UNDERSTANDING THE BLOCKAGES: STAKEHOLDER PERCEPTIONS OF GREYWATER REUSE IN METRO VANCOUVER

by

Meaghan Jean Hennessy
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Name: **Meaghan Hennessy**

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Project Number: **466**

Examining Committee:

Chair: **Megan Dickinson**
Master of Resource Management Candidate
School of Resource and Environmental Management

____

Dr. **Murray B. Rutherford**
Senior Supervisor
Assistant Professor
School of Resource and Environmental Management
Simon Fraser University

____

Dr. **Toddi A. Steelman**
Committee Member
Associate Professor,
Department of Forestry and Environmental Resources
North Carolina State University

Date Defended/Approved: ____

ABSTRACT

Greywater reuse – using water from sinks, showers and laundry to flush toilets and irrigate landscapes - is often cited as a management technique with potential to increase the efficiency of urban water use. Yet, in spite of government interest and opportunities for water conservation and environmental protection, only approximately 3% of British Columbia's total wastewater is being recycled. Understanding the barriers to greywater reuse would aid resource managers in designing better policies and facilitating appropriate implementation. In the present study, Q methodology is used to explore key stakeholder perspectives concerning the presence and relative importance of possible barriers to greywater reuse in Metro Vancouver. Three distinct perspectives (Institutional Reformers, Centralized Managers and Technical Pragmatists) are identified and illustrated. Points of consensus and conflict among the three perspectives are illuminated and used to discern options for approaching the identified barriers.

Keywords: Water recycling; water reuse; Metro Vancouver, British Columbia; Q methodology; stakeholder perspectives; policy decision-making

Subject Terms: Water Conservation Canada; Municipal Water Supply Metro Vancouver; Water Management; Water Reuse Canada; Water Policy; Resource Management

To my family,

Who teased me incessantly about the life of a "perma-student" with one breath,

Then wholeheartedly reassured me about the wisdom of my

Decisions and the strength of my abilities

With the next

…Thanks…

To Mike,

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For challenging me when I needed to dig deeper, for your patience, and your

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GLOSSARY

Water Reuse Terminology[1]

Biological oxygen demand	The amount of oxygen that organisms in wastewater require to decompose the organic matter content, under standard aerobic conditions. Used as a measure of the amount of organic matter in wastewater. An important measure of water quality.
Blackwater	Wastewater originating from toilets and urinals.
Direct reuse	The use of recycled water straight from a wastewater treatment plant.
Greywater	Wastewater generated by water-using fixtures and appliances (baths, sinks, washing machines), excluding toilets and urinals.
Indirect reuse	Use of reclaimed water after it has passed through water bodies (storages, wetlands, rivers etc.) following treatment.
Parcel level systems	The collection, treatment and disposal or reuse of wastewater from individual homes or commercial/institutional buildings, or small clusters of homes or commercial/institutional buildings.
Potable water	Water that is drinkable and considered safe for human consumption.
Renovated or reclaimed water	Wastewater that has been treated or processed and can be reused for beneficial purposes.
Stormwater	Precipitation that falls on and flows through urban spaces. Often conducted through an urban space via a storm sewer system.
Suspended solids	Small particles of solid material suspended or dispersed in water. An important measure of water quality.
Wastewater	Water carrying contaminants from human use. Consists of both blackwater and greywater

[1] Water Reuse Terminology adapted from UNEP, (2005), Health Canada (2007), and Dimitriadis, (2005).

Water consumption	When human use removes water from the resource stream such as converting water to steam or incorporating it into a product.
Water discharge	Water that is returned to the environment after human uses regardless of quality.
Water reclamation	The treatment of wastewater to a specified quality to facilitate water reuse or water recycling.
Water recycling	Using reclaimed water for the same purpose that it is originally used for.
Water reuse	Using reclaimed water for a purpose that differs from what it is originally used for.

Q Methodology Terminology [2]

Concourse	The possible range of opinions, positions or perspectives on a specific topic.
Conditions of instruction	The contextual statement of instructions under which the Q sample is sorted by respondents; for example ‘‘Most agree/Most disagree’’ or ‘‘Most like myself/Most unlike myself.’’
Factor array	A model Q sort constructed to represent a factor.
Factor rotation	Statistical or judgmental rotation of factor axes during analysis in order to optimise the vantage point from which the data are viewed.
Operant subjectivity	A model of subjectivity that assumes individual viewpoints are self-referent and are expressed and behaved contextually.
P sample	A subsample of the concourse, individual stimuli for ranking by study respondents; usually quotes or statements but also may be photographs, pictures, or other objects.
Q factor or factor	Structured products of factor analysis created from clusters of statistically similar Q sorts.

[2] Q methodology glossary adapted from Robbins (2004) and McKeown & Thomas (1988).

Q sort	The ordered ranking of the Q sample by an individual participant usually using a quasi-normal distribution, expressing the individual’s ranking of the P sample items relative to the conditions of instruction (e.g., ‘‘most agree to most disagree’’).
Sorter	A participant of the Q sorting process.

CHAPTER 1: INTRODUCTION

1.1 Problem Setting

Water is an essential resource, one which plays a vital role in national economies, environmental function, social and religious events, and sustaining life (UN Water, 2006). Unfortunately, the global water resource is facing many challenges: two recent reports on water, one by the Intergovernmental Panel on Climate Change (Bates, 2008) and one by the United Nations Water working group (UN Water, 2006), each identify water quantity and quality issues occurring in many reaches of the world. Climate change is beginning to alter some relied upon hydrological patterns, changing how, when and where precipitation falls (BC Ministry of the Environment, 2008; Bates, 2008), and rendering existing management strategies less effective (Gleick, 2002). Water pollution, population growth, urbanization and inappropriate management practices are impacting renewable water resources and in some locations leading to poor health, low quality of life and social unrest in the population (UN Water, 2006). Furthermore, human use of water to facilitate the production of goods and services, and as a medium to deal with wastes, has resulted in widespread contamination and destruction of aquatic ecosystems (Laws, 2000).

The problem of human impact on the natural hydrological cycle is particularly evident in urban centres. The fabric of a city changes runoff and ground water patterns, while demand for water by urban dwellers drives the extraction of immense volumes of water from waterways and aquatic ecosystems - water that is ultimately yielded as a contaminated waste stream (Marsalek et al., 2004). These impacts have intensified over the past 100 years (Okun, 1996) as the population of the planet has grown from approximately one billion to approximately six billion (Gleick, 2000), with much of this growth occurring in urban regions (Okun, 1996).

Improving the efficiency of the western world's standard once through urban water use system, could aid adaptation to changing climatic regimes and reduce society's impact on surrounding ecosystems. Parcel level greywater reuse - the practice of collecting wastewater (excluding that generated from toilets and urinals) generated in individual homes or commercial/institutional buildings, or small clusters of homes or commercial/institutional buildings, treating it, then putting it to use again - is one option for achieving such efficiency improvements (Stenekes et al., 2006). This technological adaptation has the potential to dramatically reduce urban water consumption and urban wastewater generation (Rutherford, 2007).

Despite its potential, greywater reuse has not been broadly implemented within Canada (Exall, 2004). Some work has been done internationally to identify barriers (Stenekes et al., 2006; Khan and Gerrard, 2006; Po et al., 2004; Baumann, 1983), but very little research has focused on these questions within the Canadian context. Furthermore, minimal work, if any, has focused on the subjective opinions of individuals involved in development and design, implementation, promotion or use of existing greywater reuse programs. It is these key participants, with first hand experience, who may best be able to identify existing barriers to broad scale implementation of greywater reuse.

Metro Vancouver, British Columbia, is an example of a Canadian urban centre where greywater reuse could have a positive influence on the urban hydrological cycle by reducing resource consumption and waste production. Both Metro Vancouver and the province of British Columbia have made commitments to investigate and implement water reuse (GVRD, 2005; BC Ministry of the Environment, 2008), however, there are few greywater reuse systems currently in use or under development in the Metro Vancouver area (please see Appendix A for a list of BC based greywater reuse systems). The disparity between government commitment to greywater reuse and the actual implementation of systems makes Metro Vancouver an excellent setting for exploring key participants' subjective opinions regarding important barriers to greywater reuse.

1.2 Research Objectives

The overarching applied goal of this research is to provide decision makers with information that will enable them to facilitate efficiency improvements in water management. The overarching theoretical goal of this research is to expand upon the understanding of greywater reuse policy development and implementation, and the understanding of subjective opinions of key participants involved in the greywater reuse policy process. More specifically, I intend to examine the barriers to parcel level greywater reuse in Metro Vancouver as perceived by the individuals involved in the implementation, regulation, maintenance, development and use of these systems. The following research objectives were developed in order to facilitate achieving the above goals:

- investigate presently held perspectives of key participants regarding important barriers to parcel level greywater reuse in Metro Vancouver.

- examine why these perspectives are held.

- make recommendations regarding the implementation of parcel level greywater reuse in Metro Vancouver, and regarding potential strategies for overcoming identified barriers.

1.3 Case Study Setting

The study location for this research, Metro Vancouver, British Columbia, was chosen for both environmental and social reasons. The population of British Columbia is thought to be among the most environmentally minded in Canada, with BC having the highest density of environmental activist organizations in Canada and the environment occasionally overtaking health care and employment as the number one public concern (Blake et al., 1997). Research identifying reasons for greywater reuse implementation failure often points to poor public acceptance of proposed projects (Po et al., 2005). Public acceptance of greywater reuse should be comparatively high in Metro Vancouver as the technique has the potential to reduce environmental harm. Yet, implementation has remained mainly at the demonstration or pilot project level.

While the implementation of greywater reuse has remained low, the need for it in BC and specifically Metro Vancouver has been growing. Although Metro Vancouver has historically had abundant water, it is beginning to experience challenges with water supply quantity (BC Ministry of the Environment, 2008). The majority of Metro Vancouver's potable water is generated from precipitation falling as snow and rain, in the fall and winter months. Municipal water demands during dryer months are satisfied by drawing from water stored in three reservoirs (Capilano, Seymour, Coquitlam) and from the snow pack which acts as a temporary retainer of winter precipitation, capable of storing volumes of water far greater than that of all three reservoirs combined (GVRD, 2006). Climate change poses a potential threat to Metro Vancouver's snow pack generated water supply; warmer winters have resulted in an advance of the peak spring runoff by approximately one month over the last 50 years and a decrease in total winter snowfall accumulation (Mote, 2003). These changes to the hydrological cycle will likely lead to reduced summertime water availability (British Columbia, 2005). As an indication of things to come, drought conditions in BC in the summer of 2003 reduced water flows in many places in the province to historic lows; 2.2 million people felt the affects of water shortages and 84 public water systems were under stress, including that of Metro Vancouver (J. Kinkead Consulting, 2006).

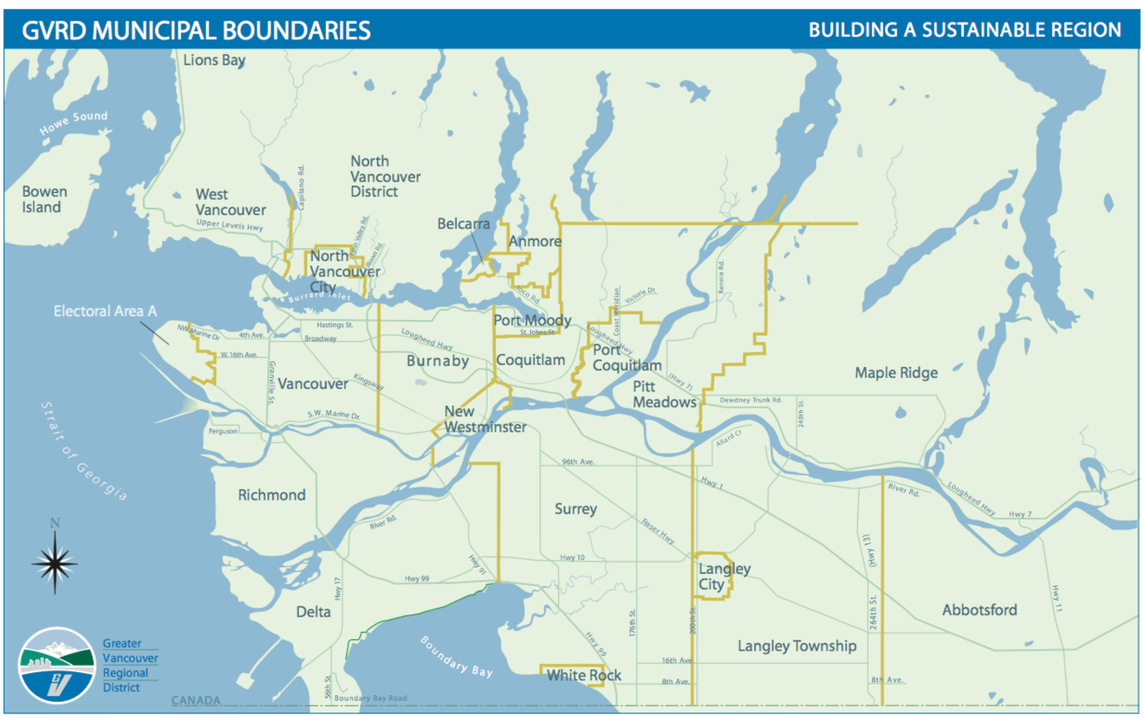
While a changing climate may diminish the volume of water available and change the timing of its availability, a growing population may exaggerate the problem by increasing demand for the resource. The population of Metro Vancouver is currently expected to grow by 1.4 million in the next 25 years (BC Ministry of the Environment, 2008). This growing population and associated intensifying urban structure will place greater demand on the existing potable water supply, which will in turn place strain on an already aged infrastructure (Krkosek, 2006). Furthermore, the volume of wastewater produced in Metro Vancouver is predicted to grow even faster than its rapidly expanding population (GVRD, 2004).

Approximately one billion litres of wastewater are discharged from Metro Vancouver's five treatment plants into Georgia Strait, the Fraser River and Burrard Inlet on an average day (GVRD, 2004). Of the five local treatment plants, three supply secondary treatment to the effluent they receive while the other two provide only primary treatment. As a result, large quantities of contaminants are being released into the environment, contributing to the pollution of Georgia Straight (Miller, 2006). Critics, who claim these releases are a violation of the federal *Fisheries Act* (R.S.C. 1985, c. F-14) (EcoJustice, 2008), have been pushing both the province and the regional district to address treatment deficiencies.

In response to water resource challenges, Metro Vancouver's 2005 Drinking Water Management Plan includes the goal of ensuring sustainable water use. One recommended strategy is matching water quality to use requirements. With this strategy, Metro Vancouver makes a commitment to "investigate the feasibility of substituting alternatives to drinking water for specific applications and locations" (GVRD, 2005, p. 7). The 2008 BC Provincial Water Plan echoes these commitments, stating, "By 2010, government will mandate purple pipes in new construction for water collection and reuse" (BC Ministry of the Environment, 2008, p. 77). While these commitments to water reuse have been made, few step to fulfil them have been taken.

On the theoretical side, research in Metro Vancouver presents an opportunity to expand upon the limited understanding of greywater reuse policy, and the perceptions about greywater reuse. Water supply issues are on the horizon for Metro Vancouver, but the urban centre is not currently facing a water crisis, which makes Metro Vancouver very different from most other locations where greywater reuse research has been conducted. Typically, research focuses on regions such as California and Australia where water supply crises have elicited implementation of greywater reuse as a reactionary response. Greywater reuse implementation in Metro Vancouver at this time would be a preventative step rather than a reaction to crisis. Some policy scholars argue that major policy changes rarely take place unless there are substantial changes in background conditions such as "public opinion, elections, economic conditions, the macropolitical system and other policy sectors" (Hoberg, 2001, p. 12). Research in a policy context that is not facing imminent and dramatic change in background conditions could help clarify whether greywater reuse can be implemented in a proactive and preventative manner, thus making this research of interest to national and international locations looking to be proactive with their water management policies.

Figure 1.1 Map of Metro Vancouver and its member municipalities.
Source: Metro Vancouver Web Site. Reproduced with permission. Downloaded February 2009.



1.4 Theoretical Setting

The policy process can be immensely complex, involving numerous parties and multiple issues. In an attempt to simplify the complexity, the process is often viewed as a series of stages in a cycle. The number and names of the exact stages varies across models, but it is common to include stages such as agenda-setting, formulation, decision-making, implementation, evaluation, and termination (Howlett & Ramesh, 2003). Within this cycle problems and the influential conditions surrounding them are identified (agenda setting) policy options are developed (formulation), a course of action or inaction is chosen (decision-making) and put into effect (implementation), the results are monitored and assessed (evaluation) and the policy either carries on, is fed back into earlier steps of the cycle, or is put to rest (termination). While this cycle appears to flow linearly, it often bounces back and fourth among the different stages, skips stages, gets stuck in a stage, or is interrupted before completing all the stages (Howlett & Ramesh, 2003).

The policy process commonly takes place in conditions of uncertainty, especially when the issue at hand is complex and controversial. In such situations, subjectivity weighs heavily in decision-making; when "the decision maker is faced with equally attractive or equally unattractive alternatives… values and preferences are everywhere involved" (Brown, 1980). The presence of such subjectivity makes it important to assess and understand the different perspectives held by stakeholders and decision makers. If the discourses involved in understanding and addressing a problem are unknown, it becomes difficult to judge which policies will be acceptable and effective (Addams & Proops, 2000). The policy process surrounding greywater reuse is an example of such a situation;

greywater reuse is a controversial water conservation strategy that is embraced and advanced by some, yet rejected and fought against by others. Researching the complexity of the subjective opinions of those individuals who have been involved in greywater reuse in Metro Vancouver will help decision makers develop a policy approach that is more informed and likely to be better received (Addams & Proops, 2000).

Q methodology is one approach to examining subjective opinion. Through Q methodology, qualitative expressions of perceptions and attitudes are assessed via quantitative statistical measures (Ellis et al., 2007). The intent of Q methodology is to facilitate modelling of opinions (Brown, 1980) to provide insight into premises and values that individuals hold (Focht, 2002). Q methodological research can aid in multiple stages of the policy cycle (Steelman & Maguire, 1999), including agenda-setting (by identifying issues or problems with existing policy), formulation (by illustrating policy options), decision-making (by identifying criteria important to key participants) and evaluation (by assessing the experiences of key participants). Accordingly, the present study of the subjective opinions of key participants in greywater reuse in Metro Vancouver could contribute to the greywater reuse policy cycle by: evaluating current policy direction; clarifying perspectives regarding barriers; exploring the influence of the background conditions on perceptions of this policy option; identifying areas of consensus and conflict among key players involved in greywater reuse development, implementation, regulation and use; and providing insight into preferences for management direction.

1.5 Report Outline

I begin this report by discussing water management paradigms pertinent to the implementation of water reuse, as well as the technical details of water reuse important to this research. I follow this with an examination of international, national and local water reuse trends and an exploration of the possible barriers to implementation in Metro Vancouver. This background information is followed by an explanation of the methodologies I used and the steps I took to develop the research. I then report on the findings of the research, followed by analysis and discussion of the results, suggestions for further work, and final conclusions.

CHAPTER 2: BACKGROUND

2.1 Trends in Water Management

Current literature addressing water management often refers to three main management paradigms: supply side management, demand side management, and soft path management (e.g. Brandes & Brooks, 2007; Brandes & Maas, 2007; Brooks, 2005; Renzetti, 2005; Gleick, 2000; Renwick & Green, 2000; Renwick & Archibald, 1998; Gleick, 1998; Tate 1990). These three categories are often viewed as a spectrum of management options with large-scale technical options (such as constructing reservoirs to supply more water) on the supply side management end, and fundamental behavioural changes (such as discontinuing the use of water to treat waste) on the soft path management end (Brandes & Brooks, 2005). Following is a brief discussion of each of the three paradigms. These descriptions are generalizations, but they give an overview of the benefits, assumptions and strategies commonly attributed to each paradigm.

2.1.1 Supply Side Paradigm

Supply side management of water resources generally focuses on manipulating naturally occurring sources of fresh water in order to secure supplies and meet forecasted societal demands (Renzetti, 2005) rather than attempting to manage or limit those demands. Future population levels, per capita water demand, agricultural production, and economic productivity are projected and used to determine the volume of water that will be required to satisfy future demand (Gleick, 2000; Maas, 2003). Underlying this paradigm is an assumption that water needs are generally not sensitive to policy designed to influence consumer behaviour (Renzetti, 2005; Maas, 2003). Therefore, efforts to meet future demand often focus on finding ways to "[tame] more of the natural hydrologic cycle through construction of more physical infrastructure, usually reservoirs for water storage and new aqueducts and pipelines for interbasin transfers" (Gleick, 2000, p. 128). Supply side planning typically does not fully account for environmental implications of manipulating the hydrological cycle, or the full economic impacts on municipal water services (Brandes et al., 2005).

Supply side management is the traditional process typically used for managing fresh water resources in Canada (Maas, 2003) and has afforded many benefits here and in other settings. It has resulted in potable water being supplied to most homes and buildings, agricultural irrigation and improved crop yield, the generation of hydropower, the reduction of water related illnesses, and mitigation of flood and drought impacts (Brandes & Brooks, 2005; Gleick, 2003; Hellebust, 2006). These advantages, however, have been supplied at substantial environmental, social and economic costs. Water levels are dropping in some Canadian groundwater and surface water bodies, and water diversions throughout Canada have caused major destruction of both habitat and species (Sprague, 2007). Increasing demand is straining ageing Canadian infrastructure, pushing up costs for municipalities (Maas, 2003). Finally, the construction of infrastructure such as reservoirs has consumed valuable land and displaced many North American people (Gleick, 2002).

Expansion of supply side management infrastructure may cause even greater damage, as ideal locations for infrastructure placement are used up, and managers turn to less appropriate locations (Brandes & Brooks, 2005). These substantial challenges with supply side management are pushing the study of and adoption of the demand side management paradigm (Tate, 1990; Renzetti, 2005).

2.1.2 Demand Side Paradigm

Demand side management is a water management paradigm that complements supply side management (Tate, 1990), but expands upon the technologically oriented focus to include explicit consideration of a broader range of economic, socio-political, and environmental factors (Maas, 2003; Tate, 1990). The general goal of demand side management is to improve the efficiency of water use in order to maintain or decrease the consumption of water supplies (Maas, 2003). Attempts to attain this goal typically occur through the implementation of policies and programs such as water pricing structures that discourage consumption, strategies to encourage installation of low-flow utilities, public education to encourage efficient water use practices, and the implementation of outright restrictions on specific uses (Brandes & Brooks, 2005; Brandes et al., 2005). These strategies illustrate one of the main differences between the demand side and supply side paradigms: supply side management distrusts policy as a means to influence and manage demand for water while demand side management relies upon it (Brandes & Ferguson, 2004).

Demand side management offers much to the management of freshwater resources. By encouraging managers to consider a broader range of economic, socio-political and environmental factors in planning and decision-making, the breadth of options available and the flexibility for creative solutions increase (Tate, 1990). In many cases demand side management can yield more cost effective solutions relative to the cost intensive technological solutions of supply side management, it can yield more sustainable solutions than the resource intensive supply side management solutions, and it can offer less environmental damage relative to the ecosystem invasive solutions of supply side management. In addition, demand side management can foster behavioural changes that some argue are required to enable more ecologically sustainable human lifestyles (Brandes & Ferguson, 2004).

It is the complexity of behavioural changes, however, that bring forth questions regarding the actual efficacy of demand side management techniques. As has been found with demand side management in the energy sector, water savings due to demand side management efforts may be diminished by what is known as the rebound effect. The rebound effect describes a phenomenon whereby water savings due to increased technological efficiency are offset by behavioural changes (Dixon & McManus, 2006). Two forms of rebound effect are particularly applicable to the water sector: direct rebound effects and indirect rebound effects (Sorrell & Dimitropoulos, 2007). Direct rebound effects occur when efficiency improvements lower the cost of a service, thereby increasing the consumption of that service. An example of this in the water sector is the installation of a low-flow showerhead decreasing a household's water bill, thereby encouraging the household to take longer showers. Indirect rebound effect occurs when efficiency improvements in one sector lead to higher consumption in others. An example of indirect rebound in the water sector is the installation of low-flow toilets, again reducing the household water bill and providing an incentive to wash the car more often (Sorrell & Dimitropoulos, 2007; Dixon & McManus, 2006). As a result, behavioural changes generated by demand side management initiatives may lead to smaller decreases than intended or even to increases in water use. While the existence of rebound effects is generally accepted and acknowledged, the magnitude of the response and the level of importance are still debated (Dixon & McManus, 2006).

2.1.3 The Soft Path Paradigm

The soft path management paradigm builds upon the efficiency principles of demand side management but looks more deeply at why, rather than how, people use water (Brandes & Brooks, 2005). Demand side management generally does not challenge many of the existing patterns of water use, but rather focuses on improving the efficiency of these uses (Brandes et al., 2005). With soft path management, the emphasis shifts from the absolute volume of water consumed to concentrate instead on the social well-being produced per unit of water used (Gleik, 2003). Rather than treating water simply as an end product, supply side management considers water as a means to accomplish tasks (Brandes et al., 2005) and questions why water is used to supply the services it does (Brandes & Brooks, 2005).

For an example of how supply side management can work, consider two of the largest household consumers of water: toilet flushing and garden watering. On average 30% to 40% of Canadian household water is used to flush toilets (Environment Canada, 2004b). In response, demand side management would replace standard toilets with low-flow toilets in order to increase the efficiency of water use. Soft path management, however, questions why water is used to process this waste stream at all when there are composting toilets and other waterless toilet technologies. In summer months the average volume of water consumed by a Canadian household often doubles because of lawn and garden watering (Environment Canada, 2004b). In response, demand side management would install more efficient sprinkler systems while soft path management would question why Canadians insist on having lawns in the first place and would encourage planting native drought resistant species that do not need to be watered (Brandes & Brooks, 2005; Brandes et al., 2005; Gleik, 2003).

2.1.4 Greywater Reuse; Demand Side Management or Soft Path

Water reuse can be viewed as either a soft path management or a demand side management technique, depending upon the specifics of the reuse strategy being employed. The water reuse techniques most likely to be implemented in BC homes, communities and institutions include using greywater to flush toilets and urinals, and to irrigate landscaping (NovaTec, 2004). Yet, theoretically, water use can be eliminated from landscaping processes and washroom facilities. Gardens can be designed with indigenous species or drought tolerant plants, in order to eliminate the use of water in landscaping (Brandes et al., 2006). Toilets and urinals do not need water to operate, as technology exists which eliminates water from the disposal of this waste stream (Brandes & Ferguson, 2004). Using the definitions of soft path management and demand side management given above, reuse strategies for toilet and urinal flushing and landscape irrigation fall somewhere closer to the demand side management end of the spectrum.

2.2 Greywater Reuse

2.2.1 Technical Setting

Water reuse refers to the process of treating wastewater to remove contaminants and using the renovated wastewater over again. Water reuse can be applied to processes in manufacturing, agriculture, thermal power generation, mining, and municipal sectors. The present research focuses on municipal water reuse, because in Canada water reuse is practiced far less in the municipal sector than in any other sector (Environment Canada, 2002) despite high potential for effective water conservation (Rutherford, 2007).

There are many technical aspects to water reuse programs that should be considered when discussing the subject, as each aspect influences the potential risks, costs and benefits involved. Unfortunately, much of the existing research on water reuse does not identify the specific features of the technique being used, making it difficult to assess the validity of the research or its applicability to other settings and approaches. For the present research it is important to identify the scale of the systems considered, the type of wastewater being used, the presence of treatment, and the final applications of the renovated water. For a brief description of these aspects, please see Table 2.1 below. For a more in-depth description, please refer to Appendix B.

Table 2.1 Technical aspects of greywater reuse considered in the present research.

Scale
The scale considered is referred to as parcel level, or reuse applied at the scale of one home or one building up to a small cluster of homes or buildings. Essentially, these are systems implemented by home or building owners rather than municipal or regional governments. Water reuse systems applied at this scale are also referred to as decentralized systems due to the treatment facilities being on-site and separate from the central municipal wastewater infrastructure (CCME, 2004).
Source
The source of the wastewater considered is greywater, defined as all domestic wastewater other than that originating from toilets and urinals. Greywater reuse is the focus of the present study, but full wastewater reuse (treating and reusing both greywater and blackwater combined) is also discussed.

Treatment	
	It is assumed that some form of treatment is employed to meet legal requirements, however, the details of the treatment need not be specified.
Application	
	Landscape irrigation and toilet and urinal flushing are the two greywater reuse applications that are most likely to be allowed under the current regulatory structure in BC (NovaTec, 2004) and are the only applications addressed in the Q study.

2.2.2 Costs and Benefits

Water reuse contributes to improving the sustainability of water resource management (UNEP, 2005). Reusing treated wastewater substantially reduces potable water consumption and wastewater generation (Rutherford, 2007), which in turn decreases the cost of distribution and treatment of both water sources, and reduces the strain placed on infrastructure (Stenekes et al., 2006). Water reuse can decrease infrastructure capacity needs, which in turn facilitates denser urban development (Hellebust, 2006), and can delay or possibly eliminate the need to develop costly and environmentally damaging new water supply infrastructure such as dams and reservoirs (UNEP, 2005). Reduction in wastewater discharge volume reduces contamination of receiving ecosystems (Miller, 2006) and reduces nutrient loading of receiving waters (Exall et al., 2004), while a reduction in the volume of water withdrawn from fresh water ecosystems lightens the impact on riparian and other aquatic spaces (Maas, 2003). Finally, the conversion of wastewater into a renovated water source produces a valuable and reliable resource stream, one that often contains nutrients, making it potentially beneficial for agriculture and landscaping (UNEP, 2005).

Water reuse strategies, particularly decentralized ones, represent a combination of technological and social approaches to water conservation, so the costs and benefits of implementation arise from both technological and social sources (Brandes & Brooks, 2005). In addition to being a technological remedy, water reuse has also been found to foster social and behavioural changes. Public use of water reuse systems tends to increase understanding of water management and improves public capacity for water conservation programs, while the quick feedback of decentralized irrigation water reuse systems effectively shows people the consequences of their water consumption and wastewater production habits (Vassos, 2007).

The costs associated with the adoption of water reuse include: development, design, implementation and maintenance of the technology and infrastructure (CBSE, 2003), increased risk to human health from accidental contact with contaminated water (Health Canada, 2007), potential groundwater and surface water contamination as a result of using greywater for irrigation, possible damage to plants and soils irrigated with greywater (CBSE, 2003), strain on existing sewerage infrastructure which relies on a minimum volume of wastewater flushing through the system (NovaTec, 2004), potential increase in municipal sewage strength due to reduced greywater collection (Lighthouse Sustainability Centre, 2007), and cost to the decision makers and implementers where there is low political feasibility due to lack of public acceptance of recycling schemes (Khan & Gerrard, 2006).

2.3 Greywater Reuse Trends

2.3.1 Global Trends

Water reuse of one form or another has been practiced in many regions of the world for centuries. Indirect reuse is a commonplace practice throughout the world while direct reuse for irrigation has been documented in over 50 countries. Farmers in locations as diverse as Mexico, Pakistan, Jordan, Palestine, Senegal, Ghana, Vietnam and Brazil access and use treated and untreated effluent for irrigation and fertilization of their crops (Scott, 2003). The application of direct greywater reuse for urban uses, however, is a relatively new idea (Lazarova et al., 2003).

There is much international expertise on water reuse (Marsalek et al., 2002). The United States of America and Japan are often looked to for examples of municipal scale water reuse projects, while Europe and Australia are often cited as locations practicing local or community scale water reuse (Lazarova et al., 2003). Other locations where water reuse has become more popular include Greece, Portugal, Israel, Belgium, France, the UK and Germany (Miller, 2006). In the Organization for Economic Cooperation and Development countries, water reuse has helped reduce industry and energy related water use by 12 percent over 20 years (OECD Observer, 2003). "World wide water reuse has been rapidly rising" (Exall, 2004, p. 2).

The most substantial applications of greywater recycling thus far have occurred in regions facing water scarcity such as the Middle East, Australia and the south-western USA (Exall et al., 2004). Yet, greywater reuse has grown not only in water stressed regions, but also in countries typically thought to be water wealthy (Miller, 2006; Lazarova et al., 2003). Other drivers include: increasingly strict requirements for treatment of wastewater, in response to environmental issues of contaminated drinking water and damaged ecosystems; intensifying urban development or development in regions with limited water services; and desire for more sustainable homes and buildings (Esteban & Miguel, 2008; Exall et al., 2004; Lazarova et al., 2003).

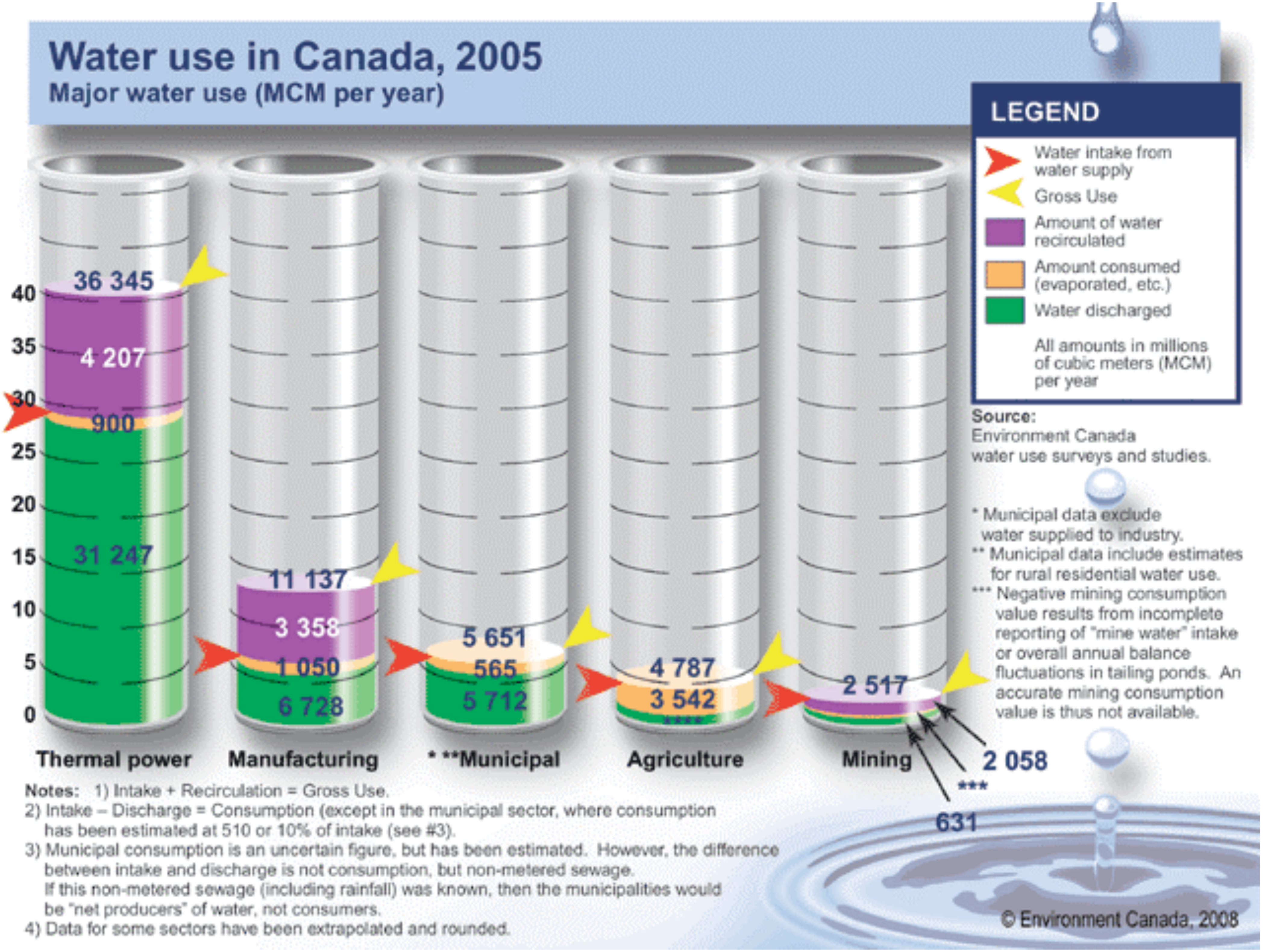
While applications of water reuse are on the rise in many regions of the world including North America, Europe and Australia (Esteban & Miguel, 2008: Bixio et al., 2006; Schafer et al., 2004), only a small fraction of the total global volume of municipal effluent generated is accessed for reuse (Miller, 2006). This indicates significant potential for an increase in the volume of water being recycled world wide (Bixio et al., 2006).

2.3.2 Trends in Canadian Municipalities

A study completed in 1998 by the Canada Mortgage and Housing Corporation (CMHC) examining regulatory barriers to on-site water reuse stated, "although there are some applications of residential on-site water reuse in Canada, this approach to water conservation is still largely unknown and is consequently often overlooked as a possibility" (CMHC, 1998, p. 1). Ten years later, greywater reuse is still practiced on a very small scale in Canada and is mainly limited to isolated demonstration projects (Schaefer et al., 2004; Exall et al., 2004).

Water use in Canada is divided among five main water user groups: thermal power production, manufacturing, municipal use, agriculture, and mining. Figure 2.1 below shows the volume of water consumed, reused and discharged by each of these five main water user groups. Notable in this figure is the actual water consumption and the

Figure 2.1 1 Canadian water use by sector.
Source: Environment Canada's Freshwater Website (ec.gc.ca/water).
Reproduced with the permission of the Department, 2009.



lack of water reuse that occurs within municipalities, illustrating how municipalities are Canada's least efficient water users (Environment Canada, 2002).

When municipalities do participate in greywater reuse, they typically use greywater to irrigate urban parkland and landscaping, golf courses and non-food agricultural crops (Schaefer et al., 2004). Within municipalities, at the scale of individual buildings, there has been some experimentation with greywater reuse for toilet flushing, irrigation and other non-potable uses. Many of these projects have been commissioned by the CMHC in order to develop information on the design and implementation, operation and maintenance, and social implications of greywater reuse for interested parties (Marsalek et al., 2002). Some well-known examples of these pilot projects are the Toronto Healthy House system, the CMHC Conservation Co-operative in Ottawa and an office building in Sooke, BC (Schaefer et al., 2004).

A recent survey done by Friends of the Earth Canada found that the driving force behind existing Canadian parcel level greywater reuse projects has largely been an ethical desire to achieve environmental sustainability. Projects have been designed and developed with the goal of reducing the urban footprint on the natural environment. Yet, many other site-specific factors were also identified as driving forces (often these factors aid immensely in the acceptability of the proposal) (Hellebust, 2006). These additional goals include: reducing costs to municipalities of water and wastewater supply and treatment, removing water servicing as an obstacle to development, extending the life of infrastructure, reducing irrigation and fertilization costs, and meeting water supply restrictions or effluent assimilation restrictions (Marsalek et al., 2002). An additional goal of financial savings on residential water costs is only applicable in communities that truck in water, as subsidized water in the majority of the country keeps water prices too low for greywater reuse to be a competitive option (Hellebust, 2006).

As with international trends, it is likely that population growth, urban development and climate change will put stresses on current Canadian water supplies. As supplies dwindle, it is foreseeable that the interest in greywater reuse will increase (Schaefer et al., 2004). In addition, regardless of water supply levels, greywater reuse may provide a viable solution to many other problems, which may also work to increase its popularity (Hellebust, 2006).

2.3.3 Trends in British Columbia

Regional disparities in water availability, suitability of receiving environments and regulatory flexibility have resulted in variable application of greywater reuse across Canada (Marsalek et al., 2002). British Columbia, along with Alberta, has more experience with water reuse than the other provinces (Marsalek et al., 2002), and British Columbia is far ahead of the rest of Canada when it comes to water reuse policy (Brandes et al., 2006). Yet, the development of parcel level greywater reuse projects in BC has mainly been restricted to isolated demonstration projects (please see Appendix A for a list of BC based water reuse projects) with only approximately 3% of BC's total wastewater being recycled as of 2002 (Scheafer et al., 2004).

2.4 Barriers to Implementation

There is much debate about why greywater reuse is not currently a widely used water conservation technique within Canada, or more specifically, within British Columbia. Many claim that regulation and policy are blocking the way (Schaefer et al., 2004; Vassos, 2007) or blame slow implementation on technological issues such as infrastructure and maintenance needs or lack of trust in existing systems (Vassos, 2007; Schaefer et al., 2004; Marsalek et al., 2002; Atkinson, 2005; Miller, 2006). Others perceive economic factors such as water pricing and infrastructure costs as hindering implementation (Tate, 1990; Miller, 2006; Schaefer et al., 2004; Marsalek et al., 2002; Stenekes et al., 2006). Finally, much work has been done internationally to explore how public and key stakeholder perception blocks the implementation of greywater reuse, as it is often claimed that public perception is the most important barrier to greywater reuse project development (Vassos, 2007; Schaefer et al., 2004; Marsalek et al., 2002; Atkinson, 2005; Stenekes et al., 2006). Following is an exploration of all four of these categories of barriers (regulation, economics, technology and public acceptance) and how they have influenced the implementation of greywater reuse techniques in Metro Vancouver.

2.4.1 Regulatory Instruments

Federal Level

There is potential for three main federal level policy instruments to impede parcel level greywater reuse strategies in Metro Vancouver. These federal instruments are: The Guidelines for Canadian Drinking Water Quality (1996), The Guidelines for Canadian Recreational Water Quality (1992), and The National Plumbing Code of Canada (2005) (CMHC, 1998). The two water quality guidelines may impose unrealistic or inappropriate standards for water quality, making it difficult to use reclaimed water for many potential uses. The third regulation, the National Plumbing Code, contains some problematic requirements: every water distribution system must be connected to a potable water supply; and the discharge of non-potable water through faucets or toilets is prohibited. However, this regulation does not directly address water reuse or water reuse technology (NovaTec, 2004), leaving it open for interpretation by those applying it. While these potential hurdles do exist, research done by the CMHC found "no absolute regulatory barriers to on-site water reuse in all of Canada" (CMHC, 1998, p. ii). Instead, it is the lack of specific regulation and perhaps, more importantly, the lack of associated guidance that is acting as the barrier to implementation (Brandes & Ferguson, 2004).

In 2006, in response to the absence of greywater reuse guidance, the Canadian Standards Association (CSA) released design and maintenance standards for non-potable water systems. *Standard B128.1-06* and *Standard B128.2-06 (Design and installation of non-potable water system;* and *Maintenance and field testing of non-potable water systems)* were produced with the intention of specifying the minimum plumbing requirements for a non-potable water system, regardless of the origin of the water. The standards were submitted to the Standards Council of Canada for approval as a National Standard in 2006 (CSA, 2006) and in September of 2008, a proposal for their inclusion in the National Plumbing Code was published for public review.

In addition to the development of the above national level standards, the Working Group on Household Reclaimed Water of the Federal-Provincial–Territorial Committee on Health and the Environment released in July of 2007, a draft version of *The Canadian Guidelines for Household Reclaimed Water for Use in Toilet and Urinal Flushing*. The objective of establishing these guidelines is to ensure the operation of water reuse systems does not endanger public health, and the intention is that they be used in conjunction with the CSA standards and be integrated into the National Building Code.

This first version of the guidelines focuses strictly on using reclaimed water for flushing toilets, however, the long-term goal is to design guidelines for multiple potential uses (WGHRW, 2007). The development of the above documents represents a significant step towards filling the guidance void, but it is yet to be seen whether these federal level regulatory instruments will help with parcel level greywater reuse implementation.

British Columbia's Provincial Regulatory Instruments

British Columbia and Alberta are the only Canadian provinces to formally address water reuse (Schaefer et al., 2004). BC has done so through the *BC Environmental Management Act's Municipal Sewage Regulation* (B.C. Reg. 129/99) which regulates municipal greywater reuse projects with daily flow-through of 27 000 litres and greater, the *BC Health Act's Sewerage System Regulation* (B.C. Reg. 326/2004) which regulates municipal greywater reuse projects with daily flow-through less than 27 000 litres, and through the *BC Plumbing Code* which regulates reuse technology such as dual distribution systems (Rutherford, 2006).

In 2001, the BC Ministry of the Environment released a companion document to the *Municipal Sewage Regulation*, titled *The Code of Practice for the Use of Reclaimed Water*. The code outlines two categories of reclaimed water (category one for unrestricted public access and category two for restricted public access) and appropriate uses for each category (CMHC, 1997). Reclaimed water is permitted to be used for irrigation (permitted category depends on what is being irrigated) and chemical spraying (permitted category depends on what is being sprayed); ponds and decorative uses, stream augmentation, habitat restoration and enhancement, commercial vehicle (category determined through an impact assessment); fire fighting, toilet/urinal flushing, driveway and street washing, and snow and ice making (category one); dust suppression and soil compaction (category two); and industrial uses (category depends on degree of worker contact) (MELP, 2001).

The *Code of Practice for the Use of Reclaimed Water* is a progressive step for water reuse implementation (Maas, 2003), but two factors limit its usefulness. First, the code currently does not apply to single-family dwellings (NovaTec, 2004) and recommends against the use of reclaimed water at this scale, unless the system is developed in consultation with the Ministry of the Environment and local health authorities (MELP, 2001). The code only applies to multi-family dwellings if the flow-through is 27 000 litres or greater. Second, the code lacks specifics when it comes to water quality and reuse technology standards (the recent federal level standards and guidelines have not yet been incorporated). Without specifics, the approval process for any reuse project application can be very cumbersome (Vassos, 2007).

When a project does fall under the guidance of the *Municipal Sewage Regulation* there are additional barriers in the form of financial and operational requirements. Each water reuse program must carry out an environmental impact assessment, develop an operations plan, either post financial security to cover 100% of the infrastructure costs in the event of a failure, or implement an assurance plan, and the design must include redundancy in the treatment system. Each of these steps has considerable associated costs (NovaTec, 2004). Finally, if the reuse application passes these steps, the local health authority must also authorize it (Rutherford, 2007), and the project must receive building permits from the local municipality. These multiple steps take much time and money (Vassos, 2007).

Permitting and regulation of greywater reuse projects too small to fall under the *Municipal Sewage Regulation* (less than 27 000 litres per day) fall to the regional health authorities. Working with the health authority represents a significant hurdle at this time as many health officials, at all levels of government across Canada, have concerns regarding the safety of water reuse applications. According to Duncan Ellison, the Executive Director of the Canadian Water and Wastewater Association, "public health ministries in Canada soundly argue that water systems are essentially risk-free at the moment. Why would they consciously make moves to increase this risk to save a bit of water?" (Maas, 2003). Provincial Public Health officials have the power to deny any application unless they are assured of public safety (CMHC, 1998; Maas, 2003), and, according to Vassos (2007), many health officials have little knowledge of water reuse technology or the *Municipal Sewage Regulation* and few resources to help them make decisions.

In addition to the health authorities' potential to make parcel level greywater reuse challenging, the *Health Act's Sewerage System Regulation* itself serves as a potential barrier. The *Sewerage System Regulation* does not address any form of water reuse (Nova Tech, 2004). With no direction within the regulation it is difficult for officials to permit a greywater reuse project. As well, the regulation defines discharging of sewage (which includes greywater) onto land as a health hazard, which works to hinder implementation of landscape irrigation with greywater. Further, the *Sewerage System Regulation* does not differentiate between greywater and backwater, which again makes it difficult for greywater reuse projects to gain approval. According to the Ministry of Health, however, water reuse projects in single dwellings are not of great concern to the Ministry while multi-family dwelling projects such as Quayside Village, are of concern (NovaTec, 2004).

Municipal Regulatory Instruments in Metro Vancouver

The regional district of Metro Vancouver is made up of 22 member municipalities (Metro Vancouver, 2009) each of which has its own municipal building and plumbing code. BC's provincial building code has provisions for water reuse (and a commitment to expand upon these with the Greening of the BC Building Code initiative (BC Housing 2008), yet many of the municipal level building codes have not been updated to incorporate water reuse technologies (Brandes et al., 2005). Of those that have, many have restricted water reuse to rainwater harvesting for landscape applications (Vassos, 2007). Municipalities are reluctant to incorporate water reuse as they feel the provincial plumbing code does not give enough guidance when it comes to the definition of water quality, technology needs and appropriate applications (Vassos, 2007).

As a result of minimal or no guidance in the municipal codes, plumbing and building inspectors may not have the knowledge or the access to advice that they need to safely issue permits (Vassos, 2007). Regulatory barriers can be important for protecting both providers and consumers (Krkosek, 2006) and since many individuals involved in the permitting process are professionals, they are bound to exercise due diligence. A lack of guidance provided by proper guidelines or standards leaves them vulnerable to the fears and realities of liability for their decisions (Schaefer et al., 2004).

Summary

Both regulation and the absence of regulation can act as barriers to innovative technologies (Krkosek, 2006). In the case of greywater reuse, the most significant regulatory hurdle appears to be an absence of up-to-date regulation at the provincial and municipal levels, or more importantly the lack of guidance these instruments and associated policies could supply. Without clear understanding of how water reuse systems can and should work, the approval process has become long and costly. It remains to be seen whether the recent guidelines and standards developed at the federal level will improve the municipal level process of implementing water reuse programs.

2.4.2 Technological Hurdles

According to a study done by J. Kinkead Consulting, Canadian municipalities typically fall behind communities in other jurisdictions when it comes to promoting and using technological solutions for water issues (J. Kinkead Consulting, 2006). Water reuse technologies are among those not being implemented, likely due to their being less politically and financially feasible than technologies using freshwater resources. Political feasibility is hampered by a perception of high risk to public and environmental health (Marsalek et al., 2002) especially for technology used at the parcel level (Schaefer et al., 2004), while financial feasibility is hindered by high development and maintenance costs (Vassos, 2007; van Roon, 2007: Schaefer et al., 2004).

Water reuse technology is used worldwide and there is much information available regarding the performance of centralized water reuse systems (Schaefer et al., 2004). There is insufficient information, however, on the extent of use of the technology and the successes and challenges of use within the Canadian context. This is especially true of the smaller decentralized systems. Not surprisingly, the shortage of field-testing results in reluctance to pursue water reuse as a solution to municipal water issues, as decision makers do not trust that the technology will protect human health (Maas, 2003). This reluctance is compounded every time research reveals a new challenging chemical contaminant in wastewater sources, such as endocrine disrupting compounds, regardless of the intended use (Marsalek et al., 2002).

In addition to the problem of poor trust in the technology is the problem of cost. There are costs associated with the construction of needed collection, transportation and treatment infrastructure (van Roon, 2007), and these costs can be quite substantial if the infrastructure is being retrofitted into existing buildings (CBSE, 2003). Also to be considered are the risks associated with human or environmental contact with improperly treated greywater. This risk increases the importance of, and need for, effective maintenance, monitoring, emergency systems and skilled workers (WGHRW, 2007) each of which has associated costs. The need for ongoing maintenance and monitoring is thought to be a large inhibitory factor when it comes to reuse systems in individual homes (Maas, 2003), especially if home owners do not have the resources and skill to properly maintain the system (Schaefer et al., 2004).

2.4.3 Economic Influences

Additional hurdles to implementation of municipal water reuse stem from the economics of water and water conservation. Water reuse must be economically viable for it to be broadly implemented; wide spread implementation of any water conservation technique is dependant upon its economic feasibility (Marsalek et al., 2002). Parcel level greywater reuse, however, is not currently economically competitive in much of BC.

Problems include a lack of full cost accounting for water pricing, low use of water metering, and widespread use of a rate structure that discourages water conservation (Renzetti, 2007; Stenekes et al., 2006: Policy Research Initiative, 2004; Marsalek et al., 2002; CMHC, 1998).

An Australian based study done by the Sydney Water Corporation found that the cost of water supplied through greywater reuse is not competitive with the low prices of water supplied via many fresh water capture systems (Sydney Water Corporation, 1999). Uncompetitive pricing serves as a disincentive for implementation of water reuse programs and does little to encourage innovation in water reuse technology and management (Brandes et al., 2005; Scheafer et al., 2004). The disparity of pricing between water reuse and freshwater capture is often a result of artificially low pricing of captured water, which is in turn a result of subsidization (Policy Research Initiative, 2004) and failure to incorporate all costs of supply, including environmental externalities (CMHC, 1998). Studies have shown that when all costs are incorporated, the cost of using reclaimed water can compare favourably with other options (Miller, 2006; Stenekes at al., 2006).

Approximately 76% of BC is on unmetered water supply service including most residences in the Metro Vancouver area (J. Kinkaed Consulting, 2006). As a result, the majority of building and home owners in the Metro Vancouver area pay a flat fee to access unlimited water. The rate of this flat fee ($30.08 per month in 2008 for the City of Vancouver (City of Vancouver Engineering Services, 2008) and an average of $26.52 per month in BC between 1991 and 1999, which is among the lowest in Canada (Burke et al., 2004)) is typically designed to cover administration costs and may not cover operation, repairs, upgrading or expansion of infrastructure (Environment Canada, 2002), let alone the environmental costs of capturing fresh water and discharging wastewater. A conclusion drawn at a recent Policy Research Initiative workshop is that "Canadian municipalities and provincial governments rarely get water prices right and that this creates a wide variety of problems, including… stifled innovation in water-conserving technologies" (Renzetti, 2007). In addition to the rate itself, the flat fee structure leads to water-wasteful behaviours as it promotes an undervaluing of the resource by its consumers (Policy Research Initiative, 2004). With such low water pricing in BC, and pricing schemes that do not encourage water conservation, water reuse is not likely to be widely implemented.

Water reuse schemes can offer financial advantages over traditional freshwater capture programs, such as a reduction in costly environmental externalities, a less vulnerable and variable water supply (Stenekes et al., 2006), and local economic development opportunities (Miller, 2006). These additional benefits are very often ignored in economic analyses (Stenekes et al., 2006; Marsalek et al., 2002), as they can be difficult to quantify. Externalities of water use are often poorly understood and tend to vary through space and time (Policy Research Initiative, 2004). Yet, until these externalities can be effectively incorporated into the price of captured freshwater, there will be less incentive to invest in water reuse. Individuals or groups looking to develop parcel level greywater reuse systems will have difficulty justifying the investment if the savings in water supply costs do not cover the infrastructure and maintenance costs (Vassos, 2007).

Effective water pricing is central to water demand management and to many of its options, including water reuse (Tate, 1990). The economic issues discussed above are substantial barriers to water reuse implementation; the removal of all regulatory and technological barriers cannot guarantee water reuse implementation if financial feasibility of water reuse is not also addressed (CMHC, 1998). Yet, at least one study of social acceptance of water reuse found that "the penalty of price increase does not appear to be effective in creating acceptance of renovated waste water" (Baumann, 1983, p. 82). At the same time, Baumann states "we cannot conclude [cost] is unimportant; it is just less important [in creating acceptance]" (Baumann, 1983, p. 82). Other steps must be taken in conjunction with supplying price signals in order to assure adoption.

2.4.4 Public Acceptance

Public acceptance is often referred to as the most significant barrier to the adoption of municipal level water reuse programs (Miller 2006; Schaefer et al., 2004; Po et al., 2004) as many greywater reuse projects internationally have failed because of community rejection (Po et al., 2005). Some research attempting to understand what influences public acceptance of greywater reuse has been undertaken in Australia and California (Po et al., 2004), but there has been little research to ascertain the level of public acceptance, and what influences it, in Canada (Schaefer et al., 2004). No published surveys of public opinion or perception of greywater reuse are available for Metro Vancouver or British Columbia. As a result, current understanding is likely insufficient to predict public reaction to greywater reuse in Metro Vancouver.

Initial research done in Australia and California attributed lack of public acceptance of greywater reuse to insufficient public understanding of the technique and the technology and a public perception that greywater reuse jeopardizes public health (Stenekes et al., 2006; Baumann, 1983). In light of this, public education campaigns were prescribed as the 'best fix'. There is now considerable evidence, however, that base knowledge is not the only factor in people's acceptance of greywater reuse, as demonstrated by frequent rejections of reuse programs despite public communication and education programs (Po et al., 2005). Social marketing and persuasion have not been effective in convincing people to use reclaimed water in California and Australia (Po et al., 2004). While public opinion may shift as information is supplied and knowledge grows (Russell & Hampton, 2006), it cannot be assumed that opinions will shift in such a way that the public will accept a reuse project; information may also strengthen any opposition (Khan & Gerrard, 2006).

More recent research looking into public acceptance of greywater reuse, again mainly done in Australia and California, has shown that despite past objection to proposed projects, generally the public is quite supportive of greywater reuse (Russell & Hampton, 2006; Atkinson, 2005). Some influential factors were, however, identified. These include: historical background of local water issues (greater acceptance tends to occur in regions that currently or historically have had water shortage problems) (Exall et al., 2004; Po et al., 2004), the degree of human contact (use of reclaimed water for toilet flushing is often found to be more acceptable than use for washing laundry) (Stenekes et al., 2006), and the opinion of "others" or "the subjective norm" (Po et al., 2004, p. 105).

Public trust in local water authorities has also been identified as an important factor in acceptance of greywater reuse. Surveys once again focusing on Australia and California have indicated that a main reason for public willingness to use reclaimed water is a high level of trust in the local water authority (Khan & Gerrard, 2006; Po et al. 2004). Researchers in Canada have found that consumer confidence in the reliability and safety of public water supplies has eroded in recent years. Fifty percent of respondents to two cross-Canada surveys conducted in 1995 and 2000 reported that they believed their tap water presented a moderate to high health risk (Krewski et al., 1995; Environics research group, 2000). This declining trust is further emphasized by rapid growth in bottled water sales, approximately 9% per year between 1995 and 2000, which was found to be due in part to public concern about tap water quality (Dupont, 2005). If trust in water providers is a factor in public acceptance of water reuse projects, it appears that some resistance to greywater reuse implementation may be experienced in Canada.

2.4.5 Summary of Barriers

Factors associated with regulation, technology, economics and public acceptance of water reuse were identified as potential barriers to the broad implementation of parcel level greywater reuse programs in Metro Vancouver, BC. The main issue associated with regulatory instruments is a shortage of guidance and standards available at the provincial and municipal level for those developing and approving water reuse systems. Tied in with this are issues associated with water reuse technology, including insufficient information regarding which technologies are appropriate, high costs of developing infrastructure and high costs of on-going maintenance. The main economic hurdle identified involves the current prices and rate structure of Metro Vancouver's municipal water and the absence of full cost accounting when identifying these prices. Finally, potential problems with public acceptance were identified due to poor understanding, concern about health risks, and declining public trust in water authorities.

CHAPTER 3: METHODOLOGY

3.1 Options for Studying Perspectives: Why Choose Q Method?

The exploration of perceptions towards water management techniques, and more specifically water reuse, is typically pursued through r-based methods such as questionnaires and surveys (e.g. Po et al., 2004). While these approaches are commonly used in the exploration of attitudes (Addams, 2000), there are difficulties associated with using these standard statistical procedures when attempting to illustrate and understand subjective viewpoints. Instruments such as scales and categorical definitions limit the respondent's ability to express the nuances of their point of view, which in turn creates a risk of misinterpretation (McKeown & Thomas, 1988; McKeown, 1984). In addition, the need to construct assessment instruments prior to the interview process results in each participant's point of view being dependent upon the pre-determined meaning associated with the scales and categories developed and imposed by the researcher (Addams, 2000; Brown, 1980). As concluded by Brown, by using survey instruments associated with pre-determined meanings "the observer uses the subjects' responses to assist him in bringing his concept into being, a transaction that is more akin to creativity than to measurement" (Brown, 1980, p. 3).

Q methodology is an alternative approach where qualitative expressions of perceptions and attitudes are assessed through quantitative statistical measures (Ellis et al., 2007), allowing for the systematic elucidation of subjective perception (Steelman & Maguire, 1999). The intent of Q methodology is to facilitate the participant in modelling his or her own opinion (Brown, 1980) and the results provide insight into the underlying premises and values that the individual holds (Focht, 2002). In reference to the aforementioned challenges with r-method techniques, definitions are not pre-determined with Q method but rather inferred from the model generated by the sorter (McKeown & Thomas, 1988). In addition to preserving the original meaning of the participants' perspectives, Q methodology has the capacity to reveal previously unidentified or unexpected discourses (Addams & Proops, 2000). The outcome is a "more authentic set of factors" (Addams & Proops, 2000, p. 1) explaining the attitudes regarding an issue. The strength of Q method is that while it is quantitatively explicit, constrained by statistical summary and replicable (Ellis et al, 2007), it is also thorough in its qualitative exploration of an individual's understanding.

Q methodology involves the participant mapping out his or her perspective, by rank ordering a common set of statements or other stimuli according to specific conditions of instruction, such as sorting statements according to those they *most agree with* to *most disagree with*. Each rank ordered sort is maintained whole and statistically analyzed relative to the sorts of the other participants. Once factor analyzed, patterns of similarity and difference among the cluster of sorts are revealed (Addams, 2000; McKeown & Thomas, 1988; Brown, 1980).

3.2 Q Methodology Applied to Natural Resource Management

Since its inception in the 1930's by William Stephenson (Brown, 1980), Q methodology has been applied to a wide variety of fields including politics, psychology, health, education, management, environmentalism and resource management (Eden et al., 2005). The use of Q methodology for environmental policy and planning research is a relatively new, but expanding, application (Webler & Tuler, 2001). Specifically in policy and natural resource management research, Q method has been used to identify stakeholders' subjective perceptions regarding forestry (Burns & Cheng, 2007; Steelman & Maguire, 1999), wind farms and energy management (Ellis et al., 2007), ecological restoration (Woolley & McGinnis, 2000), environmental conservation (Mattson et al., 2006; Byrd, 2002), public lands management (Martin & Steelman, 2004), watershed management (Focht, 2002; Webler & Tuler, 2001), and water resource management (CIPP, 2006). It has also been applied to various issues of environmental conflict and environmental policy (Addams & Proops, 2000).

3.3 Q Methodology Applied to Parcel Level Greywater Reuse in Metro Vancouver

3.3.1 The Q Sample

The Q sample, or the collection of statements to be sorted by the participants, was developed from a concourse of 250 statements addressing possible barriers to greywater reuse. I gathered these statements from international, national and local greywater reuse literature, namely reports regarding greywater reuse in Canada and British Columbia, and from journal articles addressing greywater reuse in various locations. It was important at this phase of the study to maintain as broad a variety of statements as possible; therefore, all opinions regarding barriers to greywater reuse given in the literature were retained in the initial concourse. Increasing repetition in the opinions and perspectives gathered from the literature was used as an indication that the concourse had been adequately surveyed (Brown, 1980).

Brown (1980) indicates that the preferred method for developing the initial concourse is to draw statements from a series of interviews with the individuals who will be completing the Q sort. The goal behind this is to maintain the naturalness of the statements; by maintaining the language and style of expression used by the participants, the statements will likely be more comprehensible for the sorters. The main challenge with conducting these interviews is they require substantially more time from the participants. Another frequently used method is to use written narratives from the collection of literature addressing the topic under consideration (McKeown & Thomas, 1988), which is what I have done in the present study.

As a Q sort with 250 statements would be unmanageable for sorters (Brown, 1980), I reduced the original concourse of 250 statements to a sample of 47 statements. Brown (1980) suggests that while the statement selection process is more of an art than a science, it should be done in a way that the selected statements represent all perspectives present in the concourse (van Exel & de Graaf, 2005). To carry this out, I began by grouping the statements together in themes and minimizing repetition within these groupings. From this second set of statements, an inductive set of categories and subcategories emerged, which was applied to the statement collection (McKeown & Thomas, 1988). By superimposing this structure onto the selection of statements, I attempted to ensure that a broad sampling of perspectives was included and that I was being theoretically explicit in my sample choices (Durning & Brown, 2007). The sampling structure is illustrated below in Table 3.1. When selecting the final sample of statements, I followed Brown's (1980) recommendation of the principle of heterogeneity, or maintaining the highest degree of diversity within each subcategory.

Table 3.1 Framework used to select the statements included in the Q sample.

Main Category	Subcategory	# of Statements
Perception of Necessity	Sorter's own perception of the necessity of implementing greywater reuse	*2*
	Sorter's opinion of others' perceptions of the necessity of implementing greywater reuse	*2*
Technical Feasibility	Infrastructure Issues	*5*
	Ecological Health Risks	*4*
	Human Health Risks	*5*
Institutional/legal Constraints	Laws and standards	*9*
	Perceptions of those responsible for inspections, permits, and decisions	*7*
Markets	Economic costs	*4*
	Perceptions of contractors/developers	*4*
	Perceptions of potential users	*5*

The number of statements I used in the study was in part influenced by what is realistic for sorters to comprehend and consider in one sort, and by the number of categories present in the statement framework. Forty to 50 items has been suggested as an appropriate range for the total number of statements used (van Exel & de Graaf, 2005), but it has been emphasized that the final number used should allow for adequate coverage of the topic and repetition of the opinions, yet not overwhelm the sorter (Stephen, 1985). With the framework of ten categories, I aimed for four or five statements within each; in order to maintain heterogeneity within the categories and to ensure complete coverage of each category, I deviated from this number in four of the categories. The final 47 statements were printed on 2-inch by 3-inch cards with numbers on the back for easy recording after the sorting process.

3.3.2 The P Sample

I identified the set of participants to be included in the research (the P sample) through targeted non-random sampling and the application of systematic criteria. The goal was to include people who's perspectives, in theory, were of interest to the present study (developers, regulators, greywater users etc.) (Robbins, 2004) and to ensure that representatives of as many relevant groups as possible completed the Q sort (Watts & Stenner, 2005). The purpose behind generating diversity in the P sample was to ensure that the sample would provide ample opportunity to detect all or most existing perspectives (Durning & Brown, 2007). To ensure diversity, a P sample framework was initially adapted from the one used by Durning & Brown (2007) and is illustrated in Table 3.2 below. I revised this framework as the study progressed and more information became available the from post-sort interviews, such as recommendations about additional participants whose views could be important.

Table 3.2 Initial P sample framework,

Used to identify initial interview candidates. Adapted from Durning & Brown (2007).

Systematic Criteria	**Definition/description of grouping**	**Specific sub-groupings**
Experts	- Individuals who have special knowledge concerning an issue based on careful and prolonged study or training.	- Engineers - Developers - Contractors - Academics
Authorities	- Persons who speak authoritatively because of their position in society such as government employees, inspectors or politicians.	- Health authorities - Building/Plumbing Inspectors - Utility / resource managers - Municipal / Regional / Provincial Decision Makers
Special Interest Groups	- Those who have a stake in the outcomes.	- Users of Greywater - Environmental Non Governmental Organizations

Table 3.3 Final P sample framework

Revised framework developed with information from the greywater reuse stakeholder community. Twenty-five participants completed sorts. Many participants fit into more than one participant category and as a result the sum of the participants in each category in the table below (31) is greater than the actual number of participants in the study (25).

Systematic Criteria	Definition/description of grouping	Specific sub-groupings	Participant Count
Greywater Users	- Persons who have greywater reuse systems installed in their homes or offices.	- Single or multi family building dwellers	4
Regulators	- Persons who are responsible for inspecting, authorizing and/or regulating greywater reuse at the parcel level.	- Health authorities - Building & Plumbing Inspectors - Environmental Protection Officers	6
Planners	- Persons involved in regional and local level resource management planning.	- Regional level planners - Local level planners	7
System Developers	- Persons who design, develop, and install greywater reuse systems.	- Engineers - Property developers	8
ENGOs	- Environmental non-government organizations	- Sustainable building advisory groups - Environmental law	6

With Q methodology, the exact number of participants required is not specific; all that is required is that enough subjects and views be included in order to offer the opportunity to establish the existence of factor groups representing the range of views about the subject (McKeown & Thomas, 1988; Brown, 1980). In the present study, I attempted to include three individuals representing each of the specific sub-groupings listed in Table 3.3, but this was not always possible as greywater reuse projects are rare in Metro Vancouver. Still, 25 sorts were completed in total, many of them by individuals who fit into more than one of the sub-categories. Initially, these participants were identified through personal contacts with developers, members of environmental non-government organizations, academics, and individuals living in Quayside Village (a parcel level greywater reuse project in Metro Vancouver). I then identified subsequent participants through recommendations given to me by the initial participants.

3.3.3 The Q Sort

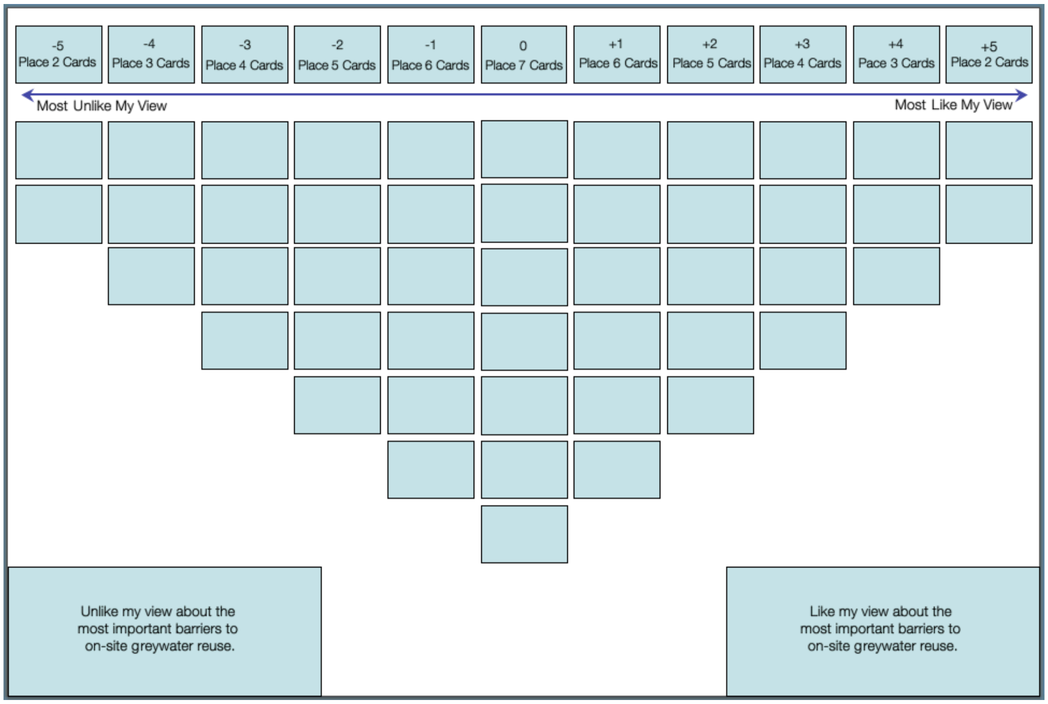
Through the Q sort, each participant modelled his or her point of view by rank-ordering the Q sample statements (McKeown & Thomas, 1988). Each Q sort was conducted during a one-on-one interview with the participant in order to maximize my understanding of the results (van Exel & de Graaf, 2005). I began each interview with a brief description of the process they were about to participate in as well as clarification of the types of greywater systems being examined in the Q study, including sources of greywater, applications of the renovated water, and the scale of the systems being considered (See Appendix C). This was done to ensure all sorters were considering the same type of greywater reuse system while completing the sort. Following this, I presented them with the conditions of instruction, which guided them through the sorting process (McKeown & Thomas, 1988). The conditions of instruction I used were drawn from my research questions and were stated as follows:

> Please sort the following statements from those that are most like your view of the most important barriers to parcel level greywater reuse in Metro Vancouver, to those that are most unlike your view of the most important barriers to parcel level greywater reuse in Metro Vancouver.

In order to facilitate the sorting process a template of the sort distribution, printed on a 24-inch by 36-inch poster, was laid out before the sorter (see Figure 3.1 below). I used a quasi-normal distribution for the card placement as this distribution emphasizes statements placed at the extremes and focuses the analysis on the statements that elicited the most meaningful responses from the sorters (Stephen, 1985). I used a slightly flattened distribution (as opposed to a more normal distribution) in the present study as I felt most individuals participating would be familiar with the ideas they were being asked to sort, and as a result, would need fewer spaces under the *neutral or unsure* category than the *like/unlike my view* categories (Brown, 1980; van Exel & de Graaf, 2005). Fitting the 47 statements into a slightly flattened quasi-normal distribution required me to use 11 columns ranging between +5 (most like my view) to -5 (most unlike my view) (Brown, 1980). The template included the number of statements to be placed within each column (represented both visually and numerically), the conditions of instruction, as well as two sorting blocks to be used in the initial phases of the sorting process (McKeown & Thomas, 1988).

As can be seen in Figure 3.3, fewer cards were to be placed at the extremes (+/-5) than in the more neutral columns. This format encourages participants to make decisions about which statements they feel are most and least important. During the sorts I encouraged participants to follow the template provided as best they could. Most participants stuck to the template with seven deviating.

Figure 3.1 Sorting template used to assist participants with the sorting process.



For the sorting process, I followed the steps recommended by McKeown & Thomas (1988). These steps are as follows:

1. The participant was asked first to read through the statements and to sort them into three general piles: statements most *like* their view of the important barriers to greywater reuse in the box on the bottom right; statements most *unlike* their view of the important barriers to greywater reuse in the box on the bottom left; and statements the sorter felt neutral, ambivalent or uncertain about were to be placed in a pile in the middle.
2. Attention was then drawn to the pile on the right and the participant was asked to spread the statements out and to pick the two statements they felt were the most like their view of the important barriers to greywater reuse in Metro Vancouver, and to place them under the +5 column.
3. I then drew their attention to the pile of statements on the left and asked them to pick out the two statements they felt were the most unlike their view of the

important barriers to greywater reuse in Metro Vancouver, and to place them under the -5 column.

4. This process was completed again for the +/- 4 columns and the +/- 3 columns, and then the participant was allowed free rein to sort the remaining statements under the more neutral columns. While I encouraged this back and forth sorting pattern, many participants were drawn to sorting one side completely, and then the other.
5. Once the sort was completed, I asked the participant to take a second look at their sort and encouraged them to make any adjustments they felt were necessary in order to ensure the sort accurately reflected their opinion.
6. Once the participant was sure about their card placement, I conducted a post sort interview. Finally, the card numbers were recorded on a separate sheet for each individual.

It has been noted that an important step in the Q sort process is the post sort interview where the Q sort is used as a conversation piece providing the basis for a structured interview (Brown, 1980). This step aids in the interpretation of the results from the sorting process (van Exel & de Graaf, 2005). I drew my post sort questions from those recommended by Watts & Stenner (2005). These included the following:

1. Looking at the statements you placed in the +5 column, can you tell me how you interpreted these statements and why it is you placed them in these spots? (Repeat for the -5, +4 and -4 columns)
2. Are there any barriers that you feel were missed from this sort? What are they and why do you feel these are important?
3. Are there any statements that you found to be particularly confusing or difficult to sort? Which ones and why?

Finally, two additional questions were included in order to take full advantage of the expertise of the individuals being interviewed. These were:

4. Do you feel that greywater reuse as described here should be pursued in Metro Vancouver? Why or why not?
5. (If yes to the above) What steps would you recommend be taken in order to help facilitate the implementation of parcel level greywater reuse in Metro Vancouver?

3.3.4 Method of Analysis

Q method studies typically follow a three-step process when analyzing the data generated by the sorters; correlation, factor analysis, and computation of factor scores (McKeown & Thomas, 1988). Correlation in Q methodology is a transition phase between the raw data and the factor analysis (Brown, 1980). Factor analysis is used to examine the correlation table and to identify how many markedly different Q sorts are evident within the collection of Q sorts (Brown, 1993). The resulting groupings of similar sorts are referred to as factors or narratives. Once the factors have been identified, factor loadings are used to ascertain how similar or dissimilar each respondent's Q sort is to each factor (McKeown & Thomas, 1988). These factor loadings are then used to generate a model of how someone who loaded 100% on a given factor would have responded during the sorting process (van Exel & de Graaf, 2005). To carry out this process, I used PQMethod (2.11) software (Schmolck & Atkinson, 2002) and I selected Principal Components factor analysis as it is more mathematically precise than other methods such as the commonly used Centroid factor analysis (McKeown & Thomas, 1988; Brown, 1980).

When using Q methodology, some form of factor rotation, or changing of the vantage point from which data are viewed, is typically employed after factor analysis (McKeown & Thomas, 1988). The goal is to fit the factors to the sorts in a more statistically or theoretically significant way. Rotation can be done objectively, driven by statistical principles, or theoretically, driven by a theory or judgment of the researcher (van Exel & de Graaf, 2005). In the present study, I tested both theoretical and objective rotations on the data and settled for a commonly used objective method, Varimax (Brown, 1980). I found no added theoretical insight in the solutions developed with the theoretical rotation and thus decided to use the more statistically based solution.

Before factor rotation can be completed, the number of factors to be rotated must be chosen. After careful consideration, and the application of seven different statistical and theoretical criteria, I chose to rotate three factors. The first statistical method I applied was the common practice of identifying how many factors had eigenvalues greater than 1.00. These factors were considered to be meaningful, while those with eigenvalues less than 1.00 were considered too weak to consider (McKeown & Thomas, 1988). In the present study, eight factors had eigenvalues greater than 1.00. I did not consider this as my sole input into the number of factors to be rotated, however, as Brown (1980) argues that eigenvalues are in fact relatively meaningless in Q studies as they are influenced to a great extent by the arbitrary number of sorters loading on each factor—in other words, by the structure of the initial sample of participants in the study.

The next test I considered was Cattell’s scree test. For this test, eigenvalues are graphed and the appropriate number of factors to retain is indicated by a substantial break in the slope (Cattell, 1966). The goal is to account for as much of the variability in the original correlation matrix with as few factors as possible (Brown, 1980); this test is an indicator of the amount of variation that is being accounted for by each of the factors. The Cattell’s Scree test for the present study indicated that two or three factors could be retained (please see Appendix E), but once again, this was not considered to be a strong indicator in my decision of how many factors to rotate due to its reliance on eigenvalues.

A criterion that was given more weight was the number of significant loadings that occurred on each of the factors when 2, 3, 4 and 5-factor solutions were calculated. The significance level was determined by calculating the standard error at $p = 0.01$ ($2.58 \times 1/\sqrt{N}$, where $N = 47$, the number of statements); I considered any loading equal or greater than this value to be significant (McKeown & Thomas, 1988). Typically a factor is only included in the rotation if there are two or more significant loadings on it (Brown, 2001), which is the case for all four solution options that I looked at. However, the 4 and 5-factor solutions did have fewer significant loadings on some of the factors, when compared to the 2 and 3-factor solutions (please see Table 3.4 below).

Any sort that is significantly loaded on more than one factor is referred to as a confounded sort; unloaded sorts are those that do not significantly load on any of the factors (Durning & Brown, 2007). Both of these measures are helpful indicators of how well a solution fits the data. As seen in Table 3.4 below, the 4-factor and 5-factor solutions have no unloaded sorts, indicating good representation of all the sorters. Yet, nearly 40% of the sorts in the 4-factor solution are confounded. The 2-factor solution contains five unloaded sorts while the 3-factor solution has four; this increase of significantly loaded sorts is, however, gained at the expense of also gaining four more confounded sorts (please see Table 3.4 below).

Table 3.4 Significant loadings, confounded loadings and unloaded sorts.

The number of significant loadings on each factor, as well as the number of confounded loadings and unloaded sorts, for each of the 2 through 5-factor solutions. Grey shading indicates the 3-factor solution used for the final analysis.

	Significant Loadings						
	F1	**F2**	**F3**	**F4**	**F5**	**Confounded**	**Unloaded**
2-Factor solution	13	9	--	--	--	2	5
3-Factor solution	10	7	10	--	--	6	4
4-Factor solution	9	7	14	4	--	9	0
5-Factor solution	12	3	3	5	6	4	0

The next statistical criterion for making the decision about how many factors to rotate is the same as the process used to identify which sorts to flag when developing the model sorts of each factor. A model sort for each factor is obtained by weighting and merging its representative Q sorts (Brown, 1980). To do this, specific sorts must be flagged in the PQMethod software in order to designate them as representative (McKeown & Thomas, 1988). I identified the specific sorts to be flagged through a three step process; first eliminating confounded and unloaded sorts (Brown, 2005); next identifying sorts where the difference between the two highest loadings was significant (Brown, 2003b); finally identifying any sorts where the non-significant loadings were very close to zero (Brown, 2003a), (please see Appendix F for a more detailed explanation of these three steps). The resulting number of flags for each factor is shown in Table 3.5 below. This step eliminated the 4 and 5-factor solutions from my solution options as each of them had one or more factors with only one representative sort.

Table 3.5 Number of flagged sorts identified for each factor for the 2 through 5-factor solution options.
Grey shading indicates the 3-factor solution used for the final analysis.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
2-Factor solution	5	5	--	--	--
3-Factor solution	4	3	3	--	--
4-Factor solution	3	2	5	1	--
5-Factor solution	4	3	1	1	1

The final statistical consideration that went into deciding how many factors to rotate, was that of correlation among the resulting factors; correlation is an indicator of the extent to which the factors are distinct from one another. The 2 and 3-factor solutions both have very low correlation values. The 4 and 5-factor solutions each have two correlation values that are substantially higher, although they are both still well within acceptable levels (please see table 3.6 below). When two factors are highly correlated, it becomes difficult to distinguish the two (Brown, 2003a) and the theoretical significance (the final element that was considered when deciding how many factors to rotate) of the two factors comes into question.

Table 3.6 Correlation values for 2, 3, 4, and 5-factor solutions. Grey shading indicates the 3-factor solution used for the final analysis.

Factors	1 & 2	1 & 3	1 & 4	1 & 5	2 & 3	2 & 4	2 & 5	3 & 4	3 & 5	4 & 5
2 factor solution	0.0330	--	--	--	--	--	--	--	--	--
3 factor solution	0.0568	0.0898	--	--	0.0003	--	--	--	--	--
4 factor solution	0.0017	0.3858	0.1547	--	0.1362	0.1548	--	0.1457	--	--
5 factor solution	0.0546	0.0462	0.0850	0.1485	-0.1755	0.2371	0.0506	0.1531	0.0750	0.0063

It has been suggested that the final importance of each factor cannot be determined by statistical criteria alone (Brown, 1980) and as a general rule, Q methodology tends to emphasize theoretical significance and relax reliance on statistical significance (McKeown & Thomas, 1988). McKeown and Thomas (1988) caution that reliance solely on statistical criteria can lead one to consider a factor that is substantively without meaning or to overlook a factor that is of theoretical interest, and that one must consider the purposes and theoretical issues of the research project when interpreting the results. Either a 2 or 3-factor solution can be justified for the present study based on the statistical measures discussed above. Yet, examination of the theoretical significance of the 3-factor solution relative to that of the 2-factor solution revealed that the additional perspective present in the 3-factor solution is of theoretical interest.

With the 2-factor solution, Factor One perceives the most important barriers to be regulatory prohibition and reluctance on the part of the regulators, and the most unimportant barriers to be the technical challenges associated with operating at the scale of a single home or building. Factor Two perceives the important and unimportant barriers to be essentially in reverse to that of Factor One. The 3-factor solution revels a more complex representation of the participants views. This solution does more than simply add a third perspective, it reorganizes the suite of perspectives increasing the detail revealed about participants views on public perception and ability, economics and environmental health.

CHAPTER 4: RESULTS

4.1 Chapter Outline

In this chapter I describe the results obtained using Q methodology to map out the perspectives of key participants in the development, application and regulation of greywater reuse in Metro Vancouver. As described in Chapter 3, a 3-factor solution was decided upon during the analysis of the data. I labelled the three factors Institutional Reformers, Centralized Managers and Technical Pragmatists. In section 4.2, I provide a brief summary and then a more detailed description of each of the three factors. After discussing the results of the Q sort, I address the responses to the post sort interview questions in section 4.3.

I occasionally refer in this chapter to the categories of barriers I developed in the background research and used to select the Q sample (regulatory, technological, economic and perception barriers). I also organize the discussion in Chapter 5 according to these categories. It is important to note, however, that I did not use this framework of categories to analyse the results of the Q study, but rather as a convenient and concise way of reporting the findings, and one that uses language consistent with that commonly used in the literature addressing water reuse. In Q method, the researcher's pre-constructed frame of reference should not be imposed on the results in place of the subjective frames of the individual sorters involved in the study. As Steven Brown explains:

> “A set of items may be conceptualized as a measure of this or that trait, but this is purely theoretical rather than instrumental and is only useful for composing Q samples ad hoc. … Whatever an investigator may define a statement to mean theoretically in no way necessarily enters into the subject’s understanding as he scores that same statement in a Q sort. Ultimately we are uninterested in the logical properties of the Q sample, but in learning how the subject, not the observer, understands and reacts to the items. …. The subject’s frame of reference is given prominence through factor analysis, which may produce results quite other than what the investigator postulated originally. (Brown, 1980, p. 191)

In the results section, the barrier topics I address do not follow the framework absolutely, but rather I group the results under barrier topics that appropriately illustrate the patterns identified: some of them match the Q sample framework while others do not. In the Discussion section, I adhere to the framework to allow for easy comparison of the barriers identified in the present Q study with the barriers identified in the background research.

4.2 Factors

4.2.1 Factor Loadings

Each of the three factors identified in the present Q study describes a cluster of individuals who share a similar perspective. These three perspectives are described through representative model sorts called factor arrays (please see Appendix G). Factor loadings are used to indicate how similar or dissimilar an individual’s Q sort is to each of the three factor arrays (McKeown & Thomas, 1988). Table 4.1 below lists the factor loadings of each participant’s sort on each of the three factors. The patterns mapped out in table 4.1 are discussed in the subsequent sections of this chapter.

Table 4.1 Factor Loadings.

Bold text indicates loadings that are statistically significant at p=0.01, shaded boxes indicate loadings that were flagged for each factor during Varimax rotation.

Participant Categories		ID	Institutional Reformers	Centralized Managers	Technical Pragmatists
Environmental Non Governmental Organizations		02	**0.4611**	**0.4234**	0.2184
Environmental Non Governmental Organizations		05	**0.5478**	**0.5565**	0.0628
Environmental Non Governmental Organizations		03	**0.3955**	-0.0108	**0.6206**
Environmental Non Governmental Organizations		24	**0.4900**	0.1847	**0.5572**
Environmental Non Governmental Organizations	Greywater Reuse System Developers	01	0.1278	**0.4680**	**0.3762**
Environmental Non Governmental Organizations	Greywater Reuse System Developers	21[3]	0.3137	0.2810	**0.6020**
	Greywater Reuse System Developers	09	0.3229	-0.0861	-0.0131
	Greywater Reuse System Developers	10	0.0754	**0.5738**	**0.4244**
	Greywater Reuse System Developers	19	0.2530	0.3338	**0.4355**
	Greywater Reuse System Developers	20	0.3339	0.1595	**0.5465**
Local and Regional Planners	Greywater Reuse System Developers	07	-0.0203	0.0825	**0.3920**
Local and Regional Planners	Greywater Reuse System Developers	15	-0.4333	0.1800	**0.6235**
Local and Regional Planners		06	**0.4193**	0.2780	**0.4343**
Local and Regional Planners		08	**0.6521**	-0.0548	0.0810
Local and Regional Planners		16	**0.7822**	0.1447	0.3127
Local and Regional Planners		22	0.0015	0.1556	0.3221
Local and Regional Planners	Greywater Reuse System Users	18	**0.7409**	0.0662	0.2662
	Greywater Reuse System Users	14	**0.6752**	0.2284	0.1252
	Greywater Reuse System Users	13	**0.5971**	0.2251	0.0578
	Greywater Reuse System Regulators	11	-0.1587	**0.6987**	0.1321
	Greywater Reuse System Regulators	23	-0.0818	**0.7011**	-0.0525
	Greywater Reuse System Regulators	25	0.1030	**0.5406**	0.0741
	Greywater Reuse System Regulators	17	0.0371	-0.3938	**0.7429**
	Greywater Reuse System Regulators	04	0.1069	0.3172	0.2022
	Greywater Reuse System Regulators	12	-0.5441	0.3398	0.1029

[3] Sorter 21 is also a Greywater Reuse System User.

4.2.2 Factor Interpretation

Brown claims "there is no set strategy for interpreting a factor structure; it depends foremost on what the investigator is trying to accomplish" (Brown, 1980, p. 247). The aim of the present study is to identify the perceived barriers to greywater reuse in Metro Vancouver, therefore the analysis of the factors should focus on which statements were placed in the +/- 3 to 5 columns (please see the factor arrays in Appendix G). To reiterate the meaning of a statement placed in these extreme columns, statements placed in the +5 to +3 columns are ones which the sorters felt were most like their own views of the important barriers to greywater reuse in Metro Vancouver, while statements placed in the -5 to -3 columns are ones which the sorters felt were most unlike their own views of the important barriers to greywater reuse in Metro Vancouver.

In addition to answering the research question, a comparison of these three perspectives will help facilitate understanding and communication of the different views and opinions held among the participating stakeholders. This suggests that, in addition to describing the factors, the analysis should also examine the differences and similarities between and among them. In order to facilitate a comparison, the more neutrally ranked statements (+/- 2 to 0) in each of the factors will also need to be examined, if the placement of neutral statements for one factor is in contrast to that of the other factors, or is commonly shared across all factors. The following six sections focus on illustrating, comparing and contrasting the factor arrays.

4.2.3 Factor One – Institutional Reformers

The important barriers are institutional. Regulation as it currently stands is a barrier and regulators are overly risk averse. Greywater reuse is not as difficult, as costly or as risky as regulators perceive it to be.

Institutional Barriers

Institutional Reformers see the important barriers to parcel level greywater reuse in Metro Vancouver as being institutional. The individuals loading on this factor believe there is a lack of guidance for working within regulation pertaining to greywater reuse systems (statement 38), and that existing applicable regulation is vague (statement 3) and prohibitive (statements 6 and 44). Comments during post sort interviews with sorters correlating with this factor included, “there is no clear authority” (Sorter 16[4]), “it is ambiguous as to who is regulating greywater” (Sorter 14) and “anything to do with regulation around greywater reuse is murky to say the least” (Sorter 18).

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
5	1	3	3. BC’s regulations governing greywater reuse in single-family dwellings are vague at best.
4	-1	4	38. There is a lack of regulatory guidance for greywater reuse.
4*	1	-2	6. Developers and residents wanting to reuse greywater often face stringent regulatory challenges.
3*	-1	0	44. Greywater reuse for surface irrigation at a single residence is not permissible under the BC Health Act’s Sewerage System Regulation.

[4] Quotations are identified by each sorter’s ID. For a list of sorter information please see Appendix D.

Institutional Reformers see the institutional barriers as being more than just problems with regulations, but also as originating from the opinions and attitudes of regulators. For example, during the post sort interview, Sorter 16 stated, “you might get designers willing to push the envelope if the local authorities would approve it, but that is not happening, in fact that is where many of the obstacles happen.” Many sorters loading as Institutional Reformers indicate that they perceive the health authorities to be “fairly conservative in terms of their willingness to accept risk” (post sort interview with Sorter 6) and reluctant to allow greywater reuse (statement 34). Along with the health authorities’ reluctance, Institutional Reformers perceive building inspectors as being reluctant to sign off on a greywater reuse system because of lack of information and training (statement 43).

Factor Scores			
I	**II**	**III**	**Statement**
4	-3	2	34. There is reluctance on the part of BC health authorities to endorse onsite reuse, particularly at the level of individual households, citing health issues.
3	1	3	43. Lack of information and training makes it difficult for municipal building inspectors to determine whether a proposed innovation for greywater reuse provides protection to the public equivalent to that of BC Building Code requirements.

Institutional Reformers feel that issues of accountability and liability cause much of the regulators’ fear and reluctance (statements 22 and 36). During a post sort interview one greywater reuse system user stated, “for us that was such a major stumbling block, this liability issue” (Sorter 14).

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01			
I	**II**	**III**	**Statement**
5*	-1	-2	22. Fear of being sued makes municipal building inspectors reluctant to approve an innovative design.
1**	-2	-1	36. Designers of water and wastewater systems (professional engineers) are bound by due diligence, making it difficult to consider and implement greywater reuse systems because of their perceived experimental nature.

Economic Barriers

Second to regulatory barriers, Institutional Reformers feel the important barriers to greywater reuse in Metro Vancouver are economic, but these barriers have more to do with accounting and less to do with actual costs. These sorters feel that greywater reuse is economically justifiable when full cost accounting is used and when environmental protection offered by greywater reuse is factored into the accounting (statement 25). This sentiment was emphasized during the post sort interview with Sorter 24 who stated, "there is an under valuation of water in our society." Institutional Reformers feel lack of metering for potable water in Metro Vancouver discourages greywater reuse (statement 4) because "with metering comes financial incentive" (post sort interview with Sorter 14). Institutional Reformers do not feel that only large systems can justify the cost (statement 1) but rather that "the economics do work at the household level" (post sort interview with Sorter 18).

Factor Scores			
I	**II**	**III**	**Statement**
3	2	1	25. The current cost analysis for providing greywater largely considers infrastructure and distribution costs, maintenance and capital costs, while the water resource itself, the change of the flow regimes, and how it effects the environment is not fully accounted for.
3	2	-5	4. Lack of metering for potable water supply discourages the public from employing greywater reuse as a water supply alternative.
-4	-4	-2	1. Only fairly large-scale applications can justify the expenses associated with greywater reuse.

Technical Barriers

Institutional Reformers see the technical issues associated with human error in the maintenance and operation of reuse systems as being *most unlike their view* of the important barriers to greywater reuse in Metro Vancouver. Individuals who correlate highly with this factor feel that small-scale greywater reuse systems are not difficult for the public to operate and maintain (statements 33 and 32). More specifically, they feel the risk of cross-connection between a greywater system and the potable water system is not an important barrier (statement 7). During the post sort interview Sorter 18 stated, "of course there is potential for cross connection but I think everybody worries about this one more than they need to. It is like electricity, I can screw up the electrical just as easily and probably with worse consequences."

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01			
I	**II**	**III**	**Statement**
-5**	5	5	7. There is the potential for accidental cross-connection of a greywater reuse system with the drinking water system.
-4**	2	0	33. Greywater reuse systems in single-family dwellings are difficult to regulate, maintain and monitor.
-4**	3	0	32. On-site treatment plants require skilled operator attention, routine maintenance, water quality sampling, and regulatory reporting, which make greywater reuse difficult.

Tied in with the perspective that parcel level greywater reuse systems are easy to operate and that technical issues associated with the systems are not important barriers, Institutional Reformers also feel the human and environmental health risks presented in the sort are unfounded and unimportant barriers (statements 8, 21, 26 & 2).

Factor Scores			
I	**II**	**III**	**Statement**
-3	-4	2	8. Users of greywater for toilet and urinal flushing and landscape irrigation may accidentally ingest small volumes of greywater through aerosols or hand-to-mouth contact with droplets.
-3	-5	4	21. Greywater reuse systems operating at a scale larger than one home have the potential to expose a large number of people to disease-causing microorganisms.
-3	-3	0	26. Greywater reuse for irrigation of lawns and gardens has the potential to cause contamination of groundwater and surface water.
-3	-3	-1	2. Greywater used for irrigation can damage soils by raising the soil alkalinity and salinity and reducing the ability of the soil to absorb and retain water.

Need for Parcel Level Grey Water Reuse in Metro Vancouver

Statement 47 was often difficult for sorters to place using the conditions of instruction presented to them. Many sorters correlating as Institutional Reformers sorted statement 47 in the -4 or -5 column, yet it was identified during the post sort interviews that this was done for different reasons. Some sorters placed it here because they *disagreed* with statement 47 (Sorters 2, 3, 8 & 18). Sorter 16 revealed during the post sort interview that he sorted it here because he felt the perception was "no longer held" and therefore not an important barrier. Finally, Sorter 13, who sorted statement 47 in the +4 column, revealed during the post sort interview that he felt this perception was commonly held and therefore an important barrier.

Regardless of how statement 47 was sorted, the participants identified as Institutional Reformers do feel that Metro Vancouver is facing water supply challenges and that greywater reuse is an important water resource alternative. This perception was shared during post sort interviews through comments such as: "it is not a question of how much rain we get, it's how much capacity we have to store it and how much it costs to treat it" (Sorter 3); "we are a growing region with finite water resources, any way we can diversify the source we are using helps accommodate that growth in population" (Sorter 6); "live here for one summer and you know how dry it is, you know about restrictions. I think that the position that water is not an issue here is a fallacy" (Sorter 16); "water shortage is a real issue here… greywater [reuse] is one way of mitigating this" (Sorter 18).

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01			
I	**II**	**III**	**Statement**
-5**	0	-3	47. Greywater reuse is not an important water resource alternative for Vancouver as water shortage is not a real issue here.

4.2.4 Factor Two – Centralized Managers

The important barriers stem from public perception and public behaviour. Greywater reuse is easy to do on a large scale, but parcel level reuse leaves too much in the hands of under-educated homeowners. The public does not perceive a need nor have the desire to reuse greywater.

Perception Barriers

Centralized Managers believe the important barriers to parcel level greywater reuse in Metro Vancouver are associated with public perceptions. Individuals who identify with this factor believe the public is reluctant to pursue greywater reuse (statements 30 and 20) claiming, "people are scared" (post sort interview with Sorter 11). In addition, they feel that the public generally doesn't perceive water supply to be an issue in Metro Vancouver (statement 28). During the post sort interview, Sorter 11 stated, "our water is so reasonable and so abundant, [the public] just doesn't think we need [greywater reuse]."

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01			
I	**II**	**III**	**Statement**
0	**5****	-3	30. Greywater reuse is seen to be a logical and necessary inclusion in the range of water resource management options, but people frequently feel a reluctance to personally use the water.
0	**4****	0	28. In Metro Vancouver, where water is seemingly abundant, there is a perception among the public that water shortage is not a real issue.
0	**4***	1	20. Public perceptions of health & environmental risks hamper greywater reuse.

On the other hand, Centralized Managers do not feel the health authorities are reluctant to endorse or allow greywater reuse in Metro Vancouver (statements 9 and 34). For example, during the post sort interview, Sorter 11 stated, "I don't believe there is reluctance, I am only speaking from my point of view, but I don't have a reluctance to endorse this onsite reuse at all." Rather, Centralized Managers see decision makers as failing to consider greywater reuse due to the perception of water abundance in Metro Vancouver (statement 45); "local governments think that we have a lot of fresh water so why would we consider doing greywater reuse" (post sort interview with Sorter 7). In addition, this factor feels that design professionals and developers are not pursuing greywater reuse because of a lack of knowledge and information (statement 11). During the post sort interview, Sorter 2 stated, "most developers just don't even think about it."

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01			
I	**II**	**III**	**Statement**
2	**-3****	2	9. The Sewerage System Regulation under the BC Health Act groups grey and black water together as domestic sewage. Without a clear differentiation between grey and black water health officials are reluctant to allow greywater reuse.
4	**-3****	2	34. There is reluctance on the part of BC health authorities to endorse onsite reuse, particularly at the level of individual households, citing health issues.
2	**3**	-4	45. Because freshwater appears to be abundant in Vancouver, local government decision makers do not consider greywater reuse as a serious option when contemplating water resource alternatives.
2	**3**	-2	11. Lack of knowledge about innovative greywater reuse practices is a barrier for design professionals and developers.

Behavioural Barriers over Technical Barriers

Centralized Managers are more concerned with human error in the operation and maintenance of parcel level greywater reuse systems than they are with the technology itself. For example, this factor is not concerned that public health will be jeopardized through aerosolization of greywater (statement 8): "There is no evidence that that's a significant pathway… The concept of this being a real issue, aerosolization, droplets flying through the air that you are going to ingest, surely your risk is exactly the same when you use a public washroom" (post sort interview with Sorter 10). Yet they feel the need for proper operation and maintenance, in order to ensure the greywater reuse systems continue to function adequately, makes parcel level greywater reuse systems difficult for homeowners and building owners to operate safely (statements 10 & 32). Sorter 15, who stated, "Many home owners have trouble maintaining fairly simple things, never mind a waste water treatment system", illustrated this.

A more specific example of the above concern regarding maintenance and operation is a fear of cross-connections (statement 7) leading to contamination of the potable water system with greywater. Centralized Managers see an increased likelihood of cross-connections when greywater reuse systems are run by home-owners rather than by a municipality or organized group; "the single family dwelling owner coming in and doing his own plumbing, not properly labelling or colouring the pipes, can be a real concern" (post sort interview with Sorter 25).

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
-3	**-4**	2	8. Users of greywater for toilet and urinal flushing and landscape irrigation may accidentally ingest small volumes of greywater through aerosols or hand-to-mouth contact with droplets.
-2	**4**	1	10. On-site greywater reuse places much of the maintenance on homeowners and property managers. Without professional maintenance, water treatment will degrade over time and jeopardize user health.
-4	**3****	0	32. On-site treatment plants require skilled operator attention, routine maintenance, water quality sampling, and regulatory reporting, which make greywater reuse difficult.
-5	**5**	5	7. There is the potential for accidental cross-connection of a greywater reuse system with the drinking water system.

Scale of the System

In response to the above concerns, sorters identified as Centralized Managers are more comfortable with greywater reuse occurring on a larger scale such as a municipally run system (statement 21). Sorter 12 stated during the post sort interview, "the only system, from my perspective, that I would be even remotely comfortable with would be a municipally controlled one." Centralized Managers feel "bigger systems are maintained a lot better, monitored, and looked after better than a single family system… More resources, more money, better technology, and maintained better" (post sort interview with Sorter 25).

Yet, while Centralized Managers see larger systems as being more acceptable than parcel level systems, this factor also feels the larger systems will be harder for the public to accept (statement 42). Sorter 15 stated during the post sort interview, "people trust what they know, not what they don't know. If they have a small system then they are the ones putting the stuff in, there is no big bad industry across the city that is doing something really strange. I tend to think that the smaller the system the more people would be willing."

Factor Scores			
I	**II**	**III**	**Statement**
-3	**-5**	4	21. Greywater reuse systems operating at a scale larger than one home have the potential to expose a large number of people to disease-causing microorganisms.
-1	**-4**	-4	42. Greywater reuse within a group of homes as compared to a centralized municipal level system can be difficult to accept because people are more aware of the link with previous uses of the water.

Environmental Health Barriers

According to individuals correlated with the Centralized Managers factor, the potential for environmental harms from high strength sewage (statement 16), damage to soils (statement 2) and contamination of groundwater (statement 26) are not important barriers to greywater reuse in Metro Vancouver. For the most part, sorters identifying with this factor placed these statements as least like their view of the important barriers. Conversations during post sort interviews suggest this is because most have not come across these issues in their dealings with greywater reuse systems.

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01			
I	**II**	**III**	**Statement**
-2	**-5***	-4	16. Extraction of domestic greywater from sewage flows could result in high strength sewage that could increase environmental damage to the receiving environment.
-3	**-3**	-1	2. Greywater used for irrigation can damage soils by raising the soil alkalinity and salinity and reducing the ability of the soil to absorb and retain water.
-3	**-3**	0	26. Greywater reuse for irrigation of lawns and gardens has the potential to cause contamination of groundwater and surface water.

Economic Barriers

Finally, Centralized Managers disagree with the idea that only large-scale applications of greywater reuse can justify the associated expenses (statement 1). Some sorters correlating as Centralized Managers disagree with statement 1 because they feel the economics do work on the small scale, while other sorters feel the economics do not work on any scale. For example, during post sort interviews, Sorter 10 stated, "No application can justify the expense in my opinion," while Sorter 1 stated:

> "I have not come across that as a perception and I think that those who are willing to do a small amount of research into systems that are available, quickly see that although it may not immediately be something that is revenue positive in a market where you don't have metered water such as residences, that is not necessarily a barrier to entry…"

Along the same lines, those correlating as Centralized Managers tend to agree that lack of payback for water savings is an important barrier to greywater reuse: "people will not justify capital expenditure on something they are not going to get paid back for" (post sort interview with Sorter 11).

Factor Scores			
I	II	III	Statement
-4	**-4**	-2	1. Only fairly large-scale applications can justify the expenses associated with greywater reuse.
2	**3**	1	41. With small-scale systems, it is unlikely that there will be an economic payback for water savings that would justify the capital expenditure required to develop a greywater reuse system.

4.2.5 Factor Three – Technical Pragmatists

> *The important barriers have to do with regulatory and technical feasibility. The technology and the administrative infrastructure are not well enough developed. The cost of the technology discourages implementation. Greywater reuse is not the most effective conservation measure.*

Regulatory Barriers

Technical Pragmatists perceive the BC health authorities and municipal building inspectors as being reluctant to allow greywater reuse (statements 37 and 43), believing the problem is rooted in lack of knowledge and "lack of regulatory guidance" (post sort interview with Sorter 7) (statements 38, 27 and 3). During post sort interviews, Sorters 10 and 21 expanded upon this perspective:

> "The municipal building inspectors, plumbing and such, have no background in [greywater reuse] whatsoever. Health has no background in this whatsoever. Environment virtually has no background in this whatsoever… I think the lack of information and training is key" (Sorter 10);

> "The major barriers that I see getting in the way of greywater reuse are in fact regulatory and it has to do with fear, uncertainty, and doubt on the part of the regulatory authorities. Probably primarily, first it is the health

> authorities and then it is the plumbing inspectors. To that end, lack of clarity within our regulations… There is a technical capacity and knowledge issue on the part of the regulatory authorities, but that also extends to the professional and the service industries. The plumbers don't know anything about greywater" (Sorter 21).

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
1	-2	**5***	37. Without recognized standards for safe design, treatment quality and operations, BC health authorities are reluctant to allow greywater reuse.
3	1	**3**	43. Lack of information and training makes it difficult for municipal building inspectors to determine whether a proposed innovation for greywater reuse provides protection to the public equivalent to that of BC Building Code requirements.
4	-1	**4**	38. There is a lack of regulatory guidance for greywater reuse.
1	-2	**4**	27. There is no mandatory requirement to include separate greywater reuse piping in new buildings.
5	1	**3**	3. BC's regulations governing greywater reuse in single-family dwellings are vague at best.

The difference in how the Technical Pragmatists and the Institutional Reformers perceive regulatory barriers is illustrated by how the two factors sorted statements 37, 27 34 and 22. The Technical Pragmatists feel the reluctance of health authorities reluctance to endorse greywater reuse stems from lack of guidance in the regulation, while the Institutional Reformers feel this reluctance is a result of the perspectives of the health authorities perceptions, such as fear of public health issues and fear of litigation. During post sort interviews, sorters correlating as Institutional Reformers were more likely to refer to perception barriers on the part of the regulators while Technical Pragmatists would cite more technical issues such as a lack of appropriate technology for the regulators to work with, or a lack of guidance to aid them in assessing proposed projects.

For example, Sorter 21 elaborated on the high placement of statement 37 by stating, "If I haven't got any regulations that are going to back me up, then I am going out on a limb. There is fear… for the municipalities that are moving into uncertain regulatory ground." Sorter 22 elaborated on the high placement of statement 22 by stating, "our code officials always operate from a position of fear and there is more of an incentive for them not to do something and to keep the regulation tight and not deal with it."

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
1	-2	**5***	37. Without recognized standards for safe design, treatment quality and operations, BC health authorities are reluctant to allow greywater reuse.
1	-2	**4**	27. There is no mandatory requirement to include separate greywater reuse piping in new buildings.
4	-3	**2**	34. There is reluctance on the part of BC health authorities to endorse onsite reuse, particularly at the level of individual households, citing health issues.
5	-1	**-2**	22. Fear of being sued makes municipal building inspectors reluctant to approve an innovative design.

Human Health Barriers

Like Centralized Managers, Technical Pragmatists feel the potential health issues associated with greywater reuse, such as public exposure to pathogens, are important barriers (statement 21, 12 and 8). During the post sort interview, Sorter 15 stated, "there is the potential for jeopardizing user health." Yet, unlike Centralized Managers, Technical Pragmatists appear to feel the risk stems from technical aspects of parcel level greywater reuse, as opposed to user error. For example, sorters correlating as Technical Pragmatists indicated that contamination of the potable water system via cross-connections is an important barrier (statement 7); "there is potential for accidental cross contamination with the drinking water supply" (post sort interview with Sorter 17); "obviously there will be standards in place and [cross connections] are never supposed to happen, but they do. It is just a reality" (post sort interview with Sorter 15). Yet, while statement 7 was placed in the +5 column, these sorters placed statements addressing human operation and maintenance errors in the more neutral barrier columns (statements 10 and 32).

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
-5	5	**5**	7. There is the potential for accidental cross-connection of a greywater reuse system with the drinking water system.
-3	-5	**4****	21. Greywater reuse systems operating at a scale larger than one home have the potential to expose a large number of people to disease-causing microorganisms.
-2	-2	**2**	5. There are issues surrounding exposure to 'other people's pathogens' in greywater reuse schemes larger than those employed in a single-family dwelling.
-3	-4	**2**	8. Users of greywater for toilet and urinal flushing and landscape irrigation may accidentally ingest small volumes of greywater through aerosols or hand-to-mouth contact with droplets.
-2	4	**1**	10. On-site greywater reuse places much of the maintenance on homeowners and property managers. Without professional maintenance, water treatment will degrade over time and jeopardize user health.
-4	3	**0**	32. On-site treatment plants require skilled operator attention, routine maintenance, water quality sampling, and regulatory reporting, which make greywater reuse difficult.

Environmental Health Barriers

Like the other two factors, Technical Pragmatists do not feel that high strength sewage is a barrier to greywater reuse (statement 16). During the post sort interview Sorter 6 stated:

> "After an extended period of dry weather, hot weather, there might be a notable slight increase in concentration [of contaminants in sewage]. But the vast majority of the time that won't be an issue because there is so much ground water, or down spout connections that are connected to the sanitary system rather than the storm system, that it is very unlikely it is going to be an issue."

Technical Pragmatists are, however, less certain about the potential for environmental harm due to irrigation with greywater (statements 2 and 26) than the other two factors. For example, when asked if any of the statements were difficult to place, Sorter 7 stated, "I am not a chemist so things like how it actually affects groundwater – I am not sure. I lean towards I guess so."

Factor Scores			
I	**II**	**III**	**Statement**
-2	-5	**-4**	16. Extraction of domestic greywater from sewage flows could result in high strength sewage that could increase environmental damage to the receiving environment.
-3	-3	**-1**	2. Greywater used for irrigation can damage soils by raising the soil alkalinity and salinity and reducing the ability of the soil to absorb and retain water.
-3	-3	**0**	26. Greywater reuse for irrigation of lawns and gardens has the potential to cause contamination of groundwater and surface water.

Economic Barriers

Technical Pragmatists see parcel level greywater reuse as economically infeasible. This was iterated, for example, by Sorter 10 who stated during the post sort interview that greywater reuse systems "are just not economically viable. Somebody really has to want to spend that money because they perceive that as a sustainable environmental Systems initiative." Yet, while Technical Pragmatists do not see greywater reuse as economically feasible, they also do not feel that lack of metering (statement 4), or the failure to use full cost accounting (statement 12), are barriers to greywater reuse.

For example, during the post sort interview Sorter 15 said, “Metering or not isn’t a barrier to greywater reuse. We have lots of metering across the country and there is no correlation between metering and greywater reuse… If it was a lot cheaper to go to greywater reuse then [maybe], but the payback isn’t there at all.” The Technical Pragmatists appear to feel the economic barriers are not a mater of accounting, but rather a function of high infrastructure and technology costs.

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
-1	2	**3**	24. Single household treatment systems are not economically viable considering the high cost of supplying and installing systems plus the cost of operation and maintenance, relative to the characteristically low cost of potable water supply.
3	2	**-5****	4. Lack of metering for potable water supply discourages the public from employing greywater reuse as a water supply alternative.
2	0	**-3****	12. Greywater reuse projects are often undervalued when compared to other projects due to the failure to properly quantify benefits of reuse such as watershed protection, local economic development, and improvement of public health.

Efficacy Barriers

Technical Pragmatists do not feel that parcel level greywater reuse is the most effective water conservation measure (statement 29). Some sorters correlating with this factor feel this is relative to other conservation measures, claiming “we could just use less in the first place” by using “more efficient fixtures and change habits about irrigation systems” (post sort interview with Sorter 3). Sorter 15 furthered this by stating:

> “I think, the most effective dollar for a municipality or for Metro Vancouver to spend would be on other things like low flow toilets rebate programs and things like that because they save more water at a lower cost... We have done economic studies that show there are more effective ways to spend money than on greywater reuse.”

Yet, other sorters indicated concern with lack of efficiency relative to other water reuse methods: “I don’t believe greywater reuse is [an effective conservation method]. That is specifically the word greywater. In the case of full water reuse, I believe it absolutely is” (post sort interview with Sorter 10); “I would put more emphasis on stormwater reuse… and I would also put the [focus] on blackwater reuse systems” (post sort interview with Sorter 20). Finally, one correlating sorter questioned the efficacy of greywater reuse in changing behaviour:

> “Does it actually teach water conservation? It is just providing people with a different quality of water for use in their homes, so it is not really teaching them to reduce it is just giving them an alternative... Certainly by re-using this water overall within a community you are going to reduce water use. But on a personal basis will someone actually use less water within a home? I don’t think so” (post sort interview with Sorter 7).

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
0	0	**3****	29. Greywater reuse is not the most effective water conservation measure.

Behavioural Barriers

Technical Pragmatists do not see the important barriers to greywater reuse in Metro Vancouver as being derived from stakeholder behaviour or perception. These sorters placed statements addressing public trust of water authorities (statement 17) and public acceptance of greywater reuse (statements 42 and 30) in the *unlike my view* of the important barriers columns. Statements indicating decision makers (statement 45) and developers (statement 18) do not consider greywater reuse because of the apparent abundance of freshwater in Metro Vancouver were also placed in these columns. This is in contradiction to the Institutional Reformers who feel the health authorities’ reluctance is an important barrier, and the Centralized Managers who feel public perception and behaviour are important barriers. Technical Pragmatists feel the important barriers to greywater reuse are derived less from behaviour and perception of the stakeholders and more from current technical and regulatory infeasibility of parcel level greywater reuse systems.

Factor Scores – Statistically defining statements are indicated at * p = 0.05 and ** p = 0.01

I	II	III	Statement
-2	-1	**-5****	17. Lack of public trust in water authorities limits the application of greywater reuse.
-1	-4	**-4**	42. Greywater reuse within a group of homes as compared to a centralized municipal level system can be difficult to accept because people are more aware of the link with previous uses of the water.
0	5	**-3****	30. Greywater reuse is seen to be a logical and necessary inclusion in the range of water resource management options, but people frequently feel a reluctance to personally use the water.
2	3	**-4****	45. Because freshwater appears to be abundant in Vancouver, local government decision makers do not consider greywater reuse as a serious option when contemplating water resource alternatives.
-1	0	**-3***	18. Developers favour rainwater & stormwater reuse over greywater reuse because of Metro Vancouver's abundant rainfall.

4.2.6 Consensus Perspectives

***Like My View* Consensus Statements**

There were only three statements that all factors consistently sorted as *like their view* of the important barriers to greywater reuse in Metro Vancouver. All factors (the Centralized Managers less than the others) feel that BC's regulations governing parcel level greywater reuse are vague (statement 3) and that the approval process is difficult because there is a lack of information and training (statement 43). All factors also feel that current cost analysis for greywater reuse fails to consider positive environmental externalities (statement 25).

Factor Scores – * statements non-significant at p > 0.01. ** Statement non-significant at p > 0.05.			
I	**II**	**III**	**Statement**
5	1	3	*3. BC's regulations governing greywater reuse in single-family dwellings are vague at best.
3	1	3	**43. Lack of information and training makes it difficult for municipal building inspectors to determine whether a proposed innovation for greywater reuse provides protection to the public equivalent to that of BC Building Code requirements.
3	2	1	*25. The current cost analysis for providing greywater largely considers infrastructure and distribution costs, maintenance and capital costs, while the water resource itself, the change of the flow regimes, and how it effects the environment is not fully accounted for.

***Unlike My View* Consensus Statements**

Over all, five statements were agreed upon by all factors as *unlike* their view of important barriers to parcel level greywater reuse in Metro Vancouver. Firstly, all factors consistently ranked the idea that greywater reuse will damage soils and the idea that greywater reuse will result in high strength sewage as *unlike their view* (statements 2 & 16). Four of the sorters who ranked these statements in the high negative columns stated this was because they had not come across either of these issues as barriers (post sort interviews with Sorters 1, 16, 24 and 25). Others touched on issues of groundwater infiltration and downspout connections with storm drains (Sorter 6) and capabilities of municipal sewage treatment plants (Sorter 11) in their explanation of why they placed statements 2 and 16 in the high negative columns.

Two statements addressing public perception were agreed upon by all factors as being unimportant barriers. All factors consistently feel that the public does not lack trust in the water authorities (statement 17). Four sorters felt the high quality of Metro Vancouver's water and the excellent record of high quality have led to high trust in the water authorities (Sorters 8, 20, 22 & 24). One sorter, Sorter 10, went as far as to say "it is more the other way round, where the authorities lack trust in the public, " while Sorter 15 explained that "if people truly don't trust water authorities they are more likely to want their own system. I don't see that as a barrier. If anything it would encourage it." Along these lines, when it comes to the public's acceptance of large scale systems over small scale systems, all factors disagree that knowing the previous uses of the renovated water makes small scale systems harder to accept (statement 42). This view, however, is mainly due to not encountering this perception within the public (post sort interviews with Sorters 13 and 24).

Finally, all factors do not feel that only large-scale applications can justify greywater reuse (statement 1). However, as was seen with the Technical Pragmatists, some sorters believe this because they feel that "no application can justify the expense" (post sort interview with Sorter 10) while others feel "the economics work at the household level" (post sort interview with Sorter 18).

Factor Scores – * statements non-significant at p > 0.01. ** Statement non-significant at p > 0.05.

I	II	III	Statement
-3	-3	-1	*2. Greywater used for irrigation can damage soils by raising the soil alkalinity and salinity and reducing the ability of the soil to absorb and retain water.
-2	-5	-4	16. Extraction of domestic greywater from sewage flows could result in high strength sewage that could increase environmental damage to the receiving environment.
-2	-1	-5	17. Lack of public trust in water authorities limits the application of greywater reuse.
-1	-4	-4	42. Greywater reuse within a group of homes as compared to a centralized municipal level system can be difficult to accept because people are more aware of the link with previous uses of the water.
-4	-4	-2	**1. Only fairly large-scale applications can justify the expenses associated with greywater reuse.

4.3 Post Sort Interviews

4.3.1 Missing Barriers

In order to identify whether there were any major gaps in the suite of barriers presented to the sorters, each participant was asked to comment on whether any barriers were not represented in the Q sample. While the first reaction of most sorters was to comment that the Q sample was quite extensive and thorough, 15 sorters followed this comment by suggesting one or more additional barriers. Following is a list of the missing barriers as identified in the post sort interviews.

- Sorters 1, 2, 10 and 11 share the idea that, as stated by Sorter 10 during the post sort interview, "there is a lack of technology, appropriate technology for the scale of application."
- Sorter 3 feels the variation in how regulation is interpreted within each municipality is a barrier as it makes the lessons learned in one community difficult to apply to the next.
- Sorter 16 feels the inability to change regulation when regulation is proven to be obsolete is a barrier. He asks, "when a municipality or developer has shown that [greywater reuse] can be done, why do the rules that they had to go through to show it could be done still exist?" He feels a mechanism for "building on the successes and making them, not just one off case studies that are an acceptation to the rule, but that change the rule" needs to be developed.
- Sorter 10 also touched upon regulatory barriers. He feels that a large regulatory infrastructure is required to administer greywater reuse, and the current absence of it and need to develop it, is a barrier.
- Sorter 10 also sees the absence of a market for greywater reuse systems as barrier, pointing out that "without the market you don't have the financial resources to make that technology more robust."

- Sorters 9, 10 and 11 feel there is a "fundamental lack of understanding about what greywater is" (comment by Sorter 9) and as a result a lack of trained people and knowledgeable public.
- Sorter 21 feels the issues of greywater reuse systems requiring space in dense communities and time for maintenance in a busy society are important barriers.
- Sorter 24 feels the lack of a champion in Metro Vancouver offering "vocal leadership, really talking about this issue sufficiently" is also an important barrier.

4.3.2 Should Greywater Reuse be Pursued in Metro Vancouver?

When asked for their opinion regarding whether or not greywater reuse should be pursued in Metro Vancouver, seven sorters answered with an outright *yes* or *absolutely*, seven sorters indicated *no*, and 11 stated *yes, but not as priority number one* (please see Appendix H for results for each sorter). The distribution of these three responses among the three factors, and among the different participant categories, is illustrated in Table 4.1 and Table 4.2 respectively.

Figure 4.1 Factors and perception of need for greywater reuse.

Distribution of the three responses (yes, no, & yes but not as priority number one) to the question "*Do you think parcel level greywater reuse should be pursued in Metro Vancouver?*" among the three factors. (One *No* and three *Qualified yes* responses from sorters not significantly correlated with any of the three factors.)

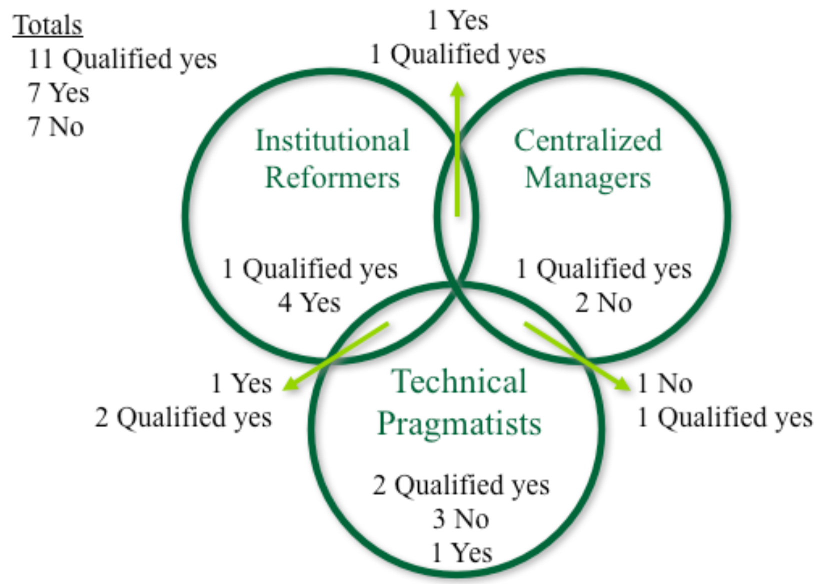
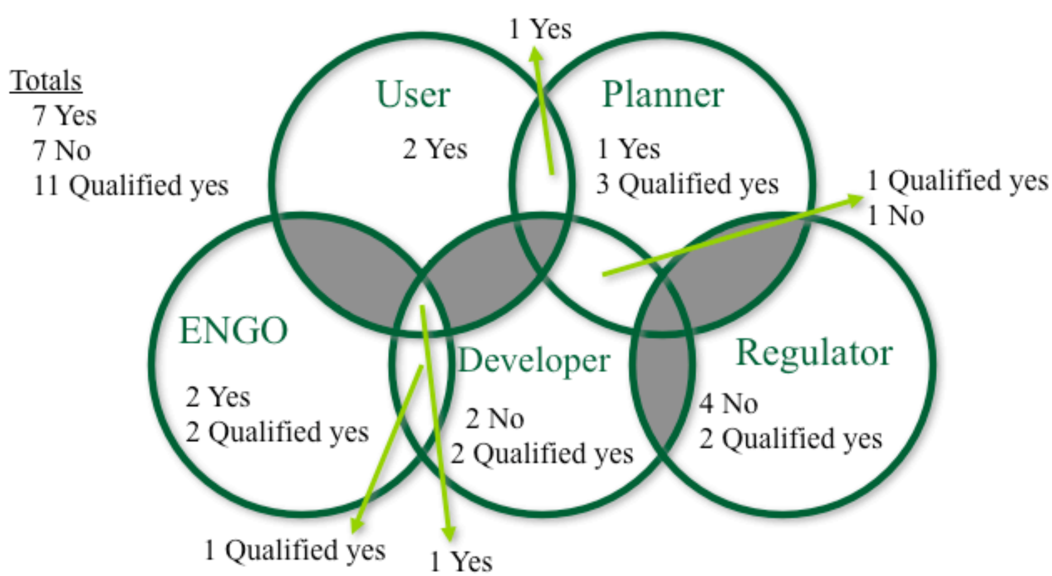


Figure 4.2 Participant categories and perception of need for greywater reuse.

Distribution of the three responses (yes, no, & yes but not as priority number one) to the question "*Do you think parcel level greywater reuse should be pursued in Metro Vancouver?*" among the five participant categories.



Of the seven sorters to answer yes, greywater reuse should be pursued in Metro Vancouver, all echo sentiments along the same theme: that we have an ethical social or environmental obligation to use our resources efficiently. For example, Sorter 14 stated, “Flushing the toilet and washing the car with drinking water when millions and millions of people around the world would do anything for that water. It is just ethically irresponsible to do that.”

Of the seven sorters who indicated no, greywater reuse should not be pursued in Metro Vancouver, two (Sorters 12 and 25) feel there is abundant water in Metro Vancouver, which eliminates the need for greywater reuse. For example, Sorter 12 stated;

> “My personal view, and certainly the view of my friends [researching greywater reuse] is, the question of necessity is number one. Do we need it? We are not experiencing a crisis with our water supply at this point in time… if we are talking about strictly the Lower Mainland I am not convinced that [greywater reuse] is needed.”

Sorters 17 and 23 feel that parcel level greywater reuse should not be pursued because, in the hands of the public, it poses a health threat, while Sorter 15 feels there are other more cost effective measures for conserving water such as using low flow appliances. Sorters 10 and 20, however, feel quite the opposite. These individuals do agree that greywater reuse should not be pursued, but, as it was put by Sorter 10, “that is specifically the word greywater.” Both individuals feel that greywater reuse does not go far enough and if we are going to invest resources in water reuse, it should be full wastewater reuse.

The final 11 sorters responded to the question of necessity with yes, greywater reuse should be pursued in Metro Vancouver as it “is part of the solution” (Sorter 16), yet “it shouldn’t be put as a number one priority” (Sorter 20). A commonly held opinion within this group is that it is better to “just use less in the first place” (Sorter 3) and there are steps other than greywater reuse which would reduce Metro Vancouver's water consumption more effectively with less cost and less effort.

Some patterns can be seen in the distribution of the three answers (No, Yes, and Qualified yes) among the three factors as well as among the five participant categories. Figure 4.1 above illustrates that all individuals loading as Institutional Reformers (both pure and confounded loadings) answered *Yes* or *Qualified yes* to the question of pursuing parcel level greywater reuse in Metro Vancouver. Additionally, only one sorter who did not load as an Institutional Reformer answered *Yes.* Figure 4.2 shows that all of the participating greywater reuse system users answered *Yes*, all of the participating ENGOs answered *Yes* or *Qualified yes*, while the participating greywater reuse regulators were the most likely to answer *No*. Furthermore, not illustrated in Figure 4.2 but of interest, is the fact that the two sorters who feel full wastewater reuse is more beneficial than greywater reuse, are the two developers who answered *No*.

4.3.3 Facilitating Greywater Reuse

The final question in the post sort interview, *what should be done to facilitate greywater reuse in Metro Vancouver*? was only posed to those sorters who feel parcel level greywater reuse should be pursued in Metro Vancouver. The recommendations given fell into five broad themes: regulatory, educational, technological, economic and implementation steps.

The most common recommendation given was that of breaking through the regulatory barriers, with 12 sorters (Sorters 1, 2, 7, 6, 11, 14, 16, 18, 20, 21, 22 and 24) echoing this sentiment. For example, Sorter 20 stated, “If you want to make it ahead you have to crack through the regulation." The suggestions on how to achieve this vary from changing the plumbing and building codes at each of the municipal, provincial and national levels (Sorters 2 and 22), to reforming regulation (Sorter 11, 16 and 21) to developing clear standards and guidelines recognized by all levels of government (Sorters 1, 7, and 18). Sorter 7 stated, "It is a matter of the three levels of government coming up with a unified set of regulation." Additionally, Sorters 6 and 16 recommend addressing the issue of accountability to help tackle liability barriers, while Sorters 14 and 24 feel government programs should be developed and put "in place to support [greywater reuse] as well as facilitate approvals" (Sorter 24).

Six sorters (Sorters 2, 4, 21, 23, 24 and 25) recommend education as a way of facilitating parcel level greywater reuse in Metro Vancouver. Many of these sorters feel it is important to educate the public about greywater and greywater reuse (Sorters 4, 21, 23, 24 and 25). As Sorter 4 commented, this will "create awareness and create demand." Sorters 2, 4 and 21 indicated that regulators and designers should be educated in order to "really teach them how to incorporate these greywater reuse systems [and] that it can be a safe system" (Sorter 2). Sorter 21 stated that education is needed in order for the regulators to "get out of the way of the enthusiasts who are going to be doing it anyway and are right now beating their heads against these regulatory barriers." Finally, Sorters 21 and 4 feel that education must be used to help "communities understand that potable water conservation is a high priority" (Sorter 21) and "home owners that water shouldn't be taken for granted" (Sorter 4).

Six sorters (Sorters 4, 11, 13, 19, 21 and 23) recommend market and economic oriented steps. Sorters 14, 19 and 23 feel that economic incentives would be effective at facilitating greywater reuse in Metro Vancouver. Furthermore, Sorter 4 thinks economic incentives should be tied with paying “the true cost of potable water.” Sorter 21, who agrees, stated, “people have to start paying the true costs of their resource use, i.e. that [Metro Vancouver] and the municipalities have to start charging the true life cycle costs and factor externalities into the price that consumers pay.” Thirdly, Sorters 4, 11, 13 and 23 feel there is a need to develop a market for greywater reuse in Metro Vancouver. They recommend doing this by generating “buy in from the consumer” (Sorter 4) and “creating more uses for that water” (Sorter 23) which will facilitate eventual consumer acceptance of applying renovated greywater to household uses such as flushing toilets.

Six sorters (Sorters 1, 8, 11, 16, 22 and 24) recommend steps be taken to push more installations of parcel level greywater reuse in the Metro Vancouver area. Sorter 24 suggests “requir[ing] it in projects as part of development permits” and “encourag[ing] home owners to retrofit.” Sorter 22 feels “the large public land holders who develop properties have to take the lead and prove it out” to “create more acceptance broadly in the market.” Sorter 1 believes the greatest success would be gained from “efforts targeted on regions where water supply and water treatment are an issue.” As Sorter 16 explained, these individuals feel that “more examples out there will help guide others.”

Finally, Sorters 4, 10, 20 and 22 made technological recommendations for facilitating parcel level greywater reuse in Metro Vancouver. These individuals feel the implementation process would be made easier and regulators would be more confident if “tried and tested” (Sorter 4), “pre-packaged solutions” (Sorter 20) were developed and made available. For example, Sorter 22 recommends we “provide prescriptive solutions that meet safety standards, that are stamped by engineers, that people can follow, and integrate them into our code." Additionally, Sorter 10 feels that "research needs to be put into more robust, more efficient, more sustainable, lower power consumption types of technologies."

CHAPTER 5: DISCUSSION

5.1 Chapter Outline

As outlined in section 1.2, the objectives of this research are: to describe currently held perspectives regarding barriers to parcel level greywater reuse in Metro Vancouver; to attempt to understand who holds these perspectives and why; and to make recommendations pertaining to disassembling these barriers and implementing greywater reuse. In this chapter I bring the research results and the background research together to achieve these objectives.

The discussion section begins in section 5.2 with an exploration of the distribution of the different participant categories among the three factors. This sets the stage for a more detailed exploration in section 5.3, of which barriers are perceived to be important in Metro Vancouver, who holds these perceptions and why. Throughout section 5.3, I compare the barriers identified in the literature review with those identified through this research, going through regulatory, technical, economic and perceptual barriers. I also make recommendations for dismantling some of the identified barriers. In section 5.4, I examine whether greywater reuse is the appropriate means for meeting underlying water conservation goals. I finish this chapter with some lessons learned about Q methodology and possibilities for extensions of this research.

Table 5.1 below summarizes the three factors and serves as a reference for the discussion that follows.

Table 5.1 Summary table of the three factors

Factor Number	Factor Name	Summary of perceived important barriers to parcel level greywater reuse in Metro Vancouver.
One	Institutional Reformers	The important barriers are institutional. Regulation as it currently stands is a barrier and regulators are overly risk averse. Greywater reuse is not as difficult, as costly or as risky as regulators perceive it to be.
Two	Centralized Managers	The important barriers stem from public perception and public behaviour. Greywater reuse is easy to do on a large scale, but parcel level reuse leaves too much in the hands of under-educated homeowners. The public does not perceive a need nor have the desire to reuse greywater.
Three	Technical Pragmatists	The important barriers have to do with regulatory and technical feasibility. The technology and the administrative infrastructure are not well enough developed. The cost of the technology discourages implementation. Greywater reuse is not the most effective conservation measure.

5.2 Distribution of the Participant Categories Among the Factors

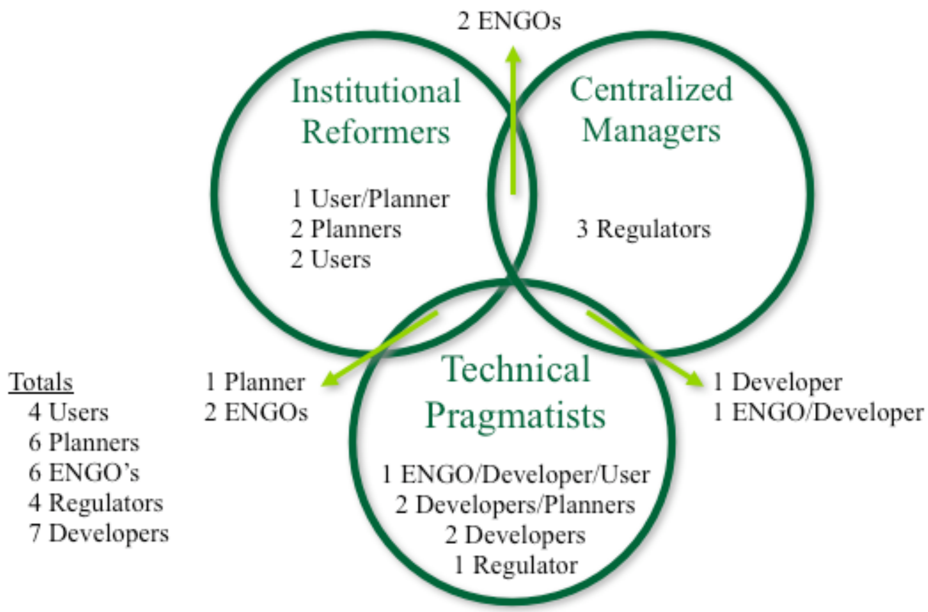
In much of the greywater reuse literature, authors assume that an individual's affiliation with a specific group, such as planners, regulators, developers, or the other participant categories in Table 3.3, dictates his or her perception of greywater reuse. This is seen extensively in the discourse addressing public acceptance of greywater reuse (for a review of this discourse, please see Po et al., 2004). By examining the distribution of the study participants, identified by their affiliation with the participant categories listed in Table 3.3, among the three factors, the results found in the present Q study can add to the above discourse, illustrating points of conflict and consensus among the various groups working with greywater reuse in Metro Vancouver. Please see Figure 5.1 below.

Some strong patterns can be seen in Figure 5.1: the participating greywater users generally correlate with the Institutional Reformer factor; the participating regulators generally correlate with the Centralized Manager factor; the participating system developers generally correlate with the Technical Pragmatist factor; the participating planners generally do not identify with the Centralized Manager factor; and the participating ENGOs generally correlate with multiple factors. This strong correlation between factors and participant categories suggests that there are underlying goals, responsibilities and shared beliefs associated with each participant category which act as important influences in each of the discourses: roles such as the regulator's responsibility to protect public or environmental health; goals such as ENGOs' drive for environmental conservation and the planner's objective of long term sustainability; and shared beliefs such as the greywater users' belief in an ethical obligation to conserve water. Yet, while these patterns can be observed, it is important to note that they apply to the participants included in the present study only and cannot be generalized to the broader population of key players in Metro Vancouver or other settings.

One more detail that is important to discuss is Sorter 17, the only regulator identified as a Technical Pragmatist in Figure 5.1, and the one individual who does not, at least to some degree, follow the distribution pattern described above. Many of the individuals correlating as Technical Pragmatists are categorized as developers. Although Sorter 17 is employed as a regulator, in the post sort interview this sorter mentioned being a "plumber by trade." This training and perhaps work experience in the plumbing trade may explain why Sorter 17's views align with those of other developers. Developers are those who design, develop and install greywater reuse systems, and a plumber might be expected to share their views. At the same time, in the post sort interview Sorter 17 expressed some views similar to other regulators regarding the publics' ability to safely reuse greywater; "homeowners can do their own plumbing work and that is scary…

adding [greywater reuse] into the mix would be even scarier… it seems quite dangerous when you have a homeowner doing that kind of work" (post sort interview with Sorter 17).

Figure 5.1 **Distribution of the sorters, by participant category, among the three factors. Categories separated by a '/' (ex. Developers/Planners) indicate individuals who fit within multiple categories. One developer, one planner and two regulators did not significantly correlate with any of the three factors.**



5.3 Understanding Barriers and Exploring Solutions

In section 2.5 possible barriers to greywater reuse and their applicability to the Metro Vancouver area were explored. Four major barrier themes were identified from the literature; these were regulatory, technological, economic, and public acceptance barriers. Following is a comparison of these theoretical barriers identified in the background research to the perceived barriers revealed through this Q study. In addition, an exploration of who holds these perspectives is carried out by identifying the 5 statements placed in the -/+ 4 and 5 columns of each of the three factors (please refer to the factor arrays in Appendix G) and comparing them to the participant category and factor overlay illustrated in Figure 5.1. Options for addressing perceived barriers are discussed as well.

5.3.1 Regulatory Barriers

Perceptions of Regulatory Barriers

Sorters identified as both Institutional Reformers and Technical Pragmatists perceive regulatory barriers to be important in Metro Vancouver. According to Institutional Reformers, regulatory barriers are the most important barriers being faced in Metro Vancouver; all five of the statements under the +4 and +5 columns of this factor touched upon regulation or regulators serving as barriers to greywater reuse. Two of the five statements in the Technical Pragmatists' +5 and +4 columns also addressed regulatory barriers. Furthermore, neither the Institutional Reformer factor nor the Technical Pragmatist factor has a statement reflecting regulatory barriers in the -4 or -5 columns. Centralized Managers on the other hand, are more neutral on the subject of regulatory barriers with no regulatory barrier statements placed in the + or – 4 or 5 columns.

Among the regulatory barriers presented in the Q sample, vagueness and lack of guidance within the regulation were more often identified as important barriers than were specific regulatory restrictions. Institutional Reformers and Technical Pragmatists especially feel that lack of guidance is an issue for greywater reuse in Metro Vancouver (statements 3 and 38). Lack of regulatory guidance also became apparent during post sort interviews, as many of the sorters were not familiar with, or were confused about, the specific details of applicable regulation and how they are currently being interpreted.

Where Institutional Reformers and Technical Pragmatists differ with regards to regulatory barriers, is in the perception that the existing regulation creates stringent challenges for those wanting to pursue greywater reuse (statement 6). Institutional Reformers feel regulation creates stringent challenges, while Technical Pragmatists do not. Interestingly, this statement was also the most highly placed regulatory barrier by the Centralized Managers, although it was only placed in the +2 column.

Factor Scores			Consensus statements non-significant at * p > 0.01 and ** p > 0.005 Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
4	-1^{++}	4	38. There is a lack of regulatory guidance for greywater reuse.
5	1	3	*3. BC's regulations governing greywater reuse in single-family dwellings are vague at best.
4^{+}	2^{+}	-1^{+}	6. Developers and residents wanting to reuse greywater often face stringent regulatory challenges.

Institutional Reformers and Technical Pragmatists again share similar perspectives regarding regulators as barriers. More specifically they feel the health authorities are reluctant to endorse greywater reuse (Institutional Reformers citing fear of heath issues and Technical Pragmatists citing lack of resources and standards) and that the building inspectors lack the information and training needed to determine whether a greywater reuse system satisfies the plumbing codes. Centralized Managers, however, do not share this view of the health authorities, and in particular feel that the health authorities are open to considering greywater reuse (statements 34, 37 and 43).

Factor Scores			Consensus statements non-significant at * p > 0.01 and ** p > 0.005 Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
4	-3^{++}	2	34. There is reluctance on the part of BC health authorities to endorse onsite reuse, particularly at the level of individual households, citing health issues.
1^{+}	-2^{++}	5^{+}	37. Without recognized standards for safe design, treatment quality and operations, BC health authorities are reluctant to allow greywater reuse.
3	1	3	**43. Lack of information and training makes it difficult for municipal building inspectors to determine whether a proposed innovation for greywater reuse provides protection to the public equivalent to that of BC Building Code requirements.

Which Participant Categories Hold these Perceptions

Combining the patterns shown in Figure 5.1 and the perceptions of regulatory barriers illustrated above reveals that it is the participating greywater reuse regulators who tend to disagree that regulation and regulators are important barriers to greywater reuse in Metro Vancouver. Here we see how the regulators reflect upon their own involvement in greywater reuse; they do not see themselves as unnecessary barriers but rather as important barriers in place to ensure that these systems will not jeopardize human or environmental health, and they view the regulation in the same light. In response to statement 6 (developers face stringent regulatory barriers) Sorter 12 stated:

> "I know they [face regulatory barriers], but that doesn't bother me. I don't consider it an important barrier, but neither is it un-important… Diverting [grey]water is outside the code so you need to have an equivalency, but they are pretty basic. Unless the building branch can prove that there is some sort of detriment to doing this, there is really no reason to hold it up (post sort interview with Sorter 12)."

In turn, Sorter 25 stated:

> "It is hard to deviate from the code. You are governed by a regulation and that is what you have to follow. At times that is good because [people] sometimes come up with something that doesn't make sense and then you

> have your code to go back on. So it can work both ways from a regulatory perspective" (post sort interview with Sorter 25).

The majority of the participants, other than the participating regulators, do tend to perceive regulators to be reluctant to allow implementation. For example, Sorter 6 stated during the post sort interview, "[health authority officials] are commonly viewed to be fairly conservative in terms of their willingness to accept risk of potential disease causing agents [from] reuse systems within business or homes." The participating greywater reuse users, and many of the participating planners and ENGOs, tend to feel this is a result of the health authorities fear of public health issues, while the participating developers generally feel it is due to a lack of standards (statements 34 and 37). As well, the majority of participants, other than the regulators, agree that there is a lack of information and training for municipal inspectors and that the existing regulation is vague and short on guidance. It is the participating users, however, who tend to see the regulation to be a stringent barrier, while the participating developers generally do not (statement 6). Perhaps the participating developers have more experience working with the existing regulation therefore making it less of a barrier to them.

Breaking down regulatory barriers

Identifying lack of regulatory guidance as a perceived important barrier in the present research is not surprising, yet it is a confirmation that the barrier exists in Metro Vancouver, in spite of the fact that BC has one of the only provincial level water recycling regulations in Canada (Exall et al., 2004). Lack of regulatory guidance was identified over ten years ago in research done by the Canada Mortgage and Housing Council (CMHC, 1998). In the years since, numerous steps have been taken to address the issue. In 2001 BC's Provincial Government developed the *Code of Practice for the Use of Reclaimed Water, a Companion Document to the Municipal Sewage Regulation* (MELP, 2001); in 2005 CMHC published a *Water Reuse Standards and Verification Protocol* (CMHC, 2005); in 2006 the Canadian Standards Association developed B128.1-06/B128.2-06, *Design and installation of non-potable water systems/Maintenance and field testing of non-potable water systems* (CSA, 2006) and in 2008 these were in the final stages of being incorporated into the National Plumbing Code; in 2007 Health Canada generated the *Canadian Guidelines for Household Reclaimed Water for Use in Toilet and Urinal Flushing* (Health Canada, 2007). On top of all this, in September of 2008 the first official steps were taken towards the greening of the BC Building Code. While greywater reuse was not addressed in these first steps, it was explicitly stated that greywater reuse is under exploration for inclusion in subsequent steps (BC Housing, 2008).

Arguably the guidance being called for by greywater reuse system consumers and developers has been, or is in the process of being, developed, but is not yet being used. If so, the next important step in dealing with regulatory barriers is to disseminate this information to ensure that those who need regulatory guidance know of its existence. During the post sort interviews it became apparent that many of the individuals involved in greywater reuse were unclear as to what regulation is applicable and available. These sorters placed statements addressing specific regulations in the neutral or unsure columns of the sorting template, commenting that they were not familiar enough with them to know the degree to which they are barriers (statements 13, 23, 39 and 40). This also suggests that effort put into disseminating information about the existing guidelines could be useful.

In addition to confusion about the availability and applicability of regulation, there is wide variation in the way regulation is interpreted. During the post sort interview, Sorter 3 described frustration with how some municipalities interpret greywater reuse as being permissible under current regulation, while others interpret the same regulation as disallowing it. As was recommended by many sorters when asked how best to facilitate greater reuse in Metro Vancouver, it will be important also to highlight the successful implementations of parcel level greywater reuse in order to clarify and unify the application of legislation. As Sorter 16 asked, if “a municipality or developer has shown that [greywater reuse] can be done, then why do the rules that they had to work through to show it could be done still exist?”

5.3.2 Technological Barriers

Perceived Technological Barriers

A handful of barriers associated with the technological side of greywater reuse were identified in Chapter 2, such as the need for maintenance, lack of field-tested technology, and potential human and environmental health risks. Some of these are perceived as barriers in the eyes of the Q sort participants, while others are not. Three of the five statements in the Institutional Reformers’ - 4 and -5 columns had to do with technical infrastructure issues; Institutional Reformers do not see the technical side of greywater reuse as challenging. Centralized Managers and Technical Pragmatists, however, placed two out of a possible five statements about technical barriers in the +4 and +5 columns.

The main point of technical disagreement among the three factors involves the potential for accidental cross connections (mixing of greywater with potable water by connecting the two water distribution networks – statement 7). Sorters identifying with the Institutional Reformers feel that cross connections are easily preventable while sorters identifying with the other two factors feel that cross connections are inevitable. Where Centralized Managers and Technical Pragmatists disagree is in the potential for human health impacts. Technical Pragmatists see potential for health impacts stemming from greywater reuse technology, while Centralized Managers perceive risk from the technology itself to be low, but risk from human error while using the technology to be high (statements 10, 32, and 33).

Factor Scores			Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
-5++	5	5	7. There is the potential for accidental cross-connection of a greywater reuse system with the drinking water system.
-2++	4	1	10. On-site greywater reuse places much of the maintenance on homeowners and property managers. Without professional maintenance, water treatment will degrade over time and jeopardize user health.
-4++	3++	0++	32. On-site treatment plants require skilled operator attention, routine maintenance, water quality sampling, and regulatory reporting, which make greywater reuse difficult.
-4++	2+	0+	33. Greywater reuse systems in single-family dwellings are difficult to regulate, maintain and monitor.

Two of the strongest points of consensus within the present study concerned technological barriers. All factors feel greywater reuse technology does not pose a large threat to natural ecosystems (statements 2 and 26), nor will the technology put strain on the centralized wastewater collection and treatment system by reducing water content of sewage flows (statement 16).

Factor Scores			Consensus statements non-significant at * p > 0.01 and ** p > 0.005 Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
-3	-3	-1	*2. Greywater used for irrigation can damage soils by raising the soil alkalinity and salinity and reducing the ability of the soil to absorb and retain water.
-3	-3	0^{++}	26. Greywater reuse for irrigation of lawns and gardens has the potential to cause contamination of groundwater and surface water.
-2	-5^{+}	-4	16. Extraction of domestic greywater from sewage flows could result in high strength sewage that could increase environmental damage to the receiving environment.

Participant Categories and Perceptions of Technological Barriers

If the factors' perceptions of technological barriers are once again combined with the results illustrated in Figure 5.1, it becomes apparent that it is the participating greywater users, and some of the participating planners and ENGOs, who feel reuse technology is not a barrier. This perspective is somewhat understandable considering the greywater users are individuals currently applying reuse technology in their homes and buildings; they appear to feel that the technology is working for them and question why others could not do the same. The system users generally feel the technology can be safe, and is not overly difficult to use, maintain and regulate.

The participating developers and regulators on the other hand, typically perceive technological barriers to be important. The regulators tend to agree that the technology, when working well, does not pose a public health risk (this is in opposition to the assertion by Mass (2003), touched on in the background chapter, that decision makers and regulators do not trust that the technology will protect human health). The participating regulators instead see a potential for human error in the maintenance and operation of the systems, and appear not to trust the home or building owner to safely and effectively operate a reuse system. The participating developers, however, perceive potential health risks as inherent in the technology and appear to be neutral on the subject of operator error- on all aspects other than cross connection potential. Essentially, the system users generally feel greywater reuse is safe and easy, the regulators tend to see it as difficult to do making it unsafe, while the developers view it as currently technically unsound.

An additional technology topic that was addressed in some of the post sort interviews was that of the scale of application. The participating regulators tend to feel that the most acceptable scale of application for greywater reuse is large scale, under the control of a municipality or professional organization. This was emphasized by Sorter 12 for example, who stated, "the only systems from my perspective that I would be even remotely comfortable with would be a municipally controlled one… a municipally controlled system would ensure the quality of the water." The participating regulators tend to feel that a municipally run system will better protect public health as it will have more resources and technically trained staff to ensure that public health is not jeopardised (statements 10 and 21). On the other hand, the regulators generally also feel that the public is less accepting of this scale because the sources of wastewater are hidden (statement 42 and post sort interview with Sorter 15).

Factor Scores			Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
-2	4	1	10. On-site greywater reuse places much of the maintenance on homeowners and property managers. Without professional maintenance, water treatment will degrade over time and jeopardize user health.
-3	-5	4	21. Greywater reuse systems operating at a scale larger than one home have the potential to expose a large number of people to disease-causing microorganisms.
-1++	-4	-4	42. Greywater reuse within a group of homes as compared to a centralized municipal level system can be difficult to accept because people are more aware of the link with previous uses of the water.

Liability and responsibility for risks

Troy Vassos, President and founder of NovaTec Consulting and a recognized water reuse expert, explains, "Innovative technologies have technical risk associated with their adoption and implementation. This technical risk leads to financial risk, and governments are generally risk averse" (Krkosek, 2006). Liability and responsibility for risk appear to be influential issues in the application of greywater reuse in Metro Vancouver. This became apparent through discussion during post sort interviews, and the Institutional Reformers' placing of statement 22 in the +5 column. While Institutional Reformers are the only sorters to feel statement 22 is an important barrier, participants spanning the three factors and the five participant groups made comments addressing liability as an important barrier. For example, Sorter 12 describes the issue of liability from the perspective of a regulator:

> "If you are the approving agency, i.e. the city or the health board that signs off on [a reuse system], you can be sure that on any lawsuit your name is going to be on it. Nobody is very comfortable with that. I am not either. So, we do our due diligence and hopefully that is good enough. If people don't look after their systems, we will still be on the hook for it. So, we have to do everything very carefully. We have our responsibilities and the developers get to build their buildings and walk away. If something

> happens down the road it is not going to be [the developers], it is going to be the [municipal regulator]. If we have proven that we have done our due diligence from day one, at least we will have some cover" (post sort interview with Sorter 12).

Factor Scores			
I	II	III	Statement
5	-1	-2	22. Fear of being sued makes municipal building inspectors reluctant to approve an innovative design.

Chris Ward who has been involved in the implementation of industrial level water reuse in the City of Edmonton suggests, "when new technologies are implemented it is important to develop a method of risk-sharing" (Krkosek, 2006) so that responsibility and liability do not fall largely on the shoulders of one stakeholder. Currently, the risk from liability for greywater reuse in Metro Vancouver appears to be unbalanced. Institutional Reformers see regulators' fear of litigation as a large barrier; for example, Sorter 14 stated, "That was such a major stumbling block, this liability issue, and who was going to sue whom." Yet, all factors perceive fear of litigation as a neutral issue for developers (statements 36 and 46). Finding a way to share the responsibility for risks taken when implementing greywater reuse may encourage regulators to become less averse to implementation while at the same time increasing system implementers' understanding and acknowledgement of the risks. When asked how best to facilitate parcel level greywater reuse in Metro Vancouver, Sorter 6 recommended steps along these lines:

> "Change things so [the health authorities] can allow some innovative practices to take place without being held accountable for any outcomes that do arise. I don't envy them, they are in a tough spot, but at the same time, the way things are set up now it is going to be difficult to get any innovation happening on the ground" (post sort interview with Sorter 6).

Factor Scores			Consensus statements non-significant at * p > 0.01 and ** p > 0.005 Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
1++	-2	-1	36. Designers of water and wastewater systems (professional engineers) are bound by due diligence, making it difficult to consider and implement greywater reuse systems because of their perceived experimental nature.
1	-1	0	**46. The majority of designers will likely not expose themselves to the potential for liability by including greywater technology that has no reference to design standards given in regulation.

An example scenario of concern for the regulators that took part in the present Q study, as described during post sort interviews with Sorters 7, 11 and 12, is that of a home with greywater reuse technology in place, changing ownership. There is concern that while the installer of the system may be keen and able to properly use and maintain the system, the new owners will have neither the required knowledge nor the interest. If a form of risk sharing were devised which placed some of the liability on the shoulders of the homeowner, a new owner would inherit the liability with the purchase of the home. This might discourage some from purchasing, however, it might also help address the regulators' current fear.

Two additional approaches for reducing technological risk, recommended by Troy Vassos of NovaTec Consultants, are technology verification and establishment of standards (Krkosek, 2006). As pointed out during the post sort interview with Sorter 18, individuals deal with arguably riskier substances than greywater in their homes and buildings already; substances such as natural gas and electricity, which if worked on by someone ignorant of proper protocol, can lead to serious injury or even death. There are systems currently in use to deal with these technologies in a safe and feasible way, making it conceivable that such systems could be successfully used to managing greywater reuse as well. These systems, however, require verified technological solutions and established standards. As mentioned in section 5.4.1, many standards for greywater reuse have been developed and are slowly being incorporated into legislation, leaving verification of the technology as the next required step. During the post sort interview, when sorters were asked how best to facilitate the implementation of greywater reuse, Sorters 3, 4, 20 and 22 recommended technology verification. For example, Sorter 22 suggested developing "prescriptive solutions that meet safety standards, that are stamped by engineers, that people can follow, and that are integrated into our code."

5.3.3 Economic Barriers

Perceived Economic Barriers

In section 2.5, lack of full cost accounting and the current pricing scheme for potable water were put forward as potential economic barriers to parcel level greywater reuse in Metro Vancouver. Results from the present research show there is disagreement among the three factors as to whether these are indeed important barriers in this location. Institutional Reformers placed the failure to use full cost accounting when considering greywater reuse and lack of water metering as just behind the regulatory barriers in terms of importance (statements 25 and 4). Centralized Managers are fairly neutral about these economic barriers, rating them just slightly on the *like their view of the important barriers* side (+2). Technical Pragmatists, however, rate lack of metering as among the least important barriers in Metro Vancouver, and ranked full cost accounting as relatively neutral.

Factor Scores			Consensus statements non-significant at * p > 0.01 and ** p > 0.005 Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
3	2	1	*25. The current cost analysis for providing greywater largely considers infrastructure and distribution costs, maintenance and capital costs, while the water resource itself, the change of the flow regimes, and how it effects the environment is not fully accounted for.
3	2	-5++	4. Lack of metering for potable water supply discourages the public from employing greywater reuse as a water supply alternative.

The one economic point that the factors all disagreed with was that only large-scale systems could justify the associated costs (statement 1). However, during the post sort interviews it was revealed that participants feel this is an unimportant barrier for different reasons (statements 24 and 41); a few sorters feel “no application can justify the expense” (Sorter 10) while most others feel “the economics work at the household level” but “it all depends on what you are charging for water” (Sorter 18). It should also be noted that the statements I originally categorized as addressing economic barriers, were least often placed in the +/- 4 or 5 columns. This shows that most sorters agree economic barriers are currently not the most important (nor the least important) barriers in Metro Vancouver.

Factor Scores			Consensus statements non-significant at * p > 0.01 and ** p > 0.005 Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
-4	-4	-2	**1. Only fairly large-scale applications can justify the expenses associated with greywater reuse.
-1++	2	3	24. Single household treatment systems are not economically viable considering the high cost of supplying and installing systems plus the cost of operation and maintenance, relative to the characteristically low cost of potable water supply.
-2+	3	1	41. With small-scale systems, it is unlikely that there will be an economic payback for water savings that would justify the capital expenditure required to develop a greywater reuse system.

Participant Categories and Perceptions of Economic Barriers

Comparing the perceptions of important barriers touched on above with figure 5.1, it becomes evident that the participating greywater system users, as well as some participating planners and ENGOs, tend to feel that failure to incorporate environmental externalities in the current water management approach makes greywater reuse economically unviable. The participating system developers and participating regulators typically share the system users' view that water is under priced, however, they focus on home and building owners and their inability to justify the costs of greywater reuse systems as the barrier, rather than on water authorities failure to set a price that incorporates externalities. During the post sort interview Sorter 15 stated:

> "If drinking water has no cost you would use it for everything because there is no cost to do that. As it gets more costly… you start looking at greywater reuse systems, because the benefits might outweigh the costs… On the costs side I believe this is true in this region. It is a barrier strictly seen from an economic point of view. There are other values that drive people, but from a strictly economic point of view, the economics are a barrier."

Where the participating regulators and the participating developers differ in their views of economic barriers is in their opinions regarding the lack of water metering in much of Metro Vancouver. Participating regulators tend to see water metering as a way of encouraging people to conserve by targeting their pocket books: "Until people start seeing what they are using and the prices start to go up, I don't think they will look at alternative systems" (post sort interview with Sorter 11). Participating developers, however, generally feel that raising the price of water and showing people how much they use will do little to encourage greywater reuse systems, but rather the perception that water is overly abundant in Metro Vancouver needs to be addressed.

Facilitating a Greywater Reuse Market

While economic barriers do not appear to be the most important barriers currently in place in Metro Vancouver, neither are they considered to be the least important. During the post sort interview Sorter 21 postulated that once the regulatory barriers and the technological barriers are worked through, the economic ones will become the next big hurdle, while Sorter 10 claimed the two types of barriers are intertwined, explaining, "In order to develop technology and spend money on that technology development you need to have a market. But without the market you don't have the [initial] financial resources to make that technology more robust." Consequently, these sorters recommend implementing carrot (cheaper water rates if you implement water reuse) and stick (charging for water by volume used) type economic incentives, along with other steps to develop a water reuse market.

Not all sorters, however, feel that market-based solutions will make a difference to greywater implementation. Two of the participating regulators (Sorters 11 and 12) sited the LEED (Leadership in Energy and Environmental Design) program as the major driving force behind adoption and implementation of greywater reuse systems. In order to attain LEED's platinum rating, developers must incorporate some form of water reuse into the building (CaGBC, 2004). As Sorter 12 explained "the financial part of it doesn't matter… if [developers] can gain their credits that is what they want." In late 2008, a residential building version of the LEED's program was in the final stages of development and different water reuse options were being incorporated into the points system (Higgins, 2008). If the observations of Sorters 11 & 12 are accurate, this development is one step that is already being taken towards improving the market for greywater reuse.

There are also differing opinions among developers regarding the marketability of greywater reuse. One developer, Sorter 22, feels “greywater reuse is usually highly valued, it is kind of a sexy green building thing. The reuse of greywater is a very powerful idea or symbol in the publics’ imagination. It is turning garbage into gold,” while another developer, Sorter 9, feels quite the opposite; “how turned on are my purchasers going to be when I tell them that, by the way, all that water that you put down the sink washing the pots, your going to reuse it again to flush the toilets? It doesn’t turn me on. It doesn’t make me feel wow, that is great.” As a way of tackling this second perspective, Sorters 4, 16 and 23 recommend implementing pilot and example projects that are in the public eye, thus working to familiarize the public with the concept of water reuse, and eventually overcome the apparent resistance.

5.3.4 Public Acceptance Barriers

Perceptions of Public Acceptance Barriers

Public acceptance of greywater reuse was put forward in the background research as one of the most important barriers to parcel level greywater reuse. While the acceptance level of the public itself was not assessed in the present study, the importance of it as a barrier in the eyes of those experienced in greywater reuse was. Participants correlating as Centralized Managers feel the public fears health risks associated with using greywater and has no real drive to conserve, making public perception an important barrier. Institutional Reformers and Technical Pragmatists, however, rate public acceptance and perception barriers as neither important, nor unimportant (Technical

Pragmatists registered statement 30 as -3, but post sort interviews revealed that this was due to correlating sorters disagreeing that greywater reuse is seen as a logical and necessary management option).

Factor Scores			Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
0	4^{++}	0	28. In Metro Vancouver, where water is seemingly abundant, there is a perception among the public that water shortage is not a real issue.
0	4^{+}	1	20. Public perceptions of health & environmental risks hamper greywater reuse.
0^{++}	5^{++}	-3^{++}	30. Greywater reuse is seen to be a logical and necessary inclusion in the range of water resource management options, but people frequently feel a reluctance to personally use the water.

One of the measures of public acceptance discussed in the background was that of public trust in the water authorities, and how public trust in water authorities could potentially be used as a proxy for public acceptance of greywater reuse. All factors feel that the public do not lack trust in the water authorities in Metro Vancouver; this was one of the stronger points of consensus among the participants. Unfortunately, after discussing statement 17 with many of the sorters I feel this statement is not a good indication of the degree to which the public will accept greywater reuse at the parcel level. For one thing, the applications considered in the present study are toilet and urinal flushing, as well as irrigation. Water for drinking and washing, which is what the public tends to associate with water authorities, was not considered. Additionally, at the parcel level scale, water authorities do not have exclusive control of the water reuse system; much of it falls on the home or building owner. As Sorter 15 explained, “If people truly don’t trust the water authorities, they are more likely to want their own system” and may be more likely to implement parcel level greywater reuse. Therefore, the finding in the present study that sorters believe that public trust in water authorities is not a barrier to parcel level greywater reuse, does not necessarily imply that these sorters feel the public is ready to accept this water conservation measure.

Factor Scores			Defining statement for column factor at + p = 0.05 and ++ p = 0.01
I	**II**	**III**	**Statement**
-2	-2	-5^{++}	17. Lack of public trust in water authorities limits the application of greywater reuse.

Participant Categories and Perceptions of Public Acceptance Barriers

Once again using the results of figure 5.1 to gain insight into how the different categories of sorters perceive barriers to parcel level greywater reuse in Metro Vancouver, it is apparent that the participating regulators generally feel the public is an important barrier to greywater reuse in Metro Vancouver, while the participating users, planners, ENGOs, and developers typically do not. During the sorting process it became apparent that most participating greywater users viewed themselves as *the public,* which could explain why they found public perception to be a neutral barrier. However, it is likely that each participating user has a strong either environmental or social ethic that drove them to implement greywater reuse, making them arguably a poor proxy for the general public. Research in England and in Australia found that individuals with a strong environmental ethic, who take measures in their homes to reduce impact on the environment, are more willing to adopt water reuse (Po et al., 2004).

While the participating system users and developers generally do not perceive public opinion to be an important barrier, they also do not perceive public opinion as an unimportant barrier; statements 20, 28 and 30 were placed in the unknown or neutral columns of the sort template by these sorters. During the post sort interviews, many mixed opinions were given when it came to public perception. For example, Sorter 3 claimed:

> "I suspect that while I am saying there is not a public perception problem, if you brought [greywater reuse] in and mandate it there might be. Suddenly people might get upset about it. But at the moment, the only people we are hearing from are the people wanting to do it. We are not hearing from the people that would probably become very upset if you actually told them they had to do it. There probably are a substantial number of people out there that do have those concerns. In the circles that I move in I am not hearing them" (Sorter 3).

Essentially, the true range of public perspectives towards greywater reuse in Metro Vancouver is unknown, along with the degree to which these perceptions hamper implementation. This remains an important area for further exploration.

Pointing Fingers & Potential for Consensus

Through the analysis of the three factors' different perceptions of barriers, a pattern of finger pointing has emerged. As described in Chapter 4.0, Institutional Reformers feel the main barriers are institutional in origin, and that regulators' risk aversion is a major hurdle. Centralized Managers on the other hand feel public behaviour and public perception are important barriers to greywater reuse. Technical Pragmatists feel the barriers stem more from technical and administrative feasibility than from the actions of any one group. Comparing the above with the patterns illustrated in Figure 5.1 shows it is generally the participating regulators who view the public as a major barrier, while the participating greywater reuse users and many of the participating planners and ENGOs, tend to view the regulators as a major barrier. This pattern of pointing fingers could indicate a lack of understanding and communication among the stakeholders.

Focht and Lawler (2000) use Q methodology in combination with six identified types of conflict (Veridical, Contingent, Displaced, Misattributed, Latent, and False conflict) to assess whether disagreeing stakeholders are likely to be able to come to consensus. In their work, only Veridical conflict is identified as true conflict, the other five are defined as different forms of misconception and misunderstanding. Focht and Lawler claim that this one true conflict would be identified in a Q study as a bipolar factor (a factor on which there are multiple significant positive as well as negative loadings). A bipolar factor was not identified in the present study; only three of the 25 sorters loaded significantly negatively on any one factor. This suggests that much of the conflict among these three factors is likely generated by misunderstanding and misconception, which further indicates that conflict and dispute resolution techniques could be used to develop a policy approach to greywater reuse that satisfies all concerned parties.

5.4 Applying Results to the Parcel Level Greywater Reuse Policy Cycle

As described earlier, the policy cycle involves agenda-setting, formulation, decision-making, implementation, evaluation, and termination (Howlett & Ramesh, 2003). The results of the present Q study as presented in Chapter 4 and in section 5.3 above provide information about, and could contribute to, the agenda-setting and policy formation stages of the parcel level greywater reuse policy cycle of Metro Vancouver. The agenda-setting stage, or the stage at which a problem is recognized, is "perhaps the most critical stage of the policy cycle" because "what happens at this early stage has a decisive impact on the entire policy process and its outcomes" (Howlett & Ramesh, 2003, p. 120). The policy formulation stage is often seen as the second stage in the cycle and is when the available options for addressing the problem are identified and assessed. The present research contributes to the agenda-setting stage by identifying the opinions and perceptions of select key players in the greywater reuse process in Metro Vancouver and by illustrating problems with the policy (or lack of policy) as it currently stands. The research feeds into the formulation process by presenting options for addressing the identified important barriers.

Background conditions such as "public opinion, elections, economic conditions, the macropolitical system and other policy sectors" (Hoberg, 2001, p. 12) impact the agenda-setting stage by influencing which problems are given attention and which are not. As discussed at the beginning of this paper, one of the interesting aspects of pursuing this study in Metro Vancouver is the unusual background conditions of this setting relative to most locations where greywater reuse is examined; Metro Vancouver is not currently facing a water crisis, while locations typically studied, such as California and Australia, are. In the following section I touch on how the historical water conditions of a location may influence the greywater reuse policy cycle.

5.4.1 Background Conditions

It has been argued that the historical background of a location's water issues influences acceptance and implementation of greywater reuse projects (Po et al., 2004). For example, approximately 9 to 14% of effluent is recycled in Australia (Dimitriadis, 2005) while only approximately 3% is recycled in BC (Scheafer et al., 2004). As of 2004, approximately 500,000 acre-feet, or 1.5% of California's source water, was renovated water (Cohen et al. 2004), while renovated water is not yet counted as a water source in

BC (Province of British Columbia, 2007). The disparities between the volumes of water being reused in water stressed California and Australia relative to perceived water wealthy Metro Vancouver suggests that the realities of water supply shortages encourage or force municipalities and individuals to overcome the barriers.

A research brief done for the Parliament of Australia in 2005 focused on issues encountered in advancing water reuse in Australia. This report stated:

> "The main barriers to reuse of water in Australia are issues of public confidence, health, the environment, reliable treatment, storage, economics, the lack of relevant regulation, poor integration in water resource management, and the lack of awareness" (Dimitriadis, 2005, p. 10).

In addition, a report done in California identified six barrier themes including: funding issues; public information, education and outreach challenges; plumbing code and cross-connection control issues; regulation and permitting barriers; economic barriers; and science and health issues (California's Recycled Water Task Force, 2003). The barriers found in these two reports are similar to the barriers identified in the present Q study. However, the methods used to identify barriers in all three studies were very different, making a meaningful comparison of perceived barriers in these two water strained locations with those of Metro Vancouver challenging. Further researcher is needed in order to make any conclusions about the influence of water abundance on barriers. Please see section 5.7.2 below for further discussion.

5.5 Applying Results to the Broader Water Conservation Policy Cycle

The original goals for the present work include providing research to help facilitate efficiency improvements in water management and expanding upon the understanding of greywater reuse policy development and implementation. To do this, the information gathered should be examined in both the context of the greywater reuse policy cycle as well as the broader water conservation policy cycle within which the greywater reuse policy cycle is nested. With regards to the broader water conservation policy cycle, the present research contributes to the policy formation stage as it presents information concerning an option for addressing water conservation needs. In this context, parcel level greywater reuse should be compared to alternative options such as other technological approaches as well as behavioural options. Space limits the extent to which this comparison can be made in the present study, but in the following section I briefly examine parcel level greywater reuse relative to other options.

5.5.1 Is Greywater Reuse the Most Effective Means of Meeting Water Management Goals?

In Chapter 1, threats to both the natural and urban hydrological cycle of Metro Vancouver, water management goals, and the regions commitment to water resource sustainability (BC Ministry of the Environment, 2008) were used to illustrate a need for the present research. The underlying assumption here is that parcel level greywater reuse is a desirable water management technique, effective at achieving sustainable water management goals and something that should be pursued. Yet, this assumption came into question throughout the research process.

The first instance of questioning the above assumption occurred when the classification of greywater reuse as a Soft Path management technique or as a Demand Side Management technique was explored. The conclusion, that greywater reuse for the application of toilet flushing and landscape irrigation is more in line with demand side management, was drawn because there are available options for eliminating water use completely from these applications. By choosing to use recycled water to flush toilets and water lawns we are still choosing to use water rather than selecting available water free strategies. In this situation, it can be argued that greywater reuse is not the *most* effective water conservation measure available.

The second instance of questioning the above assumption was during post sort interviews when I asked sorters whether they thought parcel level greywater reuse, as described here, should be pursued in Metro Vancouver. A recurring sentiment among the expert opinions I heard is that greywater reuse is an important part of the range of sustainability solutions, however, it should not be our main priority; before we begin to recycle, we must first attempt to reduce what we use. For example, Sorter 3 stated, "Yes… but we could just use less in the first place."

Greywater reuse systems are a technological fix requiring physical resources to build, implement, maintain and operate. Most sorters feel there are alternative measures available that require investing less material, financial, technological and intellectual capital, yet still offer comparable or greater water saving. One of these alternatives is initiating behavioural changes such as taking shorter showers and practising water free gardening. British Columbia's residents use on average 425 litres of water per person per day, putting them among the heaviest water users in the country (Environment Canada, 2004); and Canada places second globally for volume of water used per person (Dwivedi et al., 2001). A change in consumption habits could effectively reduce Metro Vancouver's water use.

Sorter 10 believes greywater reuse could help engender behavioural changes. Parcel level greywater reuse would lead to education of the users and provide quick feedback for actions taken, such as would happen if a user poured something toxic into the system and the surrounding landscape vegetation was damaged (post sort interview with Sorter 10). However, Sorter 7 questions whether greywater reuse would change peoples habits, relating it back to her work with solid wastes. She feels that as a result of the work put into solid waste recycling "people recycle more, but that doesn't mean that they consume less."

Behavioural changes can conserve water with little or no additional material resource consumption. Other recommended alternatives such as mandating the installation of low flow toilets and low water use appliances (recommended by Sorters 3, 15, 19, 20 & 22), do use material resources to develop, however, it is material that would otherwise be consumed in the production of less water efficient versions of those appliances. Greywater reuse is new technology above and beyond that which is currently used; materials are needed to construct dual piping systems, to build treatment systems and to install infrastructure, and energy is needed to operate the systems. If retrofitting is required to install a greywater reuse system in an existing home or building, the material capital required is even greater (Dimitriadis, 2005).

In addition to material infrastructure requirements, greywater reuse requires regulatory infrastructure. Parcel level greywater reuse is not fully accommodated in regulation in Metro Vancouver and the regulatory infrastructure required to safely monitor its implementation is not yet developed. Changing regulation and developing the needed regulatory infrastructure will take human effort to implement and coordinate, and will take time (Vassos, 2007), while currently there are water conservation options offering comparable water savings, which work easily within existing regulation.

Many of the individuals interviewed in the Q study feel that parcel level greywater reuse will likely be an integral part of the sustainable management of Metro Vancouver's water resources in the future, but that it is currently not the "low hanging fruit" (post sort interview with Sorter 1). Greywater reuse must be set in context in comparison with other water conservation options; presently it is not the *most* effective water conservation measure. Greywater reuse is an excellent solution for those who have reduced their water consumption to the maximum of their ability (likely through behavioural changes and use of low water consumption appliances) and are looking for the next option to help in meeting their water sustainability goals. In this regard, policy should be adjusted in order to enable such individuals to implement parcel level greywater reuse systems, concurrent to the promotion of other currently more efficient water conservation methods.

5.5.2 Does Full Wastewater Reuse Have More Potential Than Greywater Reuse?

While conducting the present research, Sorters 10 and 20 introduced me to the greywater reuse versus full wastewater reuse debate. These two individuals are adamant that full wastewater reuse is a much more effective water conservation solution than greywater reuse, in most situations. Full waste water reuse differs from greywater reuse in that the system collects, treats and reuses all wastewater, black water included, rather than only collecting the apparently cleanest wastewater sources.

The foundation of this argument is relatively simple; more water saved with fewer resources invested results in greater conservation efficiency. Because all the wastewater is collected from a home or building rather than only a portion of it, more water is conserved when using full wastewater reuse systems. Additionally, by collecting water from sources the reused water is being applied to, you partially close the consumption loop, further reducing overall use. The main feature that offers resource savings is that greywater reuse requires double piping infrastructure to collect the individual greywater sources. This infrastructure must be retrofit into existing buildings, which has heavy resource requirements, or designed into new ones. Full wastewater reuse does not need to separate the waste streams and therefore does not require as extensive double piping (double piping is still required for distribution of the renovated water to the reuse applications).

The next issue to consider is the treatment systems. Research has shown that the contaminant levels of greywater can at times be higher than that of full wastewater (Lighthouse Sustainable Building Centre, 2007) meaning that the level of treatment that is required for safe operation of a greywater reuse system is essentially the same as that needed for full wastewater reuse (Health Canada, 2007). As well, the additional presence of a consistent source of organic loadings in full wastewater makes the treatment process easier, as the waste stream can consistently support bacteria cultures, an effective means of cleaning wastewater and one that is applied at municipal level wastewater treatment plants. Further still, the ability to use bacterial treatment of the wastewater reduces the system's dependence on chemicals such as chlorine (Vassos, 2007). Essentially, full wastewater reuse conserves more water, requires fewer resources, and is easier to provide treatment for, making it a more efficient water conservation technique.

5.5.3 Implementing Greywater Reuse as a Step Towards Full Wastewater Reuse

While the efficacy of greywater reuse is questioned above, it can still be argued that greywater reuse is an important conservation option and possibly an essential phase in the implementation of full wastewater reuse. Aside from Sorters 10 and 20 the majority of individuals I discussed full wastewater reuse with either see it as having exponentially more barriers to work through (making greywater reuse the current battle of choice), or as being an outright unacceptable option. The inclusion of blackwater in the reuse wastewater stream appears to be beyond many peoples' current risk tolerance. Parcel level greywater reuse may be an effective way of approaching the perception barriers that appear to hinder full wastewater reuse as well. However, "new policies create new politics" (Howlett & Ramesh, 2003, p. 216) making it important to ensure that the development and implementation of parcel level greywater reuse does not result in more barriers for other water conservation measures, such as full wastewater reuse.

5.6 Methodological Lessons Learned

Lessons learned by others using Q were helpful and appreciated while carrying out this research. In the following sections I outline a few of the lessons I learned while conducting the present research, in an attempt to add to the collection of information guiding Q methodology's use.

5.6.1 Statements

Two of the lessons learned involve the length and complexity of the statements used in the sorting process. During the sorting process, I observed that the lengthier statements (for example, statements 15 and 25) tended to be read more quickly and given less attention by the sorters. During the sorting procedure participants are asked to comprehend and consider a large amount of information. Longer statements and complex perspectives are therefore more challenging and sometimes beyond what the sorter is willing to take on. This trend emphasizes the importance of concise and clear statements containing only one idea for the sorter to consider.

While generating the Q sample I felt it was important to retain a certain level of detail within the statements. For example, statements 23 and 44 both address regulatory barriers, specifically the *BC Health Act's Sewerage System Regulation*. Statement 23 states, *greywater reuse is not addressed* in this regulation while statement 44 states, *irrigation in single-family homes is not permitted* by this regulation. The sorters often missed the subtle difference between these two statements and others like them, with some sorters commenting on the presence of repetition within the set of statements. Some repetition in the Q sample is desirable, as providing the sorter with more than one opportunity to illustrate their perspective helps with identifying patterns. However, in this case I was not targeting repetition but rather attempting to identify more specific barriers. As a result of some sorters not identifying the subtle differences, clarifying the sorters interpretation of these statements during the post sort interviews became all the more important.

5.6.2 Conditions of Instruction

The standard conditions of instruction used in Q sorting directs participants to place statements ranging from those they most agree with to those they most disagree with. I decided to deviate from this practice as each of the statements in my Q sample had been identified as a barrier in the literature and it was conceivable that a sorter could agree with all of them. Initially I settled on sorting the statements according to the ones participants felt were the most important barriers and the ones they felt were the most unimportant barriers. However, many of the statements were written in negative language and sorting negative statements as unimportant barriers proved to be challenging during my pre-testing.

The conditions of instruction eventually decided upon for the present study had participants sort statements according to those *most like their view* and those *most unlike their view* of the important barriers to parcel level greywater reuse in Metro Vancouver. These conditions of instruction were quite complex and I found that many of the sorters had difficulty holding the context with which to interpret and sort the statements in their mind while also considering the statements themselves. As a result a number of the participants shifted to a framework of agree versus disagree. This shift does not appear to have had a large impact on the outcome of the sorting process, and I believe I was able to identify it in most, if not all cases, thus allowing me to consider it while interpreting the results. However, preventing a shift in the conditions of instruction is desirable.

Avoiding this challenge could be achieved by using standard and simple conditions of instruction such as *agree* versus *disagree*. However, as was pointed out by Amanda Wolf in a presentation at the 2008 ISSSS Q Conference, simple *agree* versus *disagree* conditions of instruction can have some of the same researcher driven interpretation challenges as are found in R-methodology studies. She recommends using very specific conditions of instruction. My challenges and Dr. Wolf's recommendations illustrate that the conditions of instruction must be selected carefully, in order to find an easily comprehensible framework while retaining enough detail to be useful to the researcher.

5.6.3 Sorting Template

During the sorting process I used a sorting template; a diagram of the distribution the participants were to sort the statements in, printed out on a 24 by 36 inch poster board (please see Figure 3.1). Use of this template was quite successful and is recommended for future studies. The template reduced the amount of instruction the sorters needed as it clearly illustrated how many statements were to go in each column and where the *like my view* statements versus the *unlike my view* statements belonged. In addition, the game-like feel the template brought to the process challenged many of the sorters to stick to the quasi-normal sorting distribution to a greater extent then they otherwise may have; they were challenged to cover each square with a statement, which pushed them to make difficult choices on the relative importance of each of the barriers.

5.6.4 Recording the Initial Card Distribution

In the initial phase of the sorting process, each participant was asked to sort the statements into three piles (like my view, unlike my view, and neutral or unsure). Throughout the study I observed that most sorters placed more cards in the like my view pile than they did in the unlike my view pile. Recording the number of cards placed in this initial distribution, and possibly which cards were placed there, may have added some valuable information to the study, and helped in the interpretation of the results.

5.7 Suggestions for Further Research

5.7.1 Limitations Create Opportunities

While the final product of this research provides useful information to water resource managers and planners, and contributes to the body of knowledge regarding greywater reuse, there are limitations to the applicability of the information that has been generated. First, the aim of Q methodology is to determine which perceptions are present in the targeted population, but not how pervasive these perceptions are in that population (van Exel & de Graaf, 2005). Next, the findings apply to the population surveyed only and may not be transferable either through time or across locations. Geographically, varied water resource situations within different locations will influence opinions and perceptions (Po et al., 2004); Temporally, people's attitudes change through time as more information becomes available, as political climates adjust, and as resource conditions alter. How long the information produced by this research will accurately portray its population source is impossible to know.

While the above issues are limitations to the present research, they can also be viewed as opportunities for further research. "Multiple methods of inquiry reveal different perspectives about values and objectives" (Martin & Steelman, 2004, p. 38). By examining an issue with more than one methodology, or in more than one location, we increase the thoroughness of our understanding, and the ability of decision makers to make informed decisions.

5.7.2 Alternative Locations

It is hypothesized that a location's water resource history influences the application of greywater reuse in that location (Po et al., 2004). Yet, as discussed in section 5.4 above, comparing the perceived barriers identified in the present research to those identified in locations with contrasting water resource histories is challenging, as the methods used to identify these barriers are quite different. Transplanting this Q study to alternative locations could offer further insight into the influence of place (historical resource management, natural hydrological regime) on barriers to greywater reuse.

To assess the influence of historical water issues on perceptions of parcel level greywater reuse, the present Q study could be transplanted to locations within BC with both similar and distinctly different water resource circumstances. There are a wide variety of water resource circumstances in BC from which to choose: water stressed locations such as Kelowna; water conscious locations such as Victoria; and perceived water wealthy locations such as Prince Rupert. As the statements used in this Q study were taken from literature rather than directly from interviews, the Q sample itself would likely need little change, other than altering place names and statements pertaining to local legislation. Comparisons of the alternative locations could either be done theoretically by comparing the resulting factors of the different locations after statistically analyzing them separately, or statistically by analysing the new sorts against the framework of the three factors found here.

5.7.3 Factor Distribution in the Population

Q methodology does not reveal how pervasive the identified factors are among the population (van Exel & de Graaf, 2005). Yet, this information is beneficial for researchers attempting to understand perception and influences on perception of parcel level greywater reuse, as well as for decision makers and resource managers when attempting to understand the issues and develop policy options. There are numerous ways in which the results and information gathered from the present Q study could be adapted and used to develop a broader population survey. One option is to develop summaries of each of the three factors revealed in the study and ask survey participants to indicate which factor is most in line with them. For example, a broader sample of individuals involved in greywater reuse, including regulators, system developers and implementers could be asked which of the three factors identified most accurately represents what they feel are the most important barriers to parcel level greywater reuse in Metro Vancouver. Alternatively, a Likert-scale survey could be developed from a selection of the statements used in the Q sort, or a discrete choice experiment could be developed using the results from the Q study to create the choice sets. Either of these could be used to identify what percentage of the target population is best described by each of the three factors.

5.7.4 Public Attitudes and Perceptions

An additional opportunity for further research lies in surveying the general public on their perceptions and attitudes towards greywater reuse or full wastewater reuse. While this is not a direct spinoff of the research done in the present study, it became apparent while doing the background research and surveying the participant sorters that there is a substantial gap in information pertaining to public perception of greywater reuse in Canada. Some writing and surveying of the public has been done in other countries (Po et al., 2004), but little is known about the perceptions of the Canadian or BC public regarding the acceptability and of willingness to reuse wastewater. The individuals included in the present study were each experienced with greywater reuse in some way, which limits this study's contribution to the understanding of general acceptance of greywater reuse. There are opportunities for such a study to be pursued through a combination of Q methodology and more standardized surveys or a choice model, as touched on above.

5.8 Concluding remarks

Greywater reuse – using water from sinks, showers and laundry to flush toilets and irrigate landscapes - is often cited as a management technique with potential to increase the efficiency of urban water use. Yet, in spite of government interest and opportunities for water conservation and environmental protection, only approximately 3% of British Columbia's total wastewater is being recycled. In the present study, Q methodology was used to explore perceptions of key stakeholders regarding the presence of, and the relative importance of, theoretical barriers to parcel level greywater reuse in Metro Vancouver. Three distinct perspectives emerged (Institutional Reformers, Centralized Managers, and Technical Pragmatists) and were illustrated using the patterns of consensus and conflict identified with the methodology. Some of the theoretical barriers to parcel level greywater reuse identified in greywater reuse literature were determined to be important barriers in Metro Vancouver, while other theoretical barriers were not.

A generally strong pattern of correlation between the factor an individual sorter loaded on and the role that participant plays in the greywater reuse arena (regulator, developer, system user etc.) was also identified. This pattern suggests the underlying interests and responsibilities an individual takes on, as a result of their role in the greywater reuse process, influences their perceptions of the important and unimportant barriers. Misunderstanding of the positions individuals take as a result of the interests they hold is a common source of conflict in many policy arenas, however, it is one that has been successfully addressed through interest based negotiation and dispute resolution. This further suggests that there is potential for consensus among the many different players in this historically controversial field.

Q methodology has never before been used to determine the subjective opinions of key players regarding the barriers to parcel level greywater reuse and has resulted in a much more detailed understanding of the perceived barriers in the context of Metro Vancouver. It has at the same time generated multiple opportunities for further work, either by transplanting the present Q study to locations with different water resource characteristics, or by furthering the understanding of the identified barriers by measuring their pervasiveness in the Metro Vancouver population.

APPENDICES

Appendix A: Water Reuse Projects in British Columbia

Table A. 1 – Water reuse projects in British Columbia.

Parcel Level Water Reuse Systems		
Location	**Project**	**System**
Kelowna, BC	Private Residence	• Greywater recycling for toilet use in a residence, which is expected to save the household 30 percent in water consumption and reduce demand at the waste water treatment facility. • Source: Rutherford, 2007, p. 44
Langley, BC	Private Residence	• Greywater is collected from sinks and showers, treated and used for landscape irrigation. • Using a Brac Greywater Recycling System • Source: Peters, 2007
Mill Bay, BC	Frances Kelsey Secondary School	• Wastewater is treated and used to irrigate playing fields. • Serves 1200 students. • Source: www.novatec.ca
North Vancouver, BC	Quayside Village, multi-tenant residential building with 20 units	• Greywater is treated and used for toilet flushing. • Reduced water demand and wastewater production by ~ 40%. • Construction cost of $115,000, annual cost of $1200 • Annual savings of ~ $2000 • Source: www.cmhc.ca
Parksville, BC	Morning Star Golf Course	• Treated effluent from adjacent French Creek municipal sewage treatment plant is used to augment irrigation. • Source: www.novatec.ca
Pit Meadows, BC	Swaneset Bay Resort	• Effluent from golf resort and clubhouse is treated and used to irrigate a golf course. • Source: www.novatec.ca.
Royston, BC	Kingfisher Oceanside Inn	• All greywater and blackwater is treated and reused for toilet and urinal flushing, and for garden irrigation. • Construction cost of $281,000, annual cost of $28,900 • Source: www.cmhc.ca
Sooke, BC	Ministry of Social Services – Government Office Building	• All greywater and blackwater recycled for toilet flushing. • Saves ~ 600m3/yr. • Construction cost of $88,000, annual cost of $11,400, annual savings of $15,000 to $18,000 • Source: www.cmhc.ca

Sooke, BC	Harbour House Bed and Breakfast	• All greywater and blackwater treated and recycled for toilet and urinal flushing. • Reduced water demand by 2300 m3/yr. • Construction cost of $320,000, annual cost $19,100 • Source: www.cmhc.ca
Vancouver, BC	Vancouver Convention Centre	• All black water and grey water will be treated and recycled for toilet and urinal flushing and irrigation or a green roof. • Project is currently under construction • Source: www.vccep.bc.ca
Victoria, BC	Dockside Green, multi-tenant residential building	• All greywater and blackwater will be treated and recycled for toilet flushing, landscape irrigation and water features. • Reduce water demand by 38 million gallons annually • Water treated to same standard as Singapore's drinking water. • Project is currently under construction. • Source: www.docksidegreen.com
Victoria, BC	University of Victoria	• University reclaims city-supplied water after use in its Outdoor Aquatic Facility, for use in toilets and urinals of its Medical Sciences Building • Water savings of more than 2 million litres per year. • Source: Rutherford, 2007, p. 44
Centralized Water Reuse Systems		
Location	**Project**	**System**
Vancouver, BC	Annacis Island Pilot municipal water recycling plant	• 500 m3/day effluent reclamation and reuse pilot plant. Produces high quality reclaimed water suitable for a variety of reuse applications. • $100 000 of Green Municipal Funds granted by the Federation of Canadian Municipalities. • Water will be used in the non-potable water system at the Annacis Island WWTP, reducing operating costs. • Goal is to produce water meeting MSR's unrestricted public access standard of water. • Source: www.gvrd.ca
Vernon, BC	Municipal water recycling plant	• City reclaims 100% of its treated municipal wastewater. Over 1 billion gallons of sewage annually undergoes advanced treatment, storage and disinfection. This water is then used it to irrigate 25000 acres of agricultural, forestry and recreational lands. • Source: www.cmhc.ca
Oliver, BC	Municipal water recycling	• City treats its sewage using an aerated lagoon process and uses reclaimed water for irrigation purposes. • Source: Rutherford, 2007, p. 42
Fairview, BC	Fairview Mountain Golf Course, Airport and Cemetery	• Golf course now uses reclaimed water exclusively. Surplus reclaimed water is also available for irrigation use on the cemetery and airport. • Source: Rutherford, 2007, p. 42

Victoria, BC	2007 Liquid Waste Management Plan	• Satellite water reclamation plants and water reuse included in 2007 Liquid Waste Management Plan. • Intention is to reclaim wastewater for non-potable reuse. • Planning descriptions provided primarily to demonstrate the intent of decentralized water reclamation plants. • Source: www.crd.ca

Appendix B: Technical Aspects of Water Reuse

Water reuse refers to the process of treating wastewater to remove contaminants and using the renovated wastewater over again. Water reuse can be applied to processes in manufacturing, agriculture, thermal power generation, mining, and municipal sectors; the present research focuses on municipal water reuse, because in Canada water reuse is practiced far less in the municipal sector than in any other sector (Environment Canada, 2002) despite high potential for effective water conservation (Rutherford, 2007).

There are many technical aspects to water reuse programs that should be considered when discussing the subject. These include sources of the wastewater, collection, treatment and storage techniques employed, final uses of the renovated water, scale of the operation and maintenance needs (Lighthouse Sustainable Building Centre, 2007). It is important to identify these specific features when discussing water reuse as each factor influences the potential risks, costs and benefits involved. Unfortunately, much of the existing research on water reuse does not identify the specific features of the technique being used, making it difficult to assess the validity of the research or its applicability to other settings and approaches. The following sections discuss the main technical considerations involved in water reuse and outline which specifics are being considered in the present research.

Source

The source of the wastewater determines which type of wastewater is generated; light greywater, dark greywater, or blackwater. Light-greywater includes water from bathroom sinks, bathtubs, showers, washbasins and sometimes laundry (Lighthouse Sustainable Building Centre, 2007). As laundry can be heavily soiled, some locations discourage laundry water from being included as a light greywater source (CSBE, 2003). Light greywater is generally low in contaminants and mainly contains residuals of soaps and detergents. It can, however, contain disease-causing micro-organisms (NovaTec, 2004). Dark greywater is the same as light greywater with the addition of wastewater from kitchen sinks, laundry and automatic dishwashers. These additional sources increase the content of food wastes, greases and oils in the wastewater (Lighthouse Sustainable

Building Centre, 2007). Water from swimming pools and rainfall runoff are additional sources that can be incorporated into dark greywater applications. Finally, wastewater generated from toilet and urinal flushing is labelled blackwater (UNEP, 2005). In the present research, I lump together dark greywater and light greywater under the more general term greywater. Greywater reuse is the main focus of the present study, however, full wastewater reuse, greywater and blackwater combined, is discussed in subsequent chapters.

Scale

The scale of water reuse systems ranges from individual systems servicing one home and one family, to systems servicing large buildings such as apartment blocks, institutional buildings and business complexes, to systems servicing an entire community or municipality (Dimitriadis, 2005). With these variations of scale come variations of costs and benefits, making it difficult to discuss the strengths and weaknesses of a water reuse project without first identifying the scale at which the project is operating. In the present research I focus on what is referred to as parcel level greywater reuse, or reuse applied at the scale of one home or one building up to a small cluster of homes or buildings. Essentially these are systems that are implemented by home or building owners rather than municipal or regional governments. Water reuse systems applied at this scale are also sometimes referred to as decentralized systems due to the treatment facilities being on-site and separate from the central municipal wastewater infrastructure (CCME, 2004). In comparison, centralized greywater reuse systems are tied into the municipal wastewater treatment infrastructure and typically involve one system servicing the entire municipality or community (Dimitriadis, 2005). Centralized systems represent the conventional approach to water management, focusing on 'end-of-pipe' measures to manage waste (Schaefer et al., 2004). Decentralized water reuse strategies represent a shift in philosophy as reuse technology is used as a means of preventing wastewater generation (Stenekes et al., 2006).

Collection

Collection of greywater can be a simple process such as catching sink water in a bucket under an open drain, or a complicated process such as a closed dual plumbing system that keeps greywater and blackwater separate. The more complicated closed systems are often preferable as they limit human contact with the greywater and reduce risk of exposure to contaminants and pathogens. A dual plumbing system can be installed easily while a structure is being constructed, but retrofitting plumbing changes into an old structure can be complicated, costly and sometimes unworkable (CSBE, 2003).

Transportation

Greywater is transported from the site of generation to where it is collected, treated and stored, then ultimately to where it is put to use. With systems servicing one home or one building the distance the greywater needs to be transported is quite short, which keeps construction and maintenance costs for transport down. As the scale of the reuse system increases the distance the greywater must be transported also increases, as do the costs for construction and maintenance of the transport network. The resources needed to construct a transportation network for a centralized greywater reuse system can be prohibitively large. While most communities have pre-existing pipe infrastructure, the lower quality of greywater necessitates that this water resource be kept separate from the potable water already being delivered, hence a new distribution system must be constructed whenever centralized greywater reuse is being adopted (Dimitriadis, 2005).

Treatment

Like collection, treatment of greywater ranges from simple techniques, such as basic filtering, to complex techniques involving multiple stages and systems. As the likelihood for human contact with greywater increases the complexity of treatment required also increases. As with transportation, the more complex the process, the higher the financial and material resources required. Following is a list of components commonly included in greywater treatment:

- Filtration of hair, lint and coarse solids
- Sedimentation to remove grease, oil and settle out solids
- Biological treatment to remove organics
- Disinfection to remove disease causing micro-organisms
- Storage (NovaTec, 2004).

For a more detailed discussion of treatment processes please refer to the 2004 report prepared by NovaTec Consultants Inc. for the Capital Regional District (NovaTec, 2004). For the present research, it is assumed that some form of treatment is employed in the systems under consideration, however, the details of the treatment are not specified.

Storage

Variations in demand for greywater throughout a day or throughout a season result in the need for storage capabilities in most water reuse systems. In addition, it is recommended that most greywater reuse systems have storage capabilities to deal with events when water quality does not meet prescribed standards, in which case the water must be diverted and stored until compliance is ensured (CCME, 2004). Greywater needs to be stored in such a way that it does not pose a threat to the public via contact with contaminated water. It also needs to address issues of water degradation over time due to regrowth of bacteria and other microorganisms feeding on the nutrient content of the renovated water (Exall et al., 2004). If greywater with minimal treatment is stored for any length of time, the water will become septic and generate noxious odours (NovaTec, 2004).

Application

When discussing applications for renovated greywater, the first distinction that should be made is between direct and indirect reuse. Indirect reuse occurs whenever wastewater is discharged into a waterway that is then drawn from as a water source further downstream. This process has been practiced globally for centuries. Direct reuse refers to using wastewater a second time without first directing the water back into a natural waterway, a practice that is less common (Esteban & de Miguel, 2008). A second distinction that should be made is between potable and non-potable reuse; potable reuse refers to using the renovated greywater for a use that will result in human consumption, such as drinking water or watering of consumable crops, while non-potable reuse refers to any application that will not result in human consumption of the water. I do not consider potable reuse in the present study.

There are numerous non-potable direct applications for renovated greywater, such as toilet flushing, laundry, street and car washing, fire fighting and irrigation. Each application involves varying degrees of human and environmental exposure to potentially contaminated water, and therefore involves varying levels of risk to human and environmental health. As a result, the intended use for the treated greywater dictates the greywater system's transportation, treatment and storage needs (NovaTec, 2004).

The most common applications of treated greywater generated by decentralized or on-site systems are irrigation, and toilet and urinal flushing (Exall et al., 2004). This is likely due to reduced human contact with the renovated water, which involves lower risk making it relatively more acceptable to the public (Po et al., 2004). As well, these uses require minimal treatment because of the low likelihood of human contact with the water, which keeps associated costs down. Landscape irrigation and toilet and urinal flushing are the two greywater reuse applications that are most likely to be allowed under the current regulatory structure in BC (NovaTec, 2004) and are the only applications addressed during the interview process.

Maintenance and Operation

The intended application of the renovated greywater dictates the complexity of treatment and storage required of any system. This complexity further dictates the level of maintenance needed and the degree of technical expertise required for day-to-day operation. As the potential for health risks increases the need for reliability of operation and maintenance also increases (Health Canada, 2007). A homeowner or building maintenance team can often maintain basic systems, however, there is concern within the health community regarding leaving it up to the homeowner to maintain a system that has the potential to expose people to pathogens (Maas, 2003). Systems that are more complex often require the system's designers and developers to perform routine maintenance (NovaTec, 2004). With this maintenance comes an additional cost that may further deter a homeowner or building developer from installing the technology.

Appendix C: Instructions and Definitions for Greywater Reuse Q Sort

Instructions

- You will be given 47 cards; each card has printed on it a statement taken from greywater reuse literature.
- These statements represent peoples opinions regarding the most important barriers to greywater reuse in Metro Vancouver.
- You will be instructed to go through these statements, sorting them according to the ones you feel are the **most like your own view about important barriers** to greywater reuse and the ones you feel are **most unlike your own view**.
- Within the statements you will come across some that point to attitudes of others as being an important barrier. For example, a statement might say that public perceptions are a barrier. Please keep in mind that I am not asking you to decide whether or not you agree with the perception or attitude referred to in the statement, but rather whether you agree that this perception or attitude is an important barrier. Is this clear?

Definitions

Greywater	Wastewater originating from domestic sources other than toilets and urinals, including bathroom and kitchen sinks, showers and bathtubs, laundry machines, and automated dishwashers.
Blackwater	Wastewater originating from toilets and urinals.
Greywater Reuse	For the present study, we are defining greywater reuse as the process of collecting and treating greywater and using it a second time for an appropriate application. Only toilet and urinal flushing and landscape irrigation are being considered as appropriate applications.
On-siteor Parcel Level	A water reuse system that is not part of the centralized sewerage infrastructure. In the present study, we are considering water reuse systems applied at the scale of residential buildings (single family homes, multi family home) and institutional buildings (business buildings, educational centres, public facilities).

Appendix D: Participant Information

Table D. 1 - Participant information. Given with permission from the participant.

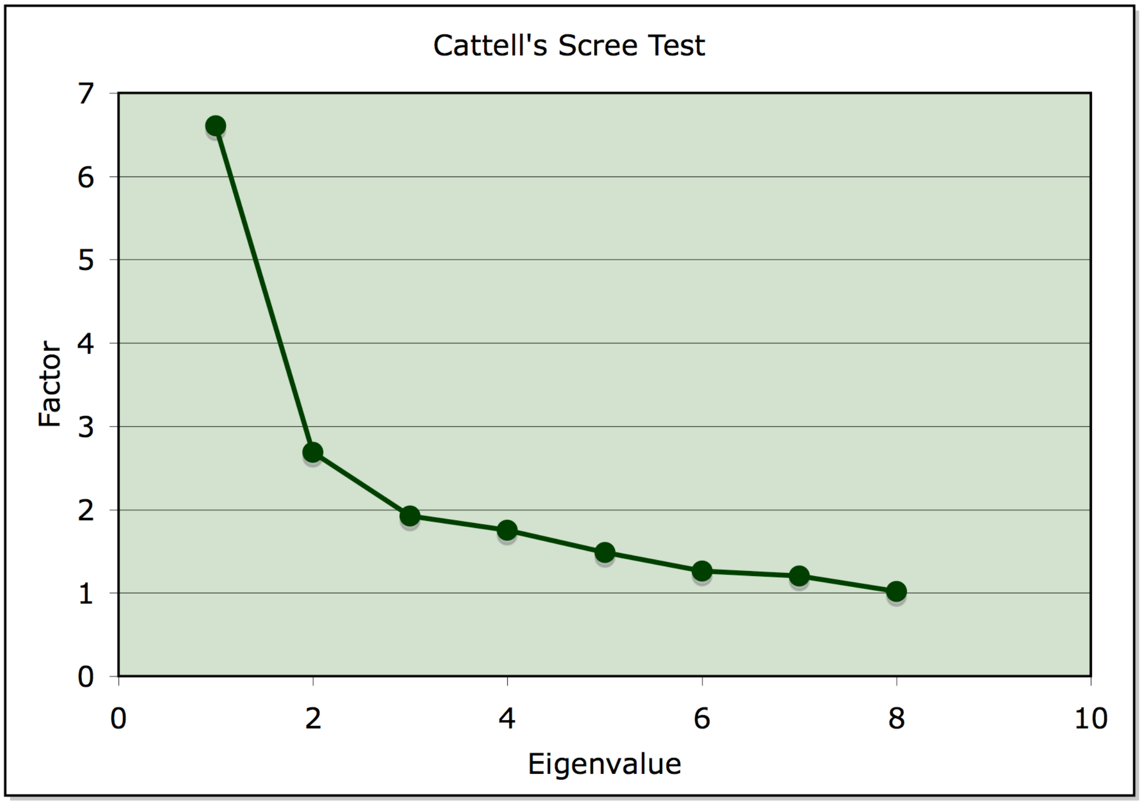
Sorter ID	Individual identification
Sorter 1	High Performance Home Consultant & Project Manager, Canadian Green Building Council
Sorter 2	Green Building Project Manager, Light House Sustainable Building Centre
Sorter 3	Green Building Project Manager
Sorter 4	Environmental Health Office
Sorter 5	Simon Fraser University Instructor
Sorter 6	Environmental Planner, Local Government
Sorter 7	Professional Engineer, Regional Government
Sorter 8	City Planner
Sorter 9	Vice President of Development
Sorter 10	Employee of NovaTec Consulting
Sorter 11	Senior Environmental Health Officer
Sorter 12	Cross Connection Prevention Program Coordinator
Sorter 13	Greywater system maintenance supervisor
Sorter 14	Homeowner, greywater reuse system operator
Sorter 15	Employee of Local Government
Sorter 16	Sr. Research Consultant, Canada Mortgage and Housing Council
Sorter 17	Cross Connection Control Specialist
Sorter 18	Employee of Simon Fraser University
Sorter 19	Consulting Engineer
Sorter 20	Engineering Consultant
Sorter 21	Mechanical Engineer, Greywater User
Sorter 22	Policy Advisor
Sorter 23	Environmental Protection Officer
Sorter 24	Environmental Lawyer
Sorter 25	Environmental Health Officer

Appendix E: Analytic Methods

Table E. 1 - Unrotated factor matrix.

Sort #	Unrotated Factors							
	One	Two	Three	Four	Five	Six	Seven	Eight
1	0.5156	0.3326	-0.0196	0.0093	0.2299	-0.3134	-0.0739	0.2035
2	0.6291	0.0326	-0.2069	-0.2108	0.3178	-0.0804	0.0698	0.3989
3	0.6259	-0.1096	0.3714	-0.2397	-0.0743	-0.2166	-0.2347	-0.2794
4	0.3323	0.1974	-0.0593	0.6033	0.3924	-0.0699	-0.0633	-0.1870
5	0.6563	0.0221	-0.4272	0.0041	-0.3593	0.0668	-0.1689	0.0267
6	0.6621	0.0203	0.0545	0.1986	-0.0643	0.1517	-0.3102	0.3093
7	0.2524	0.1757	0.2576	0.5597	0.0095	0.2779	0.4117	0.1394
8	0.4644	-0.4600	-0.0870	0.1801	0.4333	0.2530	0.0642	0.0048
9	0.1725	-0.2822	-0.0495	0.3739	-0.5145	0.1067	0.3867	0.2470
10	0.5556	0.4534	-0.0297	-0.0736	0.1479	-0.0482	0.1408	-0.0838
11	0.2819	0.6191	-0.2610	0.0867	-0.2925	-0.0761	0.1694	-0.0310
12	-0.1564	0.6298	0.0321	0.2238	-0.1635	-0.3553	-0.0371	-0.2331
13	0.5386	-0.2384	-0.2521	0.3252	-0.1806	-0.3622	0.1745	-0.1675
14	0.6324	-0.2712	-0.2242	-0.3154	-0.1080	0.0029	0.1769	-0.3409
15	0.1516	0.5859	0.4926	-0.0826	-0.1182	0.3849	-0.1117	0.0515
16	0.7771	-0.3504	-0.0617	-0.1547	-0.1084	0.1537	0.0183	-0.0373
17	0.2836	-0.0928	0.7870	0.2675	-0.0534	-0.0729	-0.0661	-0.1112
18	0.6869	-0.3882	-0.0402	0.3450	0.1111	-0.1110	-0.2033	-0.0796
19	0.5751	0.1720	0.0690	-0.3685	-0.1599	-0.1518	0.1499	0.2820
20	0.6169	0.0282	0.2329	-0.1978	-0.1842	0.3382	-0.0835	-0.0543
21	0.6899	0.1396	0.2103	-0.1091	0.2980	-0.2783	0.0293	0.2291
22	0.2588	0.1917	0.1556	-0.2472	0.1760	-0.0165	0.6351	-0.1917
23	0.2271	0.5185	-0.4249	0.1513	-0.1126	0.1567	-0.2751	0.0060
24	0.7401	-0.0582	0.1831	0.0117	-0.2616	-0.0074	-0.0829	-0.1550
25	0.3546	0.3174	-0.2861	-0.0575	0.3270	0.4806	0.0162	-0.3183
Eigen.	6.6030	2.6864	1.9212	1.7547	1.4857	1.2623	1.2040	1.0168
% Var.	26	11	8	7	6	5	5	4

Figure E. 1 Cattell's scree test. Used to help identify how many factor to retain and rotate during the analysis of the Q study data.



Appendix F: Steps for Determining Flagging

Table F. 1 The three steps used in determining which sorts to flag during the analysis. Please refer to Appendix H below for the factor loadings and complete list of which sorts were flagged.

Step One	Eliminate confounded and unloaded sorts (Brown, 2005) • Confounded sorts = 1, 2, 3, 5, 6, 10 and 24 • Unloaded sorts = 4, 9, 12 and 22

Step Two	Identify sorts where the difference between the two highest loadings is significant (Brown, 2003b)
	• Step a: find the difference between the highest and second highest loadings = *Diff*
	• Step b: find the difference between the Standard Error of the highest and second highest loadings = *SE Diff*
	• Step c: multiply the *SE Diff* by 2.58 = *2.58SE Diff*
	• If *Diff* - *2.58SE Diff* =
	  o a positive value, the difference is significant and that sort is flagged.
	  o a negative value, the difference is not significant and that sort is not flagged.
	• Ex. Sorter 16
	  o Step a: 0.7822 – 0.3127 = 0.4695
	  o Step b: $(1- (0.7822^2)/\sqrt{47}) - (1 - (0.3127^2)/\sqrt{47}) = 0.1433$
	    ▪ 47 = the number of statements in the sort.
	  o Step c: 2.58 x 0.1433 = 0.0999
	    ▪ positive number, therefore flag Sorter 16

Step Three	Identify sorts where the difference between the two highest loadings is non-significant, but the non-significant loadings are very close to zero (Brown, 2003a) • Ex. Sorter 25

Appendix G: Factor Arrays

Figure G. 1 Factor Arrays or Model Q sorts for each of the factors.

Factor array for Institutional Reformers

7	1	2	5	13	15	14	9	4	6	3
47	32	8	10	18	19	23	11	25	34	22
	33	21	16	24	20	27	12	43	38	
		26	17	35	28	36	39	44		
			41	40	29	37	45			
				42	30	46				
					31					

Factor array for Centralized Managers

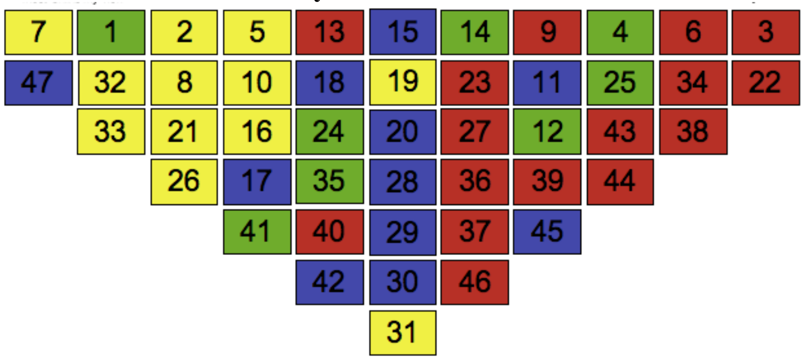
16	1	2	5	17	12	3	4	11	10	7
21	8	9	27	19	14	6	24	32	20	30
	42	26	31	22	18	13	25	41	28	
		34	36	38	23	15	33	45		
			37	44	29	40	35			
				46	39	43				
					47					

Factor array for Technical Pragmatists

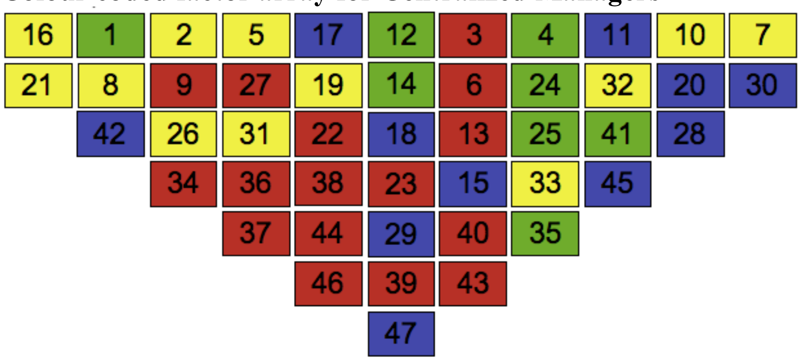
4	16	12	1	2	26	10	5	3	21	7
17	42	18	6	13	28	14	8	24	27	37
	45	30	11	15	31	20	9	29	38	
		47	22	19	32	25	23	43		
			40	35	33	39	34			
				36	44	41				
					46					

Figure G. 2 Colour coded factor arrays or model Q sorts for each of the three factors, coding them according to the categories of barriers discussed in the background and discussion chapters.

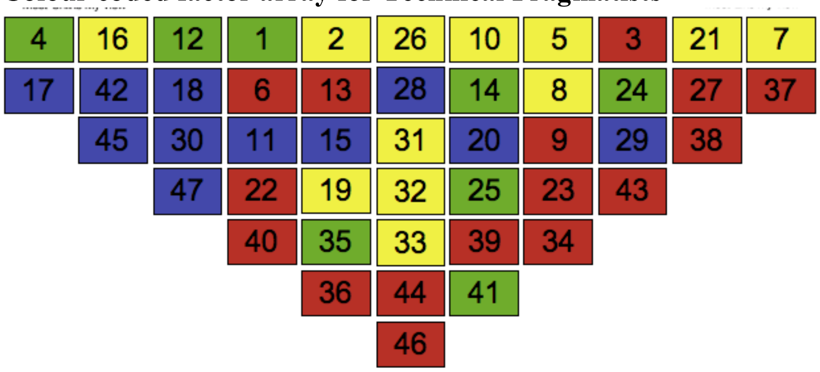
Colour coded factor array for Institutional Reformers

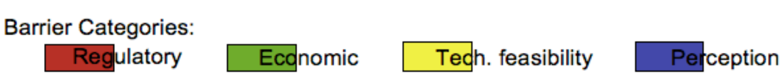


Colour coded factor array for Centralized Managers



Colour coded factor array for Technical Pragmatists





Appendix H: Answer Distribution for Question of Necessity

Figure H. 1 Factor Loadings and responses (Yes, No, Qualified yes) to the question "do you think parcel level greywater reuse should be pursued in Metro Vancouver?" Bold text indicates loadings that are statistically significant at p=0.01, shaded boxes indicate loadings that were flagged for each factor during Varimax rotation.

Participant Categories		ID	Institutional Reformers	Centralized Managers	Technical Pragmatists	Necessity
Environmental Non Governmental Organizations		02	**0.4611**	**0.4234**	0.2184	Yes
Environmental Non Governmental Organizations		05	**0.5478**	**0.5565**	0.0628	Qualified yes
Environmental Non Governmental Organizations		03	**0.3955**	-0.0108	**0.6206**	Qualified yes
Environmental Non Governmental Organizations		24	**0.4900**	0.1847	**0.5572**	Yes
Environmental Non Governmental Organizations	Greywater Reuse System Developers	01	0.1278	**0.4680**	**0.3762**	Qualified yes
Environmental Non Governmental Organizations	Greywater Reuse System Developers	21[5]	0.3137	0.2810	**0.6020**	Yes
	Greywater Reuse System Developers	09	0.3229	-0.0861	-0.0131	Qualified yes
	Greywater Reuse System Developers	10	0.0754	**0.5738**	**0.4244**	No
	Greywater Reuse System Developers	19	0.2530	0.3338	**0.4355**	Qualified yes
	Greywater Reuse System Developers	20	0.3339	0.1595	**0.5465**	No
Local and Regional Planners	Greywater Reuse System Developers	07	-0.0203	0.0825	**0.3920**	Qualified yes
Local and Regional Planners	Greywater Reuse System Developers	15	-0.4333	0.1800	**0.6235**	No
Local and Regional Planners		06	**0.4193**	0.2780	**0.4343**	Qualified yes
Local and Regional Planners		08	**0.6521**	-0.0548	0.0810	Yes
Local and Regional Planners		16	**0.7822**	0.1447	0.3127	Qualified yes
Local and Regional Planners		22	0.0015	0.1556	0.3221	Qualified yes
Local and Regional Planners	Greywater Reuse System Users	18	**0.7409**	0.0662	0.2662	Yes
	Greywater Reuse System Users	14	**0.6752**	0.2284	0.1252	Yes
	Greywater Reuse System Users	13	**0.5971**	0.2251	0.0578	Yes
	Greywater Reuse	11	-0.1587	**0.6987**	0.1321	Qualified yes
	Greywater Reuse	23	-0.0818	**0.7011**	-0.0525	No

[5] Sorter 21 is also a Greywater Reuse System User.

Participant Categories		ID	Institutional Reformers	Centralized Managers	Technical Pragmatists	Necessity
	System Regulators	25	0.1030	**0.5406**	0.0741	No
		17	0.0371	-0.3938	**0.7429**	No
		04	0.1069	0.3172	0.2022	Qualified yes
		12	-0.5441	0.3398	0.1029	No

Appendix I: Q Sample and Factor Scores

Table I. 1 Q sample statements and the associated factor scores for each of the three factors.

Statement	Factors		
	1	2	3
1. Only fairly large-scale applications can justify the expenses associated with greywater reuse.	-4	-4	-2
2. Greywater used for irrigation can damage soils by raising the soil alkalinity and salinity and reducing the ability of the soil to absorb and retain water.	-3	-3	-1
3. BC's regulations governing greywater reuse in single-family dwellings are vague at best.	5	1	3
4. Lack of metering for potable water supply discourages the public from employing greywater reuse as a water supply alternative.	3	2	-5
5. There are issues surrounding exposure to 'other people's pathogens' in greywater reuse schemes larger than those employed in a single-family dwelling.	-2	-2	2
6. Developers and residents wanting to reuse greywater often face stringent regulatory challenges.	4	1	-2
7. There is the potential for accidental cross-connection of a greywater reuse system with the drinking water system.	-5	5	5
8. Users of greywater for toilet and urinal flushing and landscape irrigation may accidentally ingest small volumes of greywater through aerosols or hand-to-mouth contact with droplets.	-3	-4	2
9. The Sewerage System Regulation under the BC Health Act groups grey and black water together as domestic sewage. Without a clear differentiation between grey and black water health officials are reluctant to allow greywater reuse.	2	-3	2
10. On-site greywater reuse places much of the maintenance on homeowners and property managers. Without professional maintenance, water treatment will degrade over time and jeopardize user health.	-2	4	1
11. Lack of knowledge about innovative greywater reuse practices is a barrier for design professionals and developers.	2	3	-2
12. Greywater reuse projects are often undervalued when compared to other projects due to the failure to properly quantify benefits of reuse such as watershed protection, local economic development, and improvement of public health.	2	0	-3

Statement	Factors		
	1	2	3
13. Regulation is less of a barrier to rainwater and stormwater reuse than greywater reuse, which quickly eliminates greywater reuse as a management option.	-1	1	-1
14. Retrofitting separate plumbing and drainage systems into an existing building may require difficult and costly installation work.	1	0	1
15. Public acceptance of greywater reuse is dependant upon the confidence that its use is safe, however, experts are rarely able to agree on the degree of risk involved. When technical experts cannot agree, it is unlikely that the general public will have confidence in the results.	0	1	-1
16. Extraction of domestic greywater from sewage flows could result in high strength sewage that could increase environmental damage to the receiving environment.	-2	-5	-4
17. Lack of public trust in water authorities limits the application of greywater reuse.	-2	-1	-5
18. Developers favour rainwater & stormwater reuse over greywater reuse because of Metro Vancouver's abundant rainfall.	-1	0	-3
19. Public health concerns resulting from new chemicals of concern (such as endocrine disruptors, pharmaceuticals and therapeutic products) is limiting the spread of greywater reuse applications.	0	-1	-1
20. Public perceptions of health & environmental risks hamper greywater reuse.	0	4	1
21. Greywater reuse systems operating at a scale larger than one home have the potential to expose a large number of people to disease-causing microorganisms.	-3	-5	4
22. Fear of being sued makes municipal building inspectors reluctant to approve an innovative design.	5	-1	-2
23. The BC Health Act's Sewerage System Regulation does not specifically address the issue of greywater or greywater reuse.	1	0	2
24. Single household treatment systems are not economically viable considering the high cost of supplying and installing systems plus the cost of operation and maintenance, relative to the characteristically low cost of potable water supply.	-1	2	3
25. The current cost analysis for providing greywater largely considers infrastructure and distribution costs, maintenance and capital costs, while the water resource itself, the change of the flow regimes, and how it effects the environment is not fully accounted for.	3	2	1

Statement	Factors		
	1	2	3
26. Greywater reuse for irrigation of lawns and gardens has the potential to cause contamination of groundwater and surface water.	-3	-3	0
27. There is no mandatory requirement to include separate greywater reuse piping in new buildings.	1	-2	4
28. In Metro Vancouver, where water is seemingly abundant, there is a perception among the public that water shortage is not a real issue.	0	4	0
29. Greywater reuse is not the most effective water conservation measure.	0	0	3
30. Greywater reuse is seen to be a logical and necessary inclusion in the range of water resource management options, but people frequently feel a reluctance to personally use the water.	0	5	-3
31. There are potential health problems because the Canadian public is not accustomed to having water below potable standards within and around homes and public facilities.	0	-2	0
32. On-site treatment plants require skilled operator attention, routine maintenance, water quality sampling, and regulatory reporting, which make greywater reuse difficult.	-4	3	0
33. Greywater reuse systems in single-family dwellings are difficult to regulate, maintain and monitor.	-4	2	0
34. There is reluctance on the part of BC health authorities to endorse onsite reuse, particularly at the level of individual households, citing health issues.	4	-3	2
35. Developers believe the financial security requirement of the BC Municipal Sewage Regulation is a disincentive to potential users. They feel that buildings become too expensive when greywater reuse technology is included.	-1	2	-1
36. Designers of water and wastewater systems (professional engineers) are bound by due diligence, making it difficult to consider and implement greywater reuse systems because of their perceived experimental nature.	1	-2	-1
37. Without recognized standards for safe design, treatment quality and operations, BC health authorities are reluctant to allow greywater reuse.	1	-2	5
38. There is a lack of regulatory guidance for greywater reuse.	4	-1	4
39. Although the National Plumbing Code provides for greywater reuse, this is not reflected in municipal policies.	2	0	1

Statement	Factors		
	1	2	3
40. Greywater reuse for toilet flushing is not permissible according to the plumbing requirements of the BC Building Code.	-1	1	-2
41. With small-scale systems, it is unlikely that there will be an economic payback for water savings that would justify the capital expenditure required to develop a greywater reuse system.	-2	3	1
42. Greywater reuse within a group of homes as compared to a centralized municipal level system can be difficult to accept because people are more aware of the link with previous uses of the water.	-1	-4	-4
43. Lack of information and training makes it difficult for municipal building inspectors to determine whether a proposed innovation for greywater reuse provides protection to the public equivalent to that of BC Building Code requirements.	3	1	3
44. Greywater reuse for surface irrigation at a single residence is not permissible under the BC Health Act's Sewerage System Regulation.	3	-1	0
45. Because freshwater appears to be abundant in Vancouver, local government decision makers do not consider greywater reuse as a serious option when contemplating water resource alternatives.	2	3	-4
46. The majority of designers will likely not expose themselves to the potential for liability by including greywater technology that has no reference to design standards given in regulation.	1	-1	0
47. Greywater reuse is not an important water resource alternative for Vancouver as water shortage is not a real issue here	-5	0	-3

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