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Incorporating the Social Dimension into the Assessment of Urban Water Services: with a particular focus on Greenfield developments

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Urban water systems are provided for supplying safe drinking water, flood mitigation and collection, treatment and disposal of wastewaters. These systems as name suggests have, multiple functions, components and interactions. Whilst previous management paradigms were relatively straightforward, focussing on a very limited set of goals, i.e. avoiding unhygienic conditions, removing storm water and avoiding damage from flooding; an increasing focus on sustainability has prompted the adoption of a systems perspective, which is well described by Hellström et al (2000). Adopting sustainability principles in urban water management involves consideration of the following six points that underpin Sustainable Urban Water Management (SUWM) (adapted from Brown et al 2007 that have identified the following based on a literature review):

1. There needs to be a consideration of all parts of the water cycle as an integrated and inter-connected system;
2. There needs to be an acceptance of the multiple purposes of water use; and flexible and multiple solutions;
3. Context is importance, and therefore all perspectives need to be considered (environmental, economic, social, cultural, political and institutional);
4. Public participation in planning and decision making is critical;
5. Programs, projects and policies need to be considered over long time frames by a common vision; and
6. An interdisciplinary approach is required.

Sharma et al (2008) have operationalised the framework described by Hellström et al (2000) and applied it to a Greenfield development in Melbourne, Australia. However, the method applied by Sharma et al (2008) partly considers the points above, as it focuses primarily on environmental and economic aspects. In particular it is lacking in the area of 1) consideration of all the multiple purposes of water use, such as recreational purposes, household gardening and for green spaces etc; 2) the social, cultural, political and institutional context; 3) public participation in the planning and decision making; and 4) consideration of a long time frame and a common vision, i.e. ensuring that no damaging and irreversible changes are made to ecosystems or the environment, and not to get locked into solutions that do not have adaptive ability for adjusting to future requirements. To build on an operational framework developed by Sharma et al (2008) building on that developed by Hellström et al (2000), this document will explore how to incorporate aspects of multiple water users, social political and institutional context, public participation in planning and decision making, and a long time frame and vision.

2. CONTEXT OF WATER MANAGEMENT IN GREENFIELD DEVELOPMENTS

Much of the population growth in cities like Melbourne occurs in the urban fringe; in areas that are previously undeveloped. Such developments are referred to as Greenfield Developments, while developments in built up suburbs are referred to as Infill Developments. When providing water services to Greenfield developments, the normal limitations and existing infrastructure constraints do not apply, and the developer has greater flexibility in the choice of infrastructure and service provision options.

For example, Mitchell et al (2003) describe a study of Heathwood in Brisbane, Queensland, which demonstrates how a Greenfield development can "*take an integrated approach to the provision and management of urban water services and produce an outcome that is more sustainable*". In fact there is an emerging trend to apply state-of-the-art water technology in Greenfield developments and the informative web site www.yourdevelompent.org lists five such developments, including better known ones such as Mawson Lakes in South Australia, the New Rouse Hill in New South Wales and Aurora in Victoria. It is believed that many more will follow into the future. The Naiad web site, www.naiad.net.au, sponsored by the CRC for Water Quality and Treatment also has a significant amount of information on similar types of developments.

Mitchell et al (2003) lists the advantages in terms of the water cycle, i.e. to:

1. Minimize potable water supplied to the site
2. Minimize wastewater flowing from the site; and
3. Mimic pre-development stormwater flows.

Presenting one of the well-known Australian cases of a state-of-the-art water sensitive Greenfield development in Aurora near Melbourne, McLean (2003) describes the water system features that have been implemented, such as:

- Demand management;
- Rain gardens;
- Rainwater tanks;
- Bioretention trenches;
- Swales at the streetscape scale;
- On-site wastewater treatment plant;
- Dual water reticulation system at the estate scale.

With this suite of measures, the volume of potable water needed to be pumped to the site is reduced by 70%; and the volume of wastewater reused means that discharges to the Port Phillip Bay would reduce by more than 90%. However, obviously the concern of water management is only one of the considerations in these developments, and www.yourdevelopment.org in fact lists a number of considerations that critical in designing sustainable Greenfield developments:

- Design for open space that meets the needs of residents and surrounding habitats, as well as a variety of recreational opportunities;
- Walkable neighbourhoods, reducing the incentives to drive;
- Safety, adhering to principles that promote safer communities;
- Considering issues of climate change, and in particular heat and risk of fire;
- Public transport and innovative transport modes;
- Density of the development with implications for the urban form, housing types etc.

We note that the design of open spaces and walkable neighbourhoods, as well as the consideration of the risk of fire is likely to have implications in terms of the water cycle. Other key implications of water servicing options relate to total costs, distribution of costs between stakeholders, operation and maintenance schedules, public health risks for community and animals, and distribution of responsibilities and roles. There is also a concern about efficient regulation in a situation where, as in the case of decentralised technology, the community takes an increasingly important role in management.

3. RESEARCH CONTEXT AND GOAL

Sharma et al (2009) have developed a framework as per Figure 1, for environmental and economic assessment of urban water services for the context of Greenfield developments. This is a stepped approach, with the following activities:

1. Understand the development specific local conditions and environment;
2. Establish development specific objectives;
3. Select sustainability assessment criteria;
4. Select water servicing options;
5. Develop water servicing scenarios;
6. Analysis and evaluation of scenarios based on water and contaminant balance;
7. Evaluate scenarios as per service objectives;
8. Conduct conceptual design of infrastructure;
9. Conduct Lifecycle Cost scenarios;
10. Assessment of scenarios against sustainability criteria;
11. Rank the scenarios based on assessment;
12. Present the ranking for social acceptance and community input;
13. Select the preferred servicing scenario.

This framework has been applied to a number of case studies, such as the Kalkallo suburb in Melbourne. It has however been argued that this framework does not incorporate social aspects in the framework for the assessment of servicing options. This report attempts to provide a better understanding of how community values can be incorporated.

As a starting point towards responding to this challenge, and what it means, we first need to define why we need to extend the framework. We have decided to frame it in terms of SUWM which is generally perceived as a goal in the sector. Therefore we have chosen to evaluate the approach against six conditions listed by Brown et al (2007) based on a literature review on SUWM, as shown in the Table below.

Sustainability condition	**Fulfilment**
Consideration of all parts of the water cycle as an integrated and inter-connected system	This condition is fulfilled considering the total water cycle and integrated urban water management approaches. The applications of models such as Aquacycle (http://mail.toolkit.net.au/mailman/listinfo/aquacycle/), and other frameworks are implemented.
An acceptance of the multiple purposes of water use; and flexible and multiple solutions	The alternative resources based on fit for purpose concept are considered in the planning. Whilst in theory, development specific objectives can be set up to incorporate these; in practice objectives mostly relate to resource efficiency and financial efficiency. The interests of the local future community are usually likely be looked after by the developer on commercial grounds, however planning policies would mandate flexible and multiple solutions. Some aspects of local ecology are considered in this study.
Context is importance, and therefore all perspectives need to be considered	Only certain perspectives are considered, namely climate, proposed allotment size, anticipated occupancy rate and available water resources,

(environmental, social, cultural, political and institutional)	which would cover environmental and economic aspects. Need to take into account social, cultural and political including some institutional perspectives.
Public participation in planning and decision making is critical	Public participation is only present in points 4, 5 and 12 (see Figure 1) of the framework developed which is probably inefficient as a public participation component. The difficulty is of course that there is no pre-existing community to consult with.
Programs, projects and policies need to be considered over long time frames by a common vision	There is little consideration of the development other than in terms of the installation and parts of the operation. Maintenance aspects and long-term health risks are not considered in detail; that may be critical in the longer time frame.
An interdisciplinary approach is required	The approach is mainly from the engineering considerations, and in fact whilst environmental and economic perspectives are considered to some extent; the approach can not be considered fully inter-disciplinary. At least not in the sense of drawing from all relevant disciplines.

We do note that the framework specified by Sharma et al (2009) has to be extended to incorporate other sustainability requirements. This leads us to state our research question: **"*How can we modify the proposed framework to better align with SUWM criteria as define above?*"**

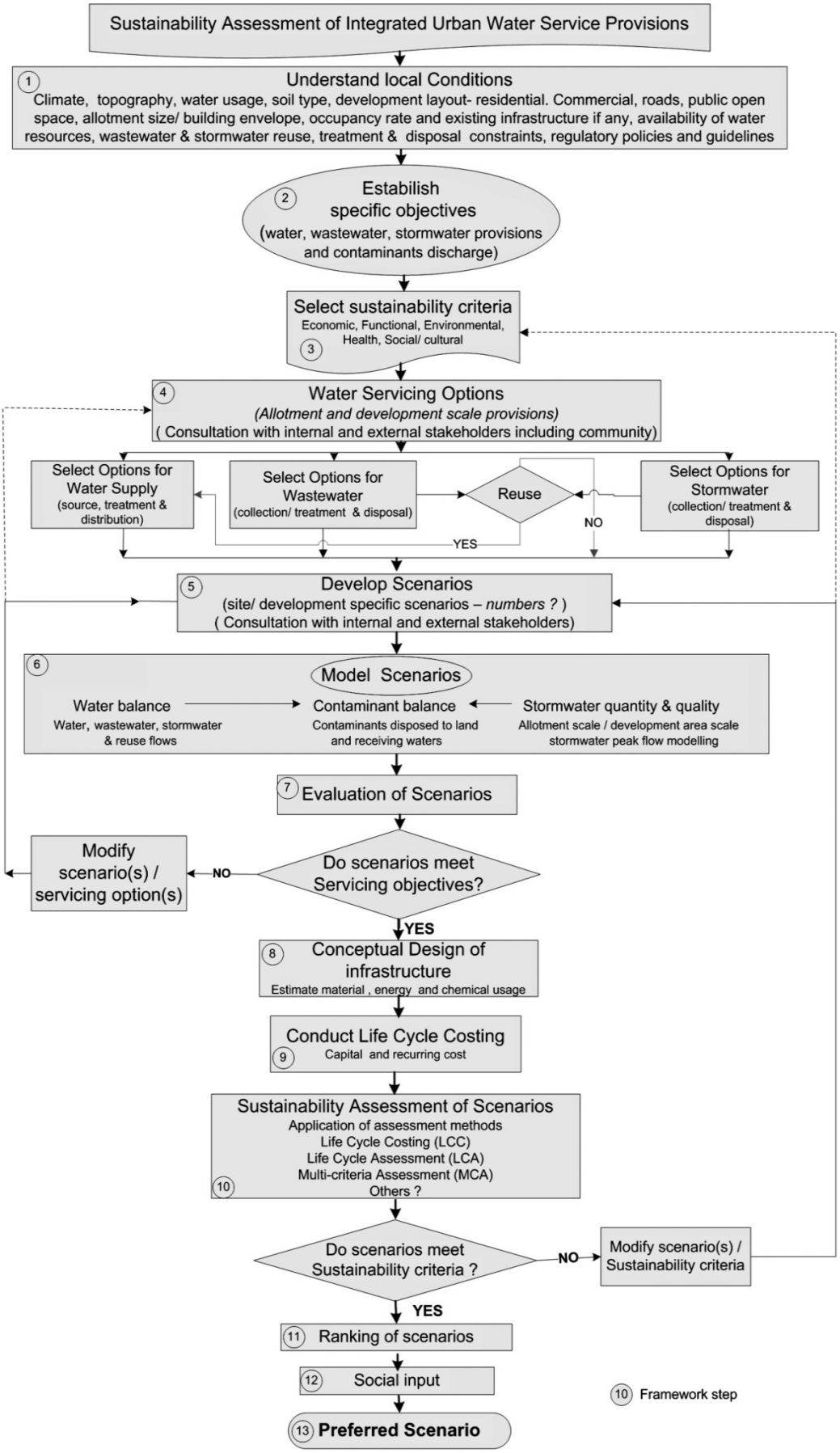

Figure 1: Assessment framework described by Sharma et al (2009)

4. PROCESS OF STUDY

In order to tackle this research question, we will carry out the following sequence of tasks:

1. Review the literature on the social and institutional perspectives of urban water systems, that are relevant in the context of greenfield developments to:
    a. Identify key themes
    b. Identify key actors and stakeholders
2. Carry out grounded theory analysis in order to identify concepts / themes and key variables that are relevant for the description of these perspectives;
3. Facilitate a workshop with a selection of key experts in order to reduce scope to a smaller and manageable number of relevant variables;
4. Embed such variables in a systems analysis framework in order to allow these being embedded into the wider assessment methodology.

In this report, we will firstly describe some of the literature of task 1; and secondly describe two candidate systems analysis frameworks that could be used. A workshop will be undertaken to help with task 3 and the choice of systems analysis framework.

5. WHAT IS THE SOCIAL DIMENSION IN URBAN WATER SERVICES?

It is not immediately clear what is entailed in the social dimension of urban water services, and the relative benefits and disadvantages of various urban water servicing options. Whilst we have already seen what Brown *et al* (2007) considers as being important in SUWM, let us now use literature to identify in more detail what social aspects may be incorporated into assessment frameworks. Such aspects will here be referred to as topic domains. Topic domains are broad topic themes relating to the social dimension of urban water systems, such as for example the common theme of public participation. In this section, we aim to 1) identify topic domains, and 2) identify links between topic domains. Such links may for example be causal relationships, non-linear influences, probabilistic tendencies or statistical correlation.
As is shown in a literature review by Russell and Lux (2006), there has been a multitude of studies on the issue of social acceptance of water recycling. In this document, we will describe a number of such studies.

CSIRO Arcwis

In one of the more advanced attempts to consider this issue, Leviston *et al* (2006) have focussed on whether a given water supply system is acceptable to community members. Using this perspective they have identified the following topic domains:

- "*Community Trust: trust in the authorities to reliably provide good, safe and well-managed water.*
- *Perceptions of Equity and Fairness: perceptions of fairness to specific groups of users as well as the overall fairness of the water supply system.*
- *Risk Perception: perceptions of risks posed by the water supply system to self, family, city and the environment.*
- *Perceived Outcomes: cognitive perceptions of outcomes relating to the sustainability, longevity, responsibility, certainty and appeal of the water supply system.*
- *Subjective Assessment: a weighted judgement of the overall risks of the water supply system versus its benefits.*

- *Personal Values: values that relate to water consumption and attitudes to water, including lifestyle preferences, conservation attitudes, intergenerational equity, levels of service and garden recreation.*
- *Acceptability: a rating of the overall acceptability of the water supply system.*

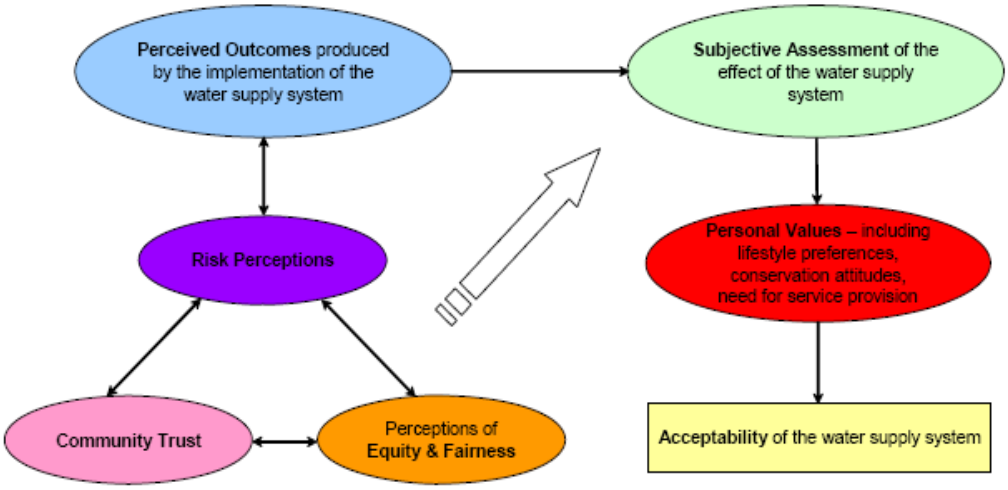

Figure 2: Hypothesized model of community acceptability of an urban water system (adapted from Leviston and colleagues, 2006)

Figure 2 shows how the topic domains identified by Leviston et al (2006) are inter-related and affecting the acceptability of the water supply system.
These topic domains are obviously inter-related as shown in Figure 2. As can be seen, the personal values are also broken up into lifestyle preferences, conservation attitudes, and the appreciation of green areas and recreation activities. By using survey input into a structural equations modelling approach, they have quantified the strengths of various links. Based on this, they have come to the following conclusions:

- Higher levels of trust in water authorities are associated with perceiving less risk in the water supply system;
- Higher levels of trust in water authorities are associated with perceiving the system as fair;
- Higher levels of perceived risk are associated with perceiving the system as unfair;
- Greater perceived risk in the water supply system leads directly to:
    - A perception of less sustainable outcomes resulting from the water supply system; and
    - A subjective assessment that the problems of the water supply system outweigh the benefits;
- A greater perception that the water supply system is fair and equitable leads directly to
    - A perception of more sustainable outcomes resulting from the water supply system;
    - A subjective assessment that the benefits of the water supply system outweigh the problems; and
    - A greater acceptability of the water supply system;
- The perception that the benefits of the water supply system outweigh its problems leads directly to greater acceptability of the water supply system.
- The perception of more sustainable outcomes resulting from the water supply system leads directly to greater acceptability of the water supply system.

It is however worth noting that slightly different conclusions and strengths of the relationships were found for different locations. Household survey data was collected from Sydney, Melbourne and Brisbane in Australia.

Mistra Urban Water program in Sweden

In a paper from the Mistra Urban Water program in Sweden, an urban water system has been assessed from a socio-cultural perspective (Söderberg and Åberg, 2002). They apply a systems ecology methodology and identify a number of crucial socio-cultural aspects to consider for sustainable urban water systems. They define the urban water system as comprising of three different sub-systems, i.e. users, the organization, and the technology. The users and the technology are here fairly straightforward to define, whilst the organization is somewhat more abstract. They argue that the organisation is strongly context dependent, but generally incorporates distribution of responsibilities (ownership, financing, decision making, operation and maintenance) among actors in the system. They further identify important aspects / topic domains relating to the organization:

- Organizational capacity, i.e. a "*structured and organized ability to manage discussions, conflicts, formulate goals, make decisions, involve stakeholders, divide responsibility, sanction the one's who disobey, etc*"
- Adaptability, i.e. "*the system's ability to handle and adapt to influences from all its related systems*". This is an important criterion for complex, adaptive systems with self-organising capabilities.

They also note a number of important aspects / topic domains relating to the users, similar to that identified by the CSIRO Arcwis team, i.e. the households':

- Motivation, which may be "*perceived as a positive attitude towards the act that, in turn, reflects personal and normative believes which in turn encompass a range of various aspects such as risks and distribution of responsibility*"
- Ability, "*relates to the availability of immaterial resources in the household that, in this case, may imply that the household managerial system is capable of changing and maintaining common routines."*
- Opportunity, *"aims towards the physical conditions that to a high extent are influenced by the institutional and technical structure of the programme"*

They also list a number of sub-criteria/topic domains for each of these issues, as shown in Table 1.

Table 1: Topic domains that are part of the model

Organization		*Users*		
Organizational capacity	*Adaptability*	*Motivation*	*Ability*	*Opportunity*
Involvement of stakeholders in the process	Coherent formal regulations	Attitudes, beliefs etc	Knowledge	Technical and organisational infrastructure
Conflict management	Coherent political visions	Norms	Routines	Robustness
Division of responsibilities	Coherent regulations		Household decision making and managerial	Transparency

			strategies	
Feedback	A place to meet physically and mentally			Adaptability towards household routines
Operation and maintenance				Distribution of responsibility

We also note that the "technical and organizational infrastructure" may also be part of the organizational capacity, in the case when the technology is more demanding and novel.

Hurlimann and colleagues

Hurlimann and colleagues have undertaken research on the perception of risk involved with recycled water schemes, and how this translates to whether or not individuals and the community accepts such schemes (Hurlimann and McKay, 2006; Hurlimann, 2007). She argues that without community acceptance, recycled water projects have indeed sometimes failed. Further, what seem to have a critical influence are the perceptions of risk and trust (Hurlimann, 2007). The perception of risk of a particular project has been found to be influenced by a number of factors (Hurlimann, 2007):

- Based on a number of studies, the public are less favourable toward recycled water the closer the use is to personal contact;
- Based on experiences in the UK, Lack of appropriate monitoring or control over the wastewater quality is another important stated risk;
- The main areas of risk concern are issues of safety for children and animals;

Perception of risk was also found to be strongly linked to (Hurlimann, 2007):

- Trust in the water authority,
- The extent of information provided to community members; and a
- Process for implementation that is perceived as fair.

Adding another aspect into the mix, a number of particular water attributes were found to be important, depending on the particular use, for influencing the acceptance of recycled water schemes (Hurlimann and McKay, 2006):

- Colour of water;
- Odour of water;
- Salt content of water;
- Availability, i.e. exempt from restrictions;
- Good pressure;
- High nutrients levels, requiring less fertilizer.

However, the importance of these factors also depend on the particular use that the water is for, i.e. gardening, drinking, clothes washing and toilet flushing etc. Actual ratings of the importance of these factors for these uses have been established based on a survey in Mawson Lakes, a greenfield development in Adelaide, South Australia.

Marks and colleagues

Marks and Zadoroznyj started their explorations with a study of social factors relating to water recycling. They based this on four case studies in the US and Australia

using face to face interviews as the main research tool. The focus of this study is primarily on the issue of trust. Initially Marks and Zadoroznyj argue that in the modern era, water has been delivered by what they characterize as “abstract systems” that are not well understood by customers, and users of these systems have little control over them (Marks and Zadoroznyj, 2005). This is however changing with the introduction of decentralised systems such as residential reuse (Marks and Zadoroznyj, 2005). They further argue that this turn creates new problems relating to public health risk, and related basic trust in the household water supply (Marks and Zadoroznyj, 2005). A number of topic domains were identified / used in this study:

- Type of organization: i.e. decentralised, centralised
- Scale of development, i.e. neighbourhood, whole suburb or metropolitan;
- Connection cost and charges;
- Awareness of regulations and rules;
- Stability through enforcement rules;
- Transparency of governance;
- Familiarity with the changed environment through formal communications;
- Accountability of persons and institutions.

Additionally a number of variables are used to describe the social actors:

- Collective capital, including social capital forged through social networks, and cultural capital;
- Social capital, the extent to which the community is reactive or proactive on these issues, and whether they work together;
- Environmental awareness, i.e. understanding of the environmental drivers for the type of development;
- Seeing benefits of residential reuse, i.e. do they perceive that there is benefit with the scheme;
- Health risk concerns, i.e. is there a perceived risk of health problems.

This all adds up to trust in the scheme, and to a “social mood”. In another paper based on related research they argue that (Marks 2006):

> *Effective public consultation involves respectful deliberation that promotes community involvement in the process. This contrasts with the alienating approach of strategic communication employed to market or ‘educate’ the public in Decide, Advise, Defend experiences that reduce public involvement to tokenism. Further, processes that put chosen consultation groups ahead of wider public participation will generate distrust regardless of whether the final decision is ‘right’ or ‘best’. Therefore, democratising power relations between the centre and the local level will aid in the delivery of sustainable outcomes.*

From this we identify a number of topic domains / variables relating to the issue of public participation:

- Respectfulness, ranging from
    - Respectful deliberation, to
    - Alienating approach of strategic communication (tokenism)
- Type of inclusion, ranging from
    - Chosen consultation groups
    - Wider public participation
- Power relations, ranging from
    - Democratized between the centre and local level; to

- Power relations between centre and local level (we tell you what to do)

They also argue that (Marks 2006):

> *To guide the day to day management of residential reuse, consideration should be given to institutionalizing residents' or home owners' associations to assist in keeping householders informed, to monitor rule compliance for the safe use of the water , and to generate feedback from local experience to improve the system.*

Based on this, we identify another set of topic domains, or variables:

- Keeping residents informed on a regular basis;
- Home owners' associations;
- Monitoring of rule compliance; and
- Feedback from local experience.

Additionally it is argued that (Marks 2006):

> *In the case of non potable reuse it has been illustrated that retrofitting reclaimed water for even common garden irrigation, should be approached with caution. Community involvement is required to assist in updating plumbing plans and cooperating with inspections to identify past plumbing violations*.

From this we identify, the following topic domains:

- Updating plumbing plans
- Inspections to identify past plumbing violations.

This last paper is very useful in providing some guidance on the type of public participation that is required in order to establish trust in the system, and in fact also a more reliable and suitable system.

6. KEY TOPIC DOMAINS – ONTOLOGICAL DEFINITION

We note that a number of key themes have already been identified in previous research, i.e. relating to:

- Organizational capacity
- Household capacity
- Health risk perceptions
- Social mood
- Public participation
- Water attributes

These are shown in Figure 3 below.

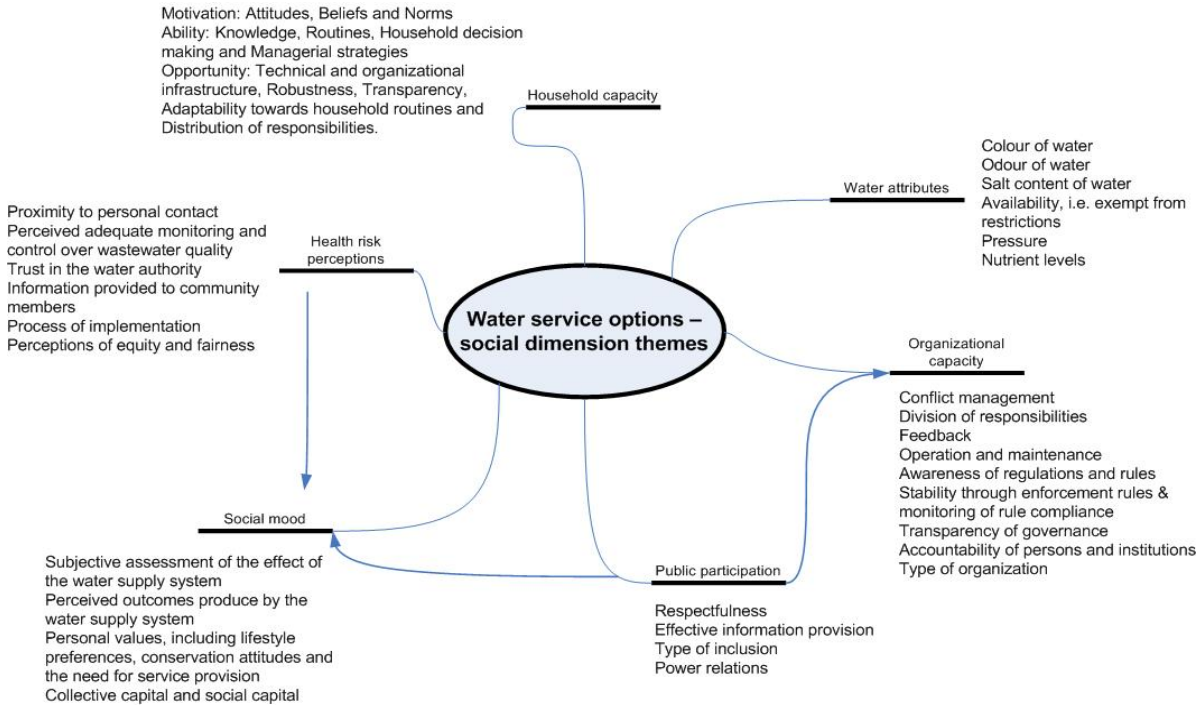

Figure 3: Themes for the social dimension relating to water servicing options

Organizational capacity

This is described by Söderberg and Åberg (2002) as: "*structured and organized ability to manage discussions, conflicts, formulate goals, make decisions, involve stakeholders, divide responsibility, sanction the one's who disobey, etc*". Within this category, the following themes have been identified:

- Conflict management
- Division of responsibilities
- Feedback
- Operation and maintenance
- Awareness of regulations and rules
- Stability through enforcement rules & monitoring of rule compliance
- Transparency of governance
- Accountability of persons and institutions
- Type of organization

Another related aspect raised by Söderberg and Åberg (2002) is the *Adaptability.* This aspect relates to the "*system's ability to handle and adapt to influences from all its related systems*" (Söderberg and Åberg 2002, p.205) and is justified under the assumption that we are dealing with a Complex and Adaptive systems with self organizing properties as is often the case in the sphere of human interactions that are in inter-play with physical systems. The adaptability is particularly concerned with systems interactions, between the water system and other system; and between the water system and governance system and is therefore focussing on setting up cross scale interactions:

- Coherent formal regulations;
- Coherent political visions;
- Coherent regulations;
- A place to meet physically and mentally;
- Feedback from local experience.

Household capacity

The following themes have been identified:

- Motivation
    - Attitudes
    - Beliefs and
    - Norms
- Ability
    - Knowledge
    - Routines
    - Household decision making and
    - Managerial strategies
- Opportunity
    - Technical and organizational infrastructure
    - Robustness
    - Transparency
    - Adaptability towards household routines
    - Distribution of responsibilities.

These topic domains are based mainly on Söderberg and Åberg (2002) and are described above. They have been shown to impact on the uptake of technologies and use of recycled water. The household also needs the ability to manage the technology, which demands clear roles and decision making, as well as knowledge and suitable routines. It is also claimed that to some degree one of these categories may replace another. In other words, a weak motivation may be compensated by good opportunities, and vice versa.

Health risk perceptions

Given the complexity and uncertainty about health risks related to water use, the perception of health risk concerns seems to be more important than actual health risk, which is in the case of wastewater reuse is influenced by:

- Proximity to personal contact;
- Perceived adequate monitoring and control over wastewater quality;
- Trust in the water authority;
- Information provided to community members;
- Process of implementation;
- Perceptions of equity and fairness.

These issues have been discussed by most of the above contributors, and the relationships concerning this have been relatively well studied.

Social mood

The social mood relates to the overall feeling of the community towards the water servicing system, i.e. considering the following themes:

- Subjective assessment of the effect of the water supply system;
- Perceived outcomes produce by the water supply system;
- Personal values, including lifestyle preferences, conservation attitudes and the need for service provision;
- Collective capital and social capital;
- Effective public consultation and respectful deliberation.

The social mood is a complex issue which relies on the interaction between individuals' attitudes, values and beliefs and a collective debate about the water servicing scheme; which may be more or less contentious depending on the chosen technology. How a particular community responds to a particular urban water servicing option also seems to be somewhat unpredictable and dependent on various lobby groups' satisfaction or dissatisfaction. It relies upon a kind of political game to be played in order to sway the social mood, but effective public consultation and respectful deliberation will be a key tool in working with the community, and thereby somewhat managing the social mood. This needs to be done in a collaborative sense rather than in a manipulative sense.

Public participation

The social mood and the perception of risk are both dependent on the public participation in the process, which has the following themes:

- Respectfulness
- Effective information provision
- Type of inclusion
- Power relations

We also note that this is where there is opportunity for all stakeholders to be involved in the process.

Public participation is a very common theme in the wider literature on water management and has been stated as a key component in water management in the Dublin principles (ICWE 1992). In the wider water literature public participation the reasons for involving stakeholders may be (adapted from Mostert 2003 and HarmoniCOP 2005):

1. There is a need for high levels of cooperation and considerable reliance on stakeholder behaviour for success;
    a. Allow stakeholders to contribute in decision making and improve the quality of plans, designs and projects by making appropriate to their needs and values
    b. Meet legal requirements
2. There are considerable disagreements about the issues at stake, to avoid conflict:
    a. Promote active citizenship and reduce the gap between citizens and planners
    b. Make implementation smoother; i.e. avoid delays, litigation, or blocking of projects
    c. To find solutions that are acceptable and rewarding to the range of diverse stakeholders
3. The issues are important enough to motivate people to participate:
    a. Involve stakeholders that are affected or have interests in the issues at stake; i.e. for "moral" reasons and to maximize benefits of interventions.

When stakeholder participation is sought, there is a wide range of engagement issues that must be considered, and it is critical that stakeholder expectations, scope and process facilitation are carefully managed. In choosing a level and type of engagement, key process decisions are:

1. What is the scope of the issue/problem? In other words, what problems are being addressed (and how are they defined), and is there disagreement about what needs to be addressed? Who has the final say about the scope?
2. Who should be included in the process?
3. Is there a need for a professional and neutral facilitator? Having a professional and independent facilitator is often seen as critical for ensuring legitimacy of the process.
4. How is on-going participation and momentum ensured? Is it appropriate to add incentives for critical stakeholders to participate? Are the participants sufficiently motivated to be involved in the long run?
5. How to deal with surprises? It is important in participatory processes to adapt and learn from surprises rather than being rigid. In this way, threats can be turned into opportunities.
6. What is the appropriate size of the group? Factors to consider here are:
    a. To maximize the diversity of the group to provide as broad a perspective as possible
    b. To limit the size in order to improve capacity for learning
    c. To maximize the ability to make projects happen
7. How to store information and data? Engagement processes tend to generate large quantities of data such as notes, recordings, decisions and reports. A note taker needs to be assigned, and information management routines developed.

Water attributes

The following themes have been identified:

- Colour of water
- Odour of water
- Salt content of water
- Availability, i.e. exempt from restrictions
- Pressure
- Nutrient levels

These water attributes have been identified by Hurlimann, and are critical in terms of what water may be used for, i.e. garden watering, toilet flushing and clothes washing. These attributes have been shown to impact on uptake of water recycling.

7. MAPPING OF ACTORS

When evaluating the socio-cultural aspect of urban water systems, we have decided to consider aspects of:

- Multiple water uses,
- Social, political and institutional context,
- Public participation in planning and decision making, as well as
- Intergenerational goals and vision.

We have subsequently reviewed a number of studies that have explored such aspects by exploring and identifying key variables and topic domains that relate to these aspects. However, it is impossible to take these aspects into account without considering whom the actors are that are involved. In the described studies (Leviston et al 2006; McLean 2004; Hurlimann and McKay 2006; Hurlimann 2007; Mitchell et al

2003; Söderberg et al 2002), we have identified the following actor categories, as shown in Figure 4:

- Water authority, i.e. the institution with the responsibility to provide water and sanitation services to the community; and in particular
    - Engineers responsible for maintaining and operating the infrastructure;
    - Accountants that keep track of expenses and costs;
- State and Federal Governments,
    - Providing policies that among other things enable/facilitate for increased levels of recycling and more sustainable communities; and
    - Regulating among other things the application of water and sewer technologies and services;
    - Providing funding for developments;
- Residents who live in the greenfield development sites, and these in particular include:
    - Individuals with pro-environmental attitudes;
    - Groups of individuals who, for recreational purposes, use facilities/features that are impacted by the water system design;
    - Residents' associations or informal collaborative networks;
    - Children;
    - Animals / pets;
- Non-residential water users, i.e.
    - Irrigators of parks and gardens;
    - Industry
    - Agricultural users.
- Local councils who play a key role in negotiations and planning of the sites, ideally looking after the best interest of their entire community;
- Technologists, i.e. engineering contractors and those providing technologies; including:
    - Providers of technology;
    - Tradesmen that manage/operate/maintain the technology;
- Developers and their contractors, i.e. the commercial organization that develops the site for profit; including
    - Builders responsible for the construction of the site;
    - Plumbers responsible for plumbing on site;
- Academics, i.e. those that undertake surveys and studies to increase our understanding of these development sites.

This map of actors in Figure 4 will be used for two purposes:

- Helping to identify different perspectives that need to be incorporated into the socio-cultural and institutional aspects of urban water systems in greenfield developments;
- To be potentially incorporated into modelling approaches that are required in order to allow for scenario analysis.

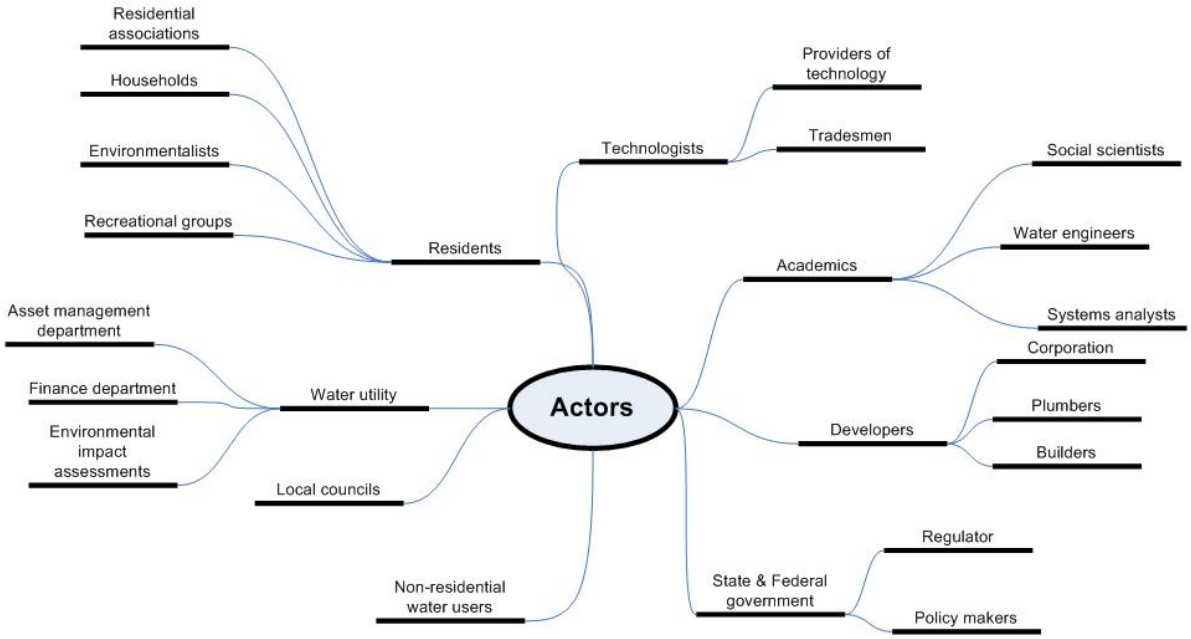

Figure 4: Actors involved in the urban water system in greenfield developments

8. ANALYSIS FRAMEWORK SELECTION CRITERIA

In order to incorporate the social issues into an assessment framework of water servicing options, a number of criteria need to be fulfilled, i.e. the framework would need to:

- Deal with the fact that for a given greenfield development, there is not yet a community present, and most information about the community would be based on previous experiences and existing knowledge, and hence the methodology would need to incorporate knowledge and information from experts and stakeholders that is inherently uncertain;
- Incorporate tentative and probabilistic causal links between issues, such as between risk perceptions and social acceptability of solutions;
- Incorporate qualitative information about the relationship between issues; or the state of play, such as the "social mood" which is difficult to quantify;
- Incorporate multiple possible futures, such as relating to climate change scenarios;
- Allow for learning over time through improved information and improved assumptions;

Additionally, it is not clear whether there is a dynamic interaction between factors, such as via negative or positive feedback. If this is the case, then unintended outcomes may be the result of an intervention, due to poor predictability in terms of input-output relationships / indirect impacts.

Two methods are suggested as options, i.e. 1) Bayesian Networks and 2) Systems Dynamics. As per Boulanger and Brechet (2005):

- Systems Dynamics approaches are excellent at incorporating inter-disciplinary information, and in fact slightly better than Bayesian Networks in this respect;
- Bayesian Networks are excellent at dealing with varying types of uncertainty, i.e. 1) in terms of model parameters, 2) in terms of model structure, and 3) in

terms of its pertinence (i.e. its granularity, selection of variables, time scale etc); Systems Dynamics is not as good from this point of view;

Both methods are suitable for participatory purposes, i.e. for involving stakeholders in model building and simulations, albeit both are inferior to Agent-Based Modelling in this respect. We also note that Systems Dynamics are good at capturing systems properties, but only operate at an “average” (systems) level; i.e. does not operate at the rich and detailed level of full diversity of situations. Bayesian Networks operate at the lower operational level in a probabilistic sense; whilst Agent-Based Models fully operates at the lower level, with more complete diversity represented in the model. We do note that the most critical aspect is the uncertainty of information and this points towards the use of Bayesian Networks, as they allows for capturing the diversity of situations; whilst there would not be enough information to capture the full diversity as in an Agent-Based Model.

9. DISCUSSION: WHERE TO NEXT

In this report we have outlined the goal of the study, and subsequently provided a review of some relevant literature in order to identify key topic domains that may be incorporated into the social dimension of new urban water servicing options. The next step is to narrow the scope and identify key variables and indicators in an assessment framework.

Once such key variables have been identified, there are two options considered for integration into a single framework, i.e. *Bayesian Networks* and *Systems Dynamics*. *Bayesian Networks* would be particularly suitable for this type of deductive, abductive and inductive reasoning in a situation of considerable uncertainty and information gaps, in order to be able to evaluate particular water servicing options. However a draw-back of the Bayesian Networks approach is that it can not adequately capture dynamics, and therefore we may also consider Systems dynamics as an option. The need for incorporating dynamic behaviour in the assessment of water servicing options is up for discussion and such a method may be justified by viewing the system performance in the long run.

The next step in this research project is two fold, 1) develop a Bayesian Network model to capture the essence of the logical relationships identified in this report, and 2) to hold a workshop to discuss this model, narrow the scope and finalize the decision about which approach that may be used.

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