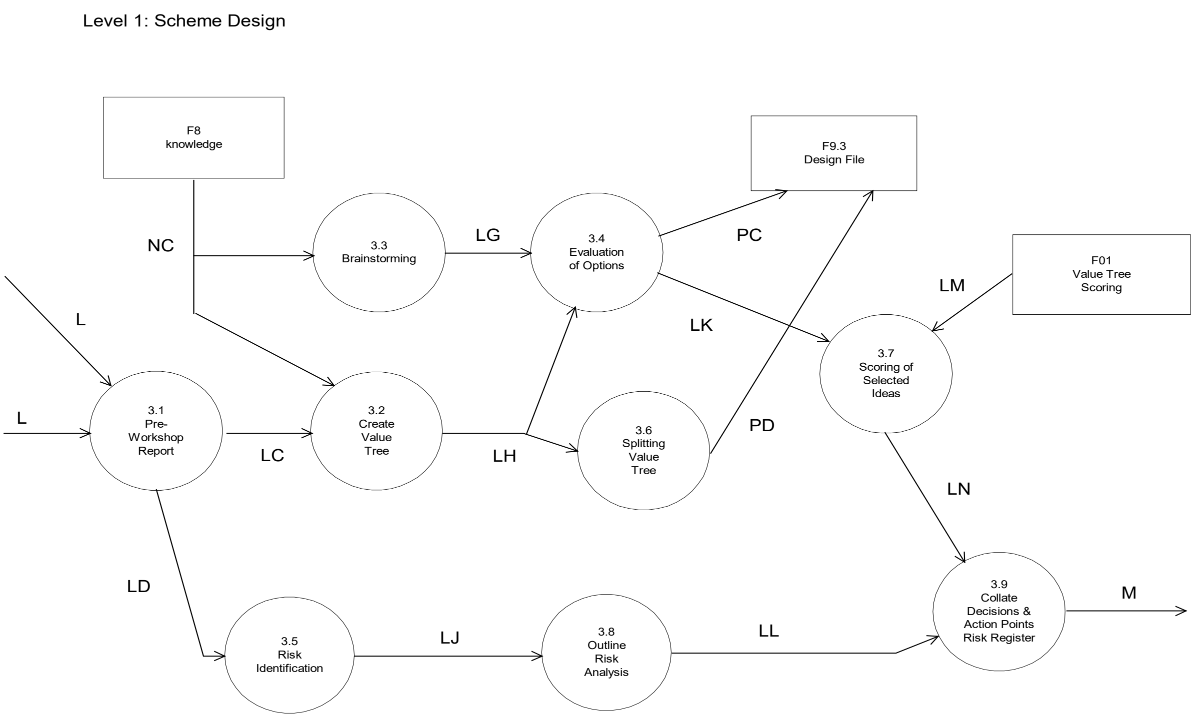

Figure 2. Example of a Level 1 Information Flow diagram

Table 1. Information Flow Diagram Notation

Symbol		Level 0	Level 1	Level 2
Information Flow	→	1 letter, A	2 letters, NC	3 letters, LHA
Process	○	1 number, 1	2 numbers, 5.2	3 numbers, 3.7.14
Information File	□	F 1 number, F4	F 2 numbers F9.6	n/a

The IFDs served two purposes. Firstly, they provided a representation of the design process that could be shown to the design team and verified. Secondly, the notation system allowed the unique identification each information flow, which to enabled all the information flows to be listed in an 'Information Dictionary', as shown in Table 2, prior to evaluation for evidence of the presence of sustainability criteria.

Table 2. Extract from Case Study Information Dictionary

Name	Letter	Source	Destination	Contents
Design brief	J	1	3.1	Outline design
Procurement decision	L	2	3.1	Budget & consultant
Project/work objectives	LC	3.1	3.2	Identified attributes
Project Parts	LD	3.1	3.5	Project components
Participant's Knowledge	NC	F8	3.2,3.3,3.5,3.8	Thoughts/opinions
Design ideas	LG	3.3	3.4	183 ideas
Value Tree	LH	3.2	3.4,3.6	Design priorities
Identified Risks	LJ	3.5	3.8	Risks
Discarded ideas	PC	3.4	F9.3	Ideas marked K
Ideas carried forward	LK	3.4	3.7	Ideas A & B
Criteria not used	PD	3.6	F9.3	Other parts of value tree
Scoring Criteria	LL	3.6	3.7	5 criteria
Analysed risks	LM	3.8	3.9	Risks & potential costs
Idea scoring method	LN	F01	3.7	Formula
Value Index Table	LP	3.7	3.9	Ideas & cost benefits
Project objectives	M	3.9	4	Design information

The data collection began with interviews with key personnel in the design team to enable a draft level 0 IFD to be produced. Follow up interviews were undertaken with the full design team to establish the validity of the diagram and to identify in more detail the nature of information used by the designers. Once the Level 0 diagram was fully verified, the Level 1 and 2 IFDs were produced in a similar fashion. Initially, it was envisaged that simple diagrams such as Figure 2 would be produced at all levels but it was realised that some diagrams at level 2 would require over 100 processes and flows which was impractical in some cases. Hence these were designated as *multiple* flows, where one name is used to designate more than one 'real' flow. The letter X was added at the end of a flow name to demonstrate this, for example LHX is a level 2 multiple flow of the level 1 flow LH.

In addition to constructing the IFDs, the nature of the information flows were determined during the interviews and logged on a spreadsheet to complete the Information Dictionary (as illustrated Table 2). The entry for each information flow included their reference codes, sources and destinations, and a brief description of their contents. The content of the information flow varied and included memoranda, technical reports, correspondence and reports on value management workshops for the projects. These contents were then reviewed to seek evidence of use of SWARD sustainability indicators in the decision making process. For example, there was reference to a section in a Value Management workshop report, which in considering design options, discussed their maintenance requirements. This fitted SWARD Criteria: Primary Criteria- Life Cycle Costs, Secondary Criteria- Maintenance Costs, Indicators- £ per catchment per annum (Foxon et al, 2002).

Table 4 presents the results of the analysis of the contents of the information flows identified in the data dictionary.

Table 4. Extract from the Criteria Flow Table

	Economic												Technical												Social															Environmental													
Letter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
A																X						X		X																													X
B	X	X	X							X	X	X			X						X	X	X	X	X																												
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J	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
M	X	X	X							X	X	X				x						x		X																			#			X							X
N																																																					
P		X													X						X	X	X	X	X						X	X									X		X				#						
Q	X	X	X							X	X	X				X						X	X	X																			#			X							X
R	X	X										X			X	X							X	X																X					X	X							X
T			X																																										X								
W(R)	X	X										X			X	X							X	X																X					X	X							X
AH																X						X																															X
AJ	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
AK	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
AL	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
AM																																																					
AN	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
AP	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
AQ	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
AR																																																					
DB																																																					
BA(B)	X	X	X							X	X	X			X						X	X	X	X	X																												
CA																																																					
DA																																																					
EA																																																					
GA																																																					
AT	X	X	X							X	X	X			X	X					X	X	X	X	X																												X
LC	X	X													X							X	X		X																												
LD																																																					
NC																																																					
LG	X	X								X		X			X	X					X	X	X	X																	X		X#		#	X	#						X
LH	X	X													X									X	X		X				X	X											X										
LJ	X	X		X						X	X	X												X	X																					X							X
PC															X						X	X	X	X																	X						#						
LK(A-P)	X	X								X		X				X						X		X																			#		#	X							X
LL	X	X													X									X			X																										
PD		X																							X						X	X											X										
LM	X	X		X						X	X	X												X																						X							X
LN																																																					
LP(A-P)	X	x								x		x				x						x		x																			#			x							x

The headings in row 1 refer to SWARD sustainability criteria groupings and the numbers to specific SWARD Sustainability Criteria. The information flows are listed in the first column and a cross in the other columns indicates where criteria have been identified in the content of the information flow. This Criteria Flow Table allows the reader to see clearly how frequently each criteria and group of criteria are used and how this usage changes during the design process.

DISCUSSION OF RESULTS OF THE CASE STUDY

The Criteria Flow Table indicates that sustainability criteria are included in the decision making within the design process. In all, 30 of the 58 criteria were found at least once. The most frequently occurring were the Economic, Technical and certain Environmental Criteria. Some of these enter the process at, or near the beginning and run all the way through. These are mainly related to costs reduction, risk and environmental impacts and maintaining flexibility and build quality.

It was also clear that the Environmental Criteria were fed into the process from the various legislation and directives that the waste water system is seeking to satisfy. The Economic Criteria cannot be so easily traced, although they do continue to enter the design process up to and including the value management workshops. The lack of an obvious source for these criteria suggests that the economic aspects of the decision are axiomatic to the design engineers, arising from their education, training and working experience. A similar explanation may account for the concentration on risk. Risk and costs are closely linked, risks need to be minimised to reduce possible over-spend, i.e. reduce costs. Most Technical Criteria can be similarly traced.

Other criteria, in particular the Social Criteria occur rarely and seem to be introduced later in the process and do not seem to have been given full consideration. Two Social Criteria were seen entering the process in a value engineering workshop but then exiting in the discarded ideas flows. The criteria were not used in the process and were not transferred for use any subsequent processes decisions.

CONCLUSIONS

This methodology provides a useful representation of the information flows for a complex stage of a new water industry capital investment project. The accuracy of the IFDs and completeness of the Criteria Flow Table were verified by the design team. Additionally, the nature of the criteria being used confirmed the findings of previous decision mapping exercises undertaken during the SWARD project. Therefore, whilst the results of this study may be case specific, some tentative conclusions can be drawn on stakeholder input to the early design stages of wastewater projects.

Figure 1 proposed that three tiers of stakeholder involvement were required to enable full consideration of the principles of sustainable development. However, this study has shown that sustainability criteria enter the design process from two tiers only. Environmental Criteria are introduced from environmental legislation, (the outer tier in Figure 1) and Economic and Technical Criteria are embedded in the process through the education, training and experience of the design team (the inner tier in figure 1). In contrast, there appears to be a minimal interface between the designer and their customers in the wider community (the middle box of figure 1) from where the majority of the Social Criteria might be expected to arise, although some social aspirations may be included indirectly through the environmental legislation.

Overall the research suggest that the current practices and processes of early stage design for wastewater projects are not amenable to the full consideration of the principles of sustainable development due to an insufficient evaluation of the social dimension of sustainability. The IFDs suggest a lack of direct engagement by design teams with the customers and communities that they serve. Fortunately, the WFD has highlighted the need for such consultation and provides an opportunity for greater integration with all stakeholders in future. It is essential, however, that the results of the consultations are fed into the design process and it is recommended that the creation of agreed Social Criteria and their measurement should form an important element of all future consultation.

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