Social Experiments in Innovative Environmental Management: The emergence of ecotechnology

By

Gregory David Rose

A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Planning

Waterloo, Ontario, Canada, 2003

ABSTRACT

Social Experiments in Innovative Environmental Management: The emergence of ecotechnology

Human production needs are met through the use of modern technology that is increasingly recognised as a threat to the planetary ecosystem and social sub-system. In light of this recognition, there is evidence that a planned transition towards more sustainable technological infrastructure is occurring across various production sectors. This change is often associated with re-orientating technology based on the concept of sustainable development and national-level strategies such as *ecological modernisation*, which prescribes phasing-out environmentally malignant conventional technology for cleaner post-industrial solutions. There is evidence, however, that a transition towards cleaner technological options is occurring at the local level. In southern Ontario, Canada ecological technology (*ecotechnology*) has been adopted in small-scale agricultural and educational facilities for the management of manure and domestic sewage. Ecotechnology is designed to meet human production requirements and to restore the environment through combining natural systems and engineered components to achieve cleaner production. Two types of ecotechnologies were investigated during this research: *constructed treatment wetlands* for the management of manure and *greenhouse-based biological technologies* for the management of domestic sewage. These options are novel and can be expected to encounter barriers resulting from a *selection environment* favouring pre-existing technological options that have previously become established.

The overall objective of the research was *to identify key factors both driving and constraining the adoption and implementation of the ecotechnology* across four case studies. This objective was accomplished through employing a qualitative, collective case study approach. The case studies revealed the motivation behind the adoption of the ecotechnology arose from the environmental values of users and formed the basis for rejecting the conventional options because they were not viewed as capable of improving the environment. However, the ecotechnology also exceeded user's aesthetic and operational level expectations. Barriers to the implementation of ecotechnology were also identified. The investigation revealed the existence of a *perspective-gap* between the ecological engineering science and traditional engineering science, which constrained implementation of the ecotechnology. Skepticism was found to arise due to the unique performance parameters and *soft* operational characteristics of ecotechnology, which contrast the *hard* technological fixes that are familiar to traditional engineering science. This perspective-gap may account for the institutional inertia, which became clear after the 1996 provincial budget reductions decreased the level of support for research and environmental technology development programs in Ontario. These reductions also devolved authority for small-scale wastewater treatment to the municipal level where lack of technical expertise and reliance on standardised regulations has constrained the development of alternatives.

Constructive technology assessment suggests that the development of technology must be guided in cooperative *social learning* processes capable of reflecting the needs and values of stakeholders in order to achieve beneficial social and technological change. Evidence from the case studies revealed that a significant amount of capacity was developed when stakeholders collaborated and legitimated the *social experiments* where the ecotechnology was applied. These experiments demonstrate the significance of creating settings where users, technology proponents and provincial and local approval agents can collaborate. Through collaboration, social learning can be facilitated during the development of alternative technological solutions that may be congruent with ecological modernisation and the re-orientation of technology toward options that are ecologically-oriented.

ACKNOWLEDGEMENTS

I would like to thank the members of my thesis committee for each of their efforts. First, recognition goes to my supervisor, Dr. Murray Haight, for his guidance and open-door policy over the previous five years. Thanks also to Dr. Stephen Murphy for his ongoing involvement in my dissertation and his willingness to engage in a constructive exchange of ideas. Dr. Susan Wismer's involvement was appreciated while I conducted my analysis and *fit the pieces together*. Thanks to Dr. Norman Ball for reviewing the draft and offering stylistic comment. Finally I would thank Dr. Farokh Afshar for acting as my external examiner and offering his insightful and constructive criticism. Each of your efforts challenged my capacity as an investigator and enhanced my facility as a communicator.

Within the university, there are numerous additional people who deserve mention, but that would be impossible. However, I would like to thank Dr. Mike Stone for his involvement as an examiner during my comprehensive exam and Ms. Edie Cardwell, the school of Planning's Graduate Coordinator, for her knowledge, helpful assistance and kindness, which made my time at Waterloo *administratively* simple. Thanks also to the School of Planning and the Graduate Studies Office for the support I received during portions of this research. In the GSO, a special thanks goes to Ms. Elaine Garner for the consideration she showed me not only as a student, but also as an individual. Ms. Margaret Aquan-Yuen in the Porter Library also deserves thanks for assisting me during this research. I would also like to express my sincere gratitude to the research participants who allowed me to interview them during this investigation: the time they invested was essential to completion of the research.

Both of my parents, Marie Gilchrist & Peter Rose, and their families, have been very supportive and encouraged me during the latter part of my education: 'Yes, I've finished school, but promise to keep learning'. Thanks Mom & Dad. To all of my close friends along the Pacific Rim, my cousin Heather Shamerhorn for always welcoming me to her home and for looking after, Kaila-Rah during my Master's and PhD. And my closest of friends, Skooker Broome & Ruth Harris-Jones, John Gardner, Mike & Deana Moorehead; thank you for being there on that mist shrouded coastline never too far from the mountains. I can't express how much it meant knowing that I was always welcome with a place to stay when I needed to return home for R&R. Robert Oster, a fine, caring and thoughtful person; the always inspirational and encouraging Dr. Stephen Allison; and, Dr. Jerry Button a true teacher and many others who influenced me along the way.

Waterloo has been a fine town to spend the last five years: *it really is the people who make it enjoyable and worthwhile* . . . To the charming, Wendy Hicks and her daughters, Madeleine & Aline, thanks for your fine company and year round festivity. Saeed Parto, Rhonda & Joshua for opening their home to and maintaining a somewhat motley crew of academic misfits; Gary Foster for his sensible, but entirely 'Kierkegaardian' insights and advice along the thesis and teaching road; Kate Connolly & Heather Black for always coming through and; Dr. Ed Bennett & family for their friendship. Beth Dempster & Eric Tucks who will be amiably remembered.

GregoryRose@alumni.uwaterloo.ca

In Memory of

Naydù Arana-Ortiz (1964 – 1998)

La Luz de la Luna en el Agua

TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS

CAO	Conservation Authority Official
CTW	Constructed Treatment Wetland
CURB	Clean Up Rural Beaches
EAC	Engineer, Architect, Consultant
GBTT	Greenhouse-Based Treatment Technology
GRCA	Grand River Conservation Authority
LGO	Local Government Official
MMAH	Ministry of Municipal Affairs and Housing (Ontario)
MOEE	Ministry of Environment and Energy (Ontario)
NRC	National Research Council of Canada
OBC	Ontario Building Code
OOP	Owner-Operator-Proponent
PGO	Provincial Government Official
UTRCA	Upper Thames River Conservation Authority

GLOSSARY OF TERMS

Clean Technology	Techniques, processes, and products that avoid or diminish environmental damage, the use of raw materials, natural resources, and energy. (Kemp 1993: 81)
Constructive Technology Assessment	Engaging a wider peer community in social learning processes that can integrate and reflect the needs and values of stakeholders during the 'co-developing' to achieve beneficial social and technological change. (Schot 1992)
Ecological Engineering	The use of predominantly natural systems to achieve specific goals such as human production needs and environmental restoration. (Ma and Yan 1989; Capra and Pauli, 1995; Mitsch, 1998)
Ecological Modernisation	Prescribes strong state-level regulations and controls (e.g. incentives and disincentives) to achieve environmental improvement by stimulating a transition from outdated industrial patterns of energy and material use towards cleaner forms of technology (Gouldson and Murphy 1998)
Ecotechnology	Technologies that operate through the use of predominantly natural sources of energy and require relatively few inputs of 'external' or supplementary fuel sources. (H.T. Odum *et al.* 1963 in Mitsch 1996)
Human Production System	The production and consumption of goods and services and the requisite management of waste that is generated to achieve human production goals. Niemczynowicz (1993a)
Selection Environment	Various factors (e.g. political, institutional, economic) that constrain or impede the development and application of new forms of technology. (Kemp 1993)
Social Learning	A process aimed towards achieving social and institutional change characterised by capacity building in efforts to affect change and change current structures during a process of learn-by-doing. (Friedmann, 1984, 1987)
Technological Determinism	Technology assumes trajectories or paths that offer few opportunities for stakeholders – external to the development process – to influence their development. (Hajar 1995)
Technological Trajectory	A technical path or direction often characterised by periods of incremental rather than radical innovation. (Gouldson and Murphy 1998)
Technological Imperative	Technology is pulled by the market, but also pushed by values intrinsic to technology itself that move technology along certain trajectories. (Rapoport 1984 in Brunk 1985)

Chapter 1.0

Background

> Sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made.
>
> *World Commission on Environment and Development*

In the industrialised north, wastewater management is achieved with sophisticated, highly capitalised and often centralised technology that requires inputs of fossil and hydroelectric energy. Although the short-term ends of waste management are achieved with these options, the technical means employed may impact the environment negatively over the long-term when ecological and human health impacts are taken into consideration. In northern nations, sophisticated and highly capitalised linear or end-of-pipe wastewater management systems have developed as the option of choice, while southern nations aspire to these high-input options as symbols of development. In neither hemisphere, however, have these wastewater management options proven to be consistent with improving the environment (Niemczynowicz 1994; World Resource Institute, UNEP *et al.* 1996).

Contemporary western industrial society has established end-of-pipe waste management approaches where wastewaters are generated and ultimately disposed of into the environment. This approach has resulted over hundred of years and has followed a consistent path or *trajectory*. The trajectory that is now firmly established has resulted after certain techniques and technology become locked-in or entrenched in what Dosi (1988) refers to as a *technological paradigm*. In wastewater management, this trajectory often results in short-term environmental and health related advantages in communities near the point of waste generation. Over the long-term, however, new problems emerge downstream in the environment as residual waste materials accumulate (Beck *et al.* 1994a; Rees 1995; Beder 1997). Ultimately, end-of-pipe waste management regimes result in higher costs that are not necessarily tacit because waste are dispersed into and shifted to the environment and the consequences paid for by society and government (Lyle 1994). This waste management trajectory has led to cumulative environmental problems and threatens ecological and human health at a global scale (Wackernagel and Rees 1996) and may act to destabilisation the entire ecosystem on which humans depend (Levins, Awerbuch *et al.* 1994; Lyle 1994; Waltner-Toews 1995).

Ulrich Beck's (1992) notion of risk society, suggests that portions of society perceive human interaction with the environment as problematic in that human technological successes and contemporary technologies may themselves be jeopardising ecosystem integrity and, by extension, human health. Evidence of this concern is found in the environmental movement and recently, expressed in national level initiatives to foster environmental improvement through ecological modernisation (Hajar 1995) as exhibited in voluntary international policy initiatives such as the Kyoto Protocol. Ecological modernisation has diverse meanings and is often used as a synonym for state policy leading to ecological re-structuring (Buttel 2000). In waste management, this includes innovations in technology and techniques such as industrial ecology to analyse the life cycle of materials as they pass through the economic sub-system (Allenby 1999). Although the root of the environmental crisis may be social, ecological modernisation suggests the environmental crisis is a result of inefficiencies in production technology and therefore, focuses on the development of technologies that are ecologically efficient (Buttel 2000). Perhaps the most significant element of these reforms is the development and dissemination of innovative and cleaner technology. Examples of technological options congruent with an ecological modernisation scenario include hydrogen fuel cells, wind and solar production energy as an answer to the dilemma caused by fossil fuels.

The focus of this thesis relates to advances in *ecological technology* (ecotechnology), which may be congruent with ecological modernisation and efforts to attain cleaner production by transitioning towards more sustainable technology. Ecotechnology combines natural and engineered components in designs that mimic natural processes to meet human requirements. Two options were examined for wastewater management in this research: constructed treatment wetlands (CTW) for agricultural manure and greenhouse based biological treatment technology (GBTT) for domestic sewage.

Derived from the ecological engineering sciences, ecotechnology also offers the dual benefits of restoring the environment by minimising external inputs of non-renewable energy and achieving production goals through performing specific tasks such as the management of wastewater (Ma and Yan 1989; Mitsch and Jorgensen 1989; Mitsch 1991b; Capra and Pauli 1995; Todd and Josephson 1996). For these reasons, ecotechnology exhibits considerable promise as one component of sustainable *human production systems*, which are defined here after, Niemczynowicz (1993a), as systems used by society in the production and consumption of goods and services and the management of resulting wastes.

Although relatively juvenile at this time, ecotechnology may offer one type of alternative to conventional technologies, which have, as Rejeski (1997: 66) suggests, reached their limits in terms of "environmental responsibility, economic efficiency, and political acceptance". Conventional options are fixed within the economic system and permit the provision of inexpensive goods and services within the current, hydrocarbon-based economy (*i.e.* hard technology), but their dominance restricts the advance of alternatives that may be more fitting within a sustainable hydrogen-based economy (*i.e.* renewable/soft technology) (Kemp and Rotmans 2001). The point is that some technologies can be considered more environmentally sound than others and should be encouraged, while less sustainable options ought to be discouraged (Rip, Misa *et al.* 1995a) as society grapples with pressing environmental problems such as climate change and uncertainty regarding the medium to long-term security of freshwater resources.

Multiple factors, however, impede the adoption and implementation of alternative and potentially cleaner environmental technologies and the rate that society can transition towards a sustainable economy (Kemp and Rotmans 2001). The opposite is also true. Many factors will also promote more sustainable options, and it is these *factors* that may leverage change at various scales. The term factor is used here to denote a process, situation or set of circumstances that impede or promote the application of alternatives. Stemming from the work of Nelson and Winter (1977 in Kemp 1993) and Kemp (1993) the 'selection environment' describes a variety of factors that will impede the adoption of innovative and potentially sustainable technology. Alternative technologies must fit into an established selection environment that is already being filled by existing technologies, which have gained consumer preference and regulatory familiarity, which acts to maintain their existing market dominance and ongoing use. It is also important to understand factors such as institutional arrangements ranging from policies and regulations to customs and economic relationships between stakeholders[1] (Forster and Southgate 1983; Mitchell 1989; Sparkes and Peattie 1998). Stakeholders include policy makers, planners, governmental organisations and their agents who can both limit or extend opportunities for innovation in project development (White and White 1979; Mitchell 1989; Grimble and Chan 1995). Stakeholders and their institutional interests can resist or support new environmental technologies and institutions are important in this respect because they are often intractable and achieve their goals by utilising familiar technologies whose very character has been shaped by those institutions and their vested interests (Kemp 1993; Kemp and Rotmans 2001). Thus, innovative waste management techniques and technologies can be constrained by legal and regulatory factors such as health codes, bylaws and nuisance laws that are difficult to modify after they have been established, become customary and institutionalised (Forster and Southgate 1983).

Organisational factors can also constrain, but also promote the adoption of innovative technology and infrastructure. Users such as businesses and organisations may reject conventional options based on a variety of considerations because alternatives may be viewed as environmentally superior, and thus fit the moral and ethical preferences of users closer than conventional options (Irwin, Georg *et al.* 1994). At the local level, Irwin (1995) notes that initiatives to adopt alternative and sustainable technology take a number of forms that are often distinct and autonomous from government led efforts and timetables to achieve sustainability. Initiatives to adopt alternative technology have also been described as empowered citizen-led efforts stemming from a desire to live in a sustainable manner through means that are relevant and comprehensible at the local level (Bookchin 1980; Irwin, Georg *et al.* 1994; Irwin 1995).

In relation to ecotechnology, and the institutional and organisational issues discussed above, it is critical to understand the specific factors that promote and impede alternative solutions for environmental management. Several knowledge-gaps have been identified that affect the implementation of alternative and potentially cleaner environmental technology. Kemp (1993) suggests these gaps must be understood in order to promote the application of more sustainable environmental technology across different selection environments. Key knowledge deficits relate to understanding how users perceive the costs and benefits of novel technology, how associated institutions influence the process, and how regulatory standards impede and promote the advancement of alternatives. Another contribution of this research is to address the knowledge gap

[1] Stakeholders are defined here as groups or individuals who can affect or who will be affected or, by default, will be

identified by Irwin, Georg *et al.* (1994), who suggest that more needs to be known about stakeholder relationships that can encourage the development and adoption of increasingly sustainable infrastructure. Lastly, Rip, Misa *et al.* (1995a) suggest that more needs to be known about how technology can be guided cooperatively in social learning exercises and to identify mechanisms to guide constructive processes that are acceptable to stakeholders. However, operational level factors also exist in relation to implementing alternative environmental technology and site-level issues that impede and promote the adoption of new forms of technology must also be identified (Callenbach, Capra *et al.* 1993; Gouldson and Murphy 1998).

With this background establishing a conceptual context for the research, the following section will outline the specific goals and objectives associated with the research.

1.1 Research Rationale and Objectives

The rationale directing this inquiry stems from the need to develop and apply sustainable technical infrastructure across various sectors. Welford (1998; 2000) maintains that current institutions and established technologies cannot be relied upon in efforts to achieve sustainability. This argument implies not only the need to identify alternative technological paths, but also to find planning approaches capable of integrating various perspectives and knowledge. In southern Ontario, widespread water quality problems attributable to farm operations and domestic settlements require an expanded suite of solutions. This thesis explores the implementation of ecotechnology in wastewater management across four organisations: two businesses and two private educational facilities. Little social research has been conducted to identify the barriers and opportunities related to the implementation of ecotechnology and few studies have fully documented case studies.

In light of this rationale, the goal of this exploratory research project was: **to identify key factors both driving and constraining the adoption and implementation of ecotechnology for wastewater management in southern Ontario, Canada**. To achieve this goal, the following objectives were established:

Objective One:

Review theoretical perspectives associated with the emergence of alternative environmental technology and discuss the barriers known to constrain its advance.

---

involved in the development of a project or policy (Grimble and Chan 1995; Selin and Chavez 1995).

Objective Two:

Conduct exploratory research in select cases where ecotechnologies had been applied and identify factors that promoted and impeded the adoption and implementation in each case.

Objective Three:

Discuss the findings related to the adoption and implementation of the ecotechnology across the case studies and propose how the dissonance between driving and constraining factors might be reconciled.

This thesis brings together areas of knowledge from the environmental social sciences that include environmental planning and management and technology and society that have implications in relation to water resource management. The thesis is organised in the following way. Chapter 2 provides a literature review and will discuss various concepts related to the environment and the emergence of ecotechnology in environmental management. Chapter 3 provides an overview of the methodology and methods that guided the investigation. Chapters 4 and 5 present the analyses of the data generated in the four case studies that were investigated during this research. Profiles detailing each case study can be found at the beginning of these chapters. Chapter 6 provides a synthesis of the findings that were established during the analysis. Chapter 7 offers a conclusion and interpretation of the findings, summarises the contributions of the research and presents recommendations for further research.

Chapter 2.0

Review of Literature

> In a world dominated by contending specialisms, arcane technologies and the proliferation of mass solutions to practical problems, we seem all too ready to give up our own critical intelligence and to accept as the solutions to our own problems the forms of life fashioned for us by others – where those 'others' are 'experts', 'specialists' or . . . 'the technologists of reason'.
>
> *Kemmis 1987*

In the Great Lakes Basin, the management of wastewater from the agricultural and domestic sectors is known to adversely effect the environment and public health. Agriculture is a main contributor of pollution to inland rivers and lakes, and as the events of Walkerton, Ontario in May 2000 demonstrate, agricultural runoff affects public health (MOEE 1992; O'Connor 2002). The management of domestic sewage in onsite septic systems also contributes to the bacterial contamination of ground and surface waters. In 1993, the Sewell Commission (1993) classified over one-third of Ontario's onsite systems as a nuisance to public health. The use of conventional wastewater infrastructure for agricultural manures and domestic sewage management has not proven entirely effective and trends reveal that water quality in the Great Lakes Basin continues to deteriorate (Auditor General of Canada 2001).

This research employed a collective case study strategy to investigate two organisations and two private schools, hereafter referred to collectively as organisations, where alternative environmental technologies (ecotechnology) were used for agricultural manure and domestic sewage management. The technologies investigated in this thesis have been referred to as *natural technology* (Kadlec and Knight 1995), *living technology* (Todd and Josephson 1996), and *ecotechnology* (Mitsch and Jorgensen

1989). The term ecotechnology will be used throughout the thesis. Across the cases investigated during this research (all of which were in southern Ontario), two variations of ecotechnology were applied in the management of wastewater: Across the cases, the CTW alternative was applied for agricultural manure management and CTWs were also a component in each Greenhouse-Based Treatment Technologies (GBTT) for domestic sewage management.

This chapter begins by outlining Ulrick Beck's (1992) *risk society,* which suggests that society has lost confidence in modern industrial processes and the instrumental reason justifying modern technological progress. The discussion then proceeds to discuss the response offered by ecological modernisation, which suggests that society can achieve environmental improvement while sustaining growth and development in transitioning from modern industrial technology to sustainable post-modern technology. Ecotechnology will then be introduced and is proposed as one form of technology congruent with the aim of ecological modernisation. The discussion then outlines planning theory relevant to the adoption and implementation of alternative technology. Traditional, programmed planning approaches have perpetuated many of the technological trajectories that have become widely established at this time. Traditional planning will be contrasted with emerging approaches that are increasingly process-oriented and capable of catalysing social learning exercises to build capacity in relation to the development and implementation of sustainable technology that is appropriate at the local level.

2.1 Risk Society and the Environment

The transition that society is making from a modern industrial age to a period of late-modernity (post-industrialisation) can be equated with the transition that occurred when feudal society was replaced by modernity in the late 19th Century (Beck 1992). In the early stages of the development continuum (*i.e.* pre-industrial), the social experience was summarised by the expression “I am hungry”, while the current social psyche can be expressed by the phrase “I am afraid” (Beck, 1992: 49). In spite of human technological achievement during the modern period, Ulrich Beck's (1992) notion of “risk society” suggests that society now has considerable anxiety and has lost confidence in modern industrial technology as well as the reigning institutions promoting their ongoing use. In terms of environmental management, Hajar (1995: 88) traces the mistrust to the 1970s when it became clear that reigning institutions intended to confront the environmental crisis with command and control of natural systems through scientific rationality and expert knowledge.

At its core, risk society illuminates the fear and anxiety that society may experience from a series of environmental and social conditions. Beck (1992) has described the distribution of "bads" in the post-modern (*i.e.* post-industrial) period just as "goods" were distributed during the modern industrial period and suggests that the toxic residual by-products of material wealth and quality of life afforded by industrialisation now poses environmental risk that is planetary in scope. Beck (1992: 4) defines risk as "the probabilities of physical harm due to given technological or other process" created in the past or present that threaten society with implications extending to all areas of social fabric and every day life. No class, nation, eco-zone or species is exempt. The threats are often insidious and unseen, and manifest in the form of contaminated food, water and air.

Environmental change is another example of risk now faced by human beings. Welford (2000: 14) describes environmental change as "ecological imbalance, environmental degradation, the growth in the number of major environmental disasters". Global climate change is one serious threat confronting risk society that, if not catalysed by human activity, has certainly hastened change. Canada confronts a variety of related issues characteristic of risk society and environmental change. The full consequences related to climate change are as yet unknown; however, extreme weather patterns during the summers of 2001 and 2002 severely impacted environmental and economic systems in the northern climate of Canada (Dunfield and Lunman 2002; Mahoney 2002; Mitchell 2002). Extreme weather conditions such as these may foreshadow continued changes in the environment.

Shifting patterns of disease affecting public health may also be linked to environmental change (Levins, Awerbuch *et al.* 1994; Waltner-Toews 1996). One example is the introduction of African West Nile Virus into Canada, a public health concern of which little is known at this time (Health Canada 2001c). Synchronous with concerns related to environmental change, are risks associated with food and water supplies. Threats include food borne illnesses such as Mad Cow Disease and contaminated food such as those seen in outbreaks of food borne Escheria coliform (E. coli) bacteria (Irwin 1995; Waltner-Toews 1995; Waltner-Toews 1996). Water supplies have also been affected. A stark example are the events in Walkerton, Ontario, where manure runoff[2] was associated with the E. coli (*strain 0157-H7*) contamination of drinking water resulting in the deaths of 7 people and illness in more than 2,300 (Health Canada 2001a; O'Connor 2002).

Cryptosporidium contamination of water supplies in North Battleford, Saskatchewan in 2001 (Health Canada 2001b), provides another example of difficulties inherent in the technology employed to provide these services. Other issues on the periphery of the human and environmental health related radar screen concern the carcinogenic effects of urban air pollution and disruption of human and ecological health from urban pesticide use (Beltrame 2002), and more recently, the detection of human pharmaceutical products in ecological systems (Beck, Chen *et al.* 1994a). All of these issues can be attributed to successes of the human species or viewed as the 'effluents of affluence' (Hajar and Fischer 1999). These examples hint at the fallibility and the negative external (social and environmental) impacts of modern human production systems and suggest that something may be wrong with the way society achieves its goals.

Modern industrial technology and technology in general, follow evolutionary courses in their development which are promoted by social forces that predetermine their path or *trajectory*. Technology is pulled by the market, but also pushed by a set of "values intrinsic to technology" itself, which has been referred to by Rapoport (1984) as the *technological imperative*, a force acting to move technology along certain trajectories (in Brunk 1985: 133). As a technology gains market prevalence it becomes 'locked-in' and is sustained by social and institutional forces with vested interests in perpetuating continued success. Expertise and associated supply-demand chains develop around technical innovations and create dependencies that become intractable and uncontrollable by external actors. In these cases, the direction of technology is determined at a sub-political level that is not easily influenced through public discourse (Irwin, Georg *et al.* 1994; Irwin 1995; Beder 1997; Kemp 2000). Brunk (1985) has suggested four *values* associated with technology that explains forces that compel the technological imperative. These are described as:

Efficient: technology is better if efficient and performs quickly with the least human input;

High-Tech: complex technology is better than low-tech because this implies intellectual advance;

Elegant: technology ought to demonstrate rationale elegance as would a mathematical solution; and,

Self-perpetuating: more technology is better, technology that depends on more technology is even better and because technological feats are achievable, they should be undertaken.

Combined, these factors, or what Brunk calls 'values' provide technology with the imperative to follow a predetermined path.

[2] Key pollutants from agricultural runoff include nitrogen, phosphorus, bacteria, suspended solids, biocides, and residual

Some technologies associated with the largest economic sectors (*e.g.* agriculture, energy, transportation) are not sustainable and account for many environmental problems (Kemp and Rotmans 2001). Society is also capable of reflecting on its role in environmental change and capable of institutional-criticism compelling a planned response[3] to the peril confronting society. Beck (1994: 177) refers to "reflexive modernisation" as the ability to respond to this peril and suggest that re-gaining ecological security at the planetary level will involve dismantling the current industrial structures and replacing them. Beck (1994: 177) suggest that "reflexive modernisation is optimistic at its core - more reflection, more experts, more science, more public sphere, more self-awareness and self-criticism will open up new and better possibilities for action in a world that has got out of joint". There is evidence that responses are being formulated.

Ecological modernisation offers a broad prescription to shift human production systems towards ecologically-sound objectives. However, this gives rise to a question regarding the development of technology: which technologies are appropriate and who makes these decisions? Environmental technology has been defined by the traditional engineering sciences and an engineering community fascinated with the application of technology in both civilian and defense related sectors (Everett 1993; Gilliland and Kash 1994). Beder (1997), for instance, suggests that the sewerage engineering community defined a narrow set of technological alternatives early in the 20th century, which is no longer relevant as it cannot contribute to the sustainability agenda. Nevertheless, she suggests that the paradigm upon which these options were based continues to dominate water engineer sciences and constrains the search for and development of alternatives, thus perpetuating the dilemma that confronts risk society.

Although the field of ecological engineering and ecotechnology may provide one direction in the development of more sustainable technology, reigning institutions and dominant technological trajectories may impede such initiatives. This is one reason that Hajar (1996: 261) has questioned whether risk society will be able to recognise and responds to its peril through reflection (and action) and suggests that this "remains an empirical question". The risk society idea and related concerns with established forms of technology provide a context to discuss advances in the development and

---

fertiliser.

[3] The Canadian government's plan to ratify the Kyoto Agreement to reduce greenhouse gas emissions in late 2002 is an example of a response to the ecological threat associated with modern industrial technology and arguments against ratification.

adoption of cleaner forms of technology to meet human needs. The discussion will now proceed to outline issues related to the implementation of new forms of technology across human production systems as proposed by ecological modernisation.

2.1.1 Ecological Modernisation

New technology must be developed that are capable of meeting society's production goals while minimally impacting the environment. A critical policy goal in the sustainable development agenda includes the reorientation of technology (WCED 1987). Where sustainable development proposes general principles and strategies to achieve sustainability, *ecological modernisation* is significantly more prescriptive in relation to the issue of technology itself. Ecological modernisation proposes the development and implementation of innovative and cleaner forms of technology across production sectors. It describes a transition from outdated modern industrial patterns of energy and material use and outlines a path towards ecologically integrated and zero-discharge human production systems that are environmentally clean. The prescriptive aspects of ecological modernisation propose government-led initiatives directing a transition towards production systems that promote ecologically efficiency and ecological integrity while enabling strong economic activity (Murphy 2000). Ecological modernisation does not imply zero-growth; it implies growth aligning environmental improvement with economic viability.

Sustainable development and ecological modernisation have both been challenged. Sustainable development gained momentum in channelling global policy towards solving the ecological crisis during the 1990s[4]. Hajar and Fischer (1999) suggest that the concept has always been problematic. The main problems associated with sustainable development are the absence of a cultural critique of modern society (*i.e.* capitalism), its insistence on wealth accumulation and dependence on techno-scientific rationality, experts and their ability to determine, control and manipulate (often to the edge) the integrity of ecological systems (Hajar and Fischer 1999).

Ecological modernisation is equally problematic. As Langhelle (2000) suggests it is concerned mainly with solving environmental problems through a technical approach without addressing issues of basic human needs, justice, equity and qualitative changes in growth or protecting planetary bio-

[4] Fischer and Hajer suggest that the 1992 World Environmental Conference in Rio was the moment when the reality of the environmental crisis was spelled out, accepted and attention focussed on the definition of solutions. However, they

diversity. Hajar (1996: 250) suggests that ecological modernisation itself, may prove to be nothing more than a form of mercantilism with a "green-twist". Although ecological modernisation does address political and policy level changes leading to increases in efficiency it should be seen not as an end to sustainability itself, but as a condition of sustainable development (Langhelle 2000).

Technology is dualistic in terms of its potential impact on society. Kemp (1993: 79) suggests that "technological change [is] both a cause and cure of environmental problems". Some optimism is warranted in that technical responses can be directed towards attaining environmental improvement through developing innovative production processes over the medium to long-term. The need to transform outdated industrial activities and reduce impacts on the environment is imperative. Rejeski suggests that current:

> [T]echnological infrastructure will prove inadequate in meeting the global challenges posed by rapid population growth over the next 50 years. The old paradigms and ways of doing business have simply reached the limits of environmental responsibility, economic efficiency, and political acceptance, and questions are being raised concerning their potential successors. (1997: 65)

In order to avoid ongoing environmental decline, technology must become ecologically efficient and must be transformed to result in production infrastructure that can reduce the net environmental damage per unit of production output (Banks and Heaton 1995: 44). To this end, ecological modernisation offers the potential for transformations at social, institutional, political and economic levels that can contribute to achieving environmental sustainability (Hajar 1996; Mol 1997; Mol 2000; Murphy 2000).

At a macro level, ecological modernisation prescribes a response to the environmental crisis through economic restructuring (*i.e.* environment - economy delinking[5]), policy measures and economic instruments that compel production sectors to innovate in terms of their impact on the environment (Griefahn 1995; Gouldson and Murphy 1997). This includes organisational changes resulting in strategic environmental decisions such as phasing out pollution-intensive technologies and the adoption of cleaner alternatives (Murphy and Gouldson 2000). One challenge of attaining environmental sustainability through ecological modernisation is that government must play a role in directing the development and diffusion of environmentally sound infrastructure. In this context,

---

also suggest that as early as 1997 during the Rio-plus-Five Conference, it was apparent that none of the commitments had been achieved.

[5] Environment - economy delinking suggests that production can be sustained with diminishing environmental impacts.

regulatory frameworks, voluntary initiatives and input from the public can be instrumental in overcoming barriers to the implementation of cleaner technology. Legislation must be coupled with education, changes in societal behaviour, consumption patterns and changes in markets that support technologies that are ecologically efficient over medium to long-term time frames (Niemczynowicz 1993a; Irwin, Georg *et al.* 1994; Murphy 2000; Murphy and Gouldson 2000).

At a micro-level, ecological modernisation prescribes the promotion of innovative, cleaner forms of technology and the implementation of tools such as industrial ecology to achieve sustainable materials use. Industrial ecology is founded on the principle that minimal wastes are created and the residuals that do result are continuously recovered and reused similar to the recycling of matter in ecological systems (Ayres and Ayres 1996). Thus two principles are central: 1) shifting end-of-pipe solutions towards clean technological options that enable source reduction and the elimination of wastes, and 2) treatment and reuse of waste resources in closed-loops close to the point of production (Allenby 1999). Industrial ecology aims to balance inputs and outputs of material and energy as they pass through the economic sub-system, and examines the implications of products, processes, services and flows of materials and energy from an ecological perspective (Lowe 1996; Frosch 1997). Up until this time, industrial ecology has focussed on the technical and spatial aspects of small to large scale industrial manufacturing and focussed less on the re-integration of organic waste generated in the agricultural and domestic sectors.

These sectors are significant in terms of their negative global impacts on the environment and must be addressed with equal effectiveness as the problems associated with the industrial manufacturing sector. The amount of animal and human waste generated is enormous. In 1950 the average daily global output of human waste (*i.e.* excrement and urine) was estimated at 3.2 million tonnes; in the year 2000, the daily output was estimated to have reached 8.5 million tonnes per day or 3 billion tonnes per year over the forty-year increase in population (Fahm 1980). These wastes create both a problem and an opportunity. If these wastes can be effectively managed and re-integrated into production systems, the ecological and economic benefits could be enormous (Gardner 1998; Sanio, Burack *et al.* 1998).

2.2 The Selection Environment

The 'selection environment' has been used to describe factors that constrain and impede the implementation of innovative and cleaner environmental technology (Nelson and Winter 1977; 1982 in Kemp, 1993). Environmental technology is used here to describe "technology that reduces the absolute or relative impact of a process or product on the environment" (Gouldson and Murphy 1998: 29). The key issue in relation to the selection environment is that it adapts to existing technologies and restricts investment in, and therefore, the development of innovative technology. In many cases, physical infrastructure already exists that conforms to existing technologies and this impedes the adoption of innovative alternatives that require new user skills and regulator knowledge, changes to existing physical infrastructure or sometimes, changes in regulatory legislation (Callenbach, Capra *et al.* 1993; Kemp 1993; Gouldson and Murphy 1998). Innovative environmental technologies, although they "may be both more efficient and more effective for society as a whole," are impeded by ". . . political and economic disadvantage in short to medium time-frames when compared with those reactive approaches that are already established" within the selection environment (Gouldson and Murphy 1998: 8).

Several relationships and linkages constitute the selection environment. Understanding these factors is essential if alternative technological options are to be encouraged. The selection environment defines a range of issues and consists of the characteristics of a technology; costs and benefits to users, regulatory implications, availability of information, associated institutions, and the relevant economic conditions (Kemp 1993). It can be used to describe why older, and less efficient conventional technologies remain dominant and are slow to be abandoned and why other innovative, cleaner options are slow to diffuse. The selection environment benefits dominant technologies for long periods after they have been adopted, regulated, widely used and become profitable.

Rip and Kemp (1998: 338) describe the interaction that occurs between technical groups and user affiliations such as engineers, suppliers and decision-makers, and suggest the actions and relationships between these groups act to perpetuate certain technologies through the "[creation of] stabilized inter-dependencies that shape further action" along one trajectory. This can be seen with the waterborne sewerage regimes that are currently used. Waterborne sewage has been dominant for some time and can be traced back to ancient Rome where sewage was moved through the *cloaca maxima* (an artefact still in use today) and discharged raw into the Tiber River. Linear, waterborne and disposal-based domestic sewerage is still widely used and benefits a network of inter-related professional-industrial fraternities with vested interest in this *status quo* approach to wastewater management. Regulatory capture theory suggests that close relationships are prone to develop between regulatory agencies and regulated industries since regulators often have a background in industry (Smith 1997; Lévêque and Nadaï 2000). Murphy and Gouldson (2000: 38) suggest that these relationships act to preserve vested interests in the dominant technical options through enabling "industry to set both the pace and the direction of environmental improvement". In some cases this can lead to policy development that is influenced by private interest groups (*e.g.* the engineering community) who attempt to 'capture' regulation and policy in order to maximise the incomes of their member affiliates (Lévêque and Nadaï 2000: 238).

Petak (1980: 289) suggests that certain technology trajectories can be explained by the influence of specialised experts (*e.g.* engineers and planners) who determine to a large extent "if a task should be attempted and how it should be [accomplished]". This results in the selection of preferred means to accomplish ends expediently while maximising profitability. The perpetuation of a technical trajectory can also stem from institutional hegemony where monetary and status-related benefits are enjoyed by established groups of bureaucrats, planners, managers and engineers. The familiarity of these groups and their comfort/familiarity with a specific regime can also act to maintain the *status quo* and discourage the identification of alternatives (Beder 1997; Black 1998). This hints of technological determinism. These issues will be discussed further in Section 2.3 when the programmed planning approach is discussed.

Regulatory frameworks can also influence the selection of technical options and inhibit the development of alternatives leading to environmental improvement. Regulations that simply impose emission standards based on the optimal performance of existing technologies will impede the development of new technology (Allenby 1999). For instance, regulations often favour one approach by requiring application of the 'best available technology'. This acts to impede the evolution of options that may prove to be economically and environmentally effective. Other key factors such as learning, the significance of institutions and the impact of government policy may also act as impediments (Kemp 1993; Allenby 1994).

Economic factors and learning combine as crucial aspects in innovation. Learning effects are defined as experiences gained through increasingly wider use of a new technology that results in its improvement (Kemp 1993). When an innovation experiences increased use and is assumed favourably by the market, learning ensues which improves its efficiency, promoting its expanded use, and allowing price to decline over time. Gouldson and Murphy (1998) describe how user and regulator confidence in a technology increases as it experiences increased use:

> On the supply-side the diffusion of innovations is normally associated with improvements in the quality of the innovation as a consequence of accumulating experience with its production and feedback from the demand side on its use. The supply-side learning effect which improves the quality of the innovation is complemented by a scale effect which potentially reduces the price of the innovation as economies of scale are realized in its production. (1998: 28)

Over time, as a favourable selection environment develops and learning effects accumulate, innovations can gain increasing market share and potentially become dominant on the market. Table 2-1 summarises a number of organisational, institutional and operational constraints identified as parts of the selection environment.

Table 2-1. Identified Barriers to Innovation.

Organisational Barriers
Regulatory complications, structural roadblocks, limits on resources, lack of information.
Capital limitations constraining R&D to commercialisation.
Initial cost of innovative technology is expensive and tangible (perceived economic risk).
Long-term economic and environmental benefits are intangible.
Conservative & resistant attitudes of engineers, consultants and users to new concepts.
Deficient socio-environmental values.
Institutional Barriers
Lack of experience and confidence with the performance of innovative technologies.
Consumer and regulatory preference and familiarity with existing technologies.
Regulatory legislation restricting innovation.
Vested interests acting to maintained the *status quo*.
Fixed social and cultural patterns – familiarity and comfort with *status quo*.
Operational/Technical
Constrained pilot projects and technology evaluations.
Absence of market level experience.
Regulatory and permitting constraints (standards and specifications).

Sources: Friedmann, Zimring *et al.* (1978), White and White (1979), Adamson (1984), Ashford (1993), Kemp (1993), Irwin, Georg *et al.* (1994), Korfiatis and Cheremisinoff (1994), Banks and Heaton. (1995), Shrivastava (1996), ETEC (1997), Gouldson and Murphy (1998), Tilley (1998), Stauffer (1999), Murphy and Gouldson (2000).

Business organisations can be restricted by access to managerial and financial capital since high short-term capital requirements impede the application of innovative environmental technologies (Adamson 1984; Ashford 1993; Gouldson and Murphy 1998). Short-term costs are tangible to decision-makers, but longer-term economic and environmental benefits are often intangible and undefined, since they diffuse over a longer period. Innovative technologies can be more expensive during the early stages of commercialisation than conventional options, which, paradoxically, preclude the acceptance of other innovations on the market and at a scale where learning effects would result in improved process efficiency and lower costs (Kemp 1993; Banks and Heaton 1995). This perpetuates dependence on conventional options because their cost, regulatory acceptance and operational-level uncertainties are recognised and understood by users, decision-makers and regulatory stakeholders. Ecotechnology can be expected to encounter these constraints. In some cases, this option may be expensive and largely unknown at this stage in its development. Stauffer (1999), for instance, suggests that one of the largest impediments to the wider adoption of ecotechnology is a lack of demonstration projects and accumulated knowledge and data confirming how they perform under various conditions.

The development of radically innovative technology may also be influenced by changes in how business organisations view the natural environment. The following section outlines how environmental concerns are being addressed by organisations through initiatives to 'green' business operations.

2.2.1 Greening Business Organisations

Although the term 'greening' lacks a clear definition, the term 'greening' denotes action by business that is intentional in its efforts to decrease impacts on the environment. Welford (2000) characterises greening in the following way:

> Green thinking draws on a clear moral stance. It provides a radical challenge which is in our grasp if we are willing to challenge power and reconstruct economic structures in a sustainable way. At the heart of that reconstruction is the need to define and develop new flexible ways of carrying out industrial activity. (2000: 23)

The greening of business is now considered to be a strategic necessity (Richards and Frosch 1997). Some corporations now realise that environmental concerns will affect profitability. Historically, the concerns of business for the environment were essentially non-existent, 'immature' and reactive, but have since evolved and become increasingly 'mature' and proactive (Greeno 1994; Gouldson and Murphy 1998).

Table 2-2 (page 19) outlines the evolution or continuum of business' attitudes and actions in relation to the environment.

Table 2-2. The Evolution of Attitudes and Action in Business.

UNFORMED (Frontier Economics) Pre 1960	Profits maximised – no regard to resource depletion; no economic valuation of the environment.
IMMATURE 1960 – 1980	Irresponsible; non-compliant; command and control regulatory policy; end-of-pipe control technology.
REACTIVE MANAGEMENT **PROACTIVE MANAGEMENT**	
FORMATIVE 1980 – 1990	Compliance (aim); responsible; pollution prevention; image and leadership; environment-economy decoupling (in concept).
MATURE 1990 – 2000 and Beyond	Compliance (achieved); innovative environmental management; anticipatory management; waste minimisation; source reduction; environmental cost accounting; clean technology environment-economy decoupling (in practice).

Sources: Greeno (1994), Richards and Frosch. (1997), Stikker (1997), Gouldson and Murphy (1998).

Globally, it is now recognised that the cumulative environmental impacts (both positive and negative) of small to medium sized businesses are significant (Gabriel 1997; Tilley 1999). Business organisations may engage in environmental improvement for a number of reasons. Tilley (1999) found that environmental ethics and values played a large role in motivating small enterprises to improve environmental behaviour. Although altruism can motivate business organisations to decrease impacts on the environment, Johnston and Stokes (1995) found that altruism ranks well below other factors such as cost savings and regulations. Over a 30-year period (1970-2000), shifts in the attitude of business towards environmental considerations have been significant - mainly in response to public pressure. Since the 1970s, increasingly stringent regulations, threats of litigation and public pressure have also been instrumental in catalysing business to seek strategies to reduce environmental impacts and to undertake greening activities (Welford 2000).

As a key issue for business organisations, the environment can present a liability. Environmental issues can also be a source of competitive advantage, if, at a strategic level, environment issues can be successfully addressed. Stikker (1997) notes that public opinion, media attention and community pressure are all significant social drivers influencing the environmental strategies that business now employs. Niche markets developed for goods and services perceived to be green are one example. Gandy (1997: 153) has characterised greening initiatives as 'bio-consumerism' or 'green consumerism' and suggests they are "a distinctive and unprecedented development in consumption where consumers choose goods they believe are environmentally superior". However, commentators also caution that these efforts may be nothing more than cosmetic when compared to measurable environmental improvement (Hajar 1996; Gandy 1997).

Costs associated with businesses and institutions decreasing their environment impacts can be high over the short-term, however, these costs can be offset over medium to long-term time horizons by substantial benefits. For example, benefits such as good public image will improve customer loyalty (Gouldson and Murphy 1998). Additionally, there are a number of intangible benefits that accrue from the adoption of environmentally sound management strategies. These can include: decreased expenditures from improved materials and energy efficiency, present and future regulatory compliance and reduced exposure to liability (Callenbach, Capra *et al.* 1993; Gouldson and Murphy 1998).

One component of greening initiatives in business is the adoption of innovative environmental technology that is perceived to be 'green'. In business, certain technology options are thought to be capable of improving public image. Many businesses want to be associated with technology that is considered 'green'. Brand (1997) suggests that these 'high-tech' green technologies can provide business with a position from where they can derive competitive market advantages. For instance, the Body Shop Headquarters, a cosmetic manufacturing company in Toronto, Ontario adopted a greenhouse based biological treatment technology (GBTT) for treating and recycle domestic sewage to exhibit the company's concern for the environment. The adoption of the GBTT by the Body Shop was a strategic decision aimed at appealing to environmentally conscious clientele.

The next section describes problems associated with conventional wastewater management in the two settings investigated in this research and will introduce the two types of ecotechnology that were used across the case studies investigated in this research.

2.3 Management Options

In the two settings examined in this research, the ecotechnology was adopted because users saw conventional options as having significant drawbacks. In the agricultural sector, the management of wastewater through detention and land spreading (*i.e.* land application) is commonly employed and is known to degrade the environment. Agricultural intensification itself is a key source of water pollution and can result in point and non-point source pollution impacting ground and surface water resources (MOEE 1992; Miller 2000; Miller 2001a).

Some management concerns related to land-application occur when wastes are applied in periods when the soil may be frozen and wastewater may runoff directly into water bodies. This can also occur in locations when spreading occurs on fields fitted with tile-drains, resulting in wastewater runoff entering water bodies. In both cases, wastewater can accumulate and impact the environment (Miller 2001a). Currently, there are no regulations or legally binding standards in Ontario that require the construction of wastewater detention systems or the spreading of manure and no mechanisms to enforce or monitor manure management practices in agriculture. For the most part, 'best' manure management practices have been promoted through the voluntary adoption of farm management plans. However, new legislation under Bill 81, Ontario's Nutrient Management Act 2000 proposes mandatory standards for agricultural operations, legislation which is expected in the future (OMAFRA, 2001).

In the management of domestic sewage, conventional techniques can also negatively impact water resources. In Ontario, centralised municipal sewage treatment facilities and onsite private septic tanks with leaching fields have been widely used for domestic sewage management. Both private schools investigated in this setting were un-sewered. Septic tanks and leaching beds were the most feasible conventional options available. Onsite septic systems, however, are known to negatively impact the environment. Failure of onsite systems can occur when they are improperly placed, poorly designed or inadequately maintained. They can also fail when the bacterial slime layer in the drainage field obstructs the systems and prevents wastewater from permeating through the soil matrix in the leaching field. When failure occurs, wastewater can short-circuit and contaminate ground and surface waters, which poses a significant public health risk.

2.3.1 Ecotechnology

Ecological engineers aim to design low-input and non-polluting solar-based technology that captures the self-organisational ability of nature in human-oriented production and restoration of the environment (Odum 1971; Ma and Yan 1989; Mitsch 1991a; Mitsch 1991b; Todd and Todd 1994; Capra and Pauli 1995; Todd and Josephson 1996; Mitsch 1998). Ecotechnology is designed to maximise inputs of renewable forms of energy (*e.g.* solar, chemical and biological) and to integrate production goals with natural processes, which can act to reduce environmental destruction (Van Der Ryn and Cowen 1996). Stauffer (1999: 75) described ecotechnology as being low cost,

> [L]ow energy solutions that work by recycling resources within a biological system, but they all rely on some or all of the following basic components: water, soil,

> bacteria, higher plants and sunlight. They can achieve as good a level of treatment as conventional systems, or better, without using lots of chemicals and without creating harmful by-products.

Table 2-3 illustrates some distinctions between conventional forms of environmental technology and ecotechnology.

Table 2-3. Distinctions Between Conventional Technology and Ecotechnology.

Aspect	Conventional Technology	Ecotechnology
Design	Structurally Complex	Structurally Simple
External Operation Costs	Usually High	Lower
Emissions	Usually High	Lower
Long-term Track Record	Proven	Unproven/Emerging
Added-Value	Low	High

Sources: Guterstam and Todd (1990), Niemczynowicz (1993a; 1993b), Todd and Todd. (1994), Farrell (1996), Frijns and Janson. (1996), MOEE (1996), Van Der Ryn and Cowen. (1996), Mitsch (1998), Stauffer (1999).

Increasingly, ecotechnology is being considered and used for the management of wastes in Canada (Pries 1996; Alberta Environment 2000; Pries 2001; MOEE n.d.-b). While conventional options require large inputs of material, energy and external inputs of chemicals to expedite the treatment process, ecotechnology requires fewer materials to construct and smaller amounts of external energy to operate, which can result in lower costs. Although mechanical devices are used in ecological engineering projects, attempts are made to decrease dependence on sophisticated components that require large inputs of energy and expertise service to maintain. In developing southern nations also, CTWs are increasingly considered a practical approach to providing sanitation and improving the environment (Denny 1997; Gaye and Diallo 1997; Price and Probert 1997; Rose 1999). Kadlec and Knight (1995: 561) suggest that if ecotechnology such as constructed treatment wetlands (CTWs) can be applied at "lower economic cost," this "benefits not only the owner and the consumer, but also the environment because of the reduction of direct and indirect environmental impacts associated with economic expenditures for raw materials and energy".

Ma and Yan (1989) have described the benefits of ecotechnology in contrast to conventional options and suggest that ecotechnology provide environmental, economic and social benefits because they are economically affordable and can be applied in a wide-range of settings. Shumacher (1973) suggested that appropriate technology should be cheap, accessible and suitable for application at small scales. Many (but not all) ecological technologies fit this definition and are understandable to non-experts. This may facilitate the use of these options in small-scale, decentralised wastewater management schemes. Todd and Todd (1994: 174) suggest that ecotechnology offer an alternative direction in the "transition from an industrially based economy to a post-industrial ecological economy". Further, ecotechnology is expected to influence the future of waste treatment, environmental restoration and remediation, food production, fuel generation, architecture, and the design of human settlements (Todd and Josephson 1996).

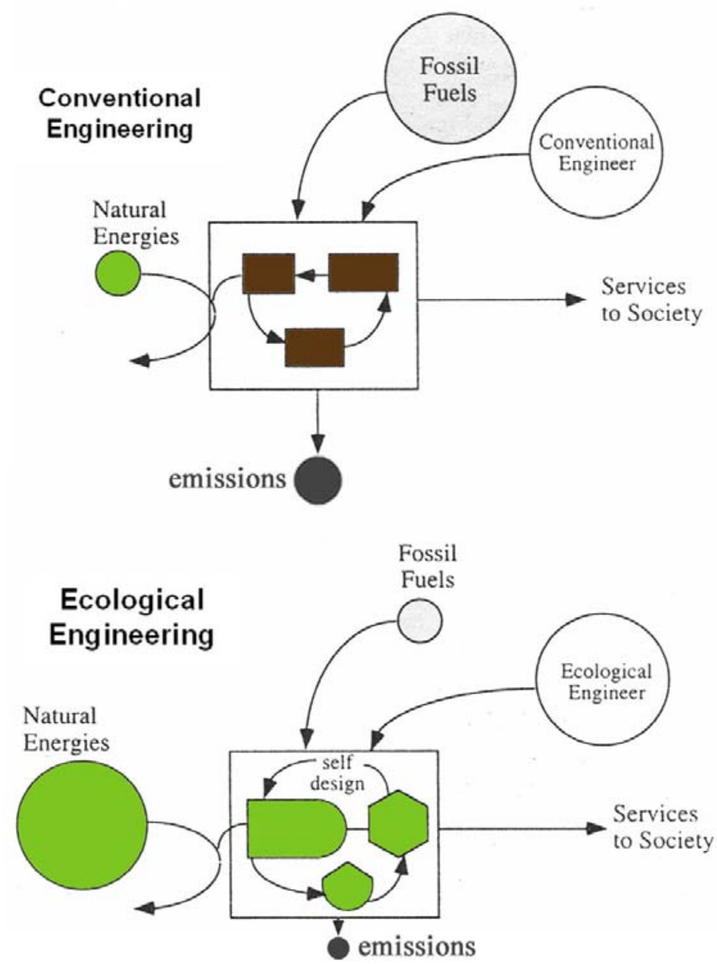


Figure 2-1. Characteristic differences between conventional and ecological engineering.
Source: Mitsch (1998).

Two types of ecotechnology were adopted across the four case studies investigated in this research. In the two cases from the agricultural sector, CTWs were applied. The first case is the French Farm, a small-herd dairy farm holding between 18-24 head of cattle. The second CTW was applied at Luckhart Transport Ltd., a livestock hauling company near Sebringville, Ontario that transports approximately 20,000 hogs monthly. The last two case studies were educational facilities that applied Greenhouse-based Treatment Technology (GBTT) to manage domestic sewage. The cases from this setting include the YMCA Outdoor Centre, a year-round youth camp near St. Clements, Ontario, which operates a day-use conference centre that is serviced by the GBTT. And finally, the second case in this setting is the Toronto Waldorf School, a private school with a student population of 420 and a staff population of 30 in Toronto, Ontario, which also adopted the GBTT to manage sewage.

Constructed Treatment Wetlands

Constructed treatment wetlands can be divided into two categories: surface-flow or subsurface-flow. In surface-flow CTWs the wastewater is visible and flows through shallow beds that are planted with wetland plants. In subsurface-flow CTWs, wastewater is not usually visible and flows (sub-surface) through a substrate of gravel or sand that acts as a media for the wetland plants to grow. In both cases, aerobic and anaerobic processes occur in the wetland that degrade organic matter, while nutrients are eliminated through a variety of physical, chemical and biological processes (Brix and Schierup 1989). Constructed treatment wetlands, used for agricultural manure or domestic sewage treatment, are not stand alone systems, but are combined with various pre-treatment components (*e.g.* wastewater stabilisation lagoons) that enable the wetland to function effectively during secondary and tertiary treatment (*i.e.* polishing) (Pries 2001; Kadlec and Knight 1995). Figure 2-2 illustrates the typical design of a sub-surface flow CTW.

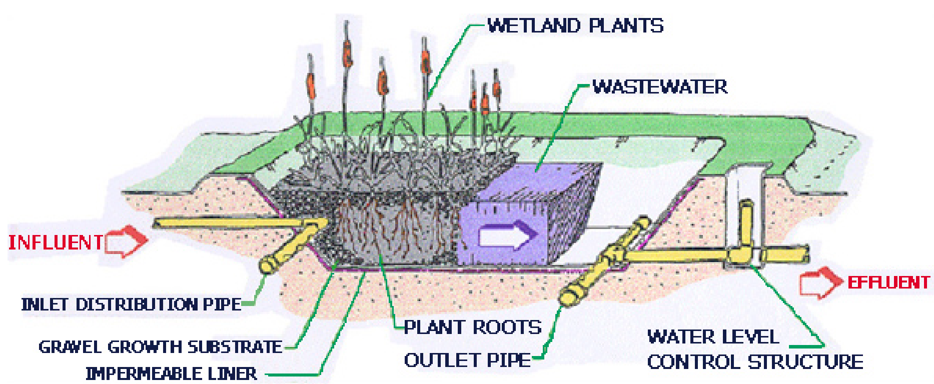


Figure 2-2. Illustration of Constructed Treatment Wetland.
Source: Anderson & Associates Inc. (2001).

Constructed treatment wetlands have been investigated for more than forty years in Europe and North American and used in waste management projects for more than two decades (Brix 1994; Kadlec and Knight 1995; Pries 1996; Price and Probert 1997; Pries 2001). By 1999, 500 CTWs had been implemented for wastewater treatment in Europe and over 600 in North America (Robinson 2002) with 67 projects existing in Canada by 1995 (Kadlec and Knight 1995). Kadlec and Knight

(1995) suggest that because CTWs originated in Europe more than 40-years ago that the technology is popular on the continent and the number of projects continues to grow. In other areas of the world the popularity of CTWs is also growing. In New Zealand, the number of CTWs is increasing rapidly; between the years 1988 to 2000 the number of operational CTWs more than tripled from 20 to 83 (Tanner, Sukias *et al.* 2000).

The benefits of using CTWs for wastewater treatment and their general performance parameters are well established (Kadlec and Knight 1995; Pries 1996). In many settings, the benefits include lower capital costs for construction and lower operation and maintenance costs (Green and Upton 1995; Price and Probert 1997; Pries 2001). In relation to domestic sewage treatment, the potential benefits of CTWs have also been recognised and are seen as appropriate solutions for under-serviced communities by replacing septic tanks to polish secondary effluent in hybrid systems combined with lagoons, which are widely used in Canadian communities (Herskowitz 1986). The advantage of applying CTWs is that they can be constructed anywhere that adequate land is available. This is a key point because CTWs are relatively land-intensive compared to conventional options and most appropriate for dispersed, small to medium scale application. Contrary to widespread belief, the investigation of CTWs in northern climates reveals that although their treatment performance may slowdown during the winter season, it does not stop and substantial treatment continues making them a viable treatment option in northern climates (Pries 1996; Pries, Borer *et al.* 1996).

Constructed treatment wetlands for domestic and agricultural manure management have been established in nine provinces and two territories. As of 1996, there had been forty-five full-scale CTW that have been implemented in Canada with only a reported six percent failure rate (Pries 1996). The Ministry of Environment and Energy (MOEE) undertook the earliest demonstration of the CTWs in the town of Listowel, Ontario (1980 – 1984). The objective of the study was to investigate efficiency and feasibility of CTWs and to develop guidelines for their design and operation (Herskowitz 1986). In the mid- 1990s, Ontario Conservation Authorities initiated 12 demonstration CTWs under the CURB program for use in the treatment of milk house wash water and barnyard runoff in the agricultural sector. The French dairy farm project originated through this program and was the first CTW used for managing agricultural barnyard runoff in Canada.

Although the treatment provided by CTWs is becoming more efficient as learning effects accrue, there continue to be barriers impeding their implementation. Kadlec and Knight (1995: 586) suggest that permitting constraints are known to delay the implementation of CTWs and may often discourage potential users who will eventually "[adopt] . . . conventional technology with well-known deficiencies instead of more risky technology with potentially high environmental benefits". Robinson (2002) suggests that there is a deficit in technical knowledge at the local level and it is difficult for local government agencies to permit novel options such as CTWs. He also notes, in relation to domestic sewage, that laws often discriminate against decentralized technology such as CTWs in favour of centralized conventional options in order to prevent hazards that are associated with de-centralised options. As technology advances, and understanding of ecotechnology grows and, as increased performance is achieved, it is expected that regulatory and public confidence in these technologies will also increase (Kadlec and Knight 1995).

Greenhouse-Based Treatment Technologies (GBTT)

The greenhouse-based treatment technology (GBTT) is the second ecotechnology explored in this research. John Todd originally conceived the concept of GBTT and referred to them as "Living Machines" (Guterstam and Todd 1990; Todd and Josephson 1996). Different companies have now developed variations of Todd's original idea; therefore, they will be referred to here as living machines, but as GBTT. Greenhouse-based treatment technologies, like CTWs, are decentralised wastewater treatment systems. The process of wastewater treatment is achieved through blending electromechanical components and 'self-designing' natural process (synergy between living systems) in translucent silos and aerated biological reactors and indoor wetland cells. These contain communities of micro-organisms, bacteria, aquatic plants and higher-level animals, which act to degrade the biological and pathogenic components of wastewater (Farrell 1996).

The GBTT is less spatially demanding and more process intensive when compared to the CTW technology because treatment is augmented by more electromechanical components, which allows treatment to be accomplished faster. The GBTT option is well suited for application in urban environments where the cost of land is high. Another advantage of GBTTs is the fact that they produce less sludge than the conventional activated sludge process and do not require chemical inputs such as chlorine (Farrell 1996). The GBTT option is also more aesthetically appealing than conventional wastewater treatment technologies, which are often aesthetically cold and unsightly. The GBTT has four key components: closed anaerobic digestion tanks; open aerobic solar cylinders with emergent vegetation, clarification tank for solids separation, and finally, discharge to a CTW for tertiary wastewater polishing. Figure 2-3 illustrates each of these components.

Figure 2-3. Illustration of Greenhouse Treatment Technology.
Source: Living Machines Inc. (2002)

This technology is currently employed in Canada, the United States, Mexico and France. In northern climates, greenhouses are most commonly used to enclose the system. Across Canada, there are approximately twelve GBTTs operating. In Bear River, Nova Scotia, the implementation of a GBTT for municipal wastewater became a destination of small-scale tourism. After the Bear River system was commissioned, it attracted large numbers of visitors between 1994 and 1999. Since that time, onsite tours have stopped because the number of visitors increased to the point that problems developed in relation to managing visitors inside the buildings (personal communication, 2002)[6].

In Ontario, six GBTTs have been implemented since 1993 for domestic sewage treatment. The first treatment system implemented was the Toronto District School Board's Boyne River Natural Science School in Boyne River (1993); followed by the Body Shop Headquarters in Toronto (1993); the MOEE sponsored demonstration at the Ontario Science Centre[7] in Toronto (1996); the Toronto Regional Conservation Authority's Kortright Centre system in Toronto (1998) as well as the two systems that were investigated during the research: the YMCA Outdoor Centre (1999) and the Toronto Waldorf School (1999). Very little published literature specifically documenting the implementation of GBTTs in Ontario since the first projects in 1993 or in other locations, is available.

2.4 Planning Alternative Technological Options

Hudson (1979) suggests that planning implies a level of foresight. Similarly, Rich (1993), states that planning is defined by decision-making that is anticipatory. Concerns regarding environment

---

[6] Personal communication (June 02, 2002), plant manager Bear River Solar Aquatics GBTT (see also: http://collections.ic.gc.ca/western/bearriver.html).
[7] During this demonstration the GBTT was established by the MOEE as an effective and viable wastewater treatment option to reduce greenhouse gas emissions (MOEE 1996; MOEE n.d.-b).

change and instability (Government of Canada 2002) require futures-oriented planning to promote local to national level initiatives during a transition towards the implementation of cleaner environmental technology. As Griefahn (1995) and Stikker (1997) warn, the research and development phase for sustainable alternatives may be as long as twenty-five years; therefore, progress towards this end must begin without delay. Moreover, Rejeski (1997) suggests that an entirely new socio-political and industrial paradigm must be accepted and mature before significant social change and environmental improvement can be achieved. The adoption and implementation of sustainable technology at the local level requires planning approaches that can capture intentional local efforts to achieve sustainability. How this is realised will depend, to a large extent, on the appropriateness and efficacy of the planning approaches employed.

In Section 2.1.1 ecological modernisation was discussed. It was suggested that environmental improvement and economic growth are mutually inclusive and can be achieved through shifting human production systems towards cleaner and increasingly sustainable technology. Ecotechnology was proposed as one option congruent with this goal. Although ecological modernisation provides a broad macro-level (*i.e.* national to international) response to the environmental crisis, it falls short in its ability to operationalise micro-level issues that concern local government, institutions and business organisations. The following discussion begins by outlining the approach to planning described as blueprint or programmed planning, which, for the most part, tends to use technical options that place decision-making in the hands of technocrats who often employ pre-determined technological strategies. The discussion then moves to a discussion of emerging approaches that are inclusive, process-oriented and aim to address equity concerns and develop knowledge that can be gained through interaction between expert and non-expert stakeholders.

2.4.1 Programmed Planning Approaches

The rationale comprehensive planning approach has been widely used in project development. This approach is hinged on expert decision-making in lengthy and often costly exercises where limited provisions exists for stakeholders and beneficiaries to define the goals or shape the form of technical options that may be preferred. Programmed planning holds many similarities to the rationale comprehensive model in the provision of physical infrastructure where decision-making lies in the hands of technical experts such as planners and engineers. The outputs and deliverables of the programmed planning approach are often predetermined, which favours the use of certain products and technology to achieve goals (Petak 1980; Beder 1997; Black 1998). Characterised as 'expert-based', this approach consists of specific, detailed objectives which guide the implementation process, limits conflict, and makes tasks 'appear' straightforward from the perspective of the expert, but at the same time, can also be viewed as self-promoting (Korten 1984; Beder 1997; Mitchell 1997; Black 1998).

In terms of the technological imperative, programmed planning approaches foster the dominant technical trajectories making them intractable to external actors. Programmed planning does not allow for beneficiary inputs leading to long-term institutional development or capacity building (discussed in the following sections) where technologies are selected and, potentially, operated and maintained by local level users themselves (White and White 1979; Cusworth 1997; Mitchell 1997). Additionally, different stakeholder perspectives are difficult to reconcile under the structure of programmed planning because multiple perspectives can act to foil the planning process. Criticisms of the approach ranges from practical level concerns regarding the availability of assets and the time needed to support a 'rationale' and 'comprehensive' technical analysis, to issues related to who makes decisions and *whose* 'technological imperative' prevails (Etzioni 1967). Planning and decision making undertaken strictly by technocrats is bound to achieve narrowly defined goals since consideration of the wider system (*i.e.* values and preferences) is limited.

For these reasons, programmed planning has not proven entirely capable of dealing with the complexity of problems arising at the socio-environmental interface. Petak (1980) has described the incongruence between traditional planners and engineers and those who support more inclusive approaches to environmental planning and management as a "perspective-gap". Irwin (1995: 44) suggests, however, that this gap is reconcilable and that there are opportunities for the wider involvement of "citizens," who are now "in a position to shape the process of modernisation rather than simply following pre-established patterns of behaviour". In the cases examined during this investigation, the technological imperative has been rejected and new forms of technology developed and adopted. These are preferable at the local level because of their social, economic and environmental advantages (Irwin 1995; Rip, Misa *et al.* 1995b). Irwin (1995) suggests that these cases represent local level efforts to achieve sustainable development and should be promoted. If these initiatives are to be fostered, however, planning approaches are required that can include the perspective of a wider stakeholder community. These will be discussed in the next section when a process-oriented approach is discussed.

The aim of this discussion has been to illustrate the distinction between the dominant planning approach and its influence in determining the use of conventional technologies that are widely used today. The discussion will now turn to describe process-based approaches that may be beneficial in capturing increased knowledge from extending the peer-community to the inclusion of more stakeholders and their perspectives.

2.4.2 Process Oriented Planning Approaches

Relationships in problem areas such as environmental management are often complex since multiple stakeholders exist; however, opening up the planning process to stakeholders can result in expanded perspectives and, potentially, more options (Mitchell and Hollick 1993; Grimble and Chan 1995). In order to encourage the development of technology that is acceptable over the long-term, opportunities must exist for stakeholders to inject their values and knowledge into the process. Institutions will inevitably play a role in shaping the outcome of projects. Institutional actors consist of elected officials, cadres of influential people, members of groups and organisations and individual citizens. The institutional arrangements[8] that are formed by these stakeholders can be described as complexes that enable society to meet its production needs, but these also act to control the actions of groups and individuals (Forster and Southgate 1983; Buttel 1997).

Process-oriented approaches stand in contrast to 'outcome'-oriented or programmed planning. Process-oriented planning widens decision-making through collaboration, which results in transaction between expert and non-expert stakeholders (Friedmann 1984). Operationally, Gray (1985) has defined collaboration as the pooling of resources by two or more parties to solve a problem. Process-oriented planning allows for opportunities to develop alternative scenarios, which are implemented and evaluated in recursive exercises of ongoing management, monitoring and governance that become increasingly relevant to the context and locality: as new knowledge is gained the planning exercise is sharpened (Kay, Regier *et al.* 1999). Ideally, these processes enable consensus to be reached and attention can be focussed on definite problem areas to affect change.

---

[8] Institutional arrangement have been fully described by Mitchell (1989) as: 1) legislation and regulations, 2) policies and guidelines, 3) administrative structures, 4) economic and financial arrangements, 5) political structures and processes, 6) historical and traditional customs and values and 7) key participants or actors.

Constructive Technology Assessment

In steering the development of technology that is acceptable to all users, *constructive technology assessment* has is been proposed. The aim of constructive technology assessment is to engage a wider peer community to integrate and reflect the needs and values of stakeholders. The purpose is beneficial social and technological change in 'co-developing' technology acceptable to concerned stakeholders (Schot 1992). Where traditional technology assessment focuses on the 'external' effects of technology (favourable and unfavourable) and the selection of options, constructive technology assessment aims to steer the 'internal' development of technology through developing consensus in relation to what is acceptable to stakeholders (Schot 1992; Rip, Misa *et al.* 1995a; Vergragt and van Noort 1996).

Schot (1992) suggests that the development of technology should be a self-determined process that is influenced by intrinsic factors of society (*e.g.* user preferences) and not imposed from outside. Constructive technology assessment assumes – as part of the process - the principles of participation and collaboration and aims to provide opportunities for social learning to occur in the development of technology (Rip, Misa *et al.* 1995a). *Social learning* suggests that participants learn-by-doing through intentional efforts to affect change and is viewed here as one approach that might be appropriate in realising the goals of constructive technology assessment.

Social Learning

In a very practical sense, social learning can be described as a political process aimed towards achieving social and institutional change that is accomplished by enabling people to change reality (*i.e.* existing structures) through action and learning. Social learning involves opportunities for participation and collaboration where expert and non-expert stakeholders 'learn-by-doing' in transactive (bi-directional) and participatory processes involving decision-making, knowledge generation and learning (Friedmann 1984; Friedmann 1987). The term 'participatory' is defined here as a process where stakeholders have influence upon initiatives and decisions which they perceive to affect them (OECD 1995; World Bank 1996). In terms of developing more sustainable technology, Irwin, Georg *et al.* (1994: 337) suggest that it is important to understand the contributions of the wider public "as the originators of technological futures". However, social learning can also result in capacity building, specifically when change is an explicit goal. The benefits of capacity building will be discussed shortly.

Social learning leads to the generation of knowledge through continual assessment and re-adjustment during the process. This knowledge spans the analysis of a problem to the implementation of a solution through iterative cycles that improve outcomes that are acceptable to stakeholders (Kay, Regier *et al.* 1999). Emerging approaches to environmental planning and management will include a social learning component, which can "enhance our decision-making structures so as to build on a wider range of interests, needs and perspectives" (Irwin, Georg *et al.* 1994: 334). The discussion will now proceed to describe the benefits of learning-by-doing and how social learning can act to build capacity at the local level through a constructive assessment of technology.

Local Institutions and Capacity Building

Although policy affecting environmental sustainability may be developed at national and international levels, the widespread planning and operationalisation of sustainable and ecologically oriented policies are thought to be most effective when developed with local level input (Roseland 1994; Van Der Ryn and Cowen 1996). How can this be achieved? Local level capacity is required and must be intentionally developed. As the case studies in this research will show, there is a response to environmental change that has taken root at the local level and involves a social learning component. Building local level capacity is essential if community-level decision-making structures are to result in sustainability (WCED 1987). Most importantly, there are notable differences between transferring technology to users under a supply agenda versus giving them the tools to meet their own needs (Korten 1984). As the proverb suggests: *give a community fish and they will eat for a day; however, teach a community to fish and they will eat for life* . . .

Capacity can be defined as the ability of individuals, groups, organisations and institutions to implement good decisions that are congruent with their values and priorities in addressing environmental issues (Eade 1997). In the absence of capacity, there is a danger that citizen-based local initiatives may be undermined by vested interest in the dominant technical trajectories. Irwin (1995) suggests that it is essential that citizens frame their own environmental responses in terms of technological alternatives and that they are not completely led by wider institutional agendas. Capacity building has practical applications in empowering communities to access the necessary resources to effectively plan, construct, operate and, ideally, maintain technology in environmental management projects that are believed to be desirable.

In the past, participation has frequently constituted low levels of involvement, and perhaps consultation. However, the efficient delivery of services and development of technology might be better achieved through scaling-up involvement and local level participation in all aspects of technology development. Lessons from the 'less developed' world show that in terms of service provision, capacity occurs on a continuum. At one end, beneficiaries are mere recipients of services, at mid-range, they participate as clients and at the far end of the continuum, become 'managers' of activities and assets (Warner and Laugeri 1991). In practice, this results in local level stakeholders becoming stewards of physical infrastructure used to manage interaction with the environment (Warner and Laugeri 1991; World Bank 1996).

Table 2-4 provides a framework for analysing the progression of local dependence to local capacity in the provision of waste management services.

Table 2-4. Progression of Capacity Building in the Delivery of Services.

Capacity	Outcome
Community Development *(Low capacity)*	• Low level of participation/payment. • Recipients as burden to municipality. • Empowerment not promoted. • Supply-driven 'old agenda'. • Centralised management.
Community Participation *(Medium capacity)*	• Decentralisation and local level participation. • Community as client. • Willingness to pay for preferred options. • Strengthening of local institutions. • Demand-driven 'new agenda'.
Community Management *(High capacity)*	• Willingness to participate. • Community as owner/manager. • Enabling policy-level support. • Devolution of authority to lowest level. • Access to information and funds. • Human resource development.

Sources: Warner and Laugeri (1991), Bartone (1995), Strong (1995), World Bank (1996) Gaye and Diallo. (1997).

Constraints do exist in local level efforts to improve the environment. In southwestern Ontario, Van Osch (1997) found that voluntary efforts undertaken by the farming community to this end were not generally impeded by legislative or local bylaws; however, technical and financial limitations were a significant constraint. The main barriers to the development of effective environmental farm plans were identified as inadequate coordination and insufficient technical support at the local level. In essence these deficits can be characterised as institutional in nature because capacity was not built that could lead to self-management through developing local level expertise. Government must create settings where local level institutions (public authorities, private sector, NGO's, community groups and individual stakeholders) can contribute to environmental improvement (Furedy 1990; Briscoe 1993). Roseland (1994) suggests that the goals of environmental planning are best achieved when upper levels of government assist local institutions to carry out environmental management projects through the creation of settings that enable action in local level settings. Settings such as these will be referred to here as enabling settings.

Enabling settings create a context where central and local governments promote local level participation and collaborate in developing 'self-help' capacity through providing expert advice, education and support services. In the management of wastewater, this can potentially liberate resources for upper levels of government. This includes the provision of financial and technical resources that can assist in developing, managing and investing in policies and projects that are perceived as sustainable at the local level. Lyle (1994: 318) suggests that planning sustainable wastewater management projects that receive approval and collaboration from local level stakeholders "will serve the purposes of regulatory agencies far better than trying to enforce minimum standards" through infrastructure and policy that permits and promotes discharge and disposal regimens.

In order to promote local level participation in environmental management, municipal-level institutions must have the capacity to assist their constituents to develop appropriate and mutually acceptable solutions. Policy that decentralises management functions must not only allow local authorities to take control of planning and management of environmental activities, but policy must promote local level capacity building (Cusworth 1997). In turn, this may allow appropriate institutional frameworks to develop which can result in the self-determined allocation of resources and the application of technology that is desirable at the local level (Pretty, Guijt *et al.* 1992).

Devolution of responsibility from provincial to municipal sectors for water and sewerage provision has occurred in Ontario since the 1997 Services Improvement Act. Promoting local level initiatives in the development of waste management options might prove more beneficial than the technology transfer method currently employed. One gap identified in relation to planning innovative technology through constructive technology assessment and the inclusion of stakeholders is the lack of mechanisms to assist in operationalising the involvement and inclusion of different actors and multiple perspectives (Rip, Misa *et al.* 1995a). This deficiency will be addressed further in the following section when the operationalisation of process-oriented planning approaches is discussed.

2.4.3 Operationalising Constructive Technology Assessment

Integrated planning as defined by Mitchell (1986; 1994; 1997) might be beneficial in achieving the aims of constructive technology assessment because novel technology development involves multiple stakeholders, opinions and agendas (Vergragt and van Noort 1996). Integrated planning stresses a systems perspective and is proposed here as a potentially valuable framework for understanding complexity in developing and implementing technologies that will be acceptable to a wide variety of stakeholders. Born and Sonzogni (1995) suggest that the benefits of integrated planning include the promotion of ecological sustainability, proactive decision-making and balancing the interests of involved parties. In relation to the adoption of more sustainable technology, integrated planning can assist in identifying solutions that will contribute to a more constructive process. Integrated planning assists in expanding and integrating the perspectives of the peer community and involving participants and generating solutions to problems built on consensus (Briassoulis 1989). It can be beneficial in situations exhibiting high levels of uncertainty and high decision stakes, such as the socio-environmental interface, where the 'ideal' management options are not certain (Mitchell 1997). Expanding the realm of problem identification and decision-making to all concerned stakeholders can lead to the implementation of novel and previously unrecognised management options (Kay, Regier *et al.* 1999).

An integrated planning framework can assist in developing an understanding of the socio-environmental context of a system. Most importantly here, an understanding of culture and ideology in relation to preferred environmental technologies is necessary. These are important in attempts to "[share and co-ordinate] the values and inputs of a broad range of agencies, publics and other interests when conceiving, designing and implementing policies, programs or projects" (Mitchell, 1986: 13). Congruent with the goals of social learning and the advancement of social activity that involves self-directed learning and positive change, integrated planning is seen as a model to assist in directing action. Integrated planning stresses an operational scope that is not comprehensive, but is directed to focus on key variables identified as relevant to the system in question. Thus integrated planning can assist in accumulating and concentrating knowledge to result in increasingly better solutions to problems during learning that allows individuals and groups to build capacity. This approach is particularly relevant to the development and implementation of alternative technology because it may also assist in bridging the 'perspective-gaps' resulting from various stakeholder attitudes since context and culture are key levels of analysis in integrated planning.

Three levels of analysis can be used to gain insight into the context of a system: "normative", "strategic" and "operational" (Mitchell 1990). The *normative* aspect relates to what should be done and is prescriptive since value assumptions are made. The different and potential opportunities and options that exist are identified within the *strategic* aspect and, it is here, that a comprehensive systems perspective is used to identify the broadest available range of options in order to develop strategy. The *operational* level aspects if integrated planning relates to focussing and concentrating (*i.e.* integrating) on "a smaller number of variables that are believed to account for a substantial portion of the management problems" so that plans can be developed, implemented and results produced (Mitchell 1990: 4). Mitchell (1990) suggests determining the scale and hierarchy through which planning and management occur are also critically important. Table 2-5 provides an outline of various aspects related to each aspect of the integrated planning framework.

Table 2-5. Framework of Integrated Planning.

Context	Addresses the wide range of aspects: social, environmental and economic.
Vision	Frame the resource management problems in terms of the positive outcomes that can be agreed upon and achieved by stakeholders.
Culture and Attitudes	Facilitates the functions that have been agreed upon as management options. Agreements must be achieved.
Legitimation	Essential to the successful implementation of an integrated approach. Legitimation must be gained from stakeholders supporting the process.
Processes and Mechanisms	The 'rules of the game' that dictate how the system will operate and to ensure that "edge problems" will be resolved. This is where stakeholder involvement is delineated and where issues related to conflict resolution and negotiation occur.
Functions	Both generic and substantive. Generic Functions relate to management process (*e.g.* regulations, approvals), Substantive Functions are procedural and relate to interventions that are physical (*e.g.* technology and its implications).
Structures	The manner in which institutions and organisations facilitate efficient performance of functions.

Sources: Mitchell (1990; 1994; 1999); Mitchell and Hollick (1993).

Breaking down the functions element into management functions that are generic and substantive can assist in delineating how things get done (*e.g.* centralisation vs. decentralisation). The different levels of responsibility are of specific interest in planning the implementation of technology. Generic management functions relate to effective orchestration and are supported through effective planning, monitoring, management and regulatory legislation. Substantive management functions can be defined as management choices, such as physical infrastructure, through which management aims are achieved. Both generic and substantive functions are supported by the structure and capacity of lower and upper level institutions and organisations. Mitchell (1990) suggests that management functions should be allocated at the levels closest to those concerned. Thus a level of decentralisation and local level decision-making in relation to the selection of suitable environmental management options is required.

2.5 Conceptual Framework

A key element of the theoretical framework for this research is influenced by Ulrich Beck's (1992) notion of risk society, which suggests that society is now suffering the environmental and health related consequences of pollution intensive industrial production technology. Beck (1994) also suggests, through what is referred to as "reflexive modernisation", that society possesses the ability to self-reflect, which may lead to societal responses to human-induced environmental changes that now jeopardise ecological, and thus, social integrity. This ability to self-reflect and to employ human ingenuity, cleverness and wisdom in anticipating problems and finding solutions to critical ecological problems has been recognised (*c.f.* Meadows *et al.* 1972; Meadows *et al.* 1992). Existing production systems and their associated technologies are not sustainable and contribute to environmental degradation. Alternative technological pathways must be developed which can assist society in meeting its production goals in a sustainable fashion. One aspect of this transition is the development of cleaner forms of technology that will result in long-term environmental improvement. To this end the broad framework of ecological modernisation has been proposed. It suggests here that ecotechnology is congruent with the aims of ecological modernisation and may be an appropriate solution for wastewater management in some situations.

Rather than following a technological trajectory built on incremental changes to existing technologies that are predetermined, this research is founded on the idea that opportunities exist for technology to be intentionally steered by local level stakeholders through a process of social learning. In this regard, linking constructive technology assessment and integrated planning is seen as a strategy to increase the local level participation and capacity in the development of ecotechnology. Figure 2-4 (page 38) combines the various elements of the conceptual framework that have developed in relation to this research.

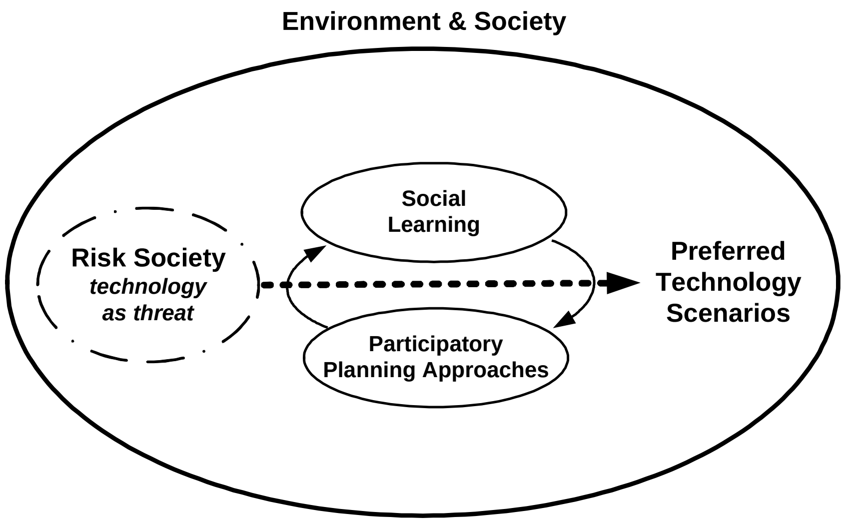


Figure 2-4. Conceptual Framework of the Research.

The investigator believes that technologies can be developed and applied that will assist human beings to meet their production needs while improving the environment. These technologies should be affordable, accessible and comprehensible to users at the local level. This is no different from previously expressed ideas by authors such as Shumacher (1973) or Bookchin (1980) who have discussed the application of technology that is socially and ecologically beneficial. Certain ecotechnologies associated with wastewater management may be capable of achieving these goals. This makes them potentially suitable options specifically for small to medium scale domestic and agricultural applications where waste streams are relatively homogenous and easily separated to achieve wastewater treatment with less sophisticated and cheaper technology. Although they are rather juvenile at this stage in their development, it is assumed that the performance of ecotechnology has not yet been optimised and they have not yet benefited from learning or scale effects that will lead to their improved performance and wider uptake by the market.

Conclusion

This chapter has provided a context for the research that will follow in Chapters 3 through 7. The discussion presented both a theoretical and empirical perspective regarding a social response to environmental change and degradation. The selection environment was discussed and is beneficial in understanding the factors that may constrain and promote the adoption and implementation of alternative technology. Participatory planning, social learning and the creation of enabling settings were also recommended in efforts to operationalise constructive technology assessment through determining the technological options that will be relevant in unique local level settings.

Chapter 3.0

Methodology and Methods

The research described here employed a qualitative methodology and specific methods relevant to this approach. A collective and comparative case study approach was used during the investigation of four cases. Qualitative research involves the collection of data in the form of words and other forms of data to explain social phenomena and human problems (Patton 1990; Neuman 1991; Miles and Huberman 1994; Cresswell 1998). The goal of the research was*:* **to identify key factors both driving and constraining the adoption and implementation of ecotechnology for wastewater management in southern Ontario, Canada**. The objectives of the research were:

Objective One:
Review theoretical perspectives associated with the emergence of alternative environmental technology and discuss the barriers known to constrain its advance.

Objective Two:
Conduct exploratory research in select cases where ecotechnologies had been applied and identify factors that promoted and impeded the adoption and implementation in each case.

Objective Three:
Discuss the findings related to the adoption and implementation of the ecotechnology across the case studies and propose how the dissonance between driving and constraining factors might be reconciled.

3.1 Research Methodology

Qualitative case study research is beneficial when attempting to collect empirical data to develop an understanding of complex social phenomena (Merriam 1990; Robson 1993; Yin 1994). Yin (1994:

3) suggests that case study research "allows an investigation to retain the holistic and meaningful characteristics of real-life events" through inquiry into a case or cases. Qualitative research reflects an awareness of the individual and is based on a humanist point of view emphasising the importance of the 'surrounding social context' as stakeholders and research informants perceive that context. In qualitative research, the researcher is the instrument of data collection. During fieldwork, researchers conduct observations, interviews and identify documents and records that are relevant for review (Lincoln and Guba 1985; Merriam 1990). This chapter discusses specific methods and steps in the design of the research.

In qualitative research, multiple methods, data sources and materials are used to triangulate findings in order to gain an accurate understanding of a situations or phenomena that is being investigated. Multiple data sources are used to 'triangulate' findings in order to increase the sensitivity of the inquiry and to uncover a rich and complex picture (Cresswell 1998). Rather than a deductive approach, where the testing of a predetermined hypothesis or challenge to existing theory might be undertaken, qualitative researchers undertake an inductive approach where 'meaning' and potentially transferable knowledge emerge through an analysis of the collected data.

3.1.1 Case Study Research

This research undertakes an instrumental case research approach, in which focus is placed on aspects of the case that are of specific interest (Stake 1995; Cresswell 1998; Stake 2000). The instrumental approach was extended to four cases in collective case study research (Miles and Huberman 1994; Yin 1994; Stake 1995; Cresswell 1998; Stake 2000). The use of multiple cases is valuable because it provides a wider range of data and allows for comparison across different settings in order to identify similarities and differences (Neuman 1990). The instrumental case approach taken in this research was guided by the objectives and supports an embedded case analysis (as opposed to an holistic case analysis) where meaning was sought in relation to specific issues - rather than all the issues - in order to reveal findings that are potentially 'transferable' outside of the case studies themselves (Cresswell 1998).

The concept of transferability is important here (Merriam 1990; Robson 1993). The intention in this research was not to produce findings that could be broadly generalised, but rather to produce findings that are potentially transferable to other unique settings. Stake (2000: 439) notes, however, that case study research can lead to further "generalization-producing studies" and can provide early steps towards building theory and frameworks. For this research, the term transferability is preferred over the term 'generalisability', since statistical representation and probabilistic sampling regimens are in no way associated with the design of this research; thus, it would be difficult to generalise outside of the cases themselves. The intent here was to focus on issues that may have a level of 'potential' transferability outside of the case studies.

3.2 Analytical Framework of the Research

The analytic phase of this research was structured after a framework for environmental design evaluation. Environmental design evaluation enables an appraisal of the degree that design meets "explicit and implicit human needs and values" (Friedmann, Zimring *et al.* 1978: 2). Based loosely on this framework, three areas of analysis will direct the inquiry across the four case studies in this investigation. The elements of the framework are: Stakeholder Attitudes, Design Activities and Implementation Setting. Each element will be described at this time.

Stakeholder Attitudes

The importance of understanding the attitudes, needs and preferences of stakeholders during the selection and implementation of technology is vital. This includes the attitudes of institutions and at a more specific level includes regulators and users. Friedmann, Zimring *et al.* (1978) describe these forces as 'participant roles' and suggest that the implications of values, preferences, attitudes and assumptions during the planning and design process dictate the ultimate project design. Understanding the attitudes of institutional and organisational stakeholders can illuminate the intentions of users and explain their motivations in adopting and paying for alternative technologies, and can also explain why other stakeholders (*e.g.* regulators) may be cautious in relation to new technology (Kemp 1993; Irwin, Georg *et al.* 1994; Niemczynowicz 1994).

Project Design Activities

Project design activities are defined here as factors that also play a role in shaping the design of projects. One example is tightly defined regulatory and approvals processes developed to protect the public interest. However, this caution may also limit the application of novel technological alternatives even if environment improvements can result (Ventre 1989; Petts 1994). As previously suggested, these conventions often result from cultural norms and tradition. This area of analysis examines the regulations and approval process affecting the implementation of alternative technology. Project development can be tightly regulated through the approval and permitting process, which reflects the intractability of the programmed planning approach. These constraints can impede innovation and restrict the expression of environmental values in terms of project design and the technological choices applied to meet human needs (Forster and Southgate 1983; Ventre 1989; Petts 1994; ETEC 1997).

Implementation Setting

This area of analysis describes the technology in terms of its fit with the operational framework of a setting where it was implemented (*e.g.* farm or institution) and describes the level of integration achieved in terms of practicality. This is significant because it can dictate whether a technology is appropriate in a specific setting (Friedmann, Zimring *et al.* 1978). This area of analysis consists of the costs and benefits to users and other issues, which relate to inputs of labour and maintenance and which can dictate if an option will be adopted successfully (Kemp 1993). Table 3-1 summarises elements of the Analytical framework that was employed.

Table 3-1. Analytical Framework of the Research.

Theme Area	Description
Stakeholder Attributes	Describes the roles of participants (*e.g.* users and regulators) and includes attitudes, values, preferences and assumptions in relation to a technology.
Project Design Activities	Describes the factors that shape projects such as the regulatory and approval process. These conventions often result from culture and tradition.
Implementation Setting	Describes the fit and appropriateness of a technology with the operational framework of the implementation setting.

Sources: Friedmann, Zimring *et al.* (1978), Kemp (1993) Irwin, Georg *et al.* (1994).

The application of this framework during analysis of data will be discussed shortly in section 3.3.3.

3.3 Research Design: Steps in the research process

Key tasks during this investigation included: 1) undertaking a purposive selection of the case studies; 2) identifying informants and other related information sources; and, 3) conducting interviews with informants. Table 3-2 summarises various steps in the research design and the dates undertaken.

Table 3-2. Steps in Design of the Research.

Steps in the Research	
Definition research problem	August 1997 – December 1999
Step 1 Identification of Potential Cases and Interviewees	
Location	Southern Ontario, Canada
Criteria Directed, Purposive Case Selection	October 2000 – December 2000
Step 2 Data Collection Procedures	
Field Interviews and Document Review	December 2000 – September 2002

Step 3 Data Analysis Procedures	
Data transcription	December 2000 – October 2001
Analysis: Coding of Data	May 2001 – October 2001
Drawing Conclusions	October 2001 – January 2002
Step 4 Data Verification Procedures (Peer Debriefing)	
Triangulation, Rich Narrative, Peer-Debriefing	December 2000 – February 2002
Peer-Debriefing sent, received and results compiled	January 2002 – April 2002
Step 5 Writing	
Writing	January 2001 – May 2002

The research design included reviewing the literature; undertaking formal, semi-structured face-to-face interviews; and review of documents and records – when available – in relation to each case study. Documents and records used as sources of data are cited within the text and the bibliography. The discussion that follows outlines the steps in the research process and the descriptions of specific methods that were employed.

3.3.1 Identification of Case Studies and Informants

The four cases were selected using a purposive case selection strategy (Neuman 1991). During purposive sampling, the researcher employs a significant amount of judgement in selecting cases that are unique in character or uncommon and will result in the collection of informative data that is relevant to the objectives of the study.

A four part criteria was developed to lead the purposive selection of cases. The criteria were developed to enable the selection of cases across two sectors that would result in the generation of informative data in order to meet the research objectives. The criteria that were determined also allowed the investigator to constrain potential cases on pragmatic grounds related to the availability of time and money.

The selection of cases followed the criteria as listed below:

1) Each case must contain at least one alternative wastewater treatment component or ecotechnology as previously discussed in Section 2.2;
2) Each case must originate from the industrial, agro-industrial or service provision sectors;
3) Each case must have been operating during the data collection phase of the proposed research, and;
4) Each case and the associated informants must be located in southern Ontario for practical reasons related to the availability of time and financial resources.

The investigator has had interest and experience related to ecotechnology in Canada and internationally (Rose 1999). Based on this knowledge, the investigator had a variety of contacts that could be questioned to identify existing projects or those being planned in southern Ontario. Through applying the above selection criteria, appropriate case studies were identified for this research.

Informants

Interviews were undertaken between December 5th, 2000 and September 4th, 2001. In total, forty interviews were completed during this time. Informants were identified through chain sampling. In chain sampling, initial contacts are invited to act as informants and are interviewed. At this time, initial informants are asked to identify other informants who they feel would be good sources of information. As the interview process progresses, additional informants are identified in 'chain' or 'snowball' sampling (Neuman 1991).

A list of informant names and their affiliations can be found in Appendix 4. For the sake of brevity, during the analysis chapters of the thesis, informants are identified by a code representing each individual informant and the group from which they originate. Informants originate from five groups: 1) owners, operators and proponents 2) conservation authority officials 3) local government officials 4) provincial government officials 5) engineers, architects, and consultants.

3.3.2 Data Collection Procedures

Data originated from mainly tape-recorded interviews. Written records and documents supplemented the interview data. Records and documents were solicited from each informant at the time of the interview, although a relatively small amount of data was actually gleaned from records and documents. Verbal data was collected during face-to-face, semi-structured interviews. In each case the interviews took place in a location that was convenient for informants. The investigator travelled to meet informants in two main settings, which included the informant's offices and the sites where the four cases studies are located. Interviewees were asked to read and sign a consent form, which was approved by the University of Waterloo Office of Research Ethics and can be found in Appendix 2.

Each interview was recorded on cassette tape, which resulted in approximately 50 total hours of tape-recorded data. Interviews were then transcribed between December 2000 and October 2001. After the transcription process was complete, each of the individual interviews was imported into

NVivo, a qualitative data analysis program (QSR International 2000). Source triangulation was employed in this research (Stake 1995). In source triangulation, one researcher conducts interviews with multiple informants and reviews any available records and documents.

Interview format, research questions and interview procedures

The interview format used to conduct the interviews in this investigation was formal, semi-structured and face-to-face (Patton 1990; Cresswell 1994). According to Fontana and Frey (2000: 653), the goal in collecting semi-structured data through the interview format is to capture and understand descriptions relating to the goals of the research without having formulised "*a priori* categorisation that may limit the field of inquiry". The semi-structured format was valuable in eliciting a wider range of verbal responses than could have emerged through a structured tool designed to capture precise responses (Fontana and Frey 2000). The semi-structured format also allowed interviewees to respond with answers they felt were relevant to address issues in relation to questions that were posed and explored. A list of question that guided the interviewer can be found in Appendix 3.

A mixed-method questionnaire that included both open-ended and closed-ended questions was used (Neuman 1991; DeGraaf, Jordan *et al.* 1999). The value in using a mixed-method questionnaire is that it can aid in reducing the amount of distortion that can occur when only one format is used. This strategy gives informants the opportunity to fully develop and articulate their thoughts in response to open-ended questions and allows researchers to 'force responses' during closed-choice questions, which can aid researchers in triangulating specific information (Neuman 1991; DeGraaf, Jordan *et al.* 1999). Mixing questions also makes the pace of an interview more interesting for the informant and researchers can use the open-ended and closed-ended question to move from broad to narrow subject matter as the interview progresses (Palys 1997).

Document Review

The second source of data originated from a document review, a common source of data in qualitative, case study research (Merriam 1990; Cresswell 1994). Documents are an objective and unobtrusive source of data because they are created for a reason other than the research process itself and thus are not affected by it (Merriam 1990; Robson 1993). Merriam (1990) notes that if a document can be obtained easily and in a systematic fashion, then it is probably a good source of data. Potential sources of documentation that were sought and specifically inquired about during the interviews included: project documentation, agency records, project engineering reports and newspaper articles. All documents that were collected were reviewed and analysed for significant content in relation to the research and were used to supplement and triangulate the information collected during interviews. A list of all relevant documents and records associated with the case studies is found in Appendix 8.

3.3.3 Data Analysis Procedures

In qualitative data analysis, concepts 'emerge' from the data and are constantly refined through what Neuman (1991) refers to as 'conceptualisation and re-conceptualisation' of major thematic issues and evolving concepts in a series of linked analysis techniques. This contrasts with a quantitative approach where variables of interest are determined in advance. The analysis undertaken in this research follows the three-part analysis process proposed by Miles and Huberman (1994), which involves data reduction, data display and conclusion drawing. Although there are three distinct phases during the analysis, there is a considerable amount of iteration that occurs between phases:

- First, data reduction occurs from the time that the research problem is conceptualised and a specific area of investigation is selected and themes are focussed upon. Reduction also occurs in the formulisation of research and interview questions as the research focus is narrowed. During the coding of qualitative data, full-text transcriptions are reduced and organised into categories and themes, which places the data into a form that is easier to comprehend;
- Second, data display is an activity that involves arranging the data into a reduced or 'compressed' fashion which is comprehensible and facilitates interpretation and is an integral part of the analysis as it "permits conclusion drawing and action" (Miles and Huberman 1994: 11).
- Third, conclusion drawing and verification are undertaken. After explanations and causal relationships have emerged from an analysis of the data, conclusions are formulated and must be verified. Techniques and steps in the procedure that were undertaken during the analysis of data originating from this research will be further outlined at this time. Verification procedures will be described later in a following section. (Miles and Huberman 1994)

Data reduction procedures

The analysis of qualitative data involves pulling the data apart and putting it back together with additional meaning in order to contribute to the intent or objective of the research being undertaken. The process is achieved through seeking patterns in the data and developing them into relevant themes and categories that can be organised (Stake 1995; Stake 2000). This type of analysis and the conclusions that can be made through interpretation, bring "meaning and significance to the analysis, [through] explaining descriptive patterns, and looking for relationships and linkages within the data" (Henderson and Bialeschki 1995: 261).

Ryan and Bernard (2000) agree with others (*c.f.* Willms *et al.*, 1990; Miles and Huberman, 1994) that the identification of initial thematic areas generally occurs through reading the literature and that new themes are developed as the analysis progresses. Themes, used in this fashion have been described as "abstract" and "often fuzzy…constructs that investigators identify before, during, and after data collection" however; they are sharpened as new understanding and meaning is integrated (Ryan and Bernard 2000: 780). Neuman (1991: 451) suggests that arranging these themes into frameworks can be helpful during the analysis if used in a "flexible manner".

The literature also assisted in preliminary development of 'theme areas' where potential opportunities and constraints to the implementation of alternative ecological technologies might emerge. Table 3-3 illustrates core thematic areas generated during the analysis phase of the research.

Table 3-3. Thematic Areas (Axial Nodes Reduced to Core Themes).

Areas of Analysis	Themes Derived During Axial-Coding		Core Themes Areas
Stakeholder Attitudes	Rejection of Conventional, Environmental Values; Selection Motive; Regulatory Driven Motive; Proposed Legislation; Competitive Advantage; Technology Preference	▶	Adoption Motives
	Organisational Constraint; Added-Value	▶	Technology Preference
	Institutional Constraint; Resistance to Change; Technology Skepticism; Champion of Innovation; Technology Impression	▶	Institutional Attitudes
Project Design Activities	Provincial Approval; Local Approval; Regulatory Issue; Planning Instrument; Contingencies	▶	Project Approval
	Regulatory Impediment; Caution & Concerns of Liability; Planning & Implementation	▶	Caution and Liability
	Support & Endorsement; Legitimacy & Credibility; Collaboration/Participation	▶	Project Legitimacy
Implementation Setting	Operation and Management; Ease of Adoption	▶	Operation and Management
	Recovery & Reuse	▶	Integrated Design
	Economics & Market	▶	Incentives and Disincentives

In case study research it is common for researchers to inform themselves in advance so as to understand "critical issues" so that the research "design can take greater advantage of already developed and preconceived coding schemes" (Stake 2000: 439). During this research, a series of theme areas related to the development of projects were identified in the literature and integrated into an analytical framework.

This framework was used initially in guiding the gathering of data (*e.g.* formulation of interview questions). It was then used to assist in the development of 'categories' or 'core theme areas' identified during the initial coding procedures (*i.e.* open-coding). A description of coding procedures will be discussed at this time. During this phase of analysis, 'core theme areas' emerging from the data were placed into an analytical framework which was loosely based on the environmental design evaluation literature and previously discussed in section 3.2.

Data Coding Procedures

Coding occurs through organising the data into categories that are based on "themes, concepts and similar features" that have been identified in the data (Neuman 1991: 415). These features are then linked together as understanding is built and evolve through analysis procedures (Ryan and Bernard 2000). Organisation through this process is facilitated through coding procedures that consists of making successive examinations or 'passes' through text, documents and records (among other artefacts and materials) in an iterative process that increasingly sharpens the interpretation and the conclusions that result.

The first step of coding procedures occurs during open coding and consists of a process that involves a first attempt to identify and organise the data into large categories as they emerge from the raw data. Open coding is used this way to reduce the data into categories, themes (newly identified themes) and patterns, as they emerge. This process also initiates the winnowing of the data in order to focus more time on most important components of the data, which, in the case of qualitative inquiry, is often the smallest portion of the data (Merriam 1990; Stake 1995). Open-coding acts initially to focus, but in no way to constrain the interpretation.

During a second pass through the data axial coding was used. In axial coding Neuman (1991) suggests that less attention be placed on the data itself and that the focus become the themes that have been identified during open coding procedures. Cross-theme and cross-category similarities are identified and an axis of key concepts begins to appear. The value of axial coding is to promote an understanding of the relationships that exists between theme and concept. As the analysis is further refined, previous codes are 'challenged'; some themes are dropped and others are examined further. Connections between key themes and concepts become stronger and more evident, which acts to increase reliability. As strong connections between "core" theme areas are identified and the evidence builds that theme areas should be consolidated, this "builds a dense web of support in the qualitative data for" key axis areas that have been formulated (Neuman 1991: 417). During the analysis phase of this research, a second pass through the data that had initially been open-coded, resulted in twenty-nine categories (*e.g.* nodes), which were compressed into nine major theme areas after their relationship had been established.

3.3.4 Conclusion Drawing and Verification

In the third and final pass through the data, selective coding was used and involves "selectively looking for cases that illustrate themes and makes comparisons and contrasts" from data that has previously been coded and reduced (Neuman 1991: 417). The data is once again scanned for evidence that illustrates the themes and concepts that were developed. Once successive passes through the data have been completed, the analysis moves into a final phase of analysis where the findings are formulated (*i.e.* assumptions and concepts) and modified against the data to see how well it fits in what is called successive approximation. Successive approximation will be discussed further in the following section.

Successive approximation was the final phase of the analysis that was performed on the data. Similar to the coding procedures previously described, this method is a process moving the 'end-stage' concepts and interpretations through repeated iterations in comparing vague ideas and concepts with "evidence [in the data] to see how well the concepts fit the evidence and reveal [important] features of the data" (Neuman 1991: 420). This is the point in the analysis when end-stage categories and themes are linked to one another and relationships between themes established.

The data is further explored in attempts to understand how well evidence in the data fits the concepts that have been developed (Neuman 1991). Refined data and theoretical concepts shape one another and "the modified concepts and the model approximate the full evidence and are modified over and over to become successively more accurate" which leads to the development of increasingly solid concepts (Neuman 1991: 420). Thus, 'successive approximation' occurs as concepts are modified through repeated analysis and comparison with the evidence originating from the data.

3.3.5 Verification Procedures

In undertaking qualitative research one assumes a methodical, complex and often laborious process in order to validate the findings and accurately meet the research objectives. The rigour exhibited in qualitative inquiry is exemplified in various techniques that are used to increase the trustworthiness and credibility of the data and findings. Various methods are used in qualitative research to verify findings. Verification procedures are an essential in securing legitimacy of qualitative case study research (Stake 1995; Cresswell 1998). Synthesising the works of various authors, Cresswell and Miller (1997: 202-203) list multiple verification procedures that are suitable to be employed in naturalistic inquiry and suggest that the utilisation of two or more techniques are adequate in attempts to gain accuracy. The verification techniques of triangulation, narrative description and peer review are often employed in qualitative research to establish the trustworthiness of the findings (Cresswell and Miller 1997).

The following verification methods have been used in this research:

- Triangulation between methods, informants and records and documents, was used to increase accuracy between sources (Cresswell and Miller 1997).
- Narrative description, presenting readers with a full of description with which decisions can be made regarding the transferability of this study to other settings (Cresswell and Miller 1997).
- Findings were also be verified through an external check of validity during peer-debriefing (Cresswell and Miller 1997; Lincoln and Guba 1985). Initial findings were submitted to informants to check accuracy. The peer-debriefing survey is explained further in the following section.

Peer Debriefing

In addition to the triangulation of data and the detailed narrative used to describe the cases in the analysis chapters, a peer-debriefing survey was mailed to informants for them to verify the preliminary findings. From January 2002 to April 2002 the preliminary findings were mailed to 38 individuals for verification. The survey was sent to 29 individuals who were previously interviewed and, in an attempt to triangulate information, also to 9 individuals who were not available during the interview process, but who were identified during chain sampling in relation to the adoption of the CTWs or the GBTTs.

Each debriefing survey that was mailed contained the findings, a description of the individual cases and a pre-stamped, pre-addressed return envelope for the survey to be returned. The peer-debriefing survey itself consisted of the preliminary findings that were established across the four cases. Each survey question was presented with a Likert Response Scale metered from 1-5. Respondents were asked to rate their level of agreement with each finding on the 1-5 scale, with '1' indicating 'full disagreement' with the findings and '5' indicating 'full agreement' (DeGraaf, Jordan *et al.* 1999; Trochim 2001). The peer-debriefing survey and the associated results can be found in Appendix 6.

3.4 Limitations of the Research

The four cases that were explored in this research were atypical and selected through a purposive sampling method. As such, the findings cannot be seen as representative to wider organisational institutional or operational settings, but nor was that the intent of the research. The findings from this investigation are not seen as being "generalisable" at a wider level although they are seen as potentially "transferable" and opportunities exist to transfer lessons learned to other settings. This is a judgement that needs to be made by the reader because their vantage and understanding will expose similarities and differences between the cases studies and external cases where similarities may exist. This feature of the research does represent a limitation and suggests the need for further research. A representative sample would assist in the accumulation of a significantly larger data set and would be useful in determining issues related to stakeholder attitudes, design activities and the implementation setting in the development of increasingly sustainable technological solutions to pressing environmental problems.

The qualitative approach that was assumed in this research allowed the collection of a rich data set that may not have been possible if a quantitative approach. However, methodological insights during this research made it apparent to the investigator that a mixed-method, that is combining data collected through both qualitative and quantitative approach, may be advantageous in terms of eliciting a wider, but not necessarily a deeper understanding of the issues. However, undertaking a wide quantitatively based survey to elicit a broader set of data in combination with a qualitative may be beneficial to increase the knowledge generation.

In terms of alterations to the research protocol made during the investigation, one change did occur. After the data had been collected and the final analysis completed, it was agreed by two committee members that the strength and legitimacy of the research would be increased if the names of informants were revealed. The investigator was advised to re-contact participants and to ask *if they would voluntarily consent* to having their names revealed in association with quotations that were used in the thesis. An amended ethics consent form (see Appendix 2) outlining this change was submitted to and approved by the Office of Research Ethics at the University of Waterloo. The investigator agreed to this change after it was established through consultation with the Office of Research Ethics that no ethics violation would result and informants would not be jeopardised if they agreed to this change. The investigator also rationalised that because the data had been fully collected, analysed and had been written-up that the findings were in no way compromised by this change. After informants had been contacted and asked if they would *voluntarily* agree to this amendment, 37 of the 40 informants agreed to go on the record - by name - for their comments.

Conclusion

This chapter has provided a detailed account of the methods and procedures used during this research. The research used a qualitative case study approach and followed a design that enabled the identification of driving and resistant forces to the application of the ecotechnology applied across the case studies.

An analysis of data collected in relation to each case study is divided into the two following chapters. Chapter 4, the next chapter, presents an analysis of the CTWs that was applied at the French Farm and Luckhart Trucking. Chapter 5 provides an analysis of data collected in relation to the greenhouse-based treatment technologies at the YMCA Outdoor Centre and the Toronto Waldorf School.

Chapters 4 and 5 present an analysis of each case. A descriptive 'case profile' can be found at the beginning of each case analysis. These profiles describe the ecotechnology that were applied in each case for wastewater treatment. Line drawings and photographs in relation to each case are also included in the profiles. Chapter 6 presents a summary of the analysis presented in Chapters 4 and 5 and presents the findings established across the cases.

Chapter 4.0

Analysis of Constructed Treatment Wetlands

> You see, getting down to the bottom of things, this is a pretty raw, crude civilization of ours - pretty wasteful, pretty cruel . . . out of gear. We've stumbled along for a while, trying to run a new civilization in old ways, but we've got to start to make this world over.
>
> *Thomas Edison*

This chapter presents the analysis of the data collected in relation to the constructed treatment wetlands (CTW) applied at the French Dairy Farm and Luckhart Transport. The two sections in this chapter provide introductions to the case studies where both CTW were applied. These cases will be referred respectively from here forward as the 'French Case' and the 'Luckhart Case'. Figure 4-1 offers a map of the analysis covered in this and the following chapter.

<table>
<tr><th colspan="4">Cross Case Analysis - Constructed Treatment Wetlands</th></tr>
<tr><td colspan="2">Current Chapter</td><td colspan="2">Following Chapter (GBTTs)</td></tr>
<tr><td colspan="2">Constructed Treatment Wetlands</td><td colspan="2">Greenhouse-Based Treatment Technologies</td></tr>
<tr><td>French Case</td><td>Luckhart Case</td><td>YMCA Case</td><td>Waldorf Case</td></tr>
<tr><td colspan="2">⟷</td><td colspan="2"></td></tr>
</table>

Figure 4-1. Map of Chapter-4 Analysis.

The analysis of each case, in this chapter and the next, is organised into three areas: Stakeholder Attitudes, Project Design Activities and Implementation Setting. Informants, their affiliation and the dates they were interviewed are represented by a code in the analysis text. The first part of the code indicates informant affiliation (*e.g.* OOP-owner-operator-proponent; CAO-conservation authority official) as illustrated in Table 4-1. A number can also be found in this code that identifies each individual informant by name through cross-referencing it the table found in Appendix 4.0. The year the interview took place is also embedded at the end of the code. For instance, an interview with conservation authority official informant in 2001 will be referenced as: (CAO-1, 2000), where the '1' specifies the individual informant. This coding system will be used throughout the analysis.

Informant	Affiliation
Owner-Operator-Proponent	OOP
Conservation Authority Informant	CAO
Engineer-Architect-Consultant	EAC
Local Government Official	LGO
Provincial Government Official	PGO

Table 4-1. Informant Coding Scheme.

4.1 French Dairy Farm Case Study

Project Description

Establishment: Family Operated Dairy Farm (Mitchell, Ontario).

Total Land Size: 40.5 hectares.

Description of Treatment System: Surface flow CTW to capture and treat barnyard runoff from a 30-head dairy farm business.

Construction Motivation: A voluntary project initiated by the farm owner.

Year Constructed: 1993 (continuous operation through 2003).

Design: The CTW consists of a three-stage gravity-flow treatment system. Runoff is collected in a shallow grassy cell where solids are settled. Wastewater then drains through a vertical pipe inlet to the second treatment cell, which consists of a shallow serpentine wetland channel that is planted with cattails, bulrushes and other wetland vegetation. Water from the second cell flows into the third cell that consists of an open, deep pond that acts to polish wastewater. Polishing in the third stage is aided by a wind-driven sub-surface propeller that circulates and aerates water (Canada-Ontario Agriculture Green Plan 1994).

Spatial Requirements: The CTW occupies approximately 0.32 hectares of land. No more than 0.4 hectare of land was taken out of production to build the CTW. The CTW drains 0.61 hectares of surface area consisting of barnyard rooftops and concrete and gravel barnyard pads (UTRCA 1992; UTRCA 1994).

Operational Capacity: Total Hydraulic Capacity 350,000 litres. Daily flows are seasonally variable.

Cost: Approximately $7,200.00 (the owner bore 25 percent of the capital cost).

Funding Partners: Contributions from the farm owner; the Upper Thames River Conservation Authority (UTRCA); the Ministry of Environment and Energy (MOEE) under Clean Up Rural Beaches (CURB); Canada Trust (Friends of the Environment Foundation); Agriculture Canada and Centralia College.

Treatment Contingencies: Land-spreading if required.

Project Objectives: The CTW was a voluntary undertaking initiated by the farm owner. The objectives were to meet provincial water quality discharge guidelines as established under the Ontario Water Resources Act.

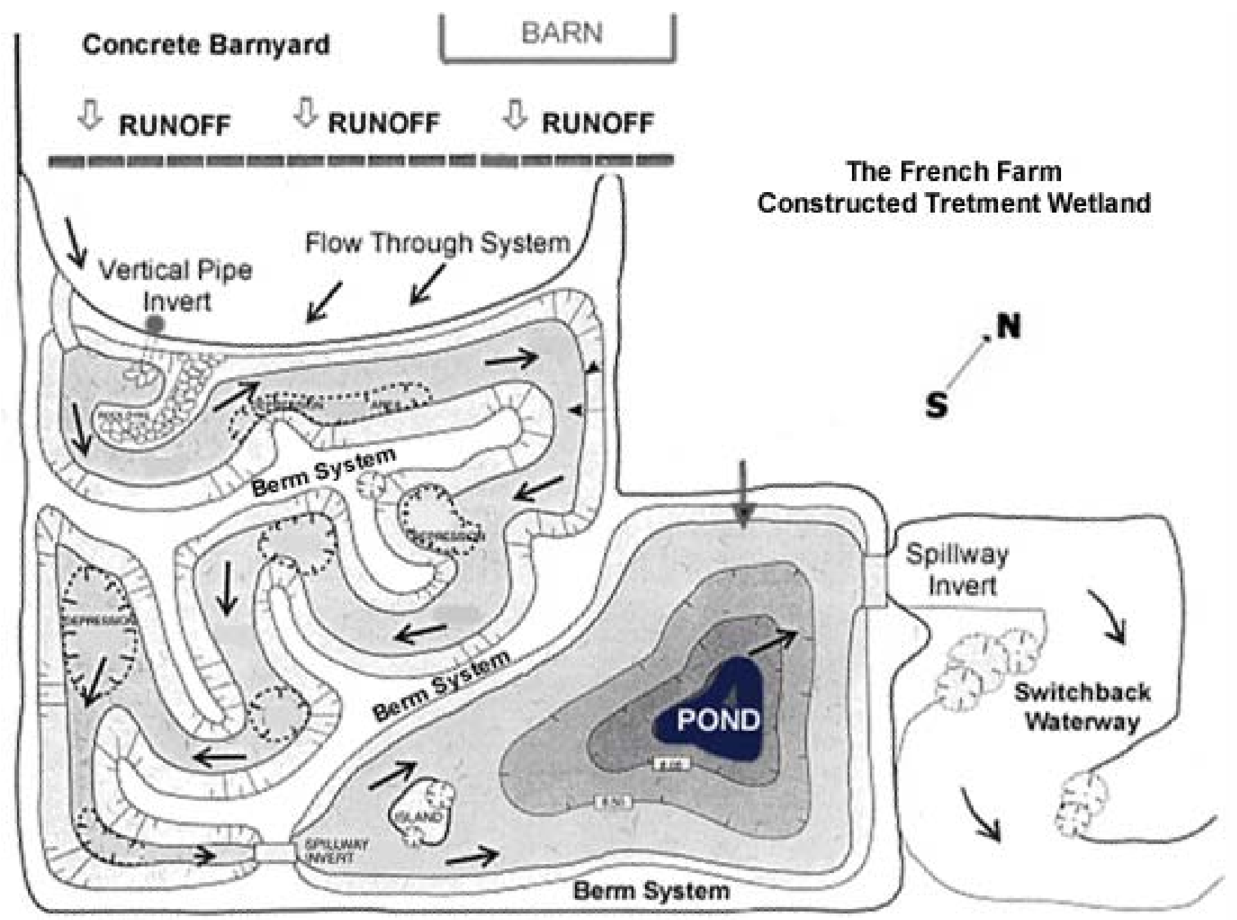


Figure 4-2. French Dairy Farm: Schematic of constructed treatment wetland.
Source: Upper Thames River Conservation Authority (1992; 1994).

Figure 4-3. Barnyard and wastewater runoff.

Figure 4-4. Constructed treatment wetland during (spring melt 2001).

Figure 4-5. Constructed treatment wetland (spring melt 2001).

Figure 4-6. Constructed treatment wetland (drought of 2000).

Project Background

The French Case CTW was a voluntary initiative undertaken by the farm owners in collaboration with the Upper Thames River Conservation Authority (UTRCA). The project was supported by a grant received through the MOEE under the Clean Up Rural Beaches Program (CURB) and in-kind donations from a variety of funding partners. The French Case was the first CTW implemented in Ontario under CURB and was also the first CTW used in Canada for the management of barnyard runoff. The CURB program was initiated in 1991 by the provincial MOEE to address the widespread pollution of Ontario's rural beaches and waterways. The program fostered cooperation between the MOEE and Ontario's Conservation Authorities to address the environmental impacts and management of livestock runoff and domestic septage, among other environmental issues. In twelve separate cases, CURB grants were used to assist in the implementation of demonstration CTWs. At this time, CTWs was considered an alternative and potentially cost effective approach to manage agricultural manure wastewater (Canada-Ontario Agriculture Green Plan 1994).

Implementation of the CTWs under CURB resulted in the generation of a considerable amount of data and learning in relation to CTWs in Ontario (Canada-Ontario Agriculture Green Plan 1994; Glasman and Briggs 1996; Pries, Borer *et al.* 1996). The CURB program was short-lived and although, a province-wide study was proposed in a joint MOEE - Agriculture Canada program to study the CTWs implemented under CURB, the assessment was never undertaken due to 1996 provincial government budget reductions. The following section begins the analysis of the French Case.

Stakeholder Attitudes

Adoption Motives

The CTW adopted in the French Case was a voluntary initiative undertaken by the farm owner. Two motives were identified in the farmer's decision to apply a wastewater management solution. The first originated from the owner's concern for the environment. The owner was concerned that runoff from his barnyard was negatively impacting the environment and he sought a solution to reduce the environmental impact of his operation. The farm owner explained this by stating: "I saw a problem and I wanted to clean up the problem . . . in keeping the natural environment clean" (OOP-2, 2000). Others involved in the project characterised the farm owner as being extremely concerned with the environment and a champion of innovation. The County of Perth Planning Director described the farm owner as "conscientious and very environmentally concerned" (LGO-4, 2000). The wetland engineer from the UTRCA said that adoption of the CTW was self-motivated: "In a legal sense, he probably didn't have to do anything. He felt that he could do better . . . and this method suited him" (CAO-1, 2000). Another UTRCA official said:

> I would say from my discussions with him, he certainly did it for environmental reasons. He was aware that his manure was running off from the drainage ditch and he certainly believed that that wasn't right. (CAO-15, 2001)

The wetland engineer from the UTRCA suggested that, for the most part, it is the "Nature of the people" in the agricultural community to be innovative in the management of farm operations and to seek options that are "Practical and cost effective" (CAO-1, 2000). A local government official reflected this and said:

> I think that most people know that that they have an issue and they want to fix it. I think they just want to come up with a system because most farmers just do not want to pollute the environment and that most farmers do a good job if they are given the tools to do so. (LGO-4, 2000)

The Director of Planning recognised that although there were economic factors involved, the decision to implement the CTW went beyond economics. He said: "It may have been initially economically motivated," but that the farm owner was "Environmentally concerned" (LGO-4, 2000). A MOEE specialist who was involved in the French Case characterised the decision to voluntarily apply the CTW as an ethical decision. He said: "[I]n the case of the farm owner . . . it was a self-motivated undertaking - an ethical approach if you will - allowing him to do what he believed was the right thing . . . and not a response to something that he had to do" (PGO-6, 2001).

The second motivation identified as compelling the farm owner to implement this CTW was his anticipation of stricter regulations in the future that would require nutrient management plans for farming. This strengthened his intention to apply a low-cost alternative. The farm owner said: "I knew it was getting to the creek and I knew that in time we were going to be forced to do something" (OOP-2, 2000). He decided to implement a wastewater management system of his choosing voluntarily rather than having one imposed through legalisation in the future. The farm owner's concern was supported by an UTRCA official who said: "He was losing a tremendous amount of nutrients off of the land to the watercourse, but sooner or later, presumably, the legislation will not tolerate that kind of environmental impact" (CAO-1, 2000).

Technology Preference

The farm owner and the UTRCA were confident that it was possible to establish a wastewater treatment system that was superior to the conventional options in terms of both its affordability and environmental effectiveness. The farmer owner rejected the widely used conventional option (*i.e.* concrete storage tanks) for the CTW technology for reasons based on both pragmatism and personal preference. Additionally, he expressed considerable skepticism regarding the conventional option. He considered storage tanks a liability from a business perspective, describing them as "Tombstone[s] in the ground," based on his knowledge of between, "Eight to ten cement liquid waste storage tanks within a 10-mile radius of [his] farm where the conventional storage tank had failed, was not repaired and is no longer operating, although it is still being paid for in the mortgage of the farm" (OOP-2, 2000; Bader 1993).

The farmer owner did not consider land-spreading a viable solution and was aware of the environmental risk associated with the technique and was skeptical of whether it was a viable long-term solution. Secondly, the farm owner favoured the CTW because it was a passive treatment system that required no electricity and very few physical inputs in terms of operation and maintenance. It was also the farmer's intent to apply a simple system that benefited from nature's ability to assist him in treating wastewater through passive operation. He wanted to "Harness nature," and to "Work with nature instead of against it" (OOP-2, 2000). The farmer described the CTW as "Virtually maintenance free" and preferred a passive system to manage barnyard runoff because he associated this type of system with lower costs:

> When I put the system in, I said that it had to go in and be virtually maintenance free [and] low cost . . . and I think that we have come up with the one that requires the least maintenance of all the options that can keep operating from year to year. (OOP-2, 2000)

The farm owner recognised significant benefits related to the CTW that included operation and maintenance. The CTW offered a solution that did not require treated effluent to be applied on land. This was preferable to the farmer because he was concerned with potential environmental impacts and the added cost that land-spreading required. It was the impression of the UTRCA's wetland engineer that the farm owner felt land-spreading was an unfavourable option because it "Didn't seem to deal with the matter appropriately in that, once a year you go out and spread it all over the place and potentially suffer the consequences" (CAO-1, 2000).

The farmer also recognised the aesthetic benefits and other amenities offered by the CTW. The CTW fit with the farmer's aesthetic vision of his site layout and he was enthusiastic about the wildlife that the CTW attracted. He was quoted in a local newspaper that the " wetland is becoming a natural habitat for a host of birds, bats and amphibians" (Kitchener-Waterloo Record Special 1994: B12). One MOEE official commented that the CTW offered the farmer the ability to manage his wastewater problem "On an ongoing basis" with a technology that is much more aesthetically pleasing than using a concrete tank" (PGO-6, 2001). One newspaper report said: "He now has an aesthetically pleasing wetland in his yard that's cleaning water naturally" (Shyplla 1994: 7). In another interview by a local newspaper, the owner said the CTW is so pleasant that you could place a picnic table beside it due to the lack of mosquitoes that have been eaten by swallows that enjoy the wetland (Reid 1995). The farmer said: "He often walks along the grassed banks of the [wetland's] winding, 300-foot long water course before stepping into the dairy barn to do chores" (Reid 1995: 9).

Institutional Attitudes

Local regulators: The UTRCA perceived itself as an innovative organisation and actively built its capacity to identify and implement water quality improvement technologies that would be acceptable and financially viable for the agricultural community. During the implementation of the CTW in the French Case, it was the UTRCA's intent to develop a CTW that might become accepted as an agricultural best management practice in their ongoing efforts to manage the effects of wastewater in rural areas (CAO-1, 2000). The UTRCA was dedicated to increasing their capacity to further develop the CTW technology for wastewater treatment and expanded considerable resources to this end.

A portion of the UTRCA's budget was aimed towards developing the CTW technology in hopes that it would become a best management practice for farming operations and that the private sector would potentially become involved and expand its use. The UTRCA's planner said: "Innovation is very important, it's in our strategic plan, we do a lot of innovation" (CAO-15, 2001). In relation to this innovation, another official said that they attempt to "Test and get things working so that we can get the private sector to take them and deliver them" (CAO-1, 2000). The UTRCA had no guidance manual to follow during the implementation of the wetland; however, one UTRCA official said: "When we started with the French wetland, we didn't have those manuals, we had principles" that guided their efforts. And it was through building on basic principles of ecological engineering that they were able to innovate in the area of the CTW technology.

The UTRCA was also willing to collaborate during the implementation of the CTW in the French Case. The UTRCA developed a collaborative relationship with the MOEE and others who sponsored the project under the provincial CURB program. One UTRCA official reflected on the MOEE's input during the French Case, stating that the MOEE's involvement and guidance offered him a reference-point in terms of the water quality parameters he was expected to achieve and how he might best achieve them (CAO-1, 2000).

Initially, local government officials met the CTW technology in the French Case with considerable skepticism and resistance. One UTRCA biologist described the resistance of the local government as fear of "Stepping outside of the box to take a risk" (CAO-16, 2001). Local council members were suspicious of the CTW and the departure from standard manure management practice that it represented. The Reeve of the township reported that council's reluctance and the lengthy approval period in relation to the CTW was a combination of caution and lack of precedence. He stated that "It didn't follow the normal pattern, and of course, Municipal people being kind of structured, follow the same pattern all of the time and tend to resist any change" (LGO-5, 2001).

The UTRCA's planner concurred and said that: "Parting with history and parting with standard practice is much more difficult for some municipalities than it is for others" (CAO-15, 2001). Another official interpreted the initial delays not as opposition to the project, but "More in set-backs from the comfort of the council at the time" (CAO-1, 2000). It was suggested that the reluctance of the municipality was apparent because this was the first time that the municipality had to take a CTW through the approvals process and it was difficult to fit the CTW into the pre-existing planning and regulatory framework that existed: "There is a culture of policies . . . [that act to] minimise official planning amendments because they're expensive and they're painful for the staff that have to administer them" (CAO-15, 2001). In countering this resistance, the Reeve said that: "You need that pioneering spirit in the minds of the enforcement body," and "You need to have the type of government that is made up of individuals who are not terrified by change" (LGO-5, 2001).

The municipal Director of Planning cautiously reviewed the application for the bylaw amendment that was required to implement the CTW on the farm owner's property. There was no explicit effort by the planning office to impede implementation of the CTW technology; however, caution was exhibited because the CTW was unfamiliar and uncertainty existed as to how to fit it into the existing planning framework. The Director of Planning said: "We didn't have an official plan or a by-law that set provisions or policies that . . . encouraged or accepted the [the CTW technology]. And the reason in part for that is the lack of familiarity with new technologies. When technologies change, people are generally resistant to [new ones]" (LGO-4, 2000). He said: "Certainly, we went into it with an open mind that we would not be confronted with [adverse effects from the CTW], but at the same time, there was that reservation with something new" (LGO-4, 2000).

There were no specific provisions or bylaws in the official plan that required corrective action if the CTW was to fail in the future. In this case, the planning office crafted the permit for the CTW by linking it to a site-plan agreement under Section 41 of the Ontario Planning Act (case record)[9]. This required certain conditions to be met by the farm owner in order to implement the CTW. This mechanism also offered the council a level of comfort in approving the CTW as it assured them that action could be taken if the CTW had any associated problems. However, the planning office needed to be assured that the project was supported by credible agencies such as the UTRCA and the MOEE. The Director of Planning said: "We have to be convinced if we're going to encourage and advise the municipality to buy into [a project]" and, additionally:

> [F]rom our standpoint, we were not saying 'no', we were saying, 'we want to see some support from the agencies that are in-the-know over these things and if you have that, we will look at that open mindedly and take it through the process'. (LGO-4, 2000)

Through collaboration with the UTRCA, the planning office developed planning provisions that eased the concerns of council and gave them confidence that they "Had guards and controls in place" that would required the farm owner to cease or repair the CTW if it did begin to adversely impact the environment (LGO-5, 2001).

Provincial regulators: The intention of the MOEE in relation to CTWs established under the CURB was to demonstrate whether they could function to improve water quality and fit into farming management practices. Specifically, CURB involved the implementation of on-farm demonstration projects to encourage the development of effective and economically feasible waste management systems. There was some optimism at the regional MOEE office in London, Ontario that the CTW technology could become a viable option for agricultural manure management (PGO-Anonymous, 2001). The Minister of the Environment at the time, Bud Wildman, visited the opening ceremonies at the French Case and was quoted as saying: "We want to make sure that innovative approaches are really given a chance to work and to be demonstrated" (Shyplla 1994: 7).

By 1996, however, the CURB program had been eliminated, MOEE staff shuffled or laid-off, and the capacity that the MOEE had developed in relation to CTW technology lost (PGO-40-Anonymous, 2001). At the time of this research, the MOEE continues to be somewhat cautious in relation to the CTW technology. An MOEE planner involved with the French Case suggested that there is still a lack of data that proves the effectiveness of CTWs, which makes it hard for the MOEE to support the technology: "On paper they would seem to work, in theory they would seem to work, [but] . . . as a result of not knowing how they will work here, then we become cautious and 'caution' is the key word" (PGO-7-Anonymous, 2001). Another MOEE official suggested that CTWs were only viable in some cases:

> [F]rom my experience from the sewage side of it, first of all it boils down to what the effluent criteria is. If you have a very stringent one then you have to have some sort of sophisticated system [for wastewater polishing], so it might wipe out the cost advantages you had. But if it is very simple, very liberal effluent criteria for the receiving water and it has a high assimilative capacity, then the CTW technology might be attractive. (PGO-39-Anonymous, 2001)

The MOEE can claim a long history of involvement with CTW technology originating from the seminal research during the seminal research conducted during the Listowel Marsh Project in Listowel, Ontario (1980-1984) where a demonstration CTW was implemented by the provincial government. Nevertheless, there was criticism revealed during this research that advances in the CTW technology for domestic sewage treatment (*e.g.* the Listowel Marsh Project) and by extension CTWs for agricultural application such as the French Case, may have been constrained by political and institutional forces. It was suggested that strong affiliation between engineers in the MOEE and the private engineering community contributed to the negative, but final, analysis that the CTW at the Listowel Marsh Project received and this acted to stigmatise future projects. Several informants suggested that there was a misinterpretation of the data that the MOEE generated during the Listowel project (EAC-34, 2001; PGO-33, 2001; EAC-25, 2001). One informant suggested that misinterpretation of data "Killed" the project, and that at a political level, there was an attempt to "[Find] a problem and this gave them the ammunition they needed to refute this process, to say that this isn't going to be an acceptable process" (EAC-34, 2001).

[9] Case record #6 (see Appendix Five).

Regarding the outcomes from the Listowel Marsh Project, one MOEE informant suggested that the performance of the CTWs during this project was dependent on which outcomes were expected (PGO-39-Anonymous, 2001). He suggested that as a stand-alone system (*i.e.* without pre-treatment) the CTW could not produce tertiary level treatment and that it "Failed miserably," in this respect. He clarified this by stating that CTWs are used in Ontario to polish wastewater to a tertiary level and that "A reasonable level of water quality" can be expected from CTW when used "For polishing secondary (or secondary equivalent) effluents" (PGO-39-Anonymous, 2001).

It was also suggested that an effort was made by the engineering community during the 1980s to constrain advancement of the CTW technology because it was seen as a threat to reigning conventional technologies. The wide-scale implementation of the conventional domestic sewage treatment systems were benefiting engineering contractors because these options were highly capitalised and awarded on a rotating contract basis, which ensured financial gain. The 'purported' failure of the CTW during the Listowel Marsh Project encouraged the continued and widespread use of conventional wastewater treatment technologies and their proportional relationship to consulting fees that accompanied highly capitalised projects (PGO-Anonymous, 2001). The Environmental commissioner of Ontario (a biological scientist), who was involved in the Listowel Marsh Project compared the project to the Canadian "Avro Arrow," and said that the marsh was bulldozed immediately after the project ended: "[Just like] it didn't happen" (PGO-33, 2001). He suggested that, although the MOEE's attitude towards CTWs is beginning to change, the "Bureaucratic echo of past biases" continue to constrain the CTW technology to this day (PGO-33, 2001).

Currently, there are no formal guidelines that have been developed by the MOEE for CTWs. Although an MOEE interim position paper states that CTWs are supported in many situations, the MOEE will only approve CTWs under stringent conditions where they are used in the polishing of pre-treated effluents. The position paper describes CTW as being: "Characterised by limited process control ability," and that the Approvals Branch, in general, ". . . supports the utilisation of wetlands treatment for sites where it is used as a polishing component of the overall treatment process" (MOEE 1998: 2-3).

Although the position paper implies prudent support of the technology, several informants believed that the MOEE has not favoured the widespread use of CTWs, which has resulted in the Ministry accruing a high-level of experience and familiarity with conventional options, but less familiarity and comfort with options like CTWs. Because of this discomfort with alternatives, it was suggested that the MOEE has a tendency to discriminate against alternative approaches. The impression of the Environmental Commissioner of Ontario is that there has been a "Prejudice" against the CTW technology that goes beyond a lack of data supporting the efficacy of the technology. He said: "It's not lack of data and it's not lack of suitable test areas," and asserted that the MOEE, as an institution, is infused with a traditional engineering mentality that has deterred the implementation of CTWs and that "Intellectual conservatism, if not stubbornness . . . has acted to stifle innovation" (PGO-33, 2001). He said that the engineering community in the MOEE has not generally supported CTWs in the past and that:

> [R]esidue of that still lasts to this day. . . .[T]he MOEE] made sure that treatment wetlands were not approvable as a first line treatment in Ontario. That was a dictum that came out of the Ministry in 1981, at the early stages of really good data, long before the verdict was in on constructed wetlands. But [it] became doctrine with the MOEE that wetlands would not be approvable. (PGO-33, 2001)

One wetland technologist suggested that institutional resistance has existed against CTWs in Ontario and is apparent in some government agencies. He reports that, in his experience, the CTW technology has met some resistance by some regulatory staff as well as skepticism that has led to stringent requirements related to the application of the CTW approach from the Ministry of Environment, the Department of Fisheries and Oceans, the Ministry of Natural Resources and the Canadian Wildlife Service. However, he also noted that these same agencies also have strong supporters of the CTW technology within them (EAC-34, 2001).

One MOEE engineer suggested that the Ministry has never intentionally engaged in stifling innovation in the area of CTW technology and he attributes various concerns of proponents to a problem of perception: "My sense is that the Ministry of Environment is being used as a scapegoat to a degree, and it is only perception that makes people think that the MOEE will suppress alternative technologies" (PGO-39-Anonymous, 2001). He went on to say:

> The question from the MOE's standpoint is whether or not any technological alternative can meet the effluent quality criteria on an ongoing basis, wetlands may not be able to and this is why we suggest their use as stated in the [MOEE] position paper. So, how to change this perception of people who would promote alternative technologies is a major question. (PGO-39-Anonymous, 2001)

This official suggested that the approvals framework is restrictive in order to protect health and environment and that this discourages a lot of innovators when they see that they will be held to stringent standards to this end (PGO-39-Anonymous, 2001). He also said that the MOEE aims, at one level, to encourage technologies that are cost-effective and if a technology is affordable, then that is " . . . Good for the environment, [however] it also has to be reliable, easy to operate and manage over the long-term," and then "The MOEE will act to assist the technology - we will not stand in its way". He also added that the key concern is that technologies are able "To meet the required effluent criteria on a reliable and consistent manner with adequate provisions of redundancy". The central question, he suggested in defining MOEE support for a technology is whether or not it can meet effluent quality criteria on an ongoing basis, and added: "Wetlands may not be able to do this and this is why we support their use as stated in the position paper" (PGO-39-Anonymous, 2001).

Project Design Activities

Caution and Concerns of Liability

Local regulators: The UTRCA was aware of the fact that CTWs were not tested in the cold weather climate of Canada. Although they were not certain how well the CTW technology would function, they were willing to take calculated risks in order to develop the technology. The UTRCA's engineer described their agency as being on the "Leading edge" of technology development and that they were aware of, and comfortable with, the risks that accompanied their pursuit of innovative solutions for water quality management (CAO-1, 2000). Regarding the CTW technology:

> [F]or this part of the world it is new technology. It may work or be proven somewhere else, but we didn't know that it would work that well here. The vegetation is different here than it is in Europe, soils are different, it's colder here, our agriculture is different, so there was that huge risk. . . .[T]here are always risks, but I like to think optimistically, that you can always overcome those risks. . . .[W]e build in the safety factors, so if a problem occurs we are comfortable enough to handle it without a major water quality impact. (CAO-1, 2000)

The well-known history of the Listowel Marsh Project was suggested as one potential reason for the hesitation and concern of the municipal government. The Director of Planning suggested that the CTW technology had been stigmatised by the Listowel Marsh Project and that municipalities in Ontario were sensitive to the implementation of CTW and that "This general knowledge [of Listowel] was around the county" (LGO-4, 2000). This knowledge made the council initially cautious in approving a CTW. When the decision was made to allow the CTW to proceed, the council looked to the municipal planning department to devise a provision that would ensure adequate controls for the CTW and protect the liability of the municipality. The Perth County

Health Department was also consulted, but had no objections to the project except suggesting regular testing to ensure water quality aspects were being met (case record)[10].

Some informants in the UTRCA believed that concerns of local government with the CTW constrained the project initially (CAO-15, 2001; CAO-16, 2001). One said that most of the problems that were encountered, in term of constraints related to the approval process, came from "Municipal standards and the need to protect the liability of the corporation" (CAO-15, 2001). This official said that: "Parting with history and parting with standard practice is much more difficult for some municipalities than it is for others. And of course there is corporate liability".

One challenge for the municipal planning office was the absence of a specific clause in the Planning Act that applied to technologies such as CTWs, which would assist in regulating the CTW and act as an instrument to ensure that action could be taken to have the CTW cease or repair the CTW if necessary. Although the municipal planning office was never against the project, there was initial uncertainty about how to best craft a bylaw provision that would allow the project to proceed safely. The Director of Planning said: "We didn't want to curb or stop the initiative of somebody wanting to take an experimental project to see if, over the long-term, it was a reasonable alternative" (LGO-4, 2000). He said that at the time his office had agreed that "From a planning perspective there is a legitimate agricultural related need," however, "There are no bold statements in our plan encouraging alternatives . . . it's sort of neutral". Although he felt the Provincial Planning Act made the planners job easier and "Provides . . . planners, with many tools," he also said that, "It doesn't include all of the tools that should be in the kit-bag to deal with planning issues." The following statement illustrated this:

> [W]e have to be able to point to a statute that gives us the authority to have the agreement. And we don't have that, if you want to call it a 'wetland development agreement' for example, we do not have that authority. We have the authority for a site plan agreement and in that we can deal with drainage and grading aspects . . .. The provision in the by-law talked about the negative effect or adverse effect on surrounding groundwater and the provisions in the site plan control by-law could do about as much as was possible under the Planning Act to ensure that they had the ability to have it shut down. (LGO-4, 2000)

[10] Case record #7 (see Appendix Five).

With this in mind, the bylaw amendment was crafted with verbiage that linked the CTW to a site plan agreement and allowed the CTW and included the maximum control over the CTW possible under the Ontario Planning Act.

The planner from the UTRCA suggested that although the "Provincial Planning Act is a very rigid document" it was not the intent of the Planning Act administrators to squash innovation and that they intended some interpretation and that plans are not "Cast in stone" and are made to be amended (CAO-15, 2001). He said that "You can be flexible, you can get the flexibility that is needed to deal with innovative new technology" and that, "Flexibility is in there, the decision making has been driven right down to the municipal level and these people can look at this thing and they can make a decision that will allow this innovative technology to come into place".

Provincial regulators: From the MOEE's perspective, strict regulations allow the maximum amount of control from an environment and health perspective, but may also constrain innovation. One informant from the MOEE suggested that the Ministry is most comfortable when innovations "Start small and go in steps and test and monitor, and have available a fall-back plan" (PGO-7-Anonymous, 2001). He suggested that for the most part, the MOEE has managed their concerns of liability through attaching strict "Terms and conditions to innovative projects" which means in some cases that "It just won't work or it is going to cost so much that it's not worth it so we go back to systems that are familiar" (PGO-7-Anonymous, 2001).

Most proponents of the CTWs were generally sympathetic to concerns of MOEE officials and admitted that their caution was justifiable to a degree. In reference to the caution that the MOEE tends to display, one wetland technologist suggested that the concern is valid. He said that they are responsible as public agents and that "If they are uncomfortable about the process and say, 'OK go ahead an do this' and if there is a future environmental problem as a result, then they get the flack for it. So I think that some of their concerns are wholly justified" (EAC-34, 2001). However, there was also concern that excessive caution and the reticence of the MOEE to grant approvals for the CTW technology, has acted to impede advances in the CTW technology. Several informants believed that caution and concern with liability would increase after the events of Walkerton and that this may constrain decisions to utilise innovative technology. One environmental health official said that with regard to the MOEE position that: "Their job . . . has become even more pronounced after Walkerton to protect the environment and public health. So they are less willing to give it a try if there is any chance of it causing a problem" (LGO-10, 2001). An UTRCA official also expressed concern that innovation might be constrained after Walkerton. He suggested that the water scare might increase corporate fear of liability, which would complicate future efforts to apply innovative solutions for wastewater management (CAO-15, 2001).

Project Legitimacy and Support

Local regulators: The support and legitimacy that the UTRCA offered the project were seen by several informants as being essential for the project to gain the necessary approvals. Several agencies ranging from the local health department to the municipal planning department admitted an increased level of comfort and confidence in the project because of the involvement of the UTRCA. The UTRCA had consistently made efforts to develop alternative wastewater treatment technologies that balanced innovation with science. This assisted in building their credibility and acted to legitimise the CTW technology. As one UTRCA official explained: "From a technical or engineering sense, you have to have the science there or you will not get the support from . . . regulatory bodies" (CAO-1, 2000). He said that by "Helping to monitor and maintain . . . we are taking some of the risk on our shoulders" and that this sharing of responsibility increased the willingness of various partners to collaborate during the French Case (CAO-1, 2001).

The level of confidence that the UTRCA had in their CTW design was unambiguous. The UTRCA had full confidence in the safeguards that were implemented to prevent environmental impacts over the long-term. In a letter to the planning department, one UTRCA official wrote:

> [T]he Conservation Authority is satisfied that the zoning for the wetland can be upgraded from temporary to permanent. We are satisfied that there is sufficient environmental legislation, such as the Environmental Protection Act, to require decommissioning or repair of the wetland system if it begins to fail. (case record)[11]

The UTRCA also collected monitoring data during the project that they considered highly acceptable. One official summarised the UTRCA's comfort with water quality results[12] that they had been collecting over a three-year period: "We were getting tremendous reductions in bacteria and phosphorus to the point that we would be comfortable with that going out to the drainage ditch. [The water quality parameters] in a lot of cases were lower than what [actually existed] in the ditch. So, from our perspective it was a huge improvement (CAO-16, 2001).

---

[11] Case Record #8 (see Appendix Five).

[12] Case record #9 (see Appendix Five). Sample results from the French-Case CTW in July 1995 were comparable to 1993/94 data. Consistent reductions of E. coli bacteria occurred of more than 99 percent, concentrations close to meeting the Ministry's guideline for recreational water quality.

The municipal planning department was cautious during the French Case because they considered the CTW "Something new" and they needed assurance that the project was environmentally sound and that its technical feasibility was supported by agencies such as the UTRCA, before encouraging municipal politicians to buy into it (LGO-4, 2000). The council's level of comfort with the CTW was secured once provisions such as the minimum-monitoring schedule, which was designed through collaboration between the UTRCA and the Perth County Planning Office was implemented. The schedule stipulated the sampling of surface and groundwater in addition to ongoing visual inspections of the CTW's physical integrity (case record)[13] in order to ensure protection of the environment. The township Reeve said: "We felt safe that we had guards and controls in place," and that there was a level of assurance that the CTW system was "Doing what it was supposed to do" (LGO-5, 2001). He said that they approached the prospect of approving a technology without a proven track record quite "Cautiously". He reflected that there was uncertainty in relation to approving the technology and said that they "Were cautiously supportive at the outset". He explained that "Human nature," and, "Suspicion" were factors affecting the council's decision to approve the CTW. He explained further the origins of this uncertainty:

> A municipal body that governs regulations is subject to an overview. Any person in the province of Ontario can appeal and that certainly is a consideration. Every time a local government strikes off on a different direction, he has that in the back of his mind and it's a lot simpler to go the established route . . .. The higher up you go, the less personal you are, the more general you are and the higher up in the senior levels of government, the more resistance to change there is. (LGO-5, 2001)

The planning office was more willing to encourage the municipality to approve the project when support from other agencies existed. This gave them confidence that the liability of the municipality could be protected and that the risks of adverse impacts on surface and groundwater could be minimised. The Director of Planning believed that collaboration between the UTRCA and the MOEE offered his office and the council an extended level of comfort in the project: "I know that the councillors had a better comfort level because of the quote/unquote expertise, that came from the UTRCA and the fact [that there was] collaborat[ion] with the MOEE" (LGO-4, 2000).

[13] Case record #10 (see Appendix Five)

Provincial regulators: Although the MOEE supported the French Case demonstration under the CURB program, they engaged in the project with a "Cautious approach", never fully endorsing the CTW as a legitimate alternative (PGO-7-Anonymous, 2001). One written memorandum from the MOEE to the municipal planning office displayed hesitance in endorsing the CTW technology. There were several issues that were seen as not being addressed (mainly insufficient hydraulic capacity). The letter said in part: "The jury remains out. More time is needed to operate, monitor and re-engineer these facilities in order to fully determine their advantages and disadvantages" (case record)[14].

However, some MOEE officials openly supported the CTW as a viable wastewater treatment option. One informant suggested that the MOEE probably did not focus enough resources or effort to validate the efficiency and total performance of the CTW technology and that they should have engaged in more testing to fully determine its potential under CURB. He said: "One of the things that worried us a bit, was that we were not taking it seriously enough to really force the technology to prove itself. I think that it would take a lot more, unfortunately, than what was done [under the CURB program]" (PGO-Anonymous, 2001).

The limited endorsement by the MOEE of the CTW in the French Case was consistent with reports from other informants who were knowledgeable about the history of CTW in Ontario. One wetland engineer said that it has been a Catch-22 up until this time, and the MOEE's reluctance to support CTWs for domestic sewage and agricultural manure management has prevented the collection of data that would have previously established its applicability (EAC-25, 2001). Another engineering consultant agreed and suggested that in order to gain the MOEE's endorsement of CTWs, their performance will have to be validated through continued data collection (EAC-30, 2001). And another informant suggested that with a history of innovation in CTWs dating from the early 1980's and the Listowel Marsh Project, the issue of where CTWs are and are not appropriate should have been resolved and would have been, "Had the resistance not been so strong from the MOEE in the past" (PGO-33, 2001). However, one wetland engineer said that things are changing rapidly at this time and that the MOEE is more willing to consider CTW systems more seriously now (EAC-25, 2001).

---

[14] Case record #11 (see Appendix Five).

Although OMAFRA's involvement was peripheral in relation to the French Case, they did make formal comment on the project and expressed their cautious enthusiasm with regard to the 'potential' use of CTW in agriculture (case record)[15]. It was suggested that OMAFRA considered the CTW a potential option for managing agricultural manure, but were waiting for the MOEE to take a stand on the acceptability of the technology one way or another. One MOEE official recalled his belief that OMAFRA was frustrated with the MOEE's full support for the CTW technology:

> OMAFRA has always been generally supportive of the idea and they have been one of our greatest critics as to why we don't take a position one way or the other. . . .I think they see CTWs and things like grass filter strips as being so much better than doing nothing and that we shouldn't be discouraging these potential solutions. I think they have been frustrated too that we haven't formally acknowledged these alternatives. (PGO-6, 2001)

However, OMAFRA officials also exhibited caution and suggested that continued monitoring is essential to generate conclusive results. Some OMAFRA officials were hopeful that CTWs would become a practical solution for barnyard runoff (PGO-8-Anonymous, 2001; PGO-9-Anonymous, 2001). However, one of these officials was also under the impression that more evidence supporting the CTWs is still required (PGO-8-Anonymous, 2001). He suggested that it has always been easier to implement conventional options because approval guidelines were established to conform to these options and are not application to options such as CTWs:

> The one challenge is that you've got to have quick and easy rules. If you're going to build a run-off tank, they phone me up and we look at this little software program about five clicks and we have the design and a print out saying, if you do this you meet the requirements. (PGO-8-Anonymous, 2001)

Project Approval

Proponents, and ultimately, the municipality viewed the CTW in the French Case as a safe and dependable wastewater treatment option. However, the farm owner believed that the municipality had delayed his project in an effort to provoke him into abandoning his interest in the project (OOP-2, 2000). Another proponent felt that the approvals process was generally a "Hassle" and suggested that even if a novel technology was environmentally friendly, most farmers would give up and continue polluting because you have to "Fight to do things better" (OOP-3, 2001).

Local regulators: In reference to the farm owner's request to gain municipal approval for the CTW technology, one UTRCA official said that there is "No doubt that the municipality . . . was his

[15] Case records #12 (see Appendix Five).

biggest challenge at the time" (CAO-1, 2000). However, the planner from the UTRCA was sympathetic to the challenge that the municipality faced in attempting to approve the CTW under the official plan and said that having safeguards in place was essential to "Control how they could go in and fix it . . . and also to ensure that there was some ongoing monitoring" (CAO-15, 2001).

In 1992, the municipality passed a temporary zoning bylaw allowing the CTW to operate for a period of three years (case record)[16]. After the project had operated for that period, the farm owner made application to the planning department for an exception to the existing zoning (Agricultural Zone: A-1), which would allow the CTW to receive permanent zoning. The temporary zoning was a cautious move by the authorities and it gave them the ability to close the project if ground and surface water impacts were detected. In addition, this also gave the farm owner the ability to close the project if he was not satisfied with the CTW. The permanent bylaw amendment was applied for and granted in 1996. This did not change the zone classification, but permitted a "Constructed wetland on the subject property for the purpose of collecting and treating barnyard run-off" (case record[17]). One of the reasons that the permanent bylaw was approved was because the UTRCA had been able to assure the municipality that there were no adverse impacts to the environment from the operation of the system and that there were adequate safeguards and contingencies in place to prevent ongoing impacts (case record)[18].

Provincial government: The issue regarding a Certificate of Approval was a very contentious issue that arose during the implementation of the CTW in the French Case. One UTRCA official recalled that things got "Tricky" when the issue of the certificate of approval arose and the MOEE "Started to back-pedal" in relation to the project and was not forthcoming in determining water quality parameters that would have to be met in order for a Certificate of Approval to be granted (CAO-16, 2001). The officials from the MOEE were not comfortable with the long-term operational ability of the CTW to meet acceptable water quality criteria parameters and rejected the farm owner's request for a Certificate of Approval, which would have allowed periodic discharges to the municipal drainage ditch[19]. The MOEE never formally specified the effluent quality criteria that

[16] Case record #13 (see Appendix Five).
[17] Case record #14 (see Appendix Five)
[18] Case record #8 (see Appendix Five).
[19] An estimated 5% hydraulic overflow has been observed from the 1,324,894 Litre capacity CTW during periods of high precipitation. The Ministry would not grant a Certificate of Approval for this overflow and requested the overflow be reduced to zero (Reid, 1995).

they would require for a Certificate of Approval to be issued and would not allow the system to discharge to the municipal drainage ditch. One UTRCA official described the situation as follows:

> Then it got to the tricky point where: 'are Certificate Approvals required for these or not?' Then it was kind of like they were putting the kibosh on the whole thing. And we had a real problem because we could not get a real firm answer on what was required and our project was already on the ground by that point. The final word from the Ministry was that there was to be no effluent from these systems and that is how they solved this problem and because there would be no effluent, there would be no Certificate of Approval required and they would not have to make a decision on what water quality parameters were required. (CAO-16, 2001)

The MOEE has expressed their reluctance to grant Certificate of Approval for CTWs because of their "Limited control ability" (MOEE 1998). The MOEE position paper states that, they are "Reluctant to [impose] any legally enforceable non-compliance values on a treatment system where the process control ability is limited" (MOEE 1998). One official from the UTRCA believed that the reluctance of the MOEE to grant a Certificate of Approval was a precaution related to their uncertainty with how to monitor the CTW project over the long-term (CAO-16, 2001).

There was also concern that restrictions placed on natural wastewater treatment technology like CTWs has resulted from a traditional engineering mentality that is thought to be pervasive with engineers in the MOEE (PGO-33, 2001). At present the MOEE approves alternative treatment systems based on "Accepted wastewater treatment principles, relevant data, technical literature and Ministry experience" (MOEE 1998). There was concern from informants with the MOEE's inability to recognise that CTW technologies require unique operation and management considerations and that it is unrealistic to require the same operational parameters and management protocols for natural systems that are required for conventional systems. One informant said: "You have to manage marshes like a living marsh and that requires a different mindset . . ." and that:

> [It's not possible to] throw an operator in and say, 'turn this dial…' it's not a machine and we have to think differently. That is the limitation . . . one that the present culture of wastewater treatment doesn't easily adapt to. (PGO-33, 2001)

Regulatory engineers expect CTW to operate like machines because they consider mechanised options to be more predictable and provide a higher level of certainty and consistency with regard to effluent quality criteria. This is exemplified in the MOEE position on CTWs that characterises them as having "Limited process control ability" and are viewed as suspect in terms of their operational abilities (MOEE 1998). One wetland technologist gave the example of how restrictive the preference of the MOEE can be when they review natural technology against the same criteria used to review conventional options where the process can be manipulated through mechanisation, electrical inputs and the addition of chemical agents (EAC-34, 2001). This technologist believes that there is sufficient data supporting the use of CTW in a variety of conditions at this time and the extreme caution of the regulators has impeded the technology. He suggests that the CTW technology is not dissimilar to the design of conventional options and that an improved understanding of the optimal design for CTW will, in fact, allow a level of control and standardisation similar to that achieved with conventional options:

> [T]he only difference between systems is the footprint. And when you think about a conventional system, if your BOD loading is 100 mg/L you're going to need a blower that is size X. If your input BOD is 300 mg/L you're going to need a blower that is sized 3X. And it is the same type of thing with wetlands, it's not a direct relationship and it isn't dealing with blowers, but as the load increases, you increase something to try and compensate for that. The same sort of thing happens in a treatment wetland, you look at all the different parameters that are coming into the system and say, 'well these are actually going to determine how large we actually make this thing'. So I guess the point here is that the systems are not really that different, and other than the aesthetic potential, you can standardise them. (EAC-34, 2001)

One wetland biologist admitted that there were critical periods during the year when the chemical regime in a CTW can change (*e.g.* low oxygen conditions) and they must be cautiously operated during these periods (PGO-33, 2001). He said that these operational conditions are "Not so much a disadvantage as it is a limitation" and that there are periods requiring caution and different management protocols from a mechanical system where more control may be possible.

Implementation Setting

Incentives and Disincentives

Cost: The farm owner in the French Case preferred the CTW because the capital costs were much lower than the conventional option and the system's operational costs lower over the long-term. The UTRCA officials considered the lower cost of the CTW to be a potential entry point for the technology into the market. One UTRCA official said that the farm owner "Was definitely attracted [to]," and, "Profoundly aware of the economics", which favoured the CTW as an option (CAO-15, 2001). Another UTRCA official suggested that the CTW was a sensible alternative when the profit margins of a small size operation such as the French Case are considered versus the cost of a conventional option (CAO-16, 2001).

From the perspective of the UTRCA, one official noted: "The solutions don't have to be the standard, high dollars, highly engineered solutions" and this contributes to the interest that has been shown by farm owners in the CTW technology (CAO-15, 2001). The farm owner in the French Case rejected the conventional option on several counts. Foremost, however, he equated lower costs with the CTW. The farm owner considered the conventional option a liability and estimated that it would cost in the range of $50,000-70,000 (seven to nine times more than the cost of the CTW), which did not include the annual cost to operate and maintain the system (*e.g.* electrical inputs).

In terms of costs, one wetland technologist suggested that the cost of the CTW option is very much linked to the availability and cost of land (EAC-34, 2001). He believes that, given that land is available, the CTW will out-perform the conventional option "Hands down" in terms of long-term nutrient removal when the capital expenditures, chemical and energy inputs are taken into account. Cost was an important factor in relation to the CTW technology. One official from the Grand River Conservation Authority (GRCA) said that: "Cost is going to be a big factor. If they're more expensive than conventional storage tanks, or if the consulting fees for the CTW are high or the compliance is extreme, then it's not going to be an adopted practice", but that:

> Obviously there is going to be an adoption curve. There's a lot of interest, but I think from a farm operator's perspective, they're interested because they think that it's a cheap alternative, a low management alternative and those might not be the reasons why it should be adopted. (CAO-36, 2001)

In terms of the wider user of the CTW technology, officials from the UTRCA hoped that the private sector would take up the technology after the initial efficacy of the technology had been demonstrated. One UTRCA official said that private sector engineering consultants are hesitant to assume alternative technologies because "In a lot of cases . . . there's not enough money to be made" and one essential issue "For the private sector is that it has to be profitable" (CAO-1, 2000).

Local Acceptability: All of the officials from the UTRCA commented on the demand for the CTW technology that was sparked around the time that the CTW in the French Case was implemented (CAO-1, 2000; CAO-16, 2001; CAO-15, 2001). News about the CTW began to spread in the media and through agricultural trade journals and, at one point, there was so much interest from the agricultural community that the UTRCA had to suppress this interest until, as one official described, they "Learned more about it and knew how the regulatory bodies would react over the long-term" (CAO-1, 2000).

One engineer believed that the marketing campaigns for the CTW technology have not been initiated and that this has limited the dissemination of knowledge regarding these systems: "People do not know about [CTWs] because there is nobody out there marketing and pushing them" (EAC-30, 2001). One Perth County Health Department official echoed this by stating that still more research is required to be able to make claims regarding performance to which the market will respond, and so that "People know when they buy, that this is what I'm going to get out of it and the research and the science can determine the effluent quality that will be generated (LGO-10, 2001). One UTRCA official suggested that wastewater treatment technologies that conform to standard specifications and can perform and operate within known parameters are obviously more favourable to planning and engineering consultants because their limitations can be established within the current approval and regulatory framework (CAO-15, 2001).

Another engineer believed that there has been no concerted effort to market the CTW technology up until this time because private consultants know that the MOEE has not generally supported the CTW technology and it would not make economic sense to try and enter the market at this time (EAC-30, 2001). He also believed that, although the technology may offer desirable benefits to some clients, very few wastewater consultants would adopt these alternatives because there is an impression that regulators frown on CTWs. In summary, he described engineers as "Conservative" and that they would generally resist pushing the envelope too far: "[It's] O.K. to be a pioneer [but the] pioneers take the arrows". An UTRCA official echoed this to some degree in suggesting that the CTW innovation is simply not well known at this time, which has restricted its use (CAO-15, 2001). He said that even though a client may want an innovation, "The downside of innovation is that you need to be able to find somebody to do the design for you". There is not a lot of market interest in the CTW at this time, which can be attributed to "Lack of exposure to the technology, as untested as it is," and the fact that "You can't go and buy canned plans off of the shelf for a wetland" (CAO-15, 2001). One business owner who was interviewed in the agricultural sector reflected this very problem. Although he was ready to adopt the CTW technology to manage his wastewater, he could not find a supplier to implement the system during the late 1990s (OOP-13, 2001). However, by early 2002 things had changed and he had found a consultant who could construct a CTW to manage his wastewater generated from agricultural manure (OOP-13, 2002).

Operation and Management

User Acceptance: A significant theme that has emerged during the investigation was the importance placed on the fit between the CTW technology and the operation and management of any particular farming operation. Several interviewees revealed that it was an essential precondition that farm owners exhibited full commitment to integrate the CTW into their farm management practices in terms of operating and maintaining the CTW:

> If they require more time or specialised operation then it is not going to work for the average livestock farm. If the management of the systems is complicated and something that will fit within their framework then this is another reason that it will not work. I think that it may suit some operators and not others. (CAO-36, 2001)

In the French Case, the farm owner was active in suggesting design elements during the design phase and the UTRCA consistently solicited his input during the implementation. One example was his request to have wider berms installed than were originally planned. This was a pragmatic request since he wanted the ability to back his tractor onto the wetland channels to cut the grass as necessary. One UTRCA official said, that in the French Case, the owner had "Become very dependent on the technology" and that it would be an extreme inconvenience if the system were to close down for any reason (CAO-15, 2001). In the French Case, the farm owner was fully committed to the CTW that he had adopted. Several interviewees revealed that his project was a success because he made every attempt to operate and manage the system with extreme diligence (PGO-6, 2001; CAO-16, 2001; LGO-4, 2001; CAO-36, 2001).

An official from the GRCA, also located in southern Ontario, revealed that they currently had plans to implement an experimental CTW within their jurisdiction. She felt that key factors related to the success of CTW would depend on design level issues affecting ongoing operation and management (CAO-36, 2001). She also suggested that cost and the level of commitment required from the operator were essential elements that would affect the success of the system.

One UTRCA official noted that some situations beg for conventional wastewater treatment systems and others are appropriate for alternative options (CAO-15, 2001). In the French Case, one pre-condition was the geo-physical nature of the region and the clay hardpan underlying the area, which acted to seal the base of the wetland making it impermeable and sound in terms of protecting the underlying aquifer. This allowed the CTW in the French Case to be constructed without trucking in clay or using an artificial liner, which would have increased the cost. Additionally, the barnyard in the French Case was well suited for the passive design of the CTW because it sloped towards the area where the CTW was constructed. These factors combined to decrease the overall cost of the implementation.

It was also very important to the farm owner to design a wastewater management technology that was passive and low-input. The farm owner insisted that he wanted to work with nature and not against it and said: "Let's harness nature. Let's not fight against it. It's costing them a lot of money to fight against nature and let's use nature to help us" (OOP-2, 2000). Officials from the UTRCA were also aware of the benefits that a low-input system offered. One UTRCA official was quoted in a local newspaper stating that "It's a really popular concept, both from cost and from the concept that we're not engineering our way out of the problem but we're creating a natural process that will treat the problem" (Shyplla 1994: 9).

Generally, it was believed that alternatives such as the CTW had to be simple, practical and fit the needs of the operator. One informant official from the GRCA suggested that even an ecotechnology with a higher level of complexity would not be appropriate (CAO-36, 2001). Any hints of increased operation and maintenance in the CTWs were expected to reduce adoption by potential users. One health official said: "What you want to do for the farmers is that you want to keep it simple, keep it inexpensive" (LGO-10, 2001). An MOEE official was under the impression that several of the wetlands implemented under the CURB program were not well managed and that:

> [T]here was a certain reliance on the farmer himself to maintain and do things and if that fell apart, consistent treatment tended to fall apart. I don't know for sure, but it is my feeling that the implementation [at the French Farm] was perhaps the most consistent. And the impression I had was that some of the frustrations, physical and otherwise, of the other [CURB] systems proved too much for some of the other co-operators. (PGO-6, 2001)

There was evidence that other CTWs implemented under the CURB program - through different conservation authorities - were problematic in terms of their ongoing operation and management, and that this ultimately led to their abandonment. Another UTRCA official described how important the perspective of the landowner is regarding the implementation of a CTW:

> [T]he owner wanted something that didn't look like square marshes, he wanted something that was meandering; something that has some irregular form to it. A lot of the farmers wouldn't be interested in that, but he was. So, it has a lot to do with personal perspective as well. (CAO-16, 2001)

Required Expertise: The official from the GRCA suggested that the CTW demanded a considerable amount of expertise in a conservation authority like hers was going to promote them as a management practice for farms. She said that her conservation authority would not, for instance, have the knowledge or resources to assist farm owners with the implementation of CTWs at this point: ". . . Anything that is going to fit into our toolbox, in terms of a best management practice, has to be easy for us and the landowner to implement and for a contractor to get out there and say that it is going to work, and that you will get this type of efficiency from X, Y and Z" (CAO-36, 2001). She said that the GRCA does not encourage CTWs because there is not enough information regarding their effectiveness and, from her perspective, CTWs are still in the research phase. It was her impression that without the endorsement of multiple regulatory groups CTWs will continue to be deterred as a rural agricultural manure management option (CAO-36, 2001). However, the wetland engineer from the UTRCA was confident with the level of operational confidence with which the CTW technology could be designed at this time and said:

> I think we have some really good information. I don't think we necessarily have a manual where you can just fill in the blanks and multiply X times Y type thing to get your answer, but we're very close to that so we know that if we start with water quality that is a certain quality we can achieve certain objectives by doing certain things. (CAO-1, 2000)

One MOEE official also commented that if the system is "Difficult or expensive" in terms of its operation and maintenance that this is a factor that will affect the success of the system (PGO-39-Anonymous, 2001).

Resource Recovery

Resource recovery was not a stated objective during the French Case. Although no wastewater is reused, the farm owner does graze sheep between the berms of the CTW. This practice maintains the length of the grass and decreases the frequency that the grass has to be cut by tractor.

The following section presents the analysis of the Luckhart Case.

4.2 Luckhart Transport Case Study

Project Description

Establishment: Livestock Transporting Business (Sebringville, Ontario).

Total Land Size: 5.7 hectares.

Description of Treatment System: Surface flow CTW to treat truck trailer washing water generated from a livestock trailer washing facility serving an 18-truck fleet.

Construction Motive: A voluntary initiative by the business owner during the 1996 relocation and expansion of the business to implement a CTW for truck-trailer washing. The objective of the UTRCA was to "[initiate] . . . an experimental project to determine the practicality and treatment effectiveness of using a created marsh system to treat manure runoff" (case record)[20].

Year Constructed: 1996 (continuous operation through 2003).

Design: Wastewater is pre-collected in the wash bay and flows to a grated collection outlet where grits; small debris and oil are intercepted in an oil and grit filter. Wastewater flows by gravity to the detention pond, which has a hydraulic detention capacity of 865 m^3. From April to September when the wetland is fully active, wastewater is pumped alternately to one of two 300 m^2 wetland cells (10 m wide and 30 m long) at a rate of 6.5 m^3/wastewater/day. The combined two-cell hydraulic capacity of the wetland is 200 m^3. The retention time is seven days or greater depending on precipitation. Wastewater flows into a 168 m^2 vegetated filter strip at the distant end of the CTW. The vegetated filter strip is 12 m wide and 114 m long with a 0.007 gradient and acts to remove excess phosphorus and offers space for infiltration (UTRCA 1996; Glasman and Jeffery 1997).

Spatial Requirements: The detention pond and wetland areas occupy approximately 0.24 – 0.30 hectares. The total size of the system including grassy filter strip is approximately 0.61 hectares. In total, approximately 1.6 hectares of land were taken out of production to incorporate the CTW into the layout of the site (UTRCA n.d.).

Operational Capacity: Wastewater is produced at a rate of 3.1 m^3/day. The wetland is active six-months per year and 6.5 cubic metres of wastewater are treated per day during the active (*i.e.* the growth) phase of the wetland (April to September), which effectively results in a zero balance of wastewater.

Cost: Approximately $40,000 in addition to monitoring costs of $20,000 over four years (Greene 1996; Reid 1996).

Funding Partners: Business owner and an innovation grant of $15,000 provided by the National Research Council of Canada (Industrial Research Assistance Program).

[20] Case record #15 (see Appendix Five).

Contingencies: The contingency for wastewater treatment consists of the primary detention lagoon, which affords a six-month or 200 m^3 wastewater capacity. The land-base to spread wastewater is also available if necessary.

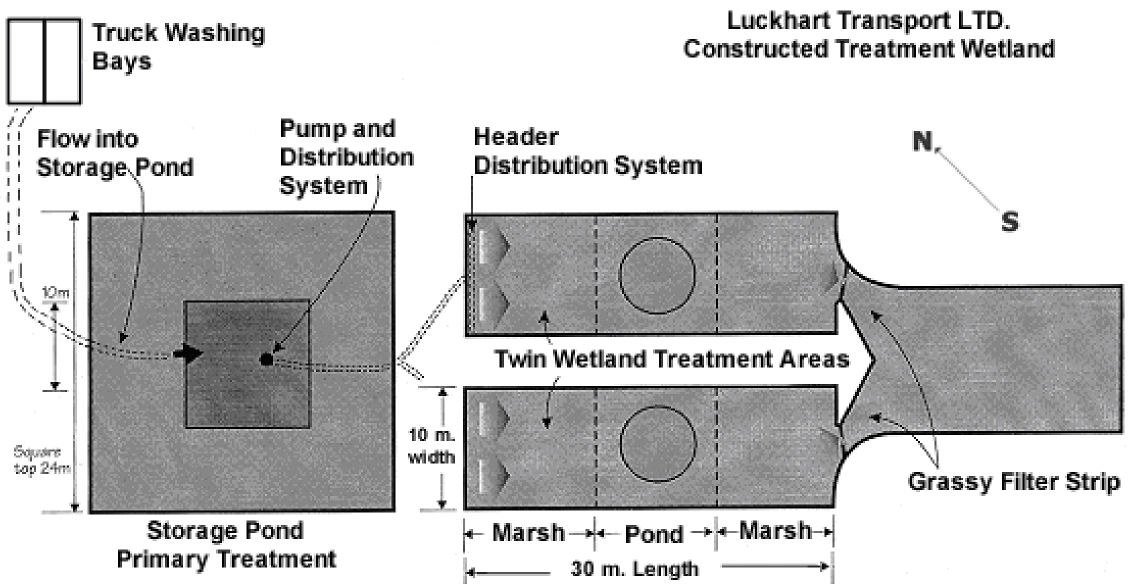


Figure 4-7. Luckhart Transport: Schematic of constructed treatment wetland.
Source: Upper Thames River Conservation Authority (1992).


Figure 4-8. Truck washing bays (background).

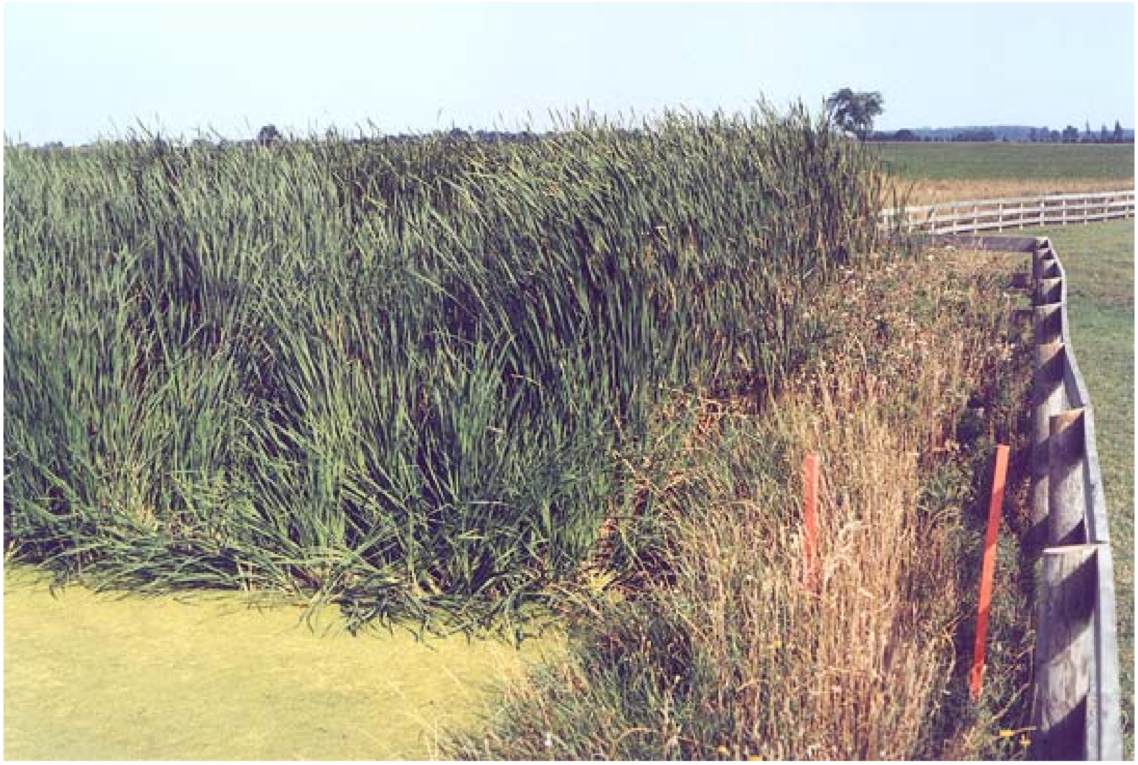


Figure 4-9. Constructed treatment wetland pond and marsh (background).

Figure 4-10. Constructed treatment wetland and trailer yard (background).

Figure 4-11. Constructed treatment wetland and grassy filter (background).

Background:

In the Luckhart Case, the conventional option that was appropriate for this site consisted of liquid storage tank and land-spreading of wastewater when permitted by environmental conditions. The spreading of wastewater in the Luckhart Case was a viable option because the business owned or had access to an adequate land base. Two scenarios for the conventional liquid storage tank were considered. The first was a large detention tank where spreading would be necessitated two or three times per year and the second was a smaller detention tank where spreading would be required more frequently. The trucking business owner ultimately selected the CTW over the conventional option even though the short-term cost was expected to be greater than that of the conventional option.

Stakeholder Attitudes

Adoption Motives

The owner in the Luckhart Case considered himself a steward of the local environment and was concerned about protecting Black Creek, which ran adjacent to his property. In terms of his reasons for adopting the CTW technology, the business owner said: “My brother [who is partial owner of the company] and I are environmentally conscious people. This was the right thing to do. We aren’t just storing the problem: we're solving it" (OOP-12, 2000). The business owner was well known in the community and was known to be concerned with the local environment. The Director of Planning in the county described him as being, "Very conscientious and very environmentally concerned" (LGO-4, 2001). Another informant went on to suggest that business owners that have a "Strong environmental ethic" would be more prone to use this type of technology (EAC-30, 2001).

The business owner, Mr. Luckhart, also recognised the relationship between environment and business, which he expressed by stating, "I'm really into trucks and I'm really into nature" (OOP-12, 2000). The owner was motivated by his goal to be seen as an environmentally conscious business. Other stakeholders also expressed their belief in his concern related to protection of the environment. One official from the UTRCA said that protecting the environment was important to the owner because he grew up in the area and having a clean stream running through his property was a motivating factor (CAO-16, 2001). Another UTRCA official said that the owner of the business was profoundly aware of his location right next to Black Creek and that his motivation "Certainly" arose out of concern for the environmental (CAO -15, 2001).

The business owner in the Luckhart Case was conscious that the trucking industry had gained a reputation as an environmental polluter and he wanted to change that image both inside and outside the community where the business was located (Reid 1996). He said: "We know that we are polluters. We're taking good water and polluting it. We know we're putting exhaust in the air. We know that we're using oil. We know we're polluting" (OOP-12, 2000). It was also evident that the owner felt he could gain a competitive advantage from 'greening' his business and he wanted to attempt to capture business based on an environmentally friendly reputation. In terms of the owner's motivation to apply the CTW, one UTRCA official said:

> [I]f he was motivated by anything, it's my perception that he was probably motivated by the industry, the concept that the industry could certainly be perceived as being dirty by washing pig manure out and just letting it [enter the stream]. So, whether he did it because he personally believes that he should protect Black Creek or he did it because he thought he would be forced ultimately to protect Black Creek. I believe he did it partly because of his personal interests [and also because] he also fancies himself as being innovative. (CAO-15, 2001)

During the planning stages of the business expansion, the owner realised that the conventional option for wastewater treatment did not fit into his vision of how an environmentally friendly company should manage their wastes. When the owner became aware of the CTW that had been established to treat barnyard runoff at a local dairy operation (*i.e.* the French Case) the concept appealed to him. He then made inquiries about using the CTW technology to treat his truck-washing water and pursued implementing the technology with his business expansion. An official from the UTRCA said:

> I really think that he is interested in being more than just some trucking company . . . and that he's just trying to show it. He views himself as more than just the standard template, he wants to do more and this was a way to do something interesting, to give something back and also to be able to answer the critics because there are critics of washing the trucks. So he needed to be able to answer to that and this was his response. (CAO-15, 2001)

The wetland engineer from the UTRCA felt that the owner's decision to implement the technology was a "Progressive," decision because "It was money that he spent, which he didn't really have to" (CAO-1, 2000).

Technology Preference

In terms of technology preference, the business owner in the Luckhart Case was not interested in trucking his wastewater off-site or in adopting a standard liquid wastewater detention system that would require storage and land-spreading. The owner preferred to treat his wastewater onsite and the CTW allowed him to meet this objective. He said: "Well you know, this is the way I look at things and maybe it's just a unique kind of way. You can store a problem or you can solve the problem" (OOP-12, 2000). He made it clear that the conventional option was not what he envisioned as environmentally sound. An UTRCA official recalled him being adamant during the planning stages that he was not going to store his wastewater above ground or put in a big cement storage tank (CAO-1, 2001).

The planner from the UTRCA recalled the owner's concerns, stating: "[He was] interested in a treatment component and not just spreading, and that's where the whole idea for something innovative [came] in" (CAO-15, 2001). Additionally, the business owner had a high level of confidence that the CTW would be able to meet his needs and would be a success. One UTRCA official explained that the business owner was confident that a natural system was capable of treating his wastewater better than a conventional option. In the Luckhart Case, the business owner had a clear and practical idea regarding how he wanted to manage the wastewater generated from the truck washing facility. The owner was quoted in a trade journal as saying that: "Not everything has to be so technical," and that "Mother Nature can do it with a bit of help" (Greene 1997: 49). An UTRCA official said that "Business owners and farmers are similar in nature in that they want wastewater management solutions that are practical and cost effective" and the CTW satisfied both of these criteria (CAO-1, 2001). A funding agent from the National Research Council of Canada (NRC) recalled that "He had looked at the engineering approach to the treatment of effluent and it was expensive and, perhaps, unnecessary" (OOP-14, 2000). Another UTRCA official recalled that the business owner had said "That he would much rather see a wetland with marsh vegetation than a concrete tank. It was partly aesthetics" (CAO-16, 2001).

Institutional Attitudes

Local regulators: This was the second CTW for agricultural manure management that the UTRCA had designed. Between the implementation of the CTWs in the French Case and Luckhart Case, considerable interest had been shown by local agricultural operators in the technology. One UTRCA biologist described how important it was to have interest by local agricultural operators who are willing to come forward and try innovative solutions to environmental problems. She said that:

> [W]e're seeing a lot of people coming out and stepping forward to try things because they have a real environmental ethic that is really driving them. It's very interesting to work with people who want to try these new technologies because they're a real key part of getting new technologies to work. (CAO-16, 2001)

The CTW in the Luckhart Case was a different design than that in the French Case and the UTRCA was somewhat uncertain with how it would function; however, the UTRCA's monitoring of the CTW generated evidence that it was functioning as expected. One informant from the UTRCA said: "To give you an example, with Luckhart's, the typical number of faecal streptococci coming into the system was a million bacteria, for instance, and at the end of the marsh we were down to a matter of a few hundred. Which to me is tremendous; and then we have the filter strip [for further treatment] beyond that, so I am very, very excited with the numbers" (CAO-1, 2001). Referring to the owner in the Luckhart Case, UTRCA's planner said that, "We fancy ourselves as being on the leading edge of technology and here's [Luckhart] who wants to do something fairly innovative" (CAO-15, 2001). In terms of the UTRCA's objective to develop an innovative technology, the representative from the NRC suggested that if things had been different, the conservation authority could have impeded the innovation and acted as an impediment to the project: "The UTRCA had a dual role [as a regulatory authority and as an innovator]. If they wanted to exert their authority because of caution, they could have been an obstacle" (OOP-14, 2000).

Local government officials in the Luckhart Case were much less cautious regarding the CTW than they had been during the French Case because they were now familiar with the CTW after a precedent had been established. In the Luckhart Case, the council members displayed only minimal opposition to approve the project and were confident that the UTRCA was capable of implementing the CTW and preventing impacts to the environment and health. The township and the UTRCA acted as the key authorities permitting the project and the MOEE were only peripherally involved in this case study (CAO-12- 2000).

Provincial regulators: The MOEE was involved minimally during the implementation of the CTW in the Luckhart Case. One UTRCA informant described this period, which was just prior to the Services Improvement Act of 1997 coming into power[21], stating, that the MOEE was increasing relying on local municipal governments and conservation authorities. He said that, "It was kind of a transition period where the MOEE was downsizing tremendously and they were putting a lot of load on local municipalities (CAO-1-001). For the most part, it appeared that the MOEE has become confident with the ability of the UTRCA to design and build the CTW technology. The MOEE suggested minimal design guidelines, but for the most part, deferred to the UTRCA during the Luckhart Case, which was a significant change from the French Case. Regarding the involvement of the MOEE in the Luckhart Case, one UTRCA official said:

> We have had - at a ground level or field-level - very good relationships with every agency including MOEE . . .. They may have listed a few things that they wanted covered as part of the design and construction, but as long as those requirements were met, they had no problems afterward; and any reporting that was required was done and submitted to them. (CAO-1, 2000)

Project Design Activities

Caution and Concerns of Liability

Initially, the business owner in the Luckhart Case had concerns about the CTW because it was innovative and still in the development phase. He said: "The only problem with the wetland at the time was that it wasn't proven; and what if we build it and it doesn't work?" (OOP-12, 2000). However, he also considered himself an innovator and was attracted by the nature of the technology and had confidence in the UTRCA staff and the wetland engineer whom he hired independently to advise him during the project.

Generally, various local level stakeholders including the UTRCA, indicated that the caution and concern that the MOEE had regarding the implementation of CTWs at this stage in the technology's development was justified, in order to protect the integrity of the environment. One UTRCA official said that, "The really long-term future of these systems is not known" (CAO-16, 2001). Another UTRCA official suggested that caution was required to some degree and said: "How well tested are these technologies and if you jump right to it, are you putting time-bombs in place all over the place. So, this gets back to the point, should the regulatory framework promote innovation? Yes. Is it easy? No" (CAO-15, 2001). The UTRCA wetland engineer admitted that regulating accessory technologies to agriculture is no easy task and that there is a risk of impacting both health and environment:

> [W]hen it comes to agriculture, I think that MOEE is a little more reluctant to create those opportunities sometimes than with the other systems that still require engineering involvement or some technical and solid background associated with the product. In agriculture, sometimes an attempt to circumvent those requirements occurs and I'm not sure if MOEE is comfortable with that process. (CAO-1, 2001)

Although the UTRCA had concerns regarding whether the design of the CTW would function as required, they also saw its implementation as a measured risk that was no different from risks that were taken when using conventional wastewater management technologies in agriculture:

> [W]e do a lot of other research type work on agricultural land and we know the impacts that manure can potentially have, I say potentially, and we know that there are risks associated with that. So if we were going to look at a conventional liquid storage tank . . . and land-spreading, we know that there can definitely be some problems associated with that. So, there are risks with anything and it depends how you manage those risks. . . . [T]here are always risk, but I like to think optimistically, that you can always overcome those risks. Different alternatives provide different levels of comfort. (CAO-1, 2001)

In terms of operational safety, the UTRCA had concerns related to the risk to operator health from being exposed to bacterial infection. However, they also felt this could be overcome through changing and improving the CTWs operation procedures as they learned what was required. One official said, "There are some inconsistencies with the operations, that we need to overcome, so the owner needs to be a bit more cautious" (CAO-1, 2001).

---

[21] By 1996 responsibility for sewage works of less than 10, 000 litres/day was transferred to municipal health units: clause 53(6)(c) of the EPA introduced the Services Improvement Act, 1997.

Regarding liability that extended to health and environment, one Perth County Health Department official said that "Many decisions now are based on liability," and if these relatively unproven systems were to discharge into the environment there is no fail-safe method to protect the environment. Another informant believed that, "The MOEE would like to have as many zero-discharge facilities as they can." (EAC-30, 2001). The funding representative from the NRC said that the UTRCA, "Were gaining confidence in the science . . . so they were prepared to take a certain amount of responsibility" (OOP-14, 2000).

Project Legitimacy and Support

Local regulators: The UTRCA had constructive relationships with all the local level government agencies working in association with the implementation in the Luckhart Case. In terms of legitimating individual projects, the UTRCA were viewed as highly credible by municipal officials. The UTRCA's planner suggested that the excellence of their staff is well known and that this has assisted in advancing alternative technology like the CTWs:

> I think that we carry a fairly high credibility with the Perth County politicians. And you have the credibility of [our] engineer, which stands almost apart from the organisation because he's a professional engineer, he's an agricultural engineer and he has a tremendous amount of credibility for the projects he has been involved with. (CAO-15, 2001)

Another UTRCA official believed that the success of the first CTW during the French Case had legitimised the planning and implementation during the Luckhart Case:

> [I]t helped with [the Luckhart Case] that the director of the municipal planning office was familiar with the treatment wetland that was applied in [the French Case] and that he knew what we were doing and that we had worked on wetlands before. He got to know us and that helps with the next systems. You kind of break the ground with the first one and get to know the people and they get to know you and what you can deliver on. (CAO-16, 2001)

Another informant agreed that because the Luckhart Case was the second CTW that they implemented, it was easier to negotiate with local officials. He believed another reason was that the business owner paid for the implementation and that it was not an externally funded project where the owner was soliciting funding. He speculated that having the UTRCA acting more or less as a consultant to implement the CTW made a difference and although there were some hurdles, they were more in the form of "Set-backs" originating from a minimal amount of discomfort from the township council (CAO-1, 2000).

During the Luckhart Case, the municipal planning office had a much higher level of comfort with the implementation of the CTW after their initial involvement in the French Case. This allowed implementation of the CTW to move into permanent zoning at the outset as opposed to a temporary three-year zoning amendment due to the fact that local council had developed a level of comfort and trust in the ability of the UTRCA. The Director of Planning in the municipality commented that the process may even be made easier after the French and Luckhart cases: "If they come in with the 'I's dotted and the 'T's crossed, upfront with all of the science, and are ready to enter into a site-plan agreement that has a monitoring provision, then maybe we can sort of jump-start the process" (LGO-4, 2001).

The municipal planning office had an increased level of comfort with the CTW technology because it was applied under the auspices and expertise of the UTRCA. After the CTW in the French Case was implemented, the technology attracted considerable interest by government officials and members of the agricultural community. This was seen as a factor that facilitated the approval process during the implementation of the CTW in the Luckhart Case. The Director of Planning commented: "I guess what was relied on - in terms of the environmental component - was the fact that it had been developed with the scrutiny of the UTRCA" (LGO-4, 2000). The municipal planning office was not as involved in approving the Luckhart Case as they had been in the French Case. He said: "I don't recall our office being asked to comment on the adequacy of the plan. We certainly didn't have the involvement that we had in the French Case." By this time the UTRCA was seen as a trusted agent capable of implementing the CTW technology.

In the Luckhart Case, the council gave permission for the CTW with no hesitancy. Again, however, it was suggested that the credibility of third party proponents such as the UTRCA and the NRC facilitated the permitting process. The funding partner from the NRC felt the legitimacy of the project was increased because of his and the UTRCA's involvement:

> I think that having NRC, and using us as leverage, was a factor because who would expect a big trucking company to have the NRC even remotely involved. Who would expect them to have a conservation authority on their team? . . .[T]hose kinds of obstacles are mitigated by the credentials of third parties. If you leave a [town] council like that to simply let their fear and concern drive them then they are going to be an obstacle, but if you can give them comfort, if you can mitigate their concern with the credentials of, for instance, NRC, then you mitigate the concern and remove the obstacle. (OOP-14, 2000)

He added that legitimising the project through expert support smoothed the approval process and the local council's willingness to permit the project. He said: "I think that the science is very important and on that, I mean you can go to a textbook for science, but one of the best examples is a tried and true example (OOP-14, 2000).

Project Approval

Local regulators: The approval for the Luckhart Case was mainly led through the municipal planning office, which advised and made recommendations to the township council on how to proceed with permitting the project. For the most part, the business owner was able to negotiate the approval process at the level of the township with very little UTRCA involvement. One official from the UTRCA recalled that Mr. Luckhart "Did a lot of that work himself as far as dealing with the council and the approval process" (CAO-16, 2001). There was no pre-consultation initiated with the township or the county and this was seen as a strategic move by the UTRCA to get the project off the ground. One official said that, "There was no pre-consultation with the township or the county. And I don't know what the county would have told them even if they did a consultation, because the county is going to go, 'oh my God! How does this duck fit into our model? It's not a chicken, it's not a sparrow, it's something different'" (CAO-15, 2001).

The bylaw and zoning requirements associated with the implementation of the CTW in the Luckhart Case were relatively simple. Because the previous property owner had used the land as a cattle lot, feedlot and holding area, "There had been some history of the collection of animals at the site" and the property was zoned ACM-7[22] appropriate to the livestock hauling business (LGO-4, 2000). The township council considered it as an accessory component to the "Agricultural Commercial/Industrial" zoning; therefore, no zoning change was required for the business to implement the CTW. The Director of Planning said that: "There was not hard and fast provision saying that he couldn't collect his waste and deal with the treatment of it. The industrial, agricultural, commercial zoning allows for agro-commercial businesses and accessory components to those businesses (LGO-4, 2000).

The health department had no objection to the CTW and only suggested that monitoring protocols be developed in association with the UTRCA (case record[23]). A health department official

[22] Zone "ACM-7" refers to 'Agricultural Commercial/Industrial' zoning.
[23] Case record #21 (see Appendix Five).

admitted, "We were not involved in design, approval or inspection of that site" (LGO-10, 2001). He suggested that, during this time, the devolution of authority under the 1997 Services Improvement Act was occurring and that there was considerable uncertainty regarding whose responsibility it was to approve and regulate commercial and industrial truck and car washing operations: "Now, under the Building Code, we find that we are dealing with more of these truck wash and car washes mainly because there has been an unwillingness on anyone's part to accept responsibility for that type of waste (LGO-10, 2001).

In relation to approval and long-term operation, one UTRCA official felt that the system implemented in the Luckhart Case was ideal and should facilitate the approval process because there was no effluent – a design element that was required by the MOEE:

> [I]f you can design them so that there is no effluent so that a Certificate of Approval isn't required, then it is a simpler process. For the Luckhart system, where the grassy filter strip is the final stage, as long a you are comfortable that it is not negatively impacting groundwater, then it is ideal because when a Certificate of Approval is required it gets more complicated for all of these small systems. (CAO-16, 2001)

The business owner and the UTRCA acted together to actively publicise the project and highlight the CTW technology to the agricultural community and the town where Luckhart Transport is located. For instance, an opening ceremony was held and the local community was invited to the site and during the CTW's construction, students from the local school assisted in the planting of the wetland plants (Greene 1996). One UTRCA official noted: "It wasn't born a success, it had to be made a success. As much as it was very attractive and very interesting, we pounded pretty hard to make sure that the public was made aware of that thing" (CAO-15, 2001). The UTRCA's wetland engineer said: "With respect to difficulties with the townships and permitting at the local level, those are more social things, and the social things are getting to be the bigger things. They are much more difficult to overcome than saying that you need to meet these specifications. I can do that, but the social part is more time consuming, more difficult, but potentially much more satisfying" (CAO-1, 2000).

Provincial regulators: The construction of the CTW in the Luckhart Case corresponded to the passing of the 1997 Services Improvement Act[24], which downloaded the approval of sewage systems under 10, 000 litres/day to the municipal level. During the approval process in the Luckhart Case, the MOEE was involved only peripherally in proposing some design considerations to the UTRCA, which they wanted to see applied during the construction phase (CAO-16, 2001; CAO-1, 2000). However, in the Luckhart Case, the CTW was designed as a zero-discharge system making the MOEE much less apprehensive about letting the UTRCA almost fully manage the project. One UTRCA informant said that the MOEE deferred to the UTRCA, leaving the responsibility with them and said that the MOEE basically said: "If you say it's OK, you have to live with it because it's in your jurisdiction" (CAO-1, 2000).

Implementation Setting

Incentives and Disincentives

Cost: The cost of implementing the CTW was approximately $40,000, 10-20 percent more than the cost of a concrete liquid storage tank (CAO-1, 2000) and monitoring costs were expected to be $20,000 over a four year period, which was paid by the owner; however it was still adopted and was expected to result in cost savings over the long-term because land-spreading costs were expected to be $5,000 annually (Greene 1996). Additionally, the business owner did not want to have a cement liquid storage tank to store wastewater onsite. He believed the conventional option to be impractical, requiring high-input of labour because wastewater had to be physically spread on land. Regarding this preference, an UTRCA official said: "Both small business people and farmers are similar in nature in that they want things that are practical, cost effective and that costs are certainly important" (CAO-1, 2000).

Regarding cost, an UTRCA official said "The alternative technology was actually more expensive, but there is less management since they don't have to land-spread" (CAO-16, 2001). Another informant said that there were only subtle financial advantages associated with the CTW because it was expensive and the business owner probably didn't save a lot of money adopting the CTW, but that he may over the lifetime that he runs the operation, however, the cost of building this wetland was quite expensive" (CAO-1, 2000). The wetland engineer employed by the business owner during

---

[24] Under the 1997 Services Improvement Act, the MOEE would no longer be circulated with the bylaw or consent for septic systems under 10,000 litres/day since the MMAH moved to a one window planning process under the Building

the project believed that if ecological technologies are seen as economically viable then they have a better opportunity to be adopted (EAC-11, 2001). She described why the business owner in the Luckhart Case chose the CTW option:

> I think that he believed in the long-run most of these systems, when they are amortised over a long period of time, end up being more economically viable, over a short period of time, compared to other systems that seem more viable. In the long-term they are not necessarily because they have to be maintained more often than one of these natural systems, in general. So economically over the long run this would be more viable for him. (EAC-11, 2001)

At this stage in their development, CTWs require full commitment by the operator (LGO-10, 2001; CAO-16, 2001). One UTRCA official believed that many of the CTWs implemented under CURB did not work over the long-term and were abandoned because the operators were not fully committed to making them work. She said that operator commitment is essential, there are still bugs that need to be worked-out and that CTW require unique operational procedures (CAO-16, 2001).

Local acceptability: The Director of Planning in the municipality believed that CTWs could potentially serve a "Legitimate agricultural related need," for an agricultural area that is highly populated with livestock facilities (LGO-4, 2000). He said, in reference to both the Luckhart Case and the French Case, that perhaps his office may have fallen a little short in the long-term monitoring of the CTWs. He was, however, confident in the ability of these owners to maintain the safety and integrity of their CTWs. There was, however, some concern that a change of ownership might be problematic in terms of the longer-term operation and maintenance of the systems and that this is something that will have to be explored in the future (LGO-4, 2000).

Another UTRCA official said that "These technologies probably haven't received the marketing boost they require because they are innovative, they are leading edge and they haven't been fully tested". He also suggested that the technology might be at a point now where they could be successfully marketed (CAO-15, 2001). The UTRCA wetland engineer said that, "If a body of knowledge can be built-up, I imagine that the private sector will eventually run with these, and start replicating and delivering them" (CAO-1, 2000). Another informant believed that they could offer a competitive advantage to agricultural business and said that, "If you can construct a wetland that treats wastewater and then allows an appropriate discharge, then that is where these and the [grassy-

---

Code Act.

filter] strips . . . are going to allow a competitive advantage for somebody to stay in business" (LGO-10, 2001).

The impediments related to the approval process have constrained the development of CTWs and they have not benefited from a selection environment that would allow scale determined learning effects, which would increase their performance efficiency. One engineer from the MOEE suggested that the market fully shapes which technologies are used. Regarding the CTW technology, he said, if they "Were good in terms of efficiency and economic viability, we would see many more of these systems . . . " (PGO-39-Anonymous, 2001). He said that if one compares two technologies, as long as they both can meet the same water quality criteria, are easy to operate and can operate in a consistent fashion, then obviously the technology that is cheaper would be selected (PGO-39-Anonymous, 2001). Another informant suggested that the CTW technology does encounter constraints at this point because it "Is still at the fringes," and that, "people do not know about it because there is nobody out there marketing and pushing them" (EAC-30, 2001).

Operation and Management

User Acceptance: The business owner in the Luckhart Case was highly satisfied with the CTW's ease of operation (OOP-12, 2000). The CTW was fully integrated into the daily waste management procedures of the operation and has become dependent on the system. One UTRCA informant said that it would be an extreme inconvenience if the system had to be shutdown for any reason (CAO-1, 2000). However, it was also suggested that there were unknowns associated with the operation of the CTW and "There are some unknowns about management over the long-term" and that "There is some uncertainty because it is a natural system" and the ideal operating procedures and best performance parameters that can be achieved are not entirely known at this stage in the development of CTWs (CAO-16, 2001). One informant outlined what the goals were in terms of the operation and management of the CTW. She said that they were aiming for: "Success over the long-term, I mean every [conventional systems] has its problems and shocks. They're not always going to get 100 percent [positive performance] results. Success for the system is that it will give us consistent results over the long-term" and that:

> [T]here are damn lies in statistics. If those systems were clearly looked at with a beginners mind, then the perception of the conventional options would change because they are still subject to shock, still subject to failure, still subject to electrical outages. (EAC-11, 2001)

In relation to the uncertainties with the long-term operation of the CTW, one UTRCA official suggested that there are unique operation and maintenance protocols required with the CTW technology:

> [I]n 20-25 years, he will have to do maintenance on it, which again will cost him some money. So, it's not a walk-away type thing. He has annual or ongoing cost of managing it and trouble shooting it where there may be some problems. He's going to have to do monitoring every year and then in 20-25 years he's going to have to deal with that marsh. He's going to probably have to re-plant it. (CAO-1, 2000)

The municipal planner was under the impression that the CTW technology was 'potentially' a longer-term solution to the management of wastewater than the conventional options. He said: "If you put a tank in, it's not going to hold forever and a day - that is kind of a fallacy - so the wetlands are good from that standpoint" (LGO-4, 2000). This was echoed by one of the wetland engineers who worked on the project. She said, in relation to the conventional options, that: "I think that money talks; a lot of the times the perceived safety of something brings it on-line whether it is good or not. Well, there really isn't a high degree of confidence with turn-key conventional systems, that's a perception that has been purchased: it's not reality, it's a perception" (EAC-11, 2001).

Similar to the French Case, one UTRCA official commented that the physical character of the Luckhart site also influenced the implementation of the CTW. He said that, "The location of the business next to Black Creek begged for an innovative solution" (CAO-15, 2001). He said: "There is a clay hardpan that exists on the site, so the opportunity existed to create an earthen/clay lined system. Through mixing the biological science with the physical layout . . . there was a series of pre-conditions that came together," and, "That's why . . . [the] Luckhart wetland was affordable, because there was a clay base that could be used as a liner", which increased the level of protection provided to the environment (CAO-15, 2001). The official also admitted that, "There are probably a lot of situations out there that the only fix is conventional technology because they don't have the pre-conditions" (CAO-15, 2001). One of the constraints to innovation in relation to the CTW technology, may be its site-specific nature: "The pre-conditions are very important and you know this is the problem with innovation: you have to look at the landscape and look at the constraints that that particular site provides and then look at the opportunities" (CAO-15, 2001). One MOEE official agreed with this line of thought, suggesting, that the policy of the MOEE in relation to CTWs has been to look at the site-specifics in relation to the receiving body and discharge quality parameters (PGO-39-Anonymous, 2001).

Another informant said: "In my mind I think that the cost savings that can be gained from using a CTW [derive from the] very passive [nature] of the technology and that's one of the key things that our clients want. So, getting somebody to buy into it is a difficult thing; but when you do get somebody to buy into it, they like it because it's a very passive system, it's very simple, it's straight-forward and it works really well" (EAC-30, 2001). One official from the GRCA believed that ease of operation and access to information was central to the success of the CTW technology:

> There are a lot of managers out there who are more than capable of handling complex systems and wanting to learn about them, but we have to make sure that there is enough information for them; and enough support too. We don't have enough people on the ground right now from our authority with enough working knowledge to properly assist those who would readily adopt the CTW technology". (CAO-36, 2001)

Resource Recovery

Wastewater recovery and reuse was not considered a feasible option for the livestock hauling business. There was concern with reusing treated wastewater because of concerns with bio-contamination and inter-herds disease transmission (OOP-12, 2000; LGO-4, 2001; CAO-1, 2000).

This ends the two cases in which the CTW technologies were applied. The following section summarises data from the analysis and the thematic areas that were generated.

4.3 Summary

This section provides a reduction of the data collected in relation to the CTWs in table and text form. The tables reflect nine key theme areas that emerged across these cases.

Stakeholder attitudes: Table 4-2 presents a synopsis of theme areas related to stakeholder attitudes.

Table 4-2. Summary of Stakeholder Attitudes (Constructed Treatment Wetlands).

Stakeholder Attitudes	
French Case	**Luckhart Case**
Adoption Motives	
Voluntary selection of the CTW technology	
Concern for the environment	
Proactive and innovative business owners	
Voluntary effort to mitigate environmental impacts (Voluntary selection of CTW)	Mandatory implementation of treatment system with business expansion (Voluntary selection of CTW)
User Technology Preferences	
No confidence in the conventional alternative	
Preferred a passive, simple and low-input wastewater management solution	
Preferred an alternative to storage and land-spreading	
Preferred aesthetic amenities of CTW	
Preferred lower capital cost of the CTW	Willing to pay more for the CTW
Institutional Attitudes and Preferences	
UTRCA consciously developed capacity in using the CTW technology	UTRCA applied the CTW technology with the capacity it had developed in previous case
UTRCA considered the risk associated with CTWs no different than conventional options	
Local government willing to innovative after credible actors legitimised the CTW technology	Local government less cautious after precedent established during the French Case
MOEE exhibited caution and were reluctant to endorse the CTW	

Sources: Research Informants (December 2000 – September 2002).

Three theme areas emerged in relation to stakeholder attitudes: adoption motives, user technology preferences and institutional attitudes and preferences. The French and Luckhart cases were voluntary initiatives stemming from the owners' concerns for the environment. The decisions to adopt the CTWs were based on the owners' skepticism with the conventional option. These can be characterised as technology preference and include issues related to aesthetics and issues of pragmatism regarding the implementation of a treatment option that required the least input of maintenance and labour. The analysis also revealed that institutional actors had a variety of attitudes that influenced their view of the CTWs. For instance, the UTRCA supported CTWs and intentionally built their capacity with the technology because it was viewed as a potential solution to water quality problems associated with agriculture. It was also revealed that local government's initial hesitation to permit the CTW in the French Case arose from unfamiliarity with the technology as an agricultural accessory. Local council members had concerns originating from the apparent failure of the Listowel Marsh Project during the 1980s and were afraid that the CTW would be a corporate liability. Although the MOEE was an active funding partner under CURB during the French Case, they exhibited caution and did not endorse the technology for agriculture. A subsequent program initiated under the Canada-Ontario Agriculture Green Plan to determine the efficacy of the twelve CTWs established under CURB was abandoned after the 1996 provincial government budget reductions and the MOEE management team that was to deliver the evaluation was dismantled due to these reductions.

Project design activities: Table 4-3 presents a summary of project design activities in relation to the CTW technology.

Table 4-3. Summary of Project Design Activities (Constructed Treatment Wetlands).

Project Design Activities	
French Case	**Luckhart Case**
Project Approvals	
MOEE's CTW demonstration project	MOEE defers approval to local level officials
Local permitting mechanism had to be created	Permitting mechanism established during French Case
3-year bylaw followed by a permanent bylaw amendment under a site plan agreement	Permitted as a permanent accessory to the agricultural commercial industrial zoning
Caution and Liability	
No precedent - CTWs a source of caution	Precedent achieved – less caution apparent
Local officials resist departing from standard practice	Local officials less resistant after precedent established
MOEE cautious and highly involved	MOEE less cautious and minimally involved
Project Legitimacy and Support	
Local government influenced by collaboration between experts	
Collaboration between the UTRCA and the MOEE legitimised the project	Collaboration between the UTRCA and the NRC legitimised the project
Support from well-respected local UTRCA legitimised the project to local government	

Sources: Research Informants (December 2000 – September 2002).

Three theme areas emerged in relation to project design activities, which played a role in shaping the design of projects and include factors such as approvals, caution and liability, and the actions of stakeholders and champions. During the French Case, the MOEE approved the project as a demonstration under CURB. Although no local permitting mechanism existed, the municipal government was compelled to develop one. This was achieved by linking aspects of the CTW to a site plan agreement under Section 41 of the Planning Act. This agreement included a minimum-monitoring schedule to ensure the protection of ground and surface water and a fencing requirement to ensure safety. During the Luckhart Case, the municipal planning office was only minimally involved and the township permitted the CTW as an accessory component to the Agricultural Commercial/Industrial (ACM-7) zoning.

There was evidence that both the provincial and local governments viewed the CTW technology with caution. There was no precedence for the CTW in the French Case and initially, local government resisted departing from standard agricultural practice due to fears related to liability. However, the French Case was precedence setting and local government was influenced by the collaboration that was recognised between the UTRCA and other partners such as and MOEE. Local government was also influenced in the Luckhart Case, by the expertise that the UTRCA developed during the French Case and collaboration with the NRC. Council permitted the project after receiving assurances that the UTRCA and the business owner would work together to develop a monitoring and maintenance program to ensure the safety of the CTW.

Implementation setting: Table 4-4 summarises additional information in relation to the implementation setting of the French and Luckhart Cases.

Table 4-4. Summary of Implementation Setting (Constructed Treatment Wetlands).

Implementation Setting	
French Case	**Luckhart Case**
Incentives and Disincentives	
Assistance from the UTRCA available	
Attracted by operational simplicity, practicality and minimal labour inputs (no land-spreading required)	
Demonstration project: user paid 25%	Innovation grant available: user paid 65% and agreed to pay ongoing monitoring fees
Attracted by lower capital costs	Willing to pay more and committed to monitoring expense
Owners willing to learn new skills associated with operation of the CTW	
Site-specific pre-conditions existed (geological features), which facilitated the implementation	
Added-value recognised: onsite aesthetic and recreational benefits	
	Competitive advantage through 'greening'
Operation and Management	
CTW proved operationally simple and Fit the operational framework of each business	
Some uncertainty related to medium to long-term treatment performance and maintenance of CTW	
Resource Recovery	
No treated wastewater reused	
Sheep grazed on wetland berms	Sludge and bedding composted for local ginseng farm

Sources: Research Informants (December 2000 – September 2002).

The implementation setting concerns issues related to incentives for adopting the CTW technology, how it fit into the operational framework where it was applied and to issues related to the recovery and reuse of treated wastewater and solid waste. In both the French and Luckhart case studies external funding was available. In both cases, owners were drawn to the aesthetic nature of the CTW, and because it was simple to operate and required only small inputs of energy, labour and ongoing maintenance. One notable disincentive was uncertainty regarding the exact performance parameters that could be achieved by the untested CTW design and issues related to maintenance and life expectancy. However, in both cases the CTW technology fit the operational framework in each case, presented no inconvenience, and performed to a standard that was acceptable to the UTRCA.

After the first year that the CTW in the French Case was operational, the MOEE raised concern that the hydraulic retention of the system was inadequate and could result in a discharge to the adjacent municipal drainage ditch, a discharge that would be illegal because no Certificate of Approval was granted for the CTW. The MOEE called for modifications that reduced the hydraulic flow to the CTW in order to prevent a potential discharge from the system during times of high precipitation and requested a full 240-day of storage (case record)[25]. The concerns raised by the MOEE in relation to hydraulic retention during the French Case resulted in lessons learned. During the Luckhart Case, the UTRCA designed a full 240-day hydraulic retention capacity and added a grassy filter strip, which eliminated any potential discharge to adjacent land or water bodies.

In terms of resource recovery, there was no reuse of the treated wastewater in either case study. In the Luckhart Case, there was initial discussion regarding the potential to recycle treated wastewater back into the truck washing facility, however this option was not favoured because of the risk associated with bio-contamination and the risk of inter-herd disease. In the French Case, although there was no wastewater reuse, the farm owner grazed his sheep on the berms between the channels of the CTW, a technique used to manage the length of the grass on the berms. This practice reduced maintenance and inputs of fuel required to operate a tractor. In the Luckhart Case, solid bedding waste from the truck-trailers was collected, composted onsite and subsequently used by local ginseng farmers as a soil amendment.

[25] Case record #11 (see Appendix Five).

Chapter 5.0

Analysis of Greenhouse-Based Treatment Technologies

> [T]he world is a vast repository of unknown biological strategies that could have immense relevance should we develop a science of integrating the stories embedded in nature into the systems we design to sustain us.
>
> *Nancy Jack Todd & John Todd*

This chapter presents an analysis of the case studies where the greenhouse-based treatment technologies (GBTT) were applied at YMCA Outdoor Centre at Paradise Lake and the Toronto Waldorf School. Both case studies will be referred to respectively from here forward as the 'YMCA Case' and the 'Waldorf Case'. The GBTT was implemented in both cases for the management of domestic sewage in educational facilities. As a component of the GBTT, each of the systems included a scaled-down, indoor CTW similar to those used in the French and Luckhart case studies. Figure 5-1 offers a map of the analysis as covered in this and the previous chapter.

Cross Case Analysis - Greenhouse-Based Treatment Technologies			
Previous Chapter		**Current Chapter**	
Constructed Treatment Wetlands		**Greenhouse-Based Treatment Technologies**	
French Case	Luckhart Case	**YMCA Case**	**Waldorf Case**
		⟵⟶	

Figure 5-1. Map of Chapter-5 Analysis.

5.1 YMCA Outdoor Centre Case Study

Project Description

Type of Establishment: Environmental Education Centre (St. Clements, Ontario).

Total Land Size: 28 hectares.

Description of Treatment System: The Greenhouse Based Biological Treatment Technology (GBTT) is housed in a 58 m^2 greenhouse structure and treats wastewater generated from 6-toilets and 3-urinals in a 362 m^2 conference facility.

Construction Motive: The greenhouse treatment system was a voluntary undertaking initiated by the facility owner to construct a wastewater treatment system that integrated the environmental aspects of the building. The greenhouse treatment system was built to augment environmental education through demonstrating an onsite, zero-discharge wastewater treatment and reuse system (Kitchener-Waterloo YMCA n.d.).

Year Constructed: The conference facility was constructed in 1996. The greenhouse treatment system was commissioned in 1999 (continuous operation through 2002).

Design: In addition to integrating with the entire building to establish energy reduction through passive heating and cooling, the 58 m^2 greenhouse houses the wastewater treatment system. Primary treatment occurs in an exterior septic tank. Secondary effluent is then pumped inside the greenhouse into a closed aerobic reactor and then into a train of three open aerobic reactor cells that are filled with emergent vegetation. Wastewater treatment is aided by living biological communities comprised of plants, bacteria, snails, molluscs etc. Effluent flows from the final open cell into a clarifier where solids are discharged by gravity back to the septic tank. Effluent then flows to and is polished in a wetland marsh that is also housed within the greenhouse. Finally, the effluent flows into a small pond. Overflow from the pond leaves the greenhouse for discharge into a tile bed and is disinfected by an ultraviolet filter for reuse (wastewater not being reused as of 2002) (Burtt 1999).

Operational Capacity: The design capacity of the greenhouse treatment system is 1,135 litres/day and the system is operational 12 months per year.

Cost: Wastewater treatment system: $35,000; Greenhouse enclosure: approximately $68,640 ($1,183 per m^2).

Funding Partners: The Kitchener-Waterloo YMCA and various funding partners.

Treatment Contingencies: The contingency for wastewater treatment consists of the pre-existing septic tank and drain field.

Project Objectives: To meet the design, construction, operation and maintenance requirements of the 1997 Ontario Building Code.

Figure 5-2. YMCA Greenhouse enclosure.

Figure 5-3. Greenhouse-based treatment technology (open aerobic reactors).

Figure 5-4. Greenhouse-based treatment technology (closed anaerobic reactors).

Figure 5-5. Greenhouse-based treatment technology (from hallway).
Source: Tom Kolbasenko, School of Architecture, University of Waterloo

Project Background

The adoption of the GBTT in the YMCA Case was a voluntary undertaking and was an addition to several other technologies that were being used to demonstrate onsite, zero-discharge wastewater management (Roe 1994). For instance, composting toilets had previously been implemented in other buildings on the site. The GBTT was adopted because it was seen as an appropriate technology for wastewater treatment system that would integrate fully with the day-use conference facility building and would also play a key role in educational programming.

The GBTT acted as an add-on component to the existing septic system (septic tank and leaching bed). The treatment system itself cost $35,000, the greenhouse enclosure in the range of $70.000. These costs were over and above the $10,000 invested in the existing septic system.

Stakeholder Attitudes

Adoption Motives

The motives for adopting the GBTT for wastewater treatment in the YMCA Case stemmed from the vision that the organisation held, and the master plan that directed the selection of a wastewater treatment alternative that would fulfil the functional needs of the facility while meeting the environmental and educational goals of the organisation. The facility manager said that, "The site, the [facility] sitting and all of the technical systems should demonstrate environmental responsibility" (OOP-19, 2001). The main goals expressed in the vision and master plan of the learning centre were documented by the architect:

> To operate an integrated environment (of natural features, buildings, technologies and programs) which will gently encourage and inspire transformation in the lifestyles of all who visit and will help them 'live more lightly on the earth. The entire site to be the teacher of environmental principles, to imbue environmental values. (Simon 1995: 57)

One of the key factors driving the selection of the GBTT was education, a central mission of the organisation. A selection committee member said that, "It is a commitment to educate people about the environment" (OOP-22-Anonymous, 2001). He said that it was "The determination of a number of people," that made the project the success that it has been. The project manager said that, "The environment is a very, very important issue [and] we should be part of the solution" (EAC-20, 2001).

The project manager suggested that another motivation for selection of the GBTT was that it would serve as a demonstration for the community along with the other technologies that were being used on the site. He said that, "The other role [of the GBTT], other than educating kids, was to educate the populace at large and to be a resource that people could come to from all around the region and see . . . a demonstration" (EAC-20, 2001). That this is the continuing role that the organisation plays in the community. One of the project engineers said:

> [T]he original premise that we put forward to the client was . . . to employ different strategies, practically different technological cultures, since it was about environmental learning and leadership, we wanted to have different experiences with the different buildings in how to interpret sustainability in its various facets. And so we used composting toilets and the Waterloo Bio-filter with a filtration trench and the other was the greenhouse treatment technology with its potential for water reuse or certainly to produce high quality effluent. (EAC-18, 2001)

Although the technology was expensive to implement, there were underlying values that guided the selection committee's decision to adopt the GBTT in spite of the cost. One informant from the organisation's board of directors revealed why the GBTT was selected. He said: "We felt that we wanted to be seen in a pure sense doing the best things. There are a number of places that have done little bits and pieces, but they haven't put it together with the best technologies. And it cost the organisation a lot of money and in some cases, a lot of tough decisions to continue to proceed" (OOP-22-Anonymous, 2001).

Technology Preference

The project manager said that several 'guiding principles' were followed during the design of the building and in the selection of the GBTT. He described the main principle that guided the waste management component and said that: "One of the principles was that we should leave things no worse and hopefully better than we found them. That includes water, soil, everything about the site. So, that's what the GBTT does" (EAC-20, 2001). In terms of the selection of technology, the architect had been quoted as saying that he was "Guided by two principles: produce zero waste and use as little energy as possible" (Roe 1994: A1).

A major goal of the selection committee was to adopt a treatment system that could play an integral part in the function of the building itself. Additionally, not only were the functional aspects of the GBTT considered in terms of wastewater management, but integration across all aspects of the building was sought. Regarding the integrated design of the facility, the architect wrote:

> The thematic idea for this building is that of the "natural building", exploring a symbiosis between architecture and biology (bio-architecture). Biota, natural elements such as rainwater and earth, mechanical systems and building design are fused to form a single interacting organic whole. The building functions as both educator and demonstrator of up-to-date thinking on sustainable design, providing a healthy indoor environment and offering pointers to a possible new vernacular architecture. (Simon 1995: 58)

The project manager in the YMCA Case felt that the GBTT technology was appealing because of the value added to the building. He said that one reason it was adopted was because it "Met all of these criteria [the selection committee had agreed on] and it was visually appealing . . . it is aesthetically beautiful" (EAC-20, 2001). He said that this type of an environment could never be replicated with conventional wastewater management technology because it could never be integrated to the same level that the GBTT allowed and that:

> [A]ll of these systems should not only demonstrate, but that they should interact . . . . [S]o a huge part of the appeal was just that, that we could combine more than only sewage treatment. We have a building that is performing all of the other functions and they're all inter-relating plus, not to mention, that those plants are cleansing air. And now we're getting that air taken into the building and that is cleansing the air in a natural way. We have all of this stuff now, which is what happens in nature where all of these systems are inter-reacting and invisible. And so to the extent that we can replicate nature, we're succeeding [but] we will never do it . . . completely. As John Todd puts it, if we honour the system of nature, it will go to work for us. And all of the millions and billions of interactions that nature can provide that we can never engineer, will do stuff for us that no engineering could ever do. (EAC-20, 2001)

At one point in the planning process, the selection committee considered a CTW for wastewater management. However, it was rejected because the technology selection committee perceived too many "Regulatory barriers" at the time they were not confident that the technology was advanced enough in its development (OOP-19, 2001; EAC-20, 2001). In regards to selecting the GBTT over the CTW, one of the managers said that, "What we were trying to do is to bring some of that stuff inside the building so it would operate all year around. . . . [S]o, on a day like today, we could have a group of kids out here that are interacting with the Living Machine [or GBTT" (OOP-19, 2001).

One member of the selection committee recalled something that he had heard at one time, which reflected the preferences of the organisation for a technology that could internalise their wastewater management. He said that, "The biggest problem in the north began when the flush toilet was designed and enabled you to flush all of your problems away" (POU-22, 2001). He suggested that convenience is important in this culture and has acted to impede personal responsibility for wastewater management at scales that would reduce impacts on the environment.

Institutional Attitudes

Local regulators: Since the GBTT in the YMCA Case had a design treatment capacity of less than 10,000 litres/day there was no provincial approval required. The MOEE was not involved during the approval process[26]. The approval fell locally to the building inspector's office in the township and to the regional health department. There was a considerable amount of interest in and support of the GBTT shown by municipal approval agents. One official from the regional health department said that, "We were quite enthused about [the GBTT]. It's nice to get information about an experimental unit" (LGO-17, 2001). He said that his office was "Very supportive" of the project. The project manager recalled that the health department was glad to see that the group was, "Pushing the envelope" in the YMCA Case and they did everything that they could to support the project (EAC-20, 2001).

One informant said that, "There was nobody that we came in touch with, like the regional environmental people, the township environmental people or the provincial environmental people, who didn't think that what we were doing was wonderful . . . but the regulations didn't talk to it so it was tough for them to give us approval" (OOP-22-Anonymous, 2001). In spite of the initial uncertainty that local health officials had with the approval the GBTT under the Ontario Building Code (OBC), few barriers were encountered. The GBTT could not be approved as a standalone system and the facility had a redundant septic system, which had been approved under the OBC and this allowed permits to be issued for the facility to operate. One informant suggested that another factor that assisted during the local approval process and enabled the installation of the GBTT to proceed without complication was the presence of an "Enlightened health officer . . . who had a degree of ability to act on his own initiative" (EAC-20, 2001).

The project manager suggested that the widespread existence of conventional infrastructure has impeded alternatives to conventional wastewater treatment because "We have got, first of all a huge investment in infrastructure that we can't just ditch. . . . [W]e have an entire profession and a large industry that is based entirely on all of that stuff " (EAC-20, 2001). Another informant said: "Why doesn't the Region have one of these? Tradition! This is what the engineers design, this is what the engineers do, this is what the engineers say, those are the big barriers . . . it's not mainstream, it's new" (OOP-19, 2001). In a general sense, one of the project engineers suggested that there were institutional and political forces acting, by design, to impede the advancement of onsite ecological technologies for wastewater management (EAC-18, 2001). He described the advantage held by the conventional options:

> [T]hey are cheaper simply because they are entrenched. It's how operators have been trained, that's how companies have been set up. They are conveyer belts for using conventional wastewater treatment. There are a lot of supply industries that add components to those systems that are proprietary and promoted, so there is a commercial vested interest in repeating those systems. So breaking the mould will require an industrial culture shift. (EAC-18, 2001)

Project Design Activities

Caution and Concerns of Liability

In terms of the adoption of the GBTT, the organisation did not feel that there were "Any risks" associated with selecting the GBTT and they had total confidence that it would meet their needs (EAC-20, 2001). One health department official that was interviewed suggested that his office used a considerable amount of discretion under the existing regulations to ensure that onsite systems will pose no risk to the environment or health. He suggested that his office has a certain amount of discretionary power and that they may, in some cases, be very rigorous with innovative systems that are not classified under the OBC (LGO-17, 2001).

Project Legitimacy and Support

The facility manager recalled that from the earliest stage of implementing the GBTT that there was a considerable amount of pre-consultation with agents at the municipal health department. He said: "Absolutely, we got them in early to bounce the ideas off'. He recalled that there were really no constraints, "As long as everything was done correctly, as long as the due diligence was done, everyone was on board . . .. [Y]ou would start to run into problems if people had taken short cuts and hadn't done their work properly" (OOP-19, 2001). One of the project engineers described the pre-consultation that had been undertaken with the approval authorities:

> [R]egarding regulatory constraints, we had anticipated that there would be some hurdles based on previous experience and we wanted to head those off. So we contacted the authorities at an early stage . . . . I think that having engaged the

[26] After responsibility for sewage works of less than 10, 000 litres/day was transferred to the local level.

> authorities at an early stage led to an understanding of what we wanted to do and we worked closely with them in gaining approvals. (EAC-18, 2001)

A health department official revealed that the level of trust that his department had with the YMCA organisation was an asset. He said: "Again we don't have a lot of hands on staff and we know that the people at [YMCA] are very dependable. We've been out there once or twice to follow up and take some water samples. We were very supportive" (LGO-17, 2001). The health official also spoke of the level of pre-consultation that was undertaken. He described that process in the following way: "We had many meetings in terms of working through the process, some of the safeguards to implement. It went very smoothly actually. I think we came to an agreement in a very rationale way on some of the things that had to be done and some of the things they won't do" (LGO-17, 2001). He described that they were more inclined to approve the technology because of the dependability of the proponents and his department's confidence that the GBTT would be well maintained by the organisation over the long-term (LGO-17, 2001).

Provincial regulators: There was no provincial level involvement during the approval of the GBTT in the YMCA Case. However, there had been four earlier implementations of the technology in Ontario and provincial regulators were highly involved in at least two of these. Interviewees suggested that there was considerable confusion regarding the approval of the GBTT between various regulatory officials, (EAC-31, 2001); and that regulatory officials viewed the GBTT with considerable skepticism (EAC-30, 2001; EAC-18, 2001). One informant previously employed in the MOEE during the first GBTT implementation in Ontario, noted that regulatory concerns centred on the inadequate and 'soft' technical description that the designers of the GBTT offered to explain the system's operational processes in treating wastewater. He went on to say:

> When they first came to us for approval we said, 'look, it's an interesting concept, we don't really have any objections to it being used, but there are some fundamental questions that we need to have answered before we can issue an approval'. It was things like process design. The designer of the GBTT were saying, '[the wastewater] comes in here and it goes out there and there are some plexi-glass silos and it goes into this end and then comes out through there'. And we said, 'well how long does it stay here, what do you expect your effluent quality from [this point to this point] to be and how long [is it retained]?' And they would say, 'well sort of 2-days retention in this tank and then through this rock filter and then this would happen' etc. etc. (EAC-30, 2001)

He suggested that this was just not adequate from a regulatory perspective and that provincial regulators expected engineered drawings of the process that were logical and fully detailed the treatment process in a technical fashion.

Project Approval

The approval was based on the septic tank and leaching bed contingency that existed. The facility manager said: "They gave us the permit based on accepting a tile bed . . ." and, "They gave us credit for secondary treatment. [T]hey gave us credit for the secondary treatment which decreased the size of our tile bed" (OOP-19, 2001). The local building inspector depended, to a large extent, on project engineers to endorse the project with their professional credibility. The facility manager said: "And our local inspector here wasn't very sophisticated. So, he really did rely on the stamped engineering drawings to say things were fine" (OOP-19, 2001). The project manager noted that the project did not experience many approval-related constraints: "Essentially it was not a rigorous process. [The inspector's] position was, basically, that as long as we had an architect's and an engineer's stamp was good enough for him. It was fortunate, because very often in rural areas there is a level of casualness that you will not get in the big city. So, the plans were not examined really that closely" (EAC-20, 2001).

Although there were no outright barriers to the implementation of the GBTT in the YMCA Case, the project manager suggested that in other places there would be and that the "Sympathetic health officer" among other things that they had during the YMCA Case had facilitated the implementation of this system (EAC-20, 2001). The facility manager and the person who operates the system, believed that the approval agents could be strict or flexible in their interpretation of the regulations and that this could make a big difference in whether or not the process went smoothly for the proponent or would be difficult. Even though the OBC did not impede the implementation of the GBTT, the facility manager believed that the OBC did pose barriers to innovative wastewater treatment technology:

> [E]ven though we didn't have any real constraints the problem is . . . that when you move to the Building Code there is no opportunity for experimentation. Either it does or it does not fit the code. So, if you want to install a GBTT as a primary source of treatment, it has to fit the code. It's not written in the Code, so, the answer is 'No'. You cannot get a permit for it. You have to be part of it, or not part of it. (OOP-19, 2001)

Another member of the selection committee said that: “For us to even get that thing approved, we had to make sure that we had a class IV septic system because that was the only thing that the engineers could sign-off on. If it wasn’t there, they could not sign-off, even though they agreed that this is way better than what the regulations talked about” (OOP-22-Anonymous, 2001). He stated: “If anything just about stopped us . . . it was the rules” (OOP-22-Anonymous, 2001). His impression was that these “Rules” tend to discourage people from adopting innovations because of the uncertainty and frustration (OOP-22-Anonymous, 2001). He followed by stating:

> I would say that is one of the major impediments is that we have gone through a whole set of regulations to put them in place, and once they are in place, it is like the Ten Commandments, they are hard to get shifted around. A lot of people would throw up their hands and say, ‘we are not going to do it - it’s too hard . . . ’. (OOP-22-Anonymous, 2001)

Regarding the OBC, another informant echoed what the proponents in the YMCA Case had said about their experience with the restrictions imposed by the OBC:

> [T]he Building Code is what we call a prescriptive kind of code, it says that. ‘if you build it and it looks like this, we will accept it.’ There is nothing in that code that says directly that this is what we want to accomplish in our system. It doesn’t say that we want to accomplish a certain amount of treatment; it doesn’t say that if you do something that doesn’t harm the environment, it is OK. These are the boxes that you have to fit your system into. If you fit into a box, you’re in. If you’re not in a box, you’re out. (EAC-32, 2001)

And ended by stating:

> The Building Code comes under the Ministry of Municipal Affairs and Housing. Its mandate is not to protect the environment [it is] to encourage building and the economy. . . the current legislative framework is so discouraging towards [innovation] that we haven’t even considered pushing in the direction of [ecologically-oriented solutions]. The legislative framework that we have is also discouraging for any form of new technology. The framework we have with our current provincial government does not provide those kinds of encouragement and it doesn’t provide a whole lot of other things that are more important at this point than loftier goals like wastewater reuse and developing natural treatment systems. (EAC-32, 2001)

One project engineer suggested that current regulatory goals are defined very narrowly at this point in relation to wastewater management and that although they may prevent catastrophic environmental damage, they do not act to improve or regenerate the environment. He suggested that regulatory agents are overly concerned with the immediate protection of health, but that this comes at the price of longer-term impacts to the environment through promoting the recovery of wastewater resources. He also said that minimum standards are what regulatory bodies aim for at this time and he recognised the need to:

> [R]ecognise [the intrinsic value of technologies like the GBTT] to essentially close the hydraulic cycle. But that lies outside of [regulator's] principal concerns. . . .[T]hey do not have an holistic viewpoint on the full water and nutrient cycles that are engaged here. . . . [M]ost regulatory thinking is to reduce damage rather than promote a renewable and regeneration proposition. (EAC-18, 2001)

One health department official admitted that his office had gained confidence in this technology after its implementation in the YMCA Case and that they would be willing to consider other treatment systems that were innovative after the confidence that they had developed with this system. He said that in terms of the approval process: "Maybe there is a stage or two that we can skip and go to a more experimental model even to handle different types of effluents" (LGO-17, 2001).

Implementation Setting

Incentives and Disincentives

Cost: A selection committee member felt that the system was far too expensive for the general public to use at this time. He said: "You would not do if there was a cost benefit analysis you would say, 'too expensive'" (OOP-22-Anonymous, 2001). He suggests that the costs of the technology would dissuade the general public because "Not all that many people are concerned about the environment" to the degree that they are willing to invest more money than required (OOP-22-Anonymous, 2001). He also suggested that there were no cost savings and said that the decision to apply the GBTT had to be entered with full knowledge of its expense and commitment to that expense or it would never be built (OOP-22-Anonymous, 2001).

Another informant said that although there is a demand for 'green' infrastructure, it is very difficult to find project engineers and managers that can design an integrated ecological infrastructure. He said that, "I have been at this for thirty years now and I'm finding that often a project begins with the intent to design a green building, but it's very difficult to find the expertise," required to complete a project and, "It's like pulling teeth to get the architectural and engineering fraternities to come around and serve a clientele who have an intent that is beyond the capacities of these fraternities to deliver at this time". He went on to say, "[I]f you had a readily approvable solution that can contend on small lots safely and environmentally, then you would open wide and change the rules of the game. Undoubtedly there are parties that would not consider that to be a desirable outcome" (EAC-18, 2001).

The project manager described the level of integration that had been achieved between the GBTT and the building stating that the greenhouse "Is providing a large part of the heating, a large part of the cooling and it offers an education function and natural lighting. So there is a lot of stuff it is doing for the building other than just enclosing the GBTT" (EAC-20, 2001). He expressed his enthusiasm regarding the GBTT as an aesthetic amenity and the added-value to the day-use facility (EAC-20, 2001). He described the GBTT from an aesthetic perspective by offering the following vignette:

> One story about that is that a couple decided to have their wedding and reception next to the GBTT. Now they were not staff and didn't know anything about the machine. But I think just that the fact that a couple decided to get married in a sewage treatment plant, speaks to the beauty of the thing. (EAC-20, 2001)

The project manger noted the added-value of the GBTT brings to the building in terms of the economic value. He said that, "Greenhouse is also providing a programmatic function for education and so forth, it providing heat and cooling, it is providing natural light" (EAC-20, 2001). The facility manager also described the level of integration that had been achieved between the GBTT and the building. He said, "To separate the living machine from the solarium is very, very difficult; [the GBTT] is an integral part of that building. It is completely blended right in. It is completely part of what goes on there" and it contributes to the energy balance of the building (OOP-19, 2001).

In terms of the added-value from the GBTT, the site manager described the role it plays in their educational goals as well as the advantage the system offers the organisation in terms of attracting clients who rent the day-use conference facility where the GBTT is located:

> [I]n some of the stuff we are working on, in the science and technology part of the new curriculum, the K-8 side, we can pick off things like conservation of energy, water conservation and talk about all of that stuff. So, absolutely, it has given us a competitive advantage. One group will have their conference here, now coming up three years in a row. They have never done that before [anywhere]. Our location and what we have to offer has definitely given us a competitive advantage. (OOP-19, 2001)

Operation and Management

The system operator noted that the GBTT was very simple to operate and had not posed any problems. The consultant who installed the system[27] is located in the United States, but is readily available by phone or through the Internet for technical questions when problems arise. On several occasions this has required digital photographs of the open aerobic reactors and plants as well as information on water chemistry parameters to be sent to the supply engineer by email to have problems 'diagnosed'. To date, this has been adequate to support the continued operation of the GBTT without expert intervention from the original installers.

Resource Recovery

Although no recycling of wastewater was being carried out at the time of the research, it was the intent of the organisation to fully close the loop on the water cycle of the day-use conference facility in the near future. At present, all of the plumbing fixtures for recycling are in place and just need to be hooked-up; however, approval from the health department and building inspector are still required. This is one area where the health department displayed caution. By no means was it taken for granted that wastewater recycling would be allowed. In speaking about the idea of recycling non-potable water, the community health official said that, "If it only goes through the toilets, through their urinal and it's not a point of contact for the public, or for the staff then we may consider it in the future" (LGO-17, 2001).

The following section presents the analysis of the Waldorf Case.

[27] This GBTT was installed by Dr. John Todd, the initial inventor of Solar Aquatics for wastewater treatment http://www.oceanarks.org/.

5.2 Toronto Waldorf School Case Study

Project Description

Type of Establishment: K-12 Private School (Toronto, Ontario).

Description of Treatment System: The GBTT is used to treat wastewater generated in a 450-person private school (420 students and 30 staff). The aesthetic character of the GBTT was also enhanced by the installation of a Flowform water aeration device that produced the sound of cascading water (see Figure 5-9). The Water Foundation claims that the Flowform can "provide powerful aeration and reorganize water subtly at the molecular level which improve[s] water quality [through allowing it to] better carry biological information" (The Water Foundation 2002).

Construction Motive: The system was constructed because the existing septic/leaching bed was over capacity and failing. The GBTT was selected to allow the full treatment, recovery and reuse of the wastewater back into toilets and urinals, thus extending the functional life of the existing septic and leaching bed system. The GBTT was also built to compliment the school's educational curriculum and to provide a venue for student's environmental science projects.

Year Constructed: Commissioned in 1999 (continuous operation through 2003).

Design: Primary treatment occurs in an exterior septic tank. Secondary effluent is drawn inside the greenhouse and to the first of three aeration tanks. The wastewater then enters a clarifier where the sludge is pumped back to the septic tank. Clarified wastewater flows into the vertical flow CTW for polishing and treated water percolates into a sub-surface constructed aquifer at this point where it is both stored and recycled back into toilets and urinals. Treated water from the constructed aquifer is constantly pumped to the surface and through the Flowform, which provides aesthetic benefits (*e.g.* the sound of rushing water). Treated water is drawn from the constructed aquifer and passed through an ultraviolet filter before being recycled back to toilets and urinals.

Spatial Requirements: The size of the greenhouse is 55 m^2.

Operational Capacity: The system operates at a treatment rate of 8,000 litres/day and reuses 5,600 litres of the treated wastewater daily. The system is operational 12 months per year.

Cost: Approximately $185,000 including the cost of the greenhouse enclosure.

Funding Partners: The facility owners.

Treatment Contingencies: The contingency for wastewater treatment consists of the existing septic tank and leaching-bed and, if required, pumping of the septic tank. The engineering consultants who installed the system offered a 27-month warranty period.

Project Objectives: The greenhouse treatment system was undertaken to upgrade an existing undersized septic/leaching bed system that was failing. The objectives were to meet or exceed the requirements of the 1997 Ontario Building Code (OBC).

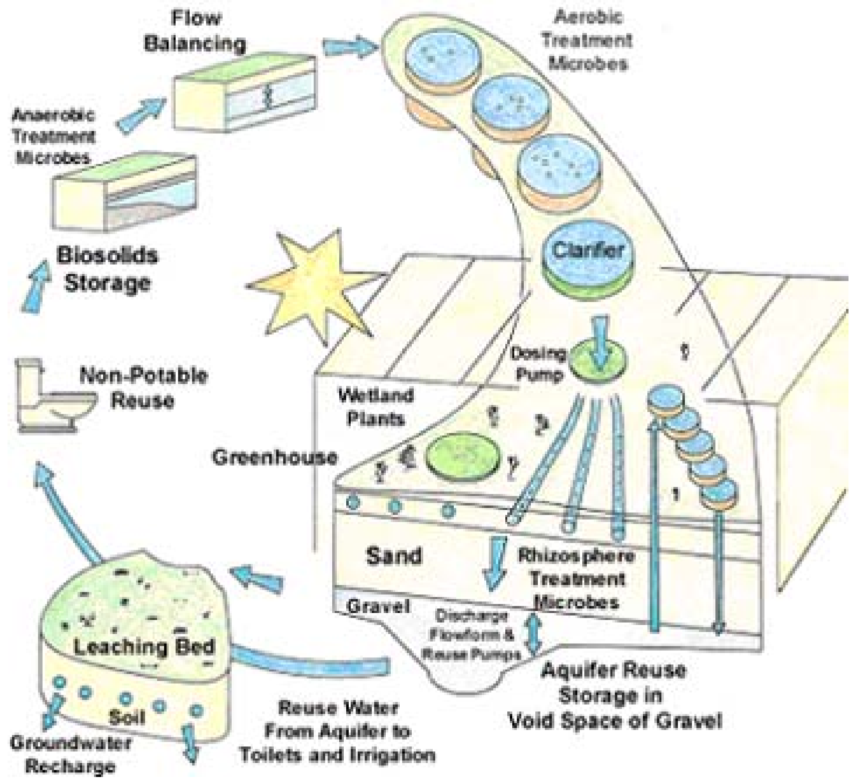


Figure 5-6. Toronto Waldorf School: Schematic of greenhouse-based treatment technology.
Source: Ontario Centre for Environmental Technology Advancement (2002a).

Figure 5-7. Toronto Waldorf School Greenhouse enclosure.
Source: EcoWerks Technologies Corporation (2002).

Figure 5-8. Greenhouse-based treatment technology: Flowform and closed aerobic reactors.

Figure 5-9. Greenhouse-based treatment technology showing Flowform cells and splash pool.

Background

The adoption of the GBTT in the Waldorf Case was a voluntary initiative precipitated by the imminent failure of the school's septic system in 1997. At that time, it became apparent that the septic system was under capacity, was failing and could no longer support the wastewater being generated by the 420 students and 30 staff. Through the fall and winter of 1997-1998, sewage was pumped and trucked off-site while the wastewater treatment options were established and the selection of a system made by the selection committee. Although the GBTT was ultimately selected, the board identified two additional wastewater management options:

Option 1: To re-install a new septic system in order to replace the existing, but undersized and failing system at a cost of approximately $110,000. This option was rejected because of physical constraints because a raised septic bed would reduce the size of the playing field.

Option 2: To establish a hook-up to the main sewage trunk at a cost of approximately $140,000. This option was rejected because it would have required monthly service fees to the Region and would contribute to an end-of-pipe sewerage management regimen that contrasted the school's principles of community and environmental responsibility and their desire to be self-sufficient.

Option 3 (selected): To retain the existing septic system and invest in the GBTT at a cost of approximately $185,000. This option allowed full recycling of treated non-potable wastewater back into the toilets and urinals, which effectively rehabilitated the leaching-bed and met the school's criteria as environmentally sound because it allowed them to internalise the responsibility for their wastewater onsite. Additionally, the recycling of wastewater also allows the school to reduce its extraction of freshwater from the water supply, which was provided by an onsite well.

Stakeholder Attitudes

Adoption Motives

The decision to select the GBTT in the Waldorf Case over the other available options was based on a variety of motivations as explained by various interviewees. The selection committee had decided that they did not want to annex space from the playing field to expand the existing leaching bed and neither did they want to hook-up to the regional sewage trunk. After the conventional options had been eliminated, it became evident that the group was, as one informant described: "Interested in exploring alternatives to the traditional method of dealing with sewage" (OOP-26, 2001). This member described his understanding of the motivation behind the decision to invest considerably more money to implement the GBTT than the cost of any conventional option. He said: "The primary motivation, I would have to say is consistent with our ideals around education which are largely alternative" (OOP-26, 2001). He described three areas of primary motivation that stemmed from the values held by the organisation:

> I think we were motivated largely by a forward-looking vision about wanting to take a step into the future, which showed leadership in the community. As faculty members, and board members in particular, we are interested in showing leadership and leading by example. So, we felt we could make a statement . . . by committing to a technology, which was alternative and stood for philosophical principals which were consistent with our basic philosophies: a sense of freedom, of biological integrity and responsibility . . . and leadership. (OOP-26, 2001)

The organisation was very concerned about being environmentally responsible and expressing their commitment to the environment in selecting a wastewater treatment technology. One of the selection committee members said that, "Doing the right thing is important" and outweighs the costs (OOP-27, 2001). Another committee member said:

> I think the community as a whole, if you want a sweeping generalisation, is a left-wing, eco-minded type of people who are attracted to a spoken commitment to the environment. Children are taught to revere the natural landscape. When it came to planning, and we were presented with these choices, our predisposition made it easier for us to say this fits in what we want to teach the children, this is a physical manifestation of what we teach the kids. (OOP-28, 2001)

The group was not comfortable with the conventional big-pipe approach to sewage disposal. The site manager said: "We were concerned about how conventional sewage water was disposed of and that chlorine was added and was dumped back into Lake Ontario. Certainly, the thought of that was not environmentally sustainable" (OOP-28, 2001). Another selection committee member said that being able to internalise the economic and environmental costs associated with the generation of wastewater was also a motivation for adopting the GBTT: "Not sending the waste downstream for offsite treatment and disposal into a potential drinking water source was also a major factor," and "The school was willing to put economic cost aside to do the right thing" (OOP-27, 2001).

The facility operator, who also served on the selection committee, recalled that the board had been in total agreement with the implementation of an alternative, onsite wastewater treatment system that would allow the school to meet their philosophical obligation to act as environmental stewards and "Do the right thing", and that "I think the [organisation] as a whole, if you want a sweeping generalisation, is a left wing, eco-minded type of people who are attracted to a spoken commitment to the environment" (OOP-28, 2001). In line with the organisation's vision of responsibility, another selection committee member described how the technology enabled them to express their vision of environmental responsibility and stewardship:

> [W]e assume a certain responsibility to clean up our own act, to deal with our own garbage right here and not expecting anybody else to deal with it. . . . So, again it ties in with our sense of independence and freedom and responsibility that we deal with our own mess. So, from a green perspective, from a sort of environmental point of view, I think it's consistent with our philosophy. (OOP-26, 2001)

The engineering consultant suggested that two selling points made the GBTT attractive to the selection committee in the Waldorf Case. One was that the GBTT allowed them to use the treatment system as a venue to augment the school's curriculum and second, it allowed them to manifest their "Environmental responsibility" (EAC-24, 2000). Commenting on the price of the system, another informant said, the GBTT is a "Very good system. It is expensive; you have to have some alternative motivation" (EAC-32, 2001). An official from the MOEE agreed stating that the GBTT has a history of attracting users even though it is more expensive because of the added benefits that include the opportunity to show the public that they are environmentally proactive (PGO-39-Anonymous, 2001). This suggested that he really didn't consider the GBTT that different from the conventional biological treatment systems except that it is packaged in a different way.

Technology Preference

One technology preference revealed by the selection committee was a desire to apply a treatment system that would allow wastewater to be managed, treated and reused onsite as well as the stated desire to be independent from the municipal system. One committee member said that, "A sense of independence and therefore freedom" was essential and this technology enabled that to occur: "If we are free from being connected into the system with respect to our sewage treatment we are also free to make decisions independent of what local government demands might be. A sense of freedom was fairly paramount" (OOP-26, 2001).

Although the selection committee did look at other alternative wastewater treatment systems, the GBTT offered considerable aesthetic and programmatic benefits and it was described as the "Obvious alternative" (OOP-28, 2001). The facility manager said: "We looked at the Waterloo Biofilter briefly, but for us, the aesthetics of the GBTT worked for us. So, the decision was made based on the fact that there was an aesthetic; the GBTT become a dynamic integrated component to the three sections of the building" (OOP-28, 2001). He said that the GBTT was preferred because it gave the school the opportunity "To dispose of our waste material without posing a health hazard, or environmental hazard, which we believe we are doing at this point in an economical and reasonable fashion". Another committee member said that, creating the opportunity to have a wastewater treatment system that was integrated into the building and the educational curriculum was considered a major benefit. He said that it makes reality more visible in the sense that they are able to deal with the waste they create onsite immediately, as opposed to flushing it down the toilet where it is never seen (EAC-26, 2001).

Having the opportunity to express and manifest the school's values and sense of ethics was also preferred in the selection of a wastewater treatment system. The school's board did not feel that the conventional sewage treatment regimen was sound from an environmental perspective: "We believe that there is a certain aspect of environmental health, which is associated with treating sewage as opposed to dumping it. It's an environmental consideration and together with that is the reduction of the waste aspect and wastewater flows" (OOP-26, 2001). The selection committee also preferred a treatment system that would allow them the opportunity to conserve water from their freshwater well, thus extending its functional use. One selection committee member said that a "Major factor in our selection of the GBTT was its ability to provide reuse water for our toilets and urinals, and thus ease the use on our well, and, potentially, lower future water demands if we switched to piped water" (OOP-27, 2001). The wetland engineer for the project said that the public were very receptive to the systems when visiting the school. He reflected that, "I have never had one negative comment about the system. People look at it and say, 'wow, that makes sense', and for me, that is probably a bigger measure of acceptance than any other thing" (EAC-25, 2001).

Institutional Attitudes

Engineering Consultant: The firm involved in engineering the GBTT in the Waldorf Case characterise themselves as providing ecologically beneficial systems that include energy, water and wastewater infrastructure for buildings and developments. The project engineer viewed water reuse projects such as that applied in the Waldorf Case as becoming increasingly "Mainstream" and that there is definitely a niche market that he intends to capture in developing the technology further (EAC-24, 2000). The project engineer revealed that there was some concern that no official approval had been required for this project and that this opened his firm up to liability. However, in order to get the project on the ground, the risk was taken. He said: "Not having some official approval was not ideal and increased our exposure to risk, but we did manage to get the project built". Mainstream penetration of the technology would definitely require approval" (EAC-24, 2000).

Local regulators: No formal approval was required at the local level because the implementation of the GBTT in the Waldorf Case was classified as a retrofit to an existing septic system. The municipal planning department was not interested in the technical aspects of the treatment system. The only requirement from the planning department was an amendment to the site plan allowing the expansion of the greenhouse that would house the GBTT. Municipal level approval under the OBC allows for some local level discretion[28] in the approval of onsite septic systems. There was some informal communication with the municipal plumbing inspection office and the inspector made informal site visits, offering verbal suggestions regarding the labelling of the recycled non-potable water lines. However, the wetland engineer reflected that the plumbing inspector "Just looked at the physical plumbing; he wasn't concerned with the process at all" (EAC-25, 2001). The project engineer commented that no health department involvement was necessary and, "In the end, the health inspector instructed us to proceed with the system as a retrofit to an existing functioning septic system, which would not require approval" (EAC-24, 2000).

In reference to the 1997 Services Improvement Act, the project engineer said: "The change in responsibility that occurred around the time of design caused some delays in finding out who had the authority to approve the GBTT" (EAC-24, 2000). The MOEE deferred to local officials because the system treated less that 10,000 litres/day and local officials considered the GBTT in the Waldorf Case as a retrofit. Because there is no provision in the OBC stating that retrofits require detailed approval, the GBTT was classified strictly as an add-on to the front end of that system that would improve water quality by adding an extra step in the treatment process. He said: "The end result was that we have not had to get approval under the OBC or the MOEE for the particular circumstances of our retrofit projects". However, he suggested that implementation of stand-alone systems where there is no existing septic system will be increasingly difficult and the merits and performance of the system will be under much more scrutiny. He said: "For a new system we will have to get approval and will need to produce water test results" (EAC-24, 2000).

Project Design Activities

Caution and Concerns of Liability

There was no evidence of concern about liability displayed by local officials in relation to the implementation of the GBTT. To some degree this can be accounted for because all of the

[28] Section 2.7 'Equivalents' of the OBC allows for local level discretion in the approval of septic systems.

provisions in the OBC were followed, which ensured protection from liability. There was however, some caution revealed regarding the decision by the school's selection committee and board of directors to select an onsite treatment technology rather than hooking-up to the municipal sewage system.

One selection committee member believed that there was a considerable amount of vision, but also risk taking that was required to adopt any alternative technology, he said: "Primarily it involves risk taking, in the sense that it demands a certain type of vision on the part of the decision makers. Not only vision, [but] vision and ideals" (OOP-27, 2001). Another selection committee member said that:

> Our curriculum is different: it is alternative and non-traditional. Our whole perception of human development, the nature of childhood and adolescence, and, indeed, human life is alternative, one could say. That is part of the reason why our clientele is attracted to us because we stand for something which is different and alternative. So, the possibility of considering alternatives in sewage treatment was facilitated. (OOP-26, 2001)

In order to manifest their ideals, the board decided that being innovative and championing a technology that offered the opportunity to express their environmental values was the right decision. At one point this meant that the original cost of the system increased because of cost overruns, which the school absorbed in order to ensure that the GBTT would fully meet their needs. One selection committee member said: "Well, you know, it was a risk that we took. We agreed to take on a technology and the risk was that it wasn't mainstream and that it was new. That was part of the risk factor, and so, we suffered some of that risk" (OOP-26, 2001). Another selection committee member spoke of the overriding philosophy directing the operation of the school. He said that adopting the GBTT was "Ethically," the correct thing to do," and ". . . because of the school's background and its philosophy it was an obvious choice, I think, for the school, to do this. It did not require much of a sell. I am quite confident that we could have sold it had it been considerably more expensive" (OOP-27, 2001).

The organisation was committed to the adoption and construction of the GBTT and was willing to take a risk because they believed that it was not only their right to select a technology that they desired, but that it was also their responsibility to select what they thought was the best technology from an environmental perspective. The project engineer revealed that although neither the municipal engineering department, or the planning department, could commit as to whether the school would be forced to hook-up to the main sewer trunk in the future, the selection committee decided that the GBTT was the best option for the school and so it was adopted (EAC-24, 2000). The municipal planner, who was interviewed, confirmed that there were no guarantees that the school would not have to hook-up to the municipal sewerage system in the future. He said: "The Region of York makes these heavy handed decisions. The Region may very well force them to connect" (LGO-23, 2001).

The municipal planners involved in the project characterised the organisation as "Environmentally motivated." He said that costs were not an issue to them and the GBTT was selected because of its "Environmental applicability". He admitted that it was quite a commitment to what the group believed in terms of their environmental values and said: "It's certainly one thing to do a septic field . . . but if you are embracing a whole new technology and recycling your waste water, that's certainly more of a commitment to environmental sensibility" (LGO-23, 2001).

Local Government Officials: Although the municipal planning office was only required to grant a building permit for the construction of the greenhouse enclosure, the municipal planner commented on the concerns with liability that approval agents experience in relation to alternative wastewater treatment system. He said that the "Powers that be are very nervous about endorsing them because they are not tested" (LGO-23, 2001). He described how liability constrains civic decision-making and limits innovation, but also acts to protect constituents over longer time frames. He suggested that approval agents are always cautious with novel technology and said:

> If it comes back that it's a terrible mistake whose fault is it. . . .[F]rom a municipal point of view, you are very cautious. . . .[A]s a public authority, your neck is always out. You know people say that the wheels of government turn really slowly. It's not because it's not necessarily inefficient. I am sure there are examples where it is, but you have to be very, very cautious. You evolve slowly because people are quick to embrace new trends and exciting new things and the government-level evolution that allows you to stand on solid ground is a lot slower. . . .Getting back to this liability issue again, they may say 'go for it, try it out'. . . .But I think the more likely response you will get out of them is 'no'. It may seem like the easy way out, but from a legal point of view they don't want the headaches later. (LGO-23, 2001)

He said: "The main barrier is getting the buy-in of the approval authority to allow you to go ahead with it because of liability and because of the expensive cleaning up afterwards. They tend to be very cautious about new technologies" and:

> The Region doesn't want to be left with a major problem in the future. For example, this is an untested system that is revolutionary and everybody is excited about it. Fifteen years from now, the system fails and we have an environmental catastrophe on this site. Also, the school can abandon the site and the City ends up taking it over, and the Region is going to end up cleaning the mess. So, there is a lot of concern about these alternative systems because they are not proven over the long-term. (LGO-23, 2001)

Another informant echoed this concern stating that:

> One concern that approval officials have is whether or not the implementation of an innovative wastewater treatment system will effectively serve the needs of future property owners. Standardised systems have made the jobs of approvals easier. It has to work well not only for the person who is going to live with it initially . . . but it has to work for the next person. (EAC-32, 2001)

One member of the selection committee said that he saw a "Major impediment to new technologies," was "The unwillingness of individuals in regulatory positions to entertain new technologies" (OOP-27, 2001). He said that "When new things come along, if someone champions it they get labelled and nobody wants to stand out in an organisation because they fear being held liable by their political masters, or being rated by them. So, there is fear of disturbing the apple cart". The planning official who was interviewed echoed this as well. He said, that from his perspective, he "Certainly wouldn't stand in front of council and say: 'this is a wonderful untested product and I think we should embrace it wholeheartedly', because it could blow up in your face" (LGO-23, 2001).

Project Legitimacy and Support

The selection committee had the opportunity to view an existing GBTT that had been established at the Body Shop, cosmetic manufacturer in Toronto, Ontario. This acted to influence the selection committee to adopt the GBTT. One committee member said that: "It looked very interesting, and we were quite enthusiastic about it. We talked about the potential" (OOP-27, 2000). Additionally, the consulting firm that had installed the GBTT in the Waldorf Case had recently completed a similar installation at the Kortright Centre, which was owned and operated by the Toronto Regional Conservation Authority. One selection committee member believed that the adoption of the GBTT by Body Shop and the Toronto Regional Conservation Authority acted to support their decision to adopt a similar system and that it assisted them in selling the idea to the school's board of directors and also facilitated negotiations with the local officials. He went on to say:

> [B]ecause the City of Vaughan had experience with the engineering consultant during the implementation at the Kortright Centre, it was a much easier sell. It's

> the second time. Now they haven't been operating a long time at the Kortright Centre, but they have received considerable good press, and the City knew us as little bit left field as a school, so they were willing to go along with us and help us in this case. I mean it adds a little bit to their ethic and prestige, as a forward-thinking community and it wasn't as hard a sell as we thought as it might be. We thought it would be a bit of a block from the bureaucratic standpoint. We were quite relieved to find that it went fairly smoothly. (OOP-27, 2001)

The project engineer suggested that there is an increasing demand for technical options for wastewater treatment that are capable of internalising the costs of wastewater management and enable the recovery and reuse of wastewater (EAC-24, 2000). However, in terms of the municipal authorities, he admitted that he did not think that the school would ever get assurances from the local municipality that they would not be forced to hook-up to the main sewer trunk. He said that if a new sewer comes in, the authorities always want to get rid of septic systems in order to protect the environment and it would be very hard to get them to promise that they will not force the school to hook up at that point.

The wetland engineer who built the CTW as a component of the GBTT in the Waldorf Case reflected in a more general sense on his experience with the implementation of CTWs in Ontario. He characterised the reticent attitude of the regulatory authorities to facilitate the adoption of alternative technologies, generally, not as "Lack of knowledge", but as "Lack of interest" that can be interpreted as fear of liability". He suggested that in this way, "They are stifling" innovations in alternative forms of wastewater treatment (EAC-25, 2001). Fully described, he said that, "They feel that they take a certain amount of responsibility for the approval and so anything that is beyond their scope of understanding or comfort, they don't necessarily want to see it approved. He suggested that in order for ecological alternatives to be become more widely used, "It requires that approval agents acquire more education and that they need to get out and make an effort to familiarise themselves with these types of technologies". He described the process of gaining a Certificate of Approval from the MOEE and suggested that they should focus less time on the treatment process itself and more time on the performance of the system and the treated water quality that could be achieved:

> I'm preparing a Certificate of Approval for a winery . . . and it is a 2-inch thick binder that includes all of the drawings all of the supporting documentation. It costs a lot of money, it sits in the MOEE's office for 3-months before you hear back from them. And then, in the end, it doesn't matter what was inside the box because all they are interested in is what is coming out of the box. (EAC-25, 2001)

And:

> [I]t could be much easier if the MOEE would almost take a black box approach and say 'here is your final wastewater quality criteria. What you do in the black box doesn't concern us as long as when it comes out it meets our criteria'. That is ultimately all that matters, what is coming out, but they spend so much time within that black box. (EAC-25, 2001)

Although the wetland engineer suggested that there is a demand for alternative wastewater treatment systems, he also feels there is lack of support from regulatory officials from the MOEE (EAC-25, 2001). He said that the lack of support from provincial authorities impedes the adoption of alternative technology and fosters rule bending by proponents:

> [W]orking with some of the clients in the wineries and the greenhouse industries, what everyone is saying now is, 'it's easier to ask for forgiveness than gain approval'. So, the idea is that you go ahead and do something and then when the MOEE gets involved you say, 'oh, forgive me how do we rectify it?' . . . I mean in the winery industry right now, the MOEE has made it so difficult on them that people are going ahead and building things and doing things because if you wait for the MOEE with all of the regulations there are [too many] time constraints and costs. (EAC-25, 2001)

Project Approval

The project engineer said that that the goal of the project was to upgrade or "Repair," an existing septic system and for this reason, the project didn't require "A detailed approval" (EAC-24, 2000). The wetland engineer said that no approval was necessary and approval agents told them to "'Just build it because there was an existing system and the tile-bed system had already been approved', so all we were doing was renovating and putting an extra filtration step in" (EAC-25, 2001). In term of building a completely new system where there had been no existing septic system, the project engineer said that it would have been much more difficult. He said that his firm, "Did not have the extensive testing on earlier systems that is required to get a system approved under the OBC," but that with the system in the Waldorf Case they, "Managed to explain the working of the system enough to get cooperation and it helped that we were only retrofitting as opposed to building complete new systems" (EAC-24, 2000). He explained, however, that a new project with a capacity of over 10,000 litres/day would require MOEE involvement and approval under Section 53 of the Ontario Water Resources Act. This was not required during the implementation of the GBTT in the Waldorf Case and the project engineer described the only requirements that were 'suggested' by the plumbing code inspectors:

> Plumbing practice for reuse was discussed verbally with plumbing inspectors who made recommendations such as backflow prevention device and 'non-potable water' labelling. They viewed piping within the treatment system as "process piping" much like a factory where the responsibility lies with the engineer who stamps the drawings, in this case myself. . . . [T]he end result was that we have not had to get approval under the Building Code or Ministry of Environment for the particular circumstances of our retrofit projects. For a new system we will have to get approval and will need to produce water test results. (EAC-24, 2000)

In terms of gaining approval for the recovery and reuse of wastewater, the project engineer said, "The current building and plumbing codes in Ontario do not deal with reuse or appear not to allow it" (EAC-24, 2000). In the Waldorf Case, the plumbing inspectors made some recommendations on how the hook-ups should be installed in order to ensure limited risk of adverse health effects.

Implementation Setting

Incentives and Disincentives

Cost: In the Waldorf Case, the additional cost over the conventional option was $45,000 total (including the cost of the greenhouse enclosure). Users and the engineering consultant admitted that the cost of the GBTT is only justifiable in terms of the added-value to the site. One of the advantages that the GBTT offered in the Waldorf Case was the opportunity to extend the life of the existing septic system while fully integrating it into the facility and offering amenity value as a functional component of the educational curriculum. One member of the selection committee said: ". . . I think the main measuring stick for the success of the greenhouse is the way that it has augmented the possibilities for curriculum work with the students" and also said:

> [O]f course, cost was a big factor. You know, as a board we are charged with being financially accountable to the school. I guess the bottom line was, we could see that it was a short-term investment and the possibility of a long-term cost saving, specifically, if we can get another 25-years out of our septic system, of course, or find a way to utilise it to its maximum. (OOP-26, 2001)

The facility manager said that the decision to adopt the system was really not a risk. He said: "The technology is not that complex . . . it is what nature does all the time, we just do it in accelerated fashion, people have done it before, it appears to work and there is a long warranty period [of twenty-seven months]" (OOP-28, 2001). Additionally, the consultant is located close to the organisation and assistance from the consultant is readily available if required. Initially, during the construction period, there were some problems related to the implementation of the GBTT. One selection committee member described them as "Financial wrangles, " that were related to, "Auxiliary work that needed to be done" (OOP-26, 2001). He admitted that they were essentially a

"Cost over-run" and that the selection committee accepted some financial loss because they "agreed to take on a technology and the risk was that it wasn't mainstream". And in retrospect, he said that: "We bit the bullet and paid it out because we didn't want it to interfere with the success of the technology and construction of the greenhouse itself. So, this was the right decision in the end".

The facility manager said: "We looked at the conventional options, they too were very costly, but comparable. So, we knew we were into a large capital commitment anyway at that point, and felt that it was justifiable to look at alternatives. And as an alternative school, we always look at alternatives" (OOP-28, 2001). Another selection committee member said: "So, the economic costs were comparable, we started looking at benefits at that point, and it seems that bringing that water treatment process, integrating that into a curriculum was an advantage at some level. It becomes a real dynamic focus of that greenhouse". Additionally, he said: "There was some comment that it was potentially also a selling point, a positive feature of the school . . . in terms of attracting students because it is an additional outward sign of our environmental ethic, and that we take these things seriously, we put our money where our mouth is" (OOP-27, 2001).

The facility manager said that: "The outreach provided by something different was a calculated selling point for us. We wanted people to come and see what we do here, we wanted to be on television, and we wanted to let everyone know we are here we do things a little differently, and do it well" (OOP-28, 2001). The municipal planner agreed that there probably would be some benefits in terms of public image. He said: "There are probably a lot of advantages to that. There could be financial advantages, but I think the most advantage would come from the appearance from being an environmental company. If you want to get that public image across to your clients, to your shareholders, that's a big step to do a system like that" (LGO-23, 2001). The wetland engineer believed that there was considerable interest in an ecological treatment system for a variety of reasons: "People in the private sector realise the opportunities that these things support, not only do they provide efficiency, they're effective, reliable, [in some cases] cheaper to implement and to operate. There is a lot of opportunity" (EAC-25, 2001).

The school's selection committee and the board of directors did, however, sense that they were taking a considerable risk in deciding to adopt the GBTT because the Region would offer no assurances they wouldn't be forced to hook-up to the main sewer trunk in the future (OOP-28, 2001). Ultimately, the group decided that they had an obligation to do the "Right thing" in their minds (OOP-27, 2001).

Operation and Management

There were some idiosyncratic issues associated with the operation of the GBTT because of the fact that wastewater recovery and reuse was a primary objective of the project. On informant stated:

> We have some brownish colour in our reused water, and it's probably organic material picked up in the wetland. There's probably more nutrients in it than in the well water, so when it hits the bowl bacterial growth probably does happen maybe faster than in our well water. So, there is a discolouring of the water which some people find aesthetically unpleasing, even though we wash, we clean our toilets every night they look brownish. People don't like that. (OOP-28, 2001)

He said, "I find it quite a challenge when kids come in, and go: 'yuck, it's dirty. It smells.' . . . [B]ut it is important for kids because it's their shit and they need to come to grasp with it in some way" (OOP-28, 2001). On this area of discussion, he ended by stating: "It is certainly part of what we want to say to the kids is, 'you are making this waste material; it's part of your responsibility. I assume some of that responsibility for the community in this building'" (OOP-28, 2001). Another selection committee members admitted that there was some concern by the board and parents regarding the recycling of wastewater and potential health risk: "There is some concern. We had one particular medical doctor on our board at that time who was concerned about bacterial contamination and splashback from urinals and toilets for instance" (OOP-27, 2001).

In association with the teaching activities that occur in the greenhouse, hand washing is constantly promoted and there are warning signs instructing students to not touch the water. One informant described how this potential health risk was mitigated: "In order to really satisfy the ultimate safety and the liability from the standpoint of the school, we installed an ultraviolet water purification system" (OOP-27, 2001). In terms of the reuse of the treated, non-potable wastewater, the project engineer said that, "The main concern in the retrofit projects was to reduce overloading of the existing leaching beds, which was a quantity issue solved by flow balancing and reuse. For the safe handling of reuse, we were directed to review our system with plumbing inspectors. Quality for reuse water is a question of human health and the only parameter tested at present is E. coli" (EAC-24, 2000).

One of the faculty members who also sat on the selection committee said that in terms of disadvantages to the GBTT is that, "It requires maintenance" (OOP-26, 2001). He described that the level of maintenance required is "Not necessarily full-time, but that an operator is needed who knows how to monitor it and, if there are problems that occur, what buttons are the right ones to push, who to call when you need certain problems to be met. And that's the only real drawback I can see". He went further and said: "It's a technology that requires a little bit of training and the knowledge to maintain. I don't think it requires too much maintenance . . . but it does require some specialised knowledge that you wouldn't necessarily call a traditional plumber if you had a problem. And that's the drawback". The system operator suggested that it is also important to be careful that the bacterial communities in the system were protected from toxins and that the system is somewhat fragile and will not tolerate a lot of bleach and cleaners at this scale (OOP-28, 2001).

Resource Recovery

Although the local plumbing inspector did not object to the reuse of treated wastewater, the reuse of wastewater is not explicitly encouraged by the OBC at this time. The project engineer said: "With reuse in particular, Ontario needs to address it in the Codes much like British Columbia has done already. The OBC has to be more flexible with allowing devices that displace drinking water, such as composting toilets, and to allow alternative water sources for non-potable demands rather than municipal water supplies or well water" (EAC-24, 2000). He suggested that at today's water prices, there is no incentive to conserve or act in the recycling of wastewater: "The payback from reduced water purchases appears to be beyond ten years at this time with Waldorf's GBTT". Regarding the indoor CTW, the engineer said: "The advantage of putting a wetland inside a greenhouse is architectural and educational, but its also allows energy savings since there is some benefit in terms of a warmer temperature and heat retention" (EAC-24, 2000). Although 40-60 percent of the water demand at the Waldorf site met from recycled wastewater, onsite reuse of the sludge collected from the septic tanks has not been considered and is currently being pumped by septic truck and transported off-site for disposal.

5.3 Summary

In this section, data collected in relation to the implementation of the GBTTs in the YMCA and Waldorf case studies is reduced and presented in three tables that reflect information related to the nine theme areas that emerged during the analysis of these two cases. The following chapter, Chapter 6, presents a synthesis of the data across the four case studies and presents the final findings that were established during the investigation.

Stakeholder attitudes: Table 5-1 presents various issues identified in relation to stakeholder attitudes in the YMCA and Waldorf Cases.

Table 5-1. Summary of Stakeholder Attitudes (Greenhouse-Based Treatment Technology).

Stakeholder Attitudes	
YMCA Case	**Waldorf Case**
Adoption Motives	
Skepticism with the conventional alternatives	
Strong environmental values, awareness and commitment to act in improving the environment	
Aspiration to demonstrate environmental values	
User Technology Preferences	
Ability to manage wastewater onsite	
To contribute zero or positive impacts on the environment	
To increase water and energy efficiency	To increase water use efficiency
To adopt a technology that would contribute aesthetic and programmatic benefits	
Integration of the technology with the physical site layout and educational curricula	
Institutional Attitudes and Preferences	
User belief that environmental responsibility supersedes cost-saving and minimum requirement	
No intention to classify GBTT under the OBC (not monitoring)	Intention of supplier to classify GBTT under the OBC (monitoring to collect performance data)
Local regulators require treatment technologies to be classified under the OBC for approval as standalone system	
Prescriptive nature of the OBC enables strict control of private onsite treatment systems	
No provisions in the OBC to promote site-level innovation or wastewater recovery and reuse	

Sources: Research Informants (December 2000 – September 2002).

In both cases, the implementation of the GTBB represented an intentional effort to exceed the *status quo* for wastewater management and an attempt to demonstrate a commitment to the environment. The adoption of the GBTTs was driven by each institution's belief that environmental responsibility meant achieving zero-discharge wastewater management and minimising each facility's water budget. There was also intent to demonstrate technology that integrated both aesthetically and productively, in the sense that it acted as a recreational amenity, but also served a functional purpose, in terms of treating wastewater. In both cases, the cost of the GBTT was considerably more than the conventional options; however, both institutions considered it the best option from an environmental perspective and, additionally, it offered aesthetic, programmatic and competitive advantages.

The two engineering firms that designed and constructed the GBTTs were committed to establishing an alternative wastewater management regime. In the YMCA Case, the firm that constructed the greenhouse treatment systems was the original innovator in the area of greenhouse-based systems and their systems have been applied in North America and Europe. In the Waldorf Case, the firm was attempting to establish a niche market for ecologically efficient architectural and infrastructure design in southern Ontario (EcoWerks Technologies Corporation 2002). In terms of regulatory perspective, the OBC clearly defined what types of systems are classified and permitted for onsite sanitary systems. The GBTT was not classified and could not be implemented as a stand-alone treatment system. Although the OBC does not explicitly address the recovery or reuse of wastewater, it appears that discretion does exist at the local level regulators can manage reuse innovations if they have the capacity to monitor it implementation and are willing to assume potential liability.

Project design activities: Table 5-2 presents a summary of project design activities related to the YMCA and Waldorf Cases.

Table 5-2. Summary of Project Design Activities (Greenhouse-Based Treatment Technology).

Project Design Activities	
YMCA Case	**Waldorf Case**
Project Approvals	
GBTT not classified under the OBC and not approvable as a standalone system	
Required a redundant backup contingency classified under OBC	
Discretion of local health department allowed reduction of leaching bed size	Discretion of local building inspector allowed full recycling of treatment wastewater
Caution and Liability	
Regulator not concerned with issues of liability if OBC provisions met	
	No assurance from the Regional that hook-up to municipal sewerage system would be waived in future
Project Legitimacy and Support	
Previously existing and operational GBTT installations available for viewing by prospective users	
Early pre-consultation with local level officials	

Sources: Research Informants (December 2000 – September 2002).

Although each of the GBTTs had been commercialised previously in Ontario, neither had undergone adequate testing that would have enabled their classification under the Part I of the OBC. In both the YMCA and the Waldorf Cases there was no approval mechanism under which the GBTTs could be approved. However, in the YMCA Case, the local health department interpreted the OBC at their discretion and credit was given for the tertiary treatment capability of the GBTT. This enabled the installation of a smaller leaching field than normally would have been required. In the Waldorf Case, the existing septic system had previously been approved, and although the septic system was overcapacity and failing, previous approval allowed the GBTT implementation to proceed as a retrofit with no additional approval under the OBC. Mainstream penetration of the technology would require further testing of the system in order for it to be classified under the OBC. Regulatory caution and concern with liability was not evident during implementation of the GBTT in either of these case studies. The prescriptive and standardised approval process outlined in the OBC with regard to sanitation systems offer a high level of protection from liability exposure if the present regulations are followed.

In terms of project legitimacy, the organisation applying the greenhouse treatment technology during the YMCA Case was well known in the community. This recognition offered local regulators an added level of confidence that the project would be well managed and maintained. In the Waldorf Case, the project engineer had recently completed an installation of the GBTT at the Toronto Regional Conservation Authority's Kortright Centre, which was in the jurisdiction; therefore local regulatory officials were familiar with this project and this was thought to increase the legitimacy of the technology and the supplier during the Waldorf Case.

Implementation setting: Table 5-3 presents various issues identified in relation to implementation setting in the YMCA and Waldorf Cases.

Table 5-3. Summary of Implementation Setting (Greenhouse-Based Treatment Technology).

Implementation Setting	
YMCA Case	**Waldorf Case**
Incentives and Disincentives	
Discretion by health department allowed reduced size of leaching bed	Upgrade of existing leaching bed eliminated need for approval under OBC
Enabled demonstration of environmental commitment and provided significant added-value	
Enabled immediate or future recycling of wastewater	
GBTT integrated fully with educational and programmatic goals of each facility	
Allowed onsite wastewater management	
Ongoing support available from supply consultant	Ongoing support available from supply consultant (27-month warranty period)
Fit each facility's operational framework	
Not yet classified in the OBC and cannot be applied as a stand alone system	
Cost to implement GBTT higher than conventional options	
No incentive to recycle wastewater	
	Region offered no assurance that hook-up to municipal sewerage system would be waived in the future
Operation and Management	
Willing to incur costs for unique operation and maintenance and operational protocols	
Resource Recovery	
GBTT recognised for its ability to recycle wastewater and reduce energy use	GBTT recognised for its ability to recycle wastewater

Source: Research Informants (December 2000 – September 2002).

There were no government financial contributions or innovation grants available for the GBTT applied in the YMCA or Waldorf Cases. Both systems were constructed with private funds. The cost of the GBTT is the YMCA Case was approximately $75,000 above what was required for a conventional system. In the Waldorf Case, the cost to implement the GBTT was $45,000 over the cost of the conventional system. The relative higher cost in both cases was not a disincentive and, in these cases, the organisations had the financial resources available to realise their objectives and implement the GBTT.

In both cases, the GBTTs offered recognised ongoing benefits that integrated fully within the operational framework of each organisation. The benefits of the GBTT included: offering a venue for educational programs, providing aesthetic amenity of the greenhouse enclosure and reducing impacts on the environment through establishing zero-discharge systems. The GBTT also provided additional advantages to each organisation. In the YMCA Case the GBTT was recognised for its unique character and was expected to increase the appeal of the conference facility to clients. In the Waldorf Case, the system provided an expression of the institution's commitment to environmental responsibility and this feature, among others, was seen as a potential competitive advantage in attracting students.

The GBTT required a trained operator and consistent ongoing maintenance, but this did not inconvenience either organisation. In the YMCA Case, although final plumbing hook-ups to for wastewater recycling were not connected at the time of the research, the system did contribute to the environment control of the building through decreased energy usage. In the Waldorf Case, wastewater reuse had been fully implemented and the system provides 40-60 percent of the facilities total water budget through recycled wastewater. In both cases, negligible amounts of plant matter are harvested from the open aerobic reactors and wetlands and composted onsite. Neither of the two facilities recovered nor reused generated solids waste (*i.e.* bio-solids).

Chapter 6.0

Synthesis of Findings

6.1 Presentation of Findings

This chapter offers a cross-case synthesis of the analysis that was presented in Chapters 4 and 5. The chapter begins by offering a concise synopsis of the findings that were established after its validity had been verified in the peer-debriefing survey. The chapter then proceeds with an interpretation of the findings and presents the results of the peer-debriefing survey in section 6.3.

Finding One: Environmental Values Were a Motivating Factor

Across the case studies, each organisation considered itself to be both environmentally conscious and as having strong environmental values. These values motivated the adoption of the ecotechnology in each case. Ecotechnology was adopted because it allowed each organisation to function with what was believed to be the least environmental impact. Conventional options were rejected because they were viewed to be inferior in terms of their ability to effectively manage the interactions of each organisation with the environment. In comparison, ecotechnology was seen as a solution that enabled wastewater to be treated onsite and allowed each user to take responsibility for the waste they created as opposed to shifting it offsite at costs to the environment and society. In three of the four case studies, the capital costs of the ecotechnology were greater than the conventional technology; however, in each of the cases, users believed that protecting the environment fully justified this added investment.

Finding Two: Perspective Gaps and Inertia Exist

Even after more than 15-years of MOEE involvement in the CTW technology for agricultural manure and domestic sewage management, no official design guidelines have been formally developed by the Ministry and they have continued to exhibit an elevated level of caution with regard to CTWs. Comprised predominantly of natural components, the performance parameters and operational characteristics of CTWs are dissimilar to conventional options and can differ because of variability in system design. This poses a unique challenge to regulators. The practical reality of regulating novel environmental technologies aside, there was criticism aimed at the MOEE for historically impeding the development of the CTW technology for agricultural manure and domestic sewage management. Interviewees suggested that the MOEE's opposition to CTWs stemmed from a bias seated in a conservative engineering mentality preferring conventional options because they are familiar and enable a high level of process control, which is often achieved through mechanisation and inputs of energy. In addition, existing regulations correspond to and were, in fact, developed with conventional options in mind, which tends to allow regulatory expediency, but also discriminates against non-conventional options despite their current or future potential.

Inertia was also evident in relation to GBTTs for the management of domestic sewage. In 1997, the enactment of the Services Improvement Act transferred authority for the management of small-scale onsite sewage systems from the MOEE to local authorities under the OBC. The OBC is a rigid and prescriptive set of regulations that is expedient in terms of promoting conformity in onsite treatment systems and, thus, preventing catastrophic failure; however, innovative technologies with potential benefits over and above the minimum standards are not encouraged. In neither case where the GBTTs were implemented did local level authorities have the ability to approve the technology with confidence because their technical expertise was not sufficient and they were not able (or willing) to determine the GBTTs viability with enough confidence to invoke the OBC "equivalents" clause. Even though the GBTT has the ability to treat and recycle domestic sewage onsite, provincial policy has been directed towards existing technological options that are preferred under the OBC. This preference impedes the approval and subsequent improvement of alternative options. This was evident in the Waldorf Case, where regional authorities refused to offer any guarantees that the school would not be required to hook-up to the regional sewer trunk when it was constructed in the future.

Finding Three: Expert Involvement Legitimated Ecotechnology and Built Local Capacity

Initially, municipal officials involved in the French Case implementation exhibited a high level of caution with regard to the CTW technology since it was the first time it had been applied. Caution originated from uncertainty related to departing from standard agricultural manure management practice and they feared creating a situation were they would be open to liability. To some extent, concerns related to liability stemmed from local government's recollection of the MOEE's Listowel Marsh Project (1984-1996) and its 'apparent' failure. However, under the auspices of the CURB program, the involvement of the MOEE (who oversaw the project), the UTRCA (who designed and managed the project), the project's credibility increased and reduced the caution of local government. Undoubtedly, the involvement and support of credible agencies and donors legitimated the project and enabled the UTRCA to champion and implement the CTW project. As a result, the UTRCA established their ability to plan, design and manage the technology, which, to some extent, can be attributed to the guidance they received through collaborating with the MOEE. Municipal officials also built capacity during this process and were compelled to develop an innovative permitting mechanism for the CTW under Section 41 of the Ontario Planning Act. The confidence that the municipal government gained during the French Case was precedence setting and three years later, the implementation of the Luckhart Case proceeded with practically no municipal-level resistance or concern of liability.

Capacity was also built at the local level in relation to the implementation of the GBTTs. In the YMCA Case, the health inspectors were very interested in the GBTT as a wastewater recycling technology and made every effort to facilitate its implementation. Although they would not approve the GBTT as a standalone system under the OBC's, they used their discretion and allowed a reduction in the size of the leaching-bed, which reduced the capital costs. Based on the collaboration between the local officials, the YMCA and the consultant engineer who installed the GBTT, local officials expected that they would be more willing to entertain future applications for innovative treatment technologies. In the Waldorf Case, municipal local officials had a level of pre-existing confidence in the GBTT and in the consulting engineer who had gained some legitimation when, one year earlier, he had implemented a GBTT within the same municipality. Although the municipality would not approve the GBTT under the OBC's equivalents clause, they did allow the project to proceed as an upgrade to the existing septic system. Again, previous experience and success during the implementation of a previous GBTT installation combined with the credibility of the consulting engineer acted to legitimate the GBTT in the Waldorf Case and reduced the municipality's concerns with potential liability. In terms of capacity building and learning effects, the implementation of the GBTT in the Waldorf Case gave the consulting engineer a second project and another opportunity to collect performance data in ongoing efforts to improve the efficiency of the GBTT and have it classified under the OBC.

Finding Four: Provincial Budget Reductions Impeded Innovation

The MOEE was engaged in a learning process and was building capacity vis-à-vis CTWs during their collaborative efforts with local conservation authorities under the CURB program. However, the 1996 provincial government budget reductions resulted in the MOEE dismantling the CURB program and the team involved in evaluating the CTWs, which subsequently, constrained the development of additional projects that were planned. This effectively dissolved the capacity that the MOEE had built with CTWs and prevented the delivery of a Canada-Ontario Agriculture Green Plan study to determine the practicality and efficacy of the CTWs implemented under the CURB program was not undertaken. As result, very little data was collected and analysed from the twelve CTWs established under CURB.

The 1997 Services Improvement Act transferred regulatory authority for small-scale onsite sewage systems from the MOEE to the Ministry of Municipal Affairs and Housing (MMAH) and the municipalities. It is not evident, however, that adequate capacity exits at the local level to enable self-determination during the implementation of innovative and potentially more sustainable technology.

Finding Five: Ecotechnology Preferred By Users

In terms of user preference, the ecotechnologies were adopted not only because of their environmental benefits, but also because of the added-value they contributed to each site. The conventional options were considered either unsightly or possessed no added-value while the ecotechnology was considered a site-level aesthetic amenity. From an operational standpoint, the CTWs were preferred because they were simple to operate and desirable because they managed wastewater with fewer inputs of energy, maintenance and labour because the need for land-spreading was eliminated. The GBTTs were preferred because they had the potential to reduce water consumption through treating and recycling wastewater and offered the dual purpose of integrating with the programmatic aims of each educational organisation through blending with their environmental curricula. Both types of ecotechnology added-value to each organisation as a centrepiece to display their environmental values and, as such, it was a source of pride. The ecotechnology also offered strategic advantages because it set each organisation apart from competitors by enabling environmental values to be manifest in the daily operations. Another reason the ecotechnology was adopted related to the expectation that it would provide a competitive advantage as part of a 'greening' strategy. The conscious decision by each of these organisations to green their operations was strategic because it was expected that acting in an environmentally responsible fashion would increase market-share through gaining an added portion of the market through widening their appeal to environmentally conscious clients.

6.2 Synthesis and Interpretation

6.2.1 Stakeholder Attitudes

Users and Proponents: Values and Environmental Responsibility (Finding One)

The attitudes of stakeholders in each of the organisations were central in motivating adoption of the ecotechnology in each case study. Finding One - *Environmental Values Were a Motivating Factor* – suggests the importance of values in promoting adoption of the ecotechnology. Concern for the environment catalysed a desire by each organisation to implement a wastewater management solution that was expected to be the most effective in reducing negative environment impacts. In both the agricultural and educational setting, the conventional options were considered unsuitable and viewed as inadequate in terms of improving the environment. In fact, the conventional options were viewed - at face value - as being incapable of contributing to environmental improvement and this catalysed interest in alternatives that were considered superior. Adoption of the ecotechnology allowed values to be demonstrated through 'action'.

In each case, the adoption of the ecotechnology was motivated internally and, from an ethical perspective, its adoption was considered the 'right' thing to do. The ecotechnology provided opportunities to treat wastewater onsite opposed to shifting the burden offsite and externalising costs to the environment and society. This behaviour can be seen as altruistic and was compelled by each organisation's values as environmental stewards and not imposed by external forces (*e.g.* regulations). The owner in the French Case anticipated stronger regulations and acted pre-emptively to adopt the ecotechnology, which was his preferred option. He did this rather than being required by regulation to implement a conventional option to attain cost savings. His decision was compelled more by a desire to adopt what was considered the best technology from an environmental perspective. In the remaining cases, the ecotechnology was implemented at capital costs higher than the conventional options, again, because it was considered the best technology and the most responsible decision to make.

The ecotechnology corresponded with the values of each organisation, which was a key factor promoting its adoption across the cases. Each organisation held a strong affinity with the local environment and the conventional options did not resonate in a culturally relevant fashion. To these organisations, the conventional options were not 'comprehensible' in Bookchin's (1980) language, because they did not embody a technical solution that 'made sense' to users.

The ecotechnology either had lower operational requirements than the conventional options or was capable of internalising wastewater management, which resonated with users as environmental stewards. This is certainly the case with the CTW, which from an operational perspective achieved its objectives almost exclusively with inputs of renewable energy. Although the GBTT is more mechanised than the conventional onsite septic systems and consumed low-levels of electricity, its ability to treat and recycle wastewater outweighed these requirements in the eyes of users. At a broader level all of the users were concerned with water resource management in Ontario and the conventional options were not seen as part of a solution to water resource management in the province. In the agricultural setting, allowing unregulated barnyard runoff to enter adjacent waterways was considered inadequate, as was storage and land spreading. In the educational facility setting the opportunity to recover treated wastewater opposed to externalising discharges to the environment was considered a desirable solution.

In terms of values, the main criterion used by each organisation in selecting the ecotechnology was the net environmental benefits expected. The ecotechnology was selected over the conventional options because it matched each organisation's idea of an environmentally sound technology. There was considerable skepticism with regard to the conventional options and a desire to implement a better solution in spite of the unknown consequences. This is reflected in the comment of one user:

> One has to be motivated by something that is more than just pragmatic in a financial sense. One needs to be motivated by a higher ideal around what's right, what is the decision that has integrity which stands for something, and can you deal with the risks involved in adopting a new and unproven technology. (OOP-26, 2001)

This mindset led to self-motivated efforts in each operational setting to change reality through implementing a technology expected to contribute to environmental improvement. At an ideological level, both types of ecotechnology matched the environmental value and objectives of each organisation and this acted as a factor motivating its adoption. The conventional options were not seen as capable of assisting to this end and this motivated adoption of the ecotechnology, which was congruent with the values of users.

Regulatory Agencies: Technology Preference and Inertia (Finding Two)

Finding Two – *Perspective Gaps and Inertia Exist*, suggests that institutional, and thus, regulatory factors will combine to impede the adoption and implementation of alternative technologies in local level environmental management initiatives. Institutions are significant factors influencing the technology used in environmental management (Forster and Southgate 1983; Bowen and Ferguson 1989). The following section discusses how perspective gaps were manifested and how they contributed to inertia in relation to the advance of ecotechnology.

Historical Attitudes

During the research, gaining access to key regulatory stakeholders within the MOEE who had been involved during the implementation of CTWs was difficult. In some instances, interviews were declined outright, and in others, informants were not willing to go on the record for their comments. The MOEE's involvement with the CTW technology has been controversial and they have been criticised for not making adequate efforts to promote the advance and development of the technology (EAC-34, 2001; PGO-Anonymous, 2001; PGO-33, 2001). The refusal of MOEE officials to discuss the subject can be interpreted as caution related to apprehension with opening another *Pandora-type* box. The Ministry has been under siege since the 1996 budget reductions and has been involved in attempts to manage political consequences resulting from the events of Walkerton in 2000 (O'Connor 2002), which occurred while this research was being conducted.

The analysis revealed that the provincial MOEE has always taken a cautionary approach with respect to CTWs and was not comfortable with endorsing their use. The seminal research conducted by the MOEE during the Listowel Marsh Project, suggested that regulators did not find the CTW technology to be an effective option for wastewater treatment. However, it has also been suggested that monitoring conducted during the Listowel Marsh Project led to erroneous results because the overall evaluation did not account for the unique performance parameters of the CTW (Miller 2001b). One informant suggested that the CTW technology did, in fact, perform better than was expected during the Listowel Marsh Project, but that the regulatory community intentionally misinterpreted the data and never had any intention of supporting the development of the technology (PGO-Anonymous, 2001). Nevertheless, the results that were generated acted to stigmatise the CTW technology in Ontario and has retarded its advance (PGO-33, 2001).

Strict approval requirements have acted as an implicit and unspoken 'signal' from the regulatory community that they do not support the technology and this has constrained its advance. One statement reflected this concisely:

> [T]he technology has a niche in the market as one of the tools that can be applied in wastewater treatment. It is not a wide niche and it is not universal, but we have to find where it works and where it doesn't. The barrier is the approval process. I think that as soon as the approval barrier breaks down then . . . very rapidly it will become apparent, which variations of the technology are acceptable and in what circumstances. (PGO-33, 2001)

Since the Listowel Marsh Project, the MOEE has not established design guidelines to promote continued development of CTWs.

Technology Preferences

Often, ecotechnology will not meet the standard approval requirements, since operational processes and performance parameters are unique compared to the conventional options. Differences between variation in design, treatment objectives, scale, pre-treatment levels, and lack of cross-seasonal performance data have contributed to uncertainty (Pries, Borer *et al.* 1996; Rew 1999; Tanner, Sukias *et al.* 2000). Ecotechnology comprise components of complex living systems that act in synergy to achieve treatment objectives. Although conventional wastewater treatment technology also utilises natural components (*e.g.* bacteria) to achieve their objectives, there is more homogeneity of these natural components, self-design is not encouraged and they usually require large amounts of external fuels to drive mechanised treatment works. Findings from the research suggest that the MOEE has discouraged the development of the CTW technology because its performance parameters are not entirely understood and track record unproven compared to conventional options, which achieve objectives with little uncertainty because their performance parameters are familiar under a wide variety of operational settings.

Traditional engineers have a level of certainty that environmental objectives can be met with conventional options and this constrains acceptance of alternatives. One informant reflected this in stating that "A lot of [approval] requirements . . . were written for these brass and concrete plants and a lot of the time they do not apply for natural treatments systems" (EAC-25, 2001). Even as late as 2000 the complexity and conflict related to the CTW technology was noted during the implementation of a system in Cobalt, Ontario. Hanna, McMullan *et al.* (2001) note the main institutional challenge encountered during the project was the regulatory community's lack of familiarity with ecotechnology and their tendency to base approvals on standard performance criteria established for conventional technology.

Likewise, prior to the 1997 Services Improvement Act (Bill 107), when responsibility for small-scale onsite septic systems was transferred to the MMAH, the earliest applications of the GBTT were overseen by the MOEE. During this time, it was revealed that the MOEE viewed the GBTT with some skepticism. This may have impeded its advance during early implementations in the province and there was some indication that the MOEE made attempts to stall the start-up of the system (EAC-18, 2001). It was also suggested that regulators viewed the technology as “A lot of mumbo-jumbo” because it did not conform to the conventional options (EAC-30, 2001). These attitudes suggest the existence of perspective-gaps between the traditional engineering mentality and engineers disposed to an ecological engineering approach. This was evidenced by a regulatory tendency to favour conventional options over alternatives that have not yet experienced learning-effects that would act to increase their performance and regulatory familiarity to develop. These factors combine to play a key role in establishing conditions of the selection environment.

It is possible that perspective-gaps also extend to local level institutions and, possible, that the MOEE’s caution and lack of support for CTWs was infectious. During the French Case, local government was initially very resistant to depart from standard agricultural practice and permit implementation of the CTW. A portion of this resistance was based on the ‘alleged’ failure of the Listowel Marsh Project. However, local concern related to *fear of the unknown* (LGO-5, 2001) could also be attributed to the hesitance that was apparent in departing from standard practice, which suggests institutional inertia or reluctance to act. One informant said that caution is certainly due to ensure that technological “Time-bombs” are not put into place that will affect health or environment in the future (LGO-10, 2001). Some of this apprehension can be attributed to the municipality’s concerns with issues of liability and their apprehension with the CTW becoming a nuisance, potentially decreasing land values and limiting future development. One informant reflected on how institutional inertia and regulatory custom can constrain local level attempts to innovate:

> [T]o innovate you start to introduce unknowns. Official plans discourage innovation because innovation causes official plans gas pains and the people who administer them gas pains. So, that’s something that we face with our innovative technology. (CAO-15, 2001)

Although fear of the unknown may have acted to initially constrain implementation of the CTW in the French Case, in no way did it constrain application of the CTW in the Luckhart Case. By the time the CTW in the Luckhart Case was implemented, local government had developed a considerable amount of confidence in the CTW technology and developed a high level of capacity and competence in terms of permitting this option. These issues will be discussed further when capacity and enabling settings are discussed in section 7.1.3.

Prescriptive Regulatory Provisions Constrained Innovation

In the setting where the GBTTs were implemented, there is no explicit evidence that perspective-gaps constrained implementation of these specific projects. However, there was evidence that the strict and prescriptive nature of the OBC, combined with deficits in the technical capacity of local level officials were factors impeding the ability of local authorities to engage in self-governed 'experiments' in the development of alternatives preferred by local stakeholders. The OBC offers a standardised approach for regulating onsite systems, which is promulgated at the level of the provincial MMAH. The OBC is effective in preventing catastrophic failure, ensuring a 'minimum' level of environmental protection and promoting economic development by protecting consumers. Very simply, a technology is classified and can be approved or is unclassified and cannot be approved without exposing local officials to liability. Although the 'equivalents'[29] clause contained in the OBC allows local officials to approve systems on a site-by-site basis, evidence from the case studies suggests that there is extreme caution in this regard again because of liability. When followed closely, the OBC fully protects local officials from liability. Deficiencies in the technical capacity of local officials to evaluate and approve unclassified systems makes it difficult to deviate from standards contained in OBC and may constrain the development and adoption of alternatives at the local level.

The goals implicit in the OBC do not promote local level innovation and neither do they address site-level experimentation or desirable end-user environmental objectives such as wastewater recycling (MMAH 1997). In British Columbia, for example, proposed regulations for municipal sewage will encourage onsite water recovery, reclamation, reuse and recycling technology that are expected to contribute to a water savings of 35 percent (British Columbia Ministry of Environment

[29] Under Section 2.7 of the OBC (Equivalents) local inspectors do have some discretion in approving systems not classified in the OBC, but the system must provide an equivalent level of performance to achieve conformance with the standard.

Lands & Parks, n.d.). The apparent deficits of local authorities with regard to the ability to approve the implementation of the GBTT, and therefore, deviate from the established standards could be viewed as a constraint to innovation at the local level. The reluctance of regulatory authorities to establish new standards or in the cases, deviate from existing standards, is a known impediment the development of innovative environmental technology (ETEC 1997). The current approach to the approval of onsite sewage systems combined with fear of deviating from the OBC because of exposure to liability, suggests a level of determinism that results in a technology transfer mentality where standardised conventional technology is pre-determined for use at the local level. This represents perpetuation of a blueprint approach to wastewater management. The prescriptive nature of the OBC combined with lack of local level capacity can be seen as leading to inertia and hampering local level self-determination in the development of potentially more sustainable options in environmental management.

There is also a level of pre-determinism evident in the apparent intention of the regional municipality where the Waldorf Case is located. The region would not guarantee the organisation in the Waldorf Case that they would be exempt from hooking-up to the municipal sewerage trunk in the future. If required to do so, this would effectively negate the purpose of the GBTT. There is potentially some discomfort with onsite systems and, when possible, it seems that centralised, water-borne sewage treatment regimens may be considered more acceptable. The implication is that municipal preference for centralised wastewater management may act to limit onsite, decentralised options that allow wastewater treatment and reuse in closed-loops opposed to the dominant end-of-pipe sewerage regimen. Although municipal level preference cannot be seen as selectively discriminating against the GBTT, the inclination for centralised systems and vested interests in highly capitalised, 'big-pipe' approaches may act as a factor contributing to a selection environment that may act to impede the development of more sustainable alternatives. These issues are discussed further in section 7.1.2.

As illustrated here, regulatory authorities have developed attitudes related to alternative technologies that contrast the conventional options with which they are most familiar. Historical attitudes are very important and reflect the intractability that institutions develop and can extend into the future. Prescriptive regulations and limited capacity might also constrain local innovation. The promulgation of regulations such as the OBC by central authorities is expedient in terms of enforcement; however, deficiencies in the technical capacity of local authorities necessitated adherence to narrow standards and guidelines to alleviate concerns of liability. Combined, this does not create enabling setting at the local level and may impede innovation. The following section discusses evidence from the research where it was demonstrated that enabling settings resulted in increased local level capacity development and legitimised local level efforts to implement a technology that was preferred over conventional options.

6.2.2 Project Design Activities

Enabling Settings (Finding Three)

There were strong distinctions between the social learning process that was operating during the CTW projects and the process operating during the projects where the GBTTs were implemented. Finding Three - *Expert Involvement Legitimated Ecotechnology and Built Local Capacity* – was a significant finding because it revealed how learning and capacity building were facilitated. This finding offers some indication of how features of a social learning process can contribute in planning efforts to bridge gaps between the preferences of local level stakeholders and regulatory conventions during the implementation of alternative technology. The capacity held by the UTRCA and their ability to champion the development of the CTW technology and create momentum around the French Case offers a prime example. The visible collaboration that took place between the UTRCA and the MOEE was indispensable in reducing the caution originally displayed by local government and created a setting that was viewed as safe for them to learn-by-doing in developing capacity.

During implementation of the CTW technology, these projects were made possible almost exclusively because of the advocacy position taken by the UTRCA in championing CTWs as a valid option for agricultural manure management. Although uncertainty did existed with regard to the CTWs short to long-term performance abilities and operational requirements of the CTW, staff members from the UTRCA recognised the potential of CTWs in agricultural manure management and supported its development. Even though the CTW technology had not previously been used for agricultural manure management in Canada, the UTRCA was willing to assume potential risks and champion its development. The UTRCA had explicitly integrated the concept of innovation into its strategic plan and possessed the technical expertise (*i.e.* engineers and biologists) that enabled them to effectively design, implement and monitor the CTW.

Funding available under the provincial CURB program and the involvement of the MOEE were also significant in promoting the French Case CTW implementation and demonstrated that involvement and guidance of regulatory officials can be instrumental in the creation of enabling setting because they act to legitimise the process, thus facilitating a process of social learning. As a local agency, the UTRCA had a very solid reputation with local government stakeholders. One municipal government official said, "Without [the UTRCA's] moral and technical support, you wouldn't accept [the CTW] with a ten-foot pole" (LGO-5, 2001). For instance, the collaboration between the UTRCA and the MOEE was a key factor that legitimised the CTW project in the eyes of local officials and decreased their fear of liability. This collaboration reduced the apprehension of local government and this circumstance catalysed their ability to develop an innovative permitting mechanism for the CTW under Section 41 (site plan agreements) of the Ontario Planning Act.

Guidance and Capacity Building

Analysis revealed the support from provincial regulatory officials combined with that of the UTRCA were significant in promoting the experimentation that the UTRCA had undertaken in developing the CTW technology. The French Case established a precedent, which built capacity in the UTRCA and local government. It also created an enabling setting that facilitated the CTW technology that was applied in the Luckhart Case three years later in 1996. By the time the Luckhart Case was proposed, local officials were familiar with the CTW as an option for agriculture, were no longer resistant to the concept, and had developed a permitting mechanism that could be used. Again, during this project also, it was suggested that involvement of the NRC that provided financial support was an additional factor acting to legitimise the project from the perspective of the local government (OOP-14, 2000).

Collaboration between the MOEE and the UTRCA during the French Case significantly increased the UTRCA's capacity and acted to improve the design of the CTW that was implemented during the Luckhart Case. By this time, it seemed that the MOEE had developed a level of trust in the technical capacity of the UTRCA and was involved only to a minor extent in the project (CAO-1, 2000). The expertise that the MOEE brought to both projects was important and they contributed to the advance of the CTW technology by establishing site-specific guidelines that the UTRCA followed. Collaborating with the MOEE in this fashion steered the UTRCA and assisted in building their capacity, which resulted in an improved final design for the CTWs. One UTRCA official said he "Liked the fact that the MOEE made some rules that otherwise may not have been there," and that their technical guidance offered "A place to aim for and a point of reference" (CAO-1, 2000). The partnership that developed between actors during the French Case illustrates a constructive process in the development of an innovative technology that was preferred by local users.

Capacity building also occurred in relation to the projects where the GBTTs were implemented in the YMCA and Waldorf cases, however, to a much smaller degree than in association with the CTWs. Likewise, the process of social learning that occurred here was far more constrained. The attempts of the organisations in these cases to change their reality through adopting an alternative wastewater management options was undoubtedly accomplished. However, the learning that occurred was much less of a political process and the ecotechnology was implemented based primarily on each organisation's access to capital. For the most part, the lack of wide-scale learning can be attributed to the prescriptive nature of the OBC and the hesitance of local officials to use the equivalents clause and approve unclassified technology.

In the cases where the GBTTs were applied, learning, for the most part, accrued very close to the projects themselves. Although the GBTTs were successfully applied, government officials in both cases were somewhat cautious and unwilling to permit the GBTT without the existence or construction of redundant conventional backup systems that were classified under the OBC. In the Waldorf Case, the municipal government's experience with the application of a GBTT previously in the municipality acted as a precedent. This seemed to reduce concerns of liability; however the project was established due to a regulatory 'loophole' due to the existence of a classified septic system and the regulations themselves were not changed (EAC-24, 2000). In this case, learning was restricted to the supply engineer who had identified a market for institutional wastewater recycling and was actively marketing the technology in this setting. The installation of the GBTT created opportunities to experiment and allowed the supply engineer to monitor and collect data in efforts to classify the technology under the OBC in the future (Hellebust 2001; OCETA 2002a; OCETA 2002b). However, local government showed very little interest in the project or the ability of the GBTT to recycle wastewater after it was determined that the systems could be applied based on the existence of the existing septic system.

The implementation of the GBTT at the YMCA contrasted with the Waldorf Case to some degree. The YMCA Case was a custom application and the supplier had no apparent intention of classifying the system under the OBC and no efficiency data was being collected. There was evidence in the YMCA Case however, that a collaborative process was in operation between users, the supply engineer and local government officials during the implementation. Local officials showed considerable interest in learning about a technology capable of recycling wastewater and offered as much guidance and support as possible. Although local officials would not permit the GBTT under the OBC equivalents clause, they used their discretion and gave the system credit for secondary level treatment. This allowed a reduced size leaching bed to be installed and decreased the capital expenditures required by the user. For the most part, however, the setting where the GBTT were applied contrasted that of the CTWs. The strict nature of the OBC, the limited capacity of the municipalities and their concern with liability made it difficult for regulatory authorities to allow these projects outside of the provisions offered by the OBC. The users who adopted the technology and the supply engineers who installed both of the systems were the compelling forces in these cases.

6.2.3 Implementation Setting

Budget Reductions and Innovation (Finding Four)

In spite of the initial and constructive involvement of the MOEE in the French Case, finding Four - *Provincial Budget Reductions Impeded Innovation* – provides insight into the loss of capacity resulting from government budget reductions. The MOEE failed to sustain their support for the CTWs after 1996. Although CURB funded the collection of data during the French Case, budget reductions affected the MOEE and the UTRCA's ability to fully analyse the data, which resulted in lost opportunity to verify the effectiveness of the CTWs in agriculture. In addition, although the MOEE supported eleven CTW demonstration projects under CURB, they abandoned the momentum developed prior to the budget reductions, which reduced the generation of information through further data collection and analysis. Budgetary constraints reduced the ability to fully evaluate all of the CTWs that were established under CURB and opportunities to assess these systems after they had matured.

The absence of guidelines has led to an ambiguous setting for the CTW technology. One informant suggested that lack of support for CTWs by the MOEE has led private engineers to abandon interest in the technology and to "Pursue avenues that are more likely to be accepted" (EAC-32, 2001). In spite of the involvement of the MOEE since the seminal research during the Listowel Marsh Project and sustained interest by a variety of stakeholders, including OMAFRA as late as 2001, no official guidelines exist for CTWs. This has undoubtedly impeded their advance in Ontario. The intent of demonstration projects is to develop interest in and to stimulate innovation in the private sector. Demonstration projects without full and sustained support by regulatory officials can, however, be equated to accelerating and braking at the same time and will not promote technological advance. Discontinuation of the experimentation in relation to the CTW technology can be, to some degree, traced to the 1996 provincial budget reductions.

Implementation of the GBTTs in both the YMCA and Waldorf cases occurred in 1999 after the 1997 Act devolved authority for onsite septic systems[30] from the MOEE to the MMAH and local level municipalities under the OBC. The devolution of authority to the provincial MMAH and the local level has been criticised because of concerns that local government agents lack the experience and expertise necessary to effectively regulate onsite sewage systems (Lindgren and Miller 1997).

The Recognised Benefits of Ecotechnology

The values of each organisation were a key factor in promoting the adoption of the ecotechnology. In addition, there were operational-level issues that also acted as factors to promote its adoption. Finding Five - *Ecotechnology Preferred by Users* - reveals that users considered the added-value associated with the ecotechnology. The ecotechnology was believed to offer operational-level benefits that included ease of operation, aesthetic benefits, and potentially, strategic advantages to improve each organisation's competitive business advantage.

One of the reasons the CTW was adopted in the agricultural setting was because users viewed it as a pragmatic solution for wastewater management. The CTW technology was expected to decrease inputs of labour, which made it an appealing option. It was also considered simple to operate, required low-inputs of energy, and required very little maintenance. These benefits were seen as desirable from an operational perspective. However, the CTW was also recognised for the site-level aesthetic benefits it provided. These were distinct from the above ground storage tanks that were viewed as unsightly in both cases. The CTWs became site-level aesthetic amenities and sources of pride that were showcased in each case.

In the educational setting, the amenity-value of the GBTTs was also a factor leading to their adoption. The GBTT was seen for its aesthetic qualities, but was also seen as being very practical because of its ability to contribute to the recreational and programmatic objectives of each educational facility. In this setting, the aesthetic benefits of the ecotechnology were important because the system was integrated directly into the physical infrastructure and became a visual focal point and a venue used by students as part of each institution's environmental curriculum. Although the GBTT required added capital investment and had higher operational and maintenance requirements over the conventional options (*e.g.* septic systems), these were acceptable trade-offs when the users weighed them against the benefits the systems provided[31]. When compared to the conventional options, which provided only a utilitarian function, the GBTT integrated into the design of each facility and provided aesthetic and programmatic amenities in addition to its ability to conserve resources through wastewater recycling[32].

From an operational perspective, the added-value by the Ecotechnology was also recognised as a potential strategic benefit. The unique character of the Ecotechnology was identified as a source of competitive business advantage. In the agricultural setting, the owner of the livestock hauling business was aware that the trucking industry was stigmatised as a polluter and believed that the implementation of the CTW was an opportunity to 'green' his business and to attract environmentally conscious clientele. In the educational setting, the GBTT was seen by users as a component of a greening strategy that would benefit each business through attracting eco-minded clientele (students) and thus provide a competitive advantage.

The Ecotechnology was viewed across the cases for its multi-functional character when compared to the conventional options that offered no added-value. Combined, these factors made adoption of the ecotechnology a logical choice from a strategic perspective because the goal of environment improvement could be achieved while benefiting from the unique amenities that the ecotechnology offered. Across the cases, the ecotechnology offered distinct advantages compared to conventional options. Users were motivated by strong environmental values and drawn to options that could be integrated into the operational framework of each facility in terms functionality and aesthetics. These findings provide insight into the expectations of users when alternative environmental technologies are considered. Local level actors and small-scale organisations undoubtedly have preferences and expectations when undertaking greening initiatives to improve their relationship with the environment. The advantages and merits of the ecotechnology recognised

---

[30] MOEE estimates that there are 1.2 million private septic systems in Ontario most of which are septic systems serving 2.5 million people (Miller, 2001a).

[31] This is congruent implementation of the GBTT in the past. For instance, the Body Shop in Toronto, Ontario implemented a GBTT because it provided a site-level amenity that was expected to improve the quality of the workplace for employees (EAC-31, 2001).

by users in these cases suggests market level drivers can 'pull' small businesses to adopt alternative environmental technology over conventional options that are currently 'pushed' by the market (Banks and Heaton 1995).

6.3 Results from Peer De-briefing

The findings that emerged from the analysis were validated in a peer-debriefing survey where various informants (peers) were asked to verify preliminary findings on a Likert Response Scale. Several original informants (n=29) were asked to respond to the peer-debriefing in addition to others who were not previously interviewed (n=9). As discussed previously in the Chapter 3, the objective of the peer-debriefing survey was to determine the level of agreement and disagreement with each of the preliminary findings, which acted to verify findings. A total of thirty-eight surveys were mailed to informants; of these, twenty-four were returned (63% response rate). The survey was sent to twenty-nine of the forty original informants (76%) in addition to nine supplemental informants (24%) who were not available for interviews during the data collection phase, but were identified during chain sampling in relation to one or more of the case studies. The preliminary findings were combined into the five final findings previously discussed in this chapter. Three preliminary findings stood alone and were established as final (findings 1 and 5). Six of the preliminary findings were combined into three separate final findings (findings 2, 3 and 4).

The preliminary findings were used to form a basis for the final findings that were established. Overall, the peer-debriefing survey revealed a high level of agreement with the preliminary findings (see table 6-1, page 159), which summarises results from the survey. Verification of the preliminary findings resulted in the following levels of agreement: Finding One - ***Environmental Values Were a Motivating Factor*** - elicited 76%; Finding Two - ***Historical Perspective Gaps and Inertia Reinforce the Selection Environment*** - elicited 74% and 81% on combining 2 preliminary findings; Finding Three - ***Expert Involvement Legitimated the Ecotechnology and Built Local Capacity*** - elicited 75% and 80% on combining 2 preliminary findings; Finding Four - ***Provincial Budget Reductions Impeded Innovation*** - elicited 94% agreement and; finally, Finding Five - ***Ecotechnology Preferred By Users*** - elicited 72% and 88% on combining 2 preliminary findings.

---

[32] In the YMCA-Case, although the plumbing connections for wastewater recycling were installed, approval from the regional municipality had not been requested during the time of this research.

Table 6-1. Summary of Likert Scales from Peer-Debriefing.

	Finding One	**Finding** Two*	**Finding** Three*	**Finding** Four	**Finding** Five*
Likert Scale Agreement	76%	74% and 81%	75% and 80%	94%	72% and 88%

* Final Findings 2, 3 and 4 were established after combining responses from 6 preliminary findings that were surveyed in the peer-debriefing.

It is assumed that the findings are trustworthy after being triangulated in the original data and verified during the peer-debriefing. The full peer-debriefing survey and tabulated responses can be found in Appendix 6.6.4. Table 6-2 provides a concise summary of the finding.

Table 6-2: Summary of Findings.

- **Finding One - Environmental Values Were a Motivating Factor**
- Users of the ecotechnology displayed skepticism with the ability of conventional options to improve the environment and displayed a preference to internalise their responsibility for managing wastewater.
- The ecotechnology was adopted because it was considered superior in its ability to improve the environment.

- **Finding Two - Perspective Gaps and Inertia Exist**
- Institutional inertia stifled the innovation resulting from the MOEE's seminal research at Listowel.
- Provincial regulators display skepticism in the ability of ecotechnology to meet environmental objectives and resisted their endorsement (specifically CTWs).
- Local level authorities demonstrated concern in departing from standard options because of issues related to liability.
- A stringent approval process and lack of a supportive regulatory framework have acted as 'signals' to discourage innovation and constrained the advance of ecotechnology.

- **Finding Three - Expert Involvement Legitimated the Ecotechnology and Built Local Capacity**
- The existence of champion promoting the ecotechnology decreased the caution of local authorities.
- Enabling settings and collaboration between proponents and experts promoted innovation and built local and provincial level capacity.

- **Finding Four - Provincial Budget Reductions Impeded Innovation**
- Provincial budget reductions reduced the provincial MOEE's ability to innovate and verify the CTWs implemented during CURB, which dissipated the capacity and momentum that they previously built.
- Transfer of authority for sewage systems to the provincial MMAH and devolution of authority to under-capacity municipalities has necessitated reliance on the strict and prescriptive regulatory provisions of the OBC, which promotes inertia by maintaining the *status quo* and impeding innovation.

- **Finding Five – Ecotechnology Preferred by Users**
- Low cost is not the only factor compelling the selection of environmental technology in business.
- Users preferred technology with added-value and not only functional utility.
- Users were willing to modify operations and investments more capital to adopt the ecotechnology.

Sources: Generated from analysis of interviews and secondary data (December 2000 – September 2002).

6.4 Summary

Multiple issues constrained and promoted the implementation of the ecotechnology that were investigated. In terms of *stakeholder attitudes*, driving forces existed that compelled adoption of the ecotechnology. In each case study, the motivation to adopt the ecotechnology stemmed from a belief that the conventional options were not congruent with the values of the organisation and their aspiration to operate their facilities in an environmentally sound fashion. Users preferred the ecotechnology because it offered unique and multi-functional benefits, which included its ability to integrate into each operation in a productive and aesthetic fashion while treating wastewater onsite, close to the point of generation.

A key issue that emerged in relation to *stakeholder attitudes* was that institutions did pose both constraints as well as opportunities to the implementation of ecotechnology. At the local level the caution that local government officials displayed originated, to a large extent, from uncertainty with departing from standard practice and how they could fit the ecotechnology into the existing regulatory framework. Although provincial regulators were instrumental in promoting the CTWs under the CURB program and did not oppose the Luckhart Case, several informants were under the impression that provincial regulators held some historical resistance to the CTW technology. To some extent, this is described here as a 'perspective-gap' existing between traditional water engineers who are familiar with conventional options, and ecological engineers, who support CTWs. Provincial regulators have been cautious and have not necessarily been comfortable, with the uncertainty related to the ability of ecotechnology to protect health and environment. Several informants believed, specifically in relation to CTWs, that there have been deliberate efforts by provincial regulators to restrict advances in the technology; this will be referred to here as 'regulatory inertia' and, along with the notion of a perspective-gap, will be discussed further in Chapter 7.

In relation to *project design activities* and from the perspective of local government, permitting the ecotechnology presented a radical departure from standard practice, which created concerns related to liability. Across the cases, it was clear that participation between expert stakeholders (provincial and local regulators), as well as a venue for collaboration, facilitated the implementation of the ecotechnology and led to capacity building at many levels. In the French and Luckhart case studies, the availability of technical experts overseeing the implementation of the CTW technologies was instrumental in reducing the caution exhibited by local officials. In this regard, champions were imperative. Another key factor was the technical capacity of the UTRCA and its efforts in championing the CTWs. Ultimately, the collaboration between expert stakeholders, and legitimation of the CTW in both cases, allowed local level officials to 'step outside the box' and develop a permitting mechanism that offered local government confidence that the risk of liability was minimal. This contrasted with the cases where the GBTTs were applied. In both the YMCA and the Waldorf Cases, local level regulators effectively lacked the technical capacity to approve the GBTTs with full confidence under the OBC's equivalence clause. This made them apprehensive. In these cases, local inspectors deferred, for the most part, to the OBC because conforming to its provisions harboured full protection from future liability.

Finally, in relation to the *implementation setting*, several factors enabled the ecotechnology to be successfully implemented. First and foremost, although the cost of the ecotechnology was greater than the conventional options in three out of four cases, this was not a disincentive for any of the organisations. In these cases, the financial resources were available and each organisation believed that the best technology for the job was, in fact, the ecotechnology. All users recognised that the ecotechnology offered environmental advantages and that it would be a central component of their operation in terms of its aesthetic, programmatic and competitive advantages. A central element making each implementation a success was the commitment of all operators to integrate the ecotechnology into their operational frameworks. In each case, this required adopting operational protocols unique to the ecotechnology itself. In the case of the GBTTs, this required more labour and ongoing maintenance compared to the conventional options, however, in each of the cases, users felt the benefits outweighed these considerations and the additional expenses. Table 6-3 (page 162) summarises key issues identified in relation to the implementation of the CTWs and GBTTs investigated across the case studies.

Table 6-3. Synthesis of Issues from Cross-case Analysis.

Issue	Evidence	
	Constructed Treatment Wetlands	**Greenhouse-Based Treatment Technologies**
Inertia	• Historical bias: No formal guidelines developed. • Approvals framework developed for conventional options.	• No incentives to promote wastewater recycling. • Strict and prescriptive regulatory guidelines.
Budget reductions	• MOEE's capacity for innovation dissipated. • Assessment and monitoring of CURBs CTWs not initiated.	• Devolution of Authority to the local level where limited capacity for onsite wastewater treatment technology existed.
Technology preference	• Added-value recognised. • Simpler to operate and maintain. • Potential strategic advantages. • Onsite wastewater management. • Consider environmentally superior.	• Added-value recognised. • Potential strategic advantages. • Onsite wastewater management. • Consider environmentally superior.
Collaboration and precedence	• Resistance and caution overcome through collaboration and precedence. • Capacity built through collaboration between provincial and local stakeholders.	• The OBC equivalency proviso exists, but rarely used due to lack of technical expertise and local government's concerns of liability.
Unique Character of Ecotechnology	• Unique performance parameters and operational issues pose complexity and uncertainty for regulators. • Full commitment of novel management regime required. • Considered simpler and less expensive to operate than conventional options.	• Unique performance parameters and operational issues pose complexity and uncertainty for regulators. • Full commitment of novel management regime required. • Compared to the conventional options, required added training, operation, and maintenance. • Added diligence to ensure the health and safety of students and staff.

Sources: Research Informants (December 2000 – September 2002).

Chapter 7.0

Discussion

> Everything is infinitely possible in the human mind, and we are moving into a world where what is internally possible is becoming externally conceivable. This expanding sense of possibility . . . fosters a sense of independence, autonomy, and a demand for choice among citizens.
>
> *Janice Gross Stein*

7.1 Lessons Learned: Reflections on theoretical implications

Ecotechnology has been discussed in this thesis as one option that is potentially congruent with ecological modernisation and reorienting technology capable of meeting human production needs with fewer negative ecological side effects. It is clear from the research that factors do exist to constrain and promote the adoption and implementation of ecotechnology. In spite of findings that suggested ecotechnology is a desirable option for users, it was obvious that this alternative is a juvenile innovation at this point in its development and can be expected to confront barriers arising from the selection environment.

The case studies provided opportunities to apply alternative technologies because there was a demand by the users and varying degrees of collaboration that created circumstances, which can be viewed as *social niches*. Social niches, described by Vergragt and van Noort (1996) as settings where new technology is protected from the selection environment during a period when they can be improved in preparation for market dissemination. In the two cases where the CTWs were applied in the agricultural sector, users created niches, albeit unintentionally, based on their demand for the ecotechnology. Learning within the niches in this setting was significant because the CURB program created a condition where the conservation authority could employ its technical capacity and desire to champion the CTW technology in collaboration with the MOEE. In the two cases where the GBTTs were applied in the service sector, users also created niches for the ecotechnology, but these cases were attended by significantly less regulatory involvement (or advocacy) and, as a result, the learning that occurred was not widespread. The following sections offer reflections on the empirical and theoretical implications associated with this investigation and lessons that were learned.

7.1.1 Environmental Values Were a Motivating Factor

In each of the cases, the decision to adopt the ecotechnology was based on the strong environmental values held by each organisation. This contrasts the dominant social model, which as Dunlap and Catton (1984 in Buttel 1997) note, is characterised by exploitation of environmental services and little regard for the ecological consequences. Across the case studies, it was apparent that each organisation rejected the conventional options because of an awareness or belief that they were not capable of improving the environment. As actors in risk society, it was evident that each organisation had engaged in a self-critical discourse that enabled them to reflect on the potentially negative environmental impacts of employing conventional options in their operations. The reflection that was possible by each organisation compelled the rejection of the conventional options because they were viewed as 'merely' adequate in terms of protecting the environment, but in no way were the seen as ideal. The ecotechnology, however, was considered superior in comparison and *enabled each organisation to translate their values into action* because it allowed them to engage in behaviour that users considered environmentally responsible and 'mature' (Bansal 1997). Had it not been for the internal motivation of each organisation, combined with assistance from champions, technology developers and, in some of the cases, regulatory agents who were willing and had the capacity to innovate during implementation of the ecotechnology, the conventional technology would have been the only available options in each case study.

Confidence in conventional options did not exist

Across the case studies, the conventional options were, from a regulatory perspective, unquestionably appropriate and were easily approvable in each of the case studies. This was not the perspective of the organisations that rejected these options. The regulatory community endorsed the conventional options, but these were not desirable to the organisations: across the cases and there was a level of skepticism regarding the *status quo* approach to wastewater management. The preference for and adoption of the ecotechnology suggests *a loss of confidence in the conventional, pre-determined strategies* and suggests the relevance of the ecotechnology in local level attempts to improve the environment. The ecotechnology fit the preferences of users and allowed them to realise their goal of improving the interaction of their facilities with the surrounding environment. This corresponds to Irwin (1995: 40) who suggests that local "preference[s] for certain kinds of technology will be a reflection of wider social, moral and ethical preferences". Viewed from the perspective of constructive technology assessment, users did not see the ecotechnology as simply as a one-dimensional apparatus in the treatment of animal waste and domestic sewage. The reasons for adopting the ecotechnology were broader and included optimism that these options might allow improved interaction with the environment.

The advantages of the ecotechnology and its "multi-functionality" stand in distinct contrast to the strict utility of the convention options (Guterstam 1996: 94). Across the case studies, both types of ecotechnology were dynamic and provided an integrated, site-level wastewater treatment option that offered aesthetic and operational amenities as well as strategic opportunities. This is important because it hints at the desire by users for ecological design where the form and function of technology assists in improving, or at the very least, only negligibly impacting the environment during activities of these facilities.

7.1.2 Historical Perspective Gaps and Inertia Impede Ecotechnology

Different perspectives can act to constrain the formulation of solutions in environmental management because conflict can arise in what Mitchell (1994) has referred to as *edge problems* between the perspectives and actions of different agencies, organisations and stakeholder groups. Petak (1980) describes these conflicts as *perspective-gaps*. Perspective-gaps can be described as paradigm conflicts where different stakeholder groups have divergent views on how to accomplish goals in environmental management. The professional engineering community, and specifically traditional engineers in regulatory positions have expert knowledge in relation to a narrow set of conventional wastewater management options to achieve environmental objectives (Petak 1980). This can lead to caution and skepticism regarding alternative options, which is manifest as resistance to alternatives (Beder 1997). This divergence forms the basis for perspective-gaps to develop between civil engineers trained in traditional water engineering science and engineers sympathetic to ecological approaches such as ecotechnology.

It was evident that the selection environment relevant to the settings where the ecotechnology was investigated was more favourable to conventional technology. The conventional options had experienced learning effects and, subsequently, were familiar to regulatory agents and readily approvable. This finding suggests that regulatory agents are not familiar with ecotechnology and existing regulations do not have adequate provisions that account for the unique operational principles and performance parameters of ecotechnology. For example, two informants from OMAFRA explained that their computer-based models to evaluate the process requirements of conventional systems for managing barnyard runoff allowed standardisation, which enabled expediency in executing existing regulations (PGO-8-Anonymous, 2001; PGO-9-Anonymous, 2001). They also admitted, however, that these models were ineffective when it came to evaluating alternatives such as CTWs, which made it difficult - if not impossible - to assess the suitability of these options for particular applications. This illustrates one element of the selection environment pertaining to the capacity of street-level regulators and the procedures and routines they are trained to use, which act to lock-in and support continued reliance on conventional technologies and regimes. As Kemp (1993) suggests, alternative technology must fit into an established selection environment that is already being filled by existing technologies that have gained regulatory familiarity, which acts to maintain their market dominance and ongoing use.

The investigation also identified examples where inertia and perspective-gaps reinforced the intractability of the selection environment and delayed development of ecotechnology. It was suggested that CTWs in Ontario might be much further advanced in terms of their operational efficiency and market level acceptance if the MOEE had not discriminated against this alternative during the demonstration at the Listowel Marsh Project (PGO-33, 2001). Ecotechnology is different from standard conventional options and have operational characteristics that do not conform to the traditional water engineering science. At one level, ecotechnology is constrained because of an approvals process established for conventional options. This process is unsympathetic to ecotechnology and does not (or cannot) account for the unique performance parameters of natural treatment technologies (Hanna, McMullan *et al.* 2001). Attempts by regulators to apply conventional standards to ecotechnology discriminates against ecotechnology and perpetuate a bias that they do not perform effectively, which may also reinforce the impression of regulators that conventional options are superior. However, there is another viewpoint the research revealed regarding the slow advance of CTWs in Ontario.

Findings from the research hint at *the existence of historical inertia associated with the development of CTWs in Ontario and efforts of certain groups to maintain the hegemonic dominance* of conventional wastewater management options (PGO-Anonymous, 2001). It is conceivable that the data collected during the Listowel Marsh Project was intentionally misinterpreted and that efforts were made to impede the advance of CTWs in Ontario. The conventional wastewater management options that have been widely employed by Ontario's engineering community have unquestionably benefited various user-supplier networks. It is feasible that intentional efforts have been made to create barriers to impede alternatives and thus perpetuate the market dominance of conventional options by groups with vested interests in these technologies.

Kemp and Rotmans (2001) note that groups with vested interests in the dominant technology will act to protect their interests when competition arises. If the CTW technology was to have gained popularity and created a demand, its potentially lower capital costs (taking into consideration learning effects that would ultimately occur) may have resulted in lower profits margins for established professional groups who depended on commissions that are often based on a percentage of capital costs. Congruent with regulatory capture theory (Smith 1997; Lévêque and Nadaï 2000) the findings allude to, but did not confirm, the potential actions of groups with vested interests in capturing regulation and maintaining a selection environment favourable to dominant wastewater treatment technology (PGO-Anonymous, 2001).

Since the 1996 provincial government budget reductions the MOEE has not yet revitalised efforts to develop design guidelines for CTWs that might encourage private sector involvement and to some degree, this can be interpreted as institutional inertia. In Alberta guidelines have been developed which act to steer the use of the CTW technology for agricultural and municipal wastewater treatment where feasible (Alberta Environment 2000). The development of guidelines in Ontario would increase the availability of information and stimulate private sector interest by providing a signal that the regulatory community considers the CTW technology a potentially viable option. Although multiple interviewees were under the impression that the MOEE is now beginning to change their attitudes in relation to CTWs, it is unclear if or when design guidelines will be proposed or even if this will be adequate in promoting the advance of the CTW technology. At this time, the MOEE supports the use of CTWs in limited use (MOEE 1998) and it is unclear what the implications for CTWs in agriculture will be after Bill 81 - the proposed Nutrients Management Act of 2001 – is legislated (OMAFRA 2001). Additionally, it is also unclear how the events of

Walkerton, Ontario in May 2000 will affect caution and inertia in relation to ecotechnology. In a post-Walkerton context, where deficiencies in the MOEE's programs have been recognised (O'Connor 2002), regulators may impede options that are unfamiliar in ongoing efforts to decrease future political liability.

Efforts by regulatory agents to impede the development of alternative environmental management technology, and to continue promoting the development of and reliance on strictly conventional options that are familiar, will expose them to increasing scrutiny. Failure to capture the motivation and enthusiasm of local level initiatives to innovate during attempts to improve the environment will result in lost opportunity. If the apparent demand for technological alternatives, such as ecotechnology, is not explored and guided in a constructive technology assessment process where various stakeholders have a voice, decision-makers will find themselves under increasing challenge (Disco 2002). Institutions that are entrenched in one paradigm or aligned with one perspective become fragile, and ultimately, risk losing any control of the domain they once held (Abbott 1988).

Abbott (1988: 3) suggests that professional jurisdictions are constantly shifting. New professions will fill a jurisdiction if an earlier tenant vacates or loses its "firm grip" on that jurisdiction. Disco (2002) describes one case in Dutch water management where traditional engineers in the Dutch Coastal Engineering Agency lost their hegemony in the management of coastal flood control strategy after they failed to acknowledge the aspiration of various citizen and professional groups to develop softer ecological solutions to problems traditionally solved by hard technical fixes. Conflict arose when the public opposed these hard technical fixes and demanded softer solutions that incorporated ecological considerations. In this case, however, the engineering agency did not have the capacity to consider problems outside of their established paradigm and, thereby, could not meet the public's demand for a broader, ecologically oriented vision. Disco (2002) explains that the narrow perspective of the Dutch Coastal Engineering Agency - in fact the bankruptcy of their perspective- resulted in ecologists extending their jurisdiction into what had previously been solely the domain of the professional engineering community who were versed only in hard technical options and unwilling to modify their approach until change was forced.

7.1.3 Expert Involvement Legitimated the Ecotechnology and Built Local Capacity

Experience from the cases where the CTWs were implemented for agricultural manure management makes it clear that the existence of champions and experts to legitimate the projects created enabling settings that were important in implementing the ecotechnology. The involvement of expert stakeholders, which included the involvement of provincial regulators in the case of the CTWs, stimulated a social learning process that was constructive because it resulted in local capacity building and allowed self-determination.

The setting created under the CURB program and the collaboration that developed between the UTRCA and the MOEE during the French Case was essential in fostering the learning that occurred. The UTRCA possessed a considerable amount of technical capacity, which was augmented by the involvement of the MOEE, who also applied knowledge they had previously gained during the Listowel Marsh Project. Murphy and Gouldson (2000) observe that the application of integrated pollution control systems in the United Kingdom's industrial sector demonstrates that interaction between regulators and companies who apply cleaner technology can result in better solutions because collaborative learning and information transferred can occur between parties. Regulators themselves gain capacity during involvement and this can act to increase their familiarity with alternative options and this experience can be useful in future projects where innovations are being considered (Murphy and Gouldson 2000).

Culture Plays a Role

Initially, however, local government's attitude toward the CTW was one of suspicion and they had considerable concerns related to liability. In addition to local government's historical memory of the Listowel Marsh Project, it is possible that cultural concerns regarding the perceived nuisance of wetlands may have been a source of municipal caution. One informant suggested that the public's concept of wetlands has traditionally been to consider them "Bad places with smells, evil vapours and mosquitoes" (PGO-33, 2001). Forster and Southgate (1983) suggest that historical precedent in the minds of government can indeed shape attitudes toward novel technologies and that government institutions are often static and reluctant to permit innovative waste management practices. This factor may account for the initial caution and fear of the unknown that local government demonstrated in relation to the French-Case project. The *collaboration between the UTRCA and the MOEE legitimised the project* and *created an enabling setting* where municipal government felt secure and more willing to permit an innovative project. During this process, local government was also able to build their capacity and developed a permitting mechanism that was used in the Luckhart Case three years later.

Radical innovations, and specifically decentralised wastewater management options such as CTWs can expect to encounter various impediments in relation to their specific selection environments. Gouldson and Murphy (1998) describe radical innovations as entirely new technologies, techniques and processes, which stand in contrast to incremental innovations where upgrades are made to old technologies and processes in an ongoing, but incremental fashion. Both the CTW technology and the GBTT can be considered radical innovations. They stand in contrast to conventional environmental technologies, techniques and processes, which depend on incremental improvements to achieve ongoing environmental objectives. At the local level, Robinson (2002) suggests one impediment to CTWs has been lack of regulatory familiarity and technical expertise with these options because local officials are often unable to make effective approval-related decisions. This was evident in relation to the GBTT where local official's apparent lack of capacity resulted in dependence on centrally mandated regulations.

In the settings where CTWs were applied, there were no regulatory provisions for this type of technology and the provisions that did exist were not rigid[33], therefore opportunities for site-level permitting existed. Conversely, in the settings where the GBTTs were applied, the regulations were rigid. There was no involvement from the provincial MMAH and the onus was on local level authorities to approve the GBTTs under the provisions contained in the OBC, which constrained their ability to experiment and promote innovation. The GBTT was not classified and it was not apparent that local officials had the technical capacity to approve the technology without liability concerns. Under these circumstances, it must be said that prudence is certainly justified. The GBTT has never been submitted for review to the MMAH[34] or classified under the OBC, which will continue to impede its wider use until a supplier verifies the performance of a GBTT model and has it classified under the OBC. The approval process under the OBC is, to a large extent, *aimed at preventing liability*. This contrasts an approach where momentum and interest in a technology is

[33] In this setting, no enforceable standards exist and OMAFRA mainly uses voluntary initiatives such as Environmental Farm Management Plans to limit the environmental impact of agricultural manure.
[34] The Building Materials Evaluation Committee has a mandate to evaluate techniques and to make recommendations related to modify changes under section 28(4) of the OBC.

tapped by taking advantage of the *pull* of market demand. Legal conditions may also act to constrain innovation due to ongoing fear of liability.

Short of the ability of users to afford and invest in redundant, backup conventional sewerage systems, the approval process for onsite wastewater treatment systems under the OBC impedes innovation and local self-determination because innovation becomes expensive. This strategy results in a technology transfer approach where no opportunities for participation exist (Rondinelli 1993 in Mitchell 1997; Cusworth 1997). Prior to the 1997 Services Improvement Act, the MOEE was responsible for onsite systems and considered the implementation of innovative onsite systems on a site-by-site basis (PGO-Anonymous, 2000). However transfer of authority to the MMAH and devolution of approval to municipalities under the OBC has resulted in a structure where cost-cutting expediency has created a capacity vacuum both at the provincial and local levels (Lindgren and Miller 1997). Again, this can be attributed to budget reductions under Conservative government's 'Common Sense Revolution' (Clark and Yacoumidis 2000) and may act to constrain the flow of information in relation to the development of innovative technology. Absence of information is a factor known to impede the development and implementation of technology (Kemp 1993; Environmental Technology Evaluation Centre 1997; Van Osch 1997), the opposite is also true, and the collaborative transfer of knowledge and information between regulators and technology developers can facilitate innovative and cleaner technology options (Gouldson and Murphy 1998). In the setting where the CTW were applied, it seemed apparent that an adequate transfer of information did occur between provincial and local authorities, although this was not clear in the setting where the GBTTs were applied. In this setting, local authorities tended to limit alternatives and adhere to the regulations to protect their exposure to liability.

The provincial MMAH sets standards, which local authorities are expected to enforce; however, they may not have the adequate technical capacity required to approve novel technology (EAC-32, 2001) and this will constrain local innovation and capacity building. The current regulatory structure for small-scale onsite domestic sewage systems *has resulted in local officials being unwilling to promote innovation due to concerns of liability*, which acts to re-enforce a setting where it is difficult to build capacity and to enable local level self-determination. This leads to a Catch-22 for alternative technology. Because it is difficult to get alternative technology implemented, this constrains opportunities for learning that would act to improve the efficiency of alternatives and enable regulatory familiarity to develop during their involvement in wider-scale implementation (Ashford

1993; Shrivastava 1996; Gouldson and Murphy 1998). It appears that the existing regulatory structure and local level adherence to the OBC will impede future attempts to implement CTWs in situations similar to that of Luckhart Transport. Local level officials are responsible to approve small-scale car and truck washing system of less than 10,000 litres per day. The CTW technology is not classified under the OBC and it is likely, that the majority of municipalities will not have the capacity to approve them and this will constrain future application and local level experimentation (Lindgren and Miller 1997; Clark and Yacoumidis 2000).

Stauffer (1999) notes that the largest impediment to the ongoing development of ecotechnology is constrained demonstration projects. Despite the potential of ecotechnology, the shortage of on-the-ground experience, places these alternatives at a disadvantage compared to conventional options. This leads to a situation where ecotechnology are seen as "inadequate, incompatible, unproven [and] unknown" to regulators due to lack of experience with these options (Murphy and Gouldson 2000: 36). Lessons learned during the implementation of the CTW suggest that the creation of enabling setting, where proponent and regulatory stakeholders can work together, can be effective in promoting local experimentation to advance alternative technology.

7.1.4 Provincial Budget Reductions Impeded Innovation

Although the MOEE co-sponsored the French Case, in addition to eleven similar projects under CURB, they never endorsed the CTW technology and their guidance in developing the technology was short-lived. In 1996, the provincial budget reductions eliminated many of the Ministry's environmental technology development programs (Winfield and Jenish 1996; Clark and Yacoumidis 2000). The MOEE's opportunity to verify the CTW technology during this period was lost and the Ministry's efforts to advance the CTW in agriculture took a backseat to the business-as-usual approach and continued reliance (and support) on conventional options.

Additionally, the MOEE abandoned the delivery of a province-wide study that had been partially funded by Agriculture Canada to assess the viability and practicality of CTWs (Canada-Ontario Agriculture Green Plan 1994). At that time, it was apparent that the MOEE did not consider CTWs a priority. The provincial budget reduction resulted in lost opportunity and can be seen as a factor constraining the ability of the MOEE to verify the CTW technology and has led to inertia and no proposed official guidelines being developed for CTWs in Ontario since that time.

The devolution of authority to the provincial MMAH and the local level has been criticised because of concerns that local government agents lack experience (Lindgren and Miller 1997). Evidence from the cases in this setting suggests that the rigid and prescriptive nature of the OBC combined with lack of technical capacity has constrained the ability of local officials to make approval related decision without exposing themselves to liability. The lack of technical expertise at the local level offers regulators little choice but to approve systems based on the strict and prescriptive provisions contained in the OBC, which can be seen as a factor that will constrain local level innovation.

In order for local regulators to be assist in the development of alternatives, they require information and opportunities to develop their skills and proficiency in assisting and guiding the development and implementation of innovative technology. Regulators must take a hands-on approach and develop a minimum understanding of alternatives options that will enable them to modify codes and regulations in order to encourage the ongoing operational efficiency of these options over the long-term. Fully stated, Murphy and Gouldson (2000) suggest that within a framework of stringent quantitative standards and target-based approach, qualitative principles are required that can be fine-tuned by street-level bureaucrats to reflect specific circumstances. Hanna, McMullan *et al.* (2001) suggest that a target approach is essential in relation to ecotechnology because of the learning curve associated with natural options and *approvals must focus on objectives that can be met over longer time periods as increasing knowledge of specific systems allows their performance to be improved.*

7.1.5 Ecotechnology Preferred by Users

Cost is not the sole consideration

Altruism has been identified as one factor compelling business to undertake environmentally responsible activities (Bansal 1997; Tilley 1998). The ecotechnology corresponded to each organisation's values and desire to improve the environment and thus its adoption can be seen as altruistic. However, other factors also compelled adoption of the ecotechnology. In each of the cases, the ecotechnology offered multiple site-level amenities and its multi-functionality was attractive to users (Guterstam 1996). The ecotechnology stood apart from the conventional options and offered added benefits for which users were willing to pay. Johnston and Stokes (1995) note that altruism ranks well below other factors such as regulations or expected cost savings in business efforts to improve the environment. The analysis of the case studies revealed that neither of these compelled adoption of the ecotechnology and in three out of four cases capital costs above that of the conventional were invested. These considerations are reflected in the case studies and confirmed by Kemp (1993) who observed that *cost is not the sole consideration in the selection of cleaner technology* and users will base their decision on an entire range of financial measures of the costs and benefits. The case studies offer examples of organisations that had integrated environmental concerns into their operations in a mature and proactive fashion and this made them feel good through acting responsibly (Bansal 1997).

Benefits of ecotechnology outweighed added cost and unique operational requirements

Regard for the environment and altruism were not the only factors promoting adoption of the ecotechnology. Each of the organisations had additional motives, which included environmental education and strategic considerations that made any unique operational protocols or added costs required by the ecotechnology justifiable. Across the cases studies, the ecotechnology was recognised by users for its unique character and its added-value at the site level, which including its aesthetic benefits. However, there were also pragmatic operational level benefits. In the agricultural setting, the CTW was adopted because users considered it to be a passive and low-input system that was easier and less expensive to operate and maintain over the long-term when compared to the conventional options. In the educational setting, the GBTTs were viewed as aesthetic amenities that integrated seamlessly into the physical infrastructure of each facility. They were also pragmatic in terms of their integration with each organisation's educational objectives. Although clean technology is often at a disadvantage because the short-term costs associated with its implementation are high while long-term economic and environmental benefits are often hidden (Gouldson and Murphy 1998), *evidence from the cases suggests that the benefits of the ecotechnology outweighed added costs*. In three out of the four case studies, the organisations recognised the potential environmental benefits and the possibility of long-term cost saving that might accrue from implementation of the ecotechnology and were willing to invest added capital.

Additionally, the *unique operational requirements of the ecotechnology were not considered an inconvenience*. Each organisation had the ability to modify their operational frameworks to incorporate the ecotechnology, which is often required when companies retrofit with cleaner technology (Callenbach, Capra *et al.* 1993). The ecotechnology that was applied in each case was viewed as living systems whose biological integrity had to be maintained through operational diligence. This is one condition that was understood and accepted by users and it posed no apparent inconvenience. In the agricultural setting the operational level changes that had to be made were considered minimal by both operators. If this willingness had not existed, the ecotechnology might not have been suitable in the cases. In fact, failure to do so would have predisposed the ecotechnology to failure. This was an issue raised in relation the CTWs applied under the CURB program. One informant recalled that lessons from the CURB program, which demonstrated that the CTW technology had to fit the needs of the users and fall within their ability to engage in unique and consistent operational procedures or it was prone to fall in into disrepair and be abandoned; which apparently, did occur in several of the CTW projects implemented under CURB (CAO-36, 2001).

7.2 Policy goals for Advancing Ecotechnology

Technical and market level issues as well as issues related to research and development (R & D) of ecotechnology will be discussed in this section. The wider dissemination of ecotechnology in Ontario has been impeded, to a large degree, by two issues that will be discussed at this time. The first relates to technical concerns associated with many ecotechnologies, which are juvenile at this stage in their development and have not undergone learning to allow for process improvement. Thus a gap in information exits. Strategies are required that will lead to an increased understanding of the unique character of ecotechnology and result in improved performance and increased regulatory confidence in these options. This leads to the second issue and the need to improve the performance of ecotechnology through creating settings (or niches) where learning and can occur to improve the economic viability and competitiveness of these options in preparation for the open market dissemination. In this regard, opportunities for R & D will play an essential role and must be established.

Overcoming technical issues

Technical issues have vexed ecotechnologies up to this stage in their development. Regulatory concerns have centred on variation in design between different products, treatment objectives, pre-treatment levels, differing project scales, lack of cross-seasonal performance data, and the ability of novel alternative to consistently meet effluent discharge standards (Pries, Borer *et al.* 1996; MOEE 1998; Rew 1999; Tanner, Sukias *et al.* 2000). The mandate of regulators is to ensure environmental quality and the functional integrity of any technical interventions employed. Key concerns voiced by the MOEE in relation to ecotechnology revolve around insufficient data establishing their efficacy over the long-term. The MOEE has been cautious in granting certificates of approvals for innovative systems not supported by sufficient data demonstrating their performance under variable effluent quality standards as stipulated under Section 53 of the Ontario Water Resources Act[35] (PGO-39-Anonymous, 2001; LGO-10, 2001). The research also revealed that initial efforts (and opportunities) for the MOEE to determine the viability and practicality of ecotechnology such as the CTWs were squandered through institutional inertia and by short-term infusions of limited support and endorsement that produced no significant results in establishing the effectiveness the CTW technology.

Although ecotechnology has gained a considerable and positive reaction from the public, to date, there have only been a few projects that resulted in the collection of significant data establishing their long-term efficacy and this must be remedied. To overcome this constraint, there must be a higher level of advocacy telegraphed from all levels of government. Government must promote and have the ability to collaborate during the development of cleaner environmental management solutions. Re-infusing the MOEE, MMAH and OMAFRA with funding for technology development and experimentation is essential, but only part of the solution.

To facilitate the continued advance of ecotechnology, it would be beneficial to establish a combined working group of regulatory officials from the MOEE, OMAFRA and the MMAH charged specifically with steering the development of ecotechnology and wastewater reuse options. Various MOEE and OMAFRA regional offices now have at least some level of experience in relation to CTWs. Experience from the case studies in the agricultural sector show that both local and provincial agents experienced considerable learning when collaboration was possible. With this in mind, creating a dynamic and active process of collaboration and information sharing between users, ecological engineers (who are gaining considerable understanding of these systems) and regulators during the inception, implementation and monitoring of projects will facilitate learning. To this end, a key policy goal must be to direct the involvement of the regulatory community during the technical development of these alternatives in a constructive assessment that incorporates concerns related to public health and environment, but does so without stifling the path of technology in a deterministic fashion.

[35] Section 53 of the Ontario Water Resource Act stipulates guidelines for the approval of treatment systems (MOEE 1994).

Establishing niche settings

Regulatory agents require exposure to ecotechnology as it is being developed. This will provide opportunities to increase their comprehension of design principles inherent to ecological engineering. One informant from the UTRCA stated that CTWs are not complicated and that a set of principles must be learned and followed in order to implement successful projects (CAO-1, 2000). Similarly, another informant suggested that for regulators, the novelty of CTWs has been an issue that has acted as a constraint (EAC-25, 2001). To overcome this, he suggested approval agents should take more of a 'black box' approach with ecotechnology, focussing less on the peculiarities of the process design itself and more on collecting objective data to establish the efficacy of these systems. It is essential that standards emerge from collaborative learning venues and that formal guidelines are established to promote continued learning that will allow ecotechnology to compete on the market as its operational requirements and performance parameters become increasingly understood and routine. Creating opportunities for ongoing monitoring of projects is essential. To this end, both ecotechnology developers and businesses that choose these alternatives must have access to *financial* resources to establish monitoring programs in real-life experiments. Any further technology development programs in relation to ecotechnology must be accompanied by a level of commitment to developing this fledgling category of technology over the long-term if learning is to occur and progress to be made.

The concept of ecological modernisation suggests that strong regulation is essential to promote competitiveness and catalyse technological innovation in various sectors. Although this task may be easily undertaken by large companies with access to capital R & D, smaller companies and service sector facilities will undoubtedly be constrained by lack of resources, which prevent innovation and the adoption of alternatives since the risk is too high. For change to occur, policy measures must be devised that not only promote the development of technological alternatives, but there must be methods to get demonstration projects in real life settings. This will also act to assist in identifying settings where these options represent ideal solutions in different settings and enable them to become increasingly competitive.

Solutions to these problems lie in a variety of policy measures capable of fostering the development of alternatives such as ecotechnology (as well as improved conventional options). Policy must be established that will guide the involvement of regulatory officials in the technology development process itself: with the explicit agenda of promoting the development of production systems that are inherently clean. Invariably, the market will play a role. Technology must be ecologically efficient, but also economically viable to result in market uptake and any subsequent environmental improvement that may be achievable. Although one approach to the development of environmental technology suggests that market mechanisms combined with regulation will allow economically feasible and competitive technologies to emerge, it is also known that market failure has lead to declining environment quality (Gouldson and Murphy 1998). Novel alternatives that show promise in improving the environment require a level of initial support if they are to become viable in environmental management.

Measures must be established that create conditions for innovation to occur that promote the application of technologies ideal to a variety of site level conditions. Thus structural changes at the ground level of regulatory agencies must change to allow more collaboration with both users and developers of technological alternatives that can lead to improvements in efficiency. Under the current regulatory framework in Ontario, it cannot be expected that provincial level regularity authorities will engage in small-scale projects. The current trend of transferring authority to the local level must be accompanied by improvements in the skills of local regulatory officials. If local municipalities are to be involved in effectively guiding the development of local level solutions to environmental problems their capacity must be increased and policy measures must promote building this capacity.

In both the small-scale agricultural and domestic sectors expanding the role of the conservation authorities to act as clearinghouses for alternative technology options may be one possible direction. Conservation authorities are in a position to raise public awareness and support and have pre-existing relationships with municipalities. As this research showed, conservation authorities such as the UTRCA can build the capacity required to develop alternative environmental technology options. Increased funding to conservation authorities that is earmarked specifically for the development of locally appropriate solutions for wastewater management may be effective. Again, all local level agencies and government require a level of technical proficiency. To this end more collaboration from experts with solid technical backgrounds from the MOEE, OMAFRA and MMAH would be valuable in providing technical resources through creating niches where there is potential interest in ecotechnology and they are deemed practical at the individual site-level.

At this point, there is no incentive for users to adopt ecotechnology due to the added time, potential regulatory complexity and expense required. This condition acts to impede the development of alternatives. Economic incentives can assist in catalysing projects. These instruments can potentially be delivered in multiple forms: adoption grants, low interest loans and deferred interest. The perceived risks associates with small operations adopting ecotechnology could also be underwritten by the government in the form of economic incentives such as relief from taxes delivered in the form of accelerated tax depreciation – a method used often in association with Canadian industries (Hanmer 1997). Additionally, the dissemination of information about the potential environmental and economic benefits of alternative such as ecotechnology would promote these options.

These claims, however, must be backed my sound methodologies (e.g. Life Cycle Analysis, Environmental Management Systems, Environmental Auditing) to support the realisation of any potential benefits (Gabriel 1997). In niche level projects that are undertaken at the local level, it may be effective to offer economic incentives to ecotechnology developers themselves by assisting them with grants to cover the costs of data collection and evaluation, which will foster evaluation of these systems. This approach would assist in facilitating the technical feasibility and protection of the environment as continued learning occurs through experimentation in these 'real life settings'. The provincial government could support alternative options and showcase success stories by promoting them in appropriate settings, thereby, creating interest in these options.

7.3 Future Research Directions

Understanding the mind-set of the civil and water engineering community is critical in efforts to develop technology that will bring human production system in line with the goals of ecological modernisation. Adherence to scientific rationality and the known fascination that engineers have had with mechanistic technology (Everett 1993) may limit the identification of alternatives such as ecotechnology. Further research is needed to understand *what will motivate members of the engineering community to focus their knowledge on the development of cleaner, more sustainable technology*. Using engineers in the military and defence sector as a model, Everett (1993) suggests the radical change is required to shift the focus and imagination of the engineers to areas of more direct benefit to society and the environment. She suggests this will require the emergence of motivational leaders and role models that recognise alternatives and who can catalyze change in the attitude and direction of the engineering community.

More needs to be known about altering the tendency of traditional engineers being influenced by the technological values described by Brunk (1985) and how to foster movement towards the development of options that are ecologically integrated and diverge through these values. In so doing, it may be possible to direct their problem solving skills away from hard technical fixes toward soft ecological solutions. A variety of technical issues continue to confound the development of ecotechnology due to its unique nature. These problems will require continued research by both civil and ecological engineers. Further research to this end must revolve around continued efforts to *evaluate operational-level issues related to the performance of ecotechnology* across a variety of setting and for use in treating a wide range of wastewaters.

Wastewater recycling and reuse is one area of policy development that is rapidly changing and requires increasing diligence as critical deficits in water resources are revealed. Across Ontario many municipalities now face difficult water related decisions and sub-watershed planning and end-use management is now a critical issue (MOEE 1993). Further research to determine the *land use planning issues* in relation to the applicability of ecotechnology is also required to integrate their use within urban areas and not strictly in agricultural and un-sewered communities. A Canada wide survey of provincial and local level governments would be valuable in revealing forces expected to pose constraints to the adoption and implementation of ecological engineering initiatives. To this end, it would also be useful *to determine the technological preferences of municipalities as they expand, retrofit and replace aging wastewater management infrastructure.*

The implications of stakeholders with vested interests in reigning conventional approaches acting to discourage the development of alternatives and to make efforts to capture regulation to maintain the *status quo* are compelling (Lévêque and Nadaï 2000; Kemp and Rotmans 2001). Further investigation to assess *institutional level impediments acting to constrain alternatives for small-scale wastewater management, recovery and reuse* would be beneficial in efforts to alter constraining aspects of the selection environment and make it less hostile to low-input options such as ecotechnology.

Understanding the effects of incentives, disincentives and improved transfer of information would be useful. Future research must identify policy formulas and policy implementation strategies that will be effective in directing the rapid development and dissemination of more sustainable environmental management options. Research must identify the ideal mix of expanded information transfer, economic incentives, rewards and assistance that will create favourable niches to develop for cleaner production options such as ecotechnology. The four cases that were explored in this research were admittedly atypical. In each of the cases, the proponents who adopted the ecotechnology were predisposed to doing so based on their environmental orientation and access to financial assets. As such, the findings cannot be seen as representative to wider organisational institutional or operational settings. The case studies do reveal, however, that demonstrations projects can be valuable in creating interest in novel environmental technology. The cases where the CTWs were employed created significant interest by the public and were effective in promoting social learning due to conditions that allowed collaboration between users, regulators and technology developers. Changes in local level regulatory structure did occur, to a large extent, as a result of experts legitimating the projects. However, the cases where the GBTTs were implemented also revealed that it is also possible for projects to develop in a vacuum when the involvement of approval and regulatory officials is limited.

The support of demonstration project is essential as they can act to foster initial niches that can be expanded through increasing the exposure of ecotechnology. Organisation barriers must also be identified (*e.g.* lack of internal structure, financial resources and technical expertise) and approaches identified to reconcile these deficits through exploring the best ways to provide adequate support to small operations and municipalities seeking alternatives. The may require government support from the federal and provincial levels leading to renewed environmental technology development funding to expand the technical skill set of local level officials.

Policy aimed specifically at creating experimental niches for ecotechnology is required and future research must evaluate various models that can best realise technology developed in this fashion. Findings from this research suggest that demonstration projects such as those that were explored can be instrumental in promoting ecotechnology at the local level; however, the wider effects of the case studies was limited in part by the limited support that the projects received from provincial regulatory bodies.

7.4 Conclusion

The case studies investigated during the research were viewed as *social experiments* (Herbold 1995) and used to gain an empirical knowledge and to further theoretical understanding regarding the constraints encountered during the application of ecotechnology. Friedmann (1987) and Herbold (1995) suggest that experiments such as these offer opportunities to conduct organised social research and to generate knowledge. As social experiments, learning did occur across the cases and provides insight into how constructive technology assessment might be used in the planning and implementation of ecotechnology.

The first element of the conceptual framework developed in association with the research was the idea that modern industrial technology is now recognised by – at least - portions of society as a risk that jeopardises the planetary ecosystem (Beck 1994). Closely associated with this is the optimistic view that society is 'capable' of planned responses in order to prevent a deepening of the environmental crisis and threats related to a changing environment (Beck 1994; Irwin, Georg *et al.* 1994; Hajar 1996; Murphy and Gouldson 2000). The implications of these ideas will be discussed below. Closely related to the first element of the conceptual framework is *Research Objective One*, to identify theoretical perspectives associated with the emergence of cleaner alternatives, is addressed in section 7.4.1. *Research Objective Two*, to conduct exploratory research to identify constraints and opportunities associated with ecotechnology, is linked with the final elements of the conceptual framework and focuses on the relationship between *social learning* and *participatory planning* and their relevance in the design of new *technology scenarios* and is discussed in section 7.4.2. Finally, *Research Objective Three*, also discussed in section 7.4.2, addresses a reconciliation of the dissonance between forces that drive and constrain the wider use of ecotechnology.

7.4.1 Regarding Technology a New Way

The ecological crisis facing society has been described as a product of the very technological infrastructure that has enabled the successes industrial society has achieved. Society is increasingly recognising the threats it confronts at this period in late modernity. Reflection may lead to planned responses and the construction of alternative scenarios away from the present environmental dilemma (Beck 1994). *Research objective one* considered national and international plans to re-orient technology (*e.g.* sustainable development and ecological modernisation). To this end, however, the question remains: which technology and which science is appropriate? Traditional engineering science tends to foster complex technical solutions to environmental problems. One key contribution of the research that stemmed from meeting *research objective one*, was to document that a re-orientation of technology is already underway at the local level although constraints do exist. Across the case studies, hard technical options were rejected for softer technical solutions that fell in line with the environmental values and operational-level needs of users.

Each of the case studies can be viewed as an internally motivated experiment in which conventional environmental management options were rejected because they were not seen as contributing to environmental improvement. Congruent with the conceptual framework that was proposed, the reigning technological options were considered a threat to risk society, which confirms the work of, Irwin, Georg *et al.* (1994), who suggests that reaction to this risk is creating opportunities for citizens to formulate their own responses through adopting alternatives that are relevant in their unique local settings. Modern-industrial technology and its requirements for inputs of energy, materials and the resulting external consequences of pollution are the crux of the predicament faced by 21st Century risk society. Evidence from the case studies suggests that the ecotechnology was adopted because it was consistent with locally motivated efforts to improve the environment. This is consistent with the idea that actors in risk society are capable of the reflection required to construct alternative paths toward an ecologically sustainable future. It also suggests that planned responses through Beck (1994) notion of reflexive modernisation are not only possible, but they are being implemented at the local level, which is congruent with the conceptual framework developed in this research.

The appeal of the ecotechnology, and the efforts of each organisation to adopt these alternatives suggest that local level actors are motivated to improve the environment on their own terms and to challenge pre-determined expert-based strategies characterised by the transfer of blueprint approaches (Irwin, Georg *et al.* 1994; Irwin 1995). As Irwin (1995: 180) notes, local initiatives such as these point to the existence of an "approach to sustainable development which is rooted in the preferred living practices and social arrangements of citizens". Living in a sustainable fashion is no easy task! Be it the necessity of driving an automobile because current model of urban planning make it difficult not to, or the obligation of having water-borne sewage systems because waterless toilets and wastewater recycling are not codified. Under the current structure all citizens are culpable of degrading the environment and the socio-ecological footprint is increasing simply because existing structures prevent a more sustainable existence (Hawken 1993). Within this context, self-determination is essential to promote the development of technology that makes sense to users at the local level where more sustainable living patterns may be desirable. This is the essence of Beck's (1992) risk society argument that considers modern technology a risk that jeopardises the future. Rather than accepting technology that is pre-determined by values that shuttle Rapoport's (1984) notion of the technological imperative, the research suggest that an alternative, more acceptable notion of technology exists in the eyes of local level actors.

Ecotechnology, and its congruence with the values and preferences of each organisation, suggests a different way of understanding the technological imperative and specifically the four intrinsic, but negative values described by Brunk (1985). These values, Efficient, High-Tech, Elegant and Self-perpetuating, do not conform to ecotechnology in the same way they do conventional options. For instance, the value Efficient can be viewed in terms of short-term operational 'efficiency' vs. long-term environmental 'effectiveness'. The wastewater treatment efficiency afforded by the CTW cannot, in conventional terms, be considered efficient (*i.e.* rapid) because its treatment objectives are achieved over longer time periods because they require fewer mechanised components or large inputs of pollution causing energy. Nor would the GBTT be considered efficient in conventional terms because of the inputs of labour and diligent maintenance it requires. The GBTT requires a higher level of operational inputs than a septic system, but the GBTT is also capable of recycling wastewater, which conventional septic systems do not achieve. For these reasons, the CTWs and the GBTTs have the potential for increased environmental effectiveness and process efficiency over mid to long-term time frames as they experience learning effects.

Likewise, ecotechnology may not meet the conventional value of High-tech or Elegant in terms of its complexity and the technical rationality required for its design; however this may not be entirely true. Ecotechnology is, in effect, extremely High-tech because the aim is to capture and utilise the complexity inherent in solar driven natural systems – the very basis of planetary ecology – in order to meet human production goals in an ecologically integrated fashion. The concept is undeniably rational when the restrictions that social organisations now impose on the environment's productive capacity (WCED 1987) are considered: not to mention the risk of complete ecological collapse (Meadows, Potomac Associates *et al.* 1972; Meadows, Meadows *et al.* 1992). Clean modes of production contrast pollution causing conventional options that depend on non-renewable energy. Neither does ecotechnology conform to the value that suggests technology that is Self-perpetuating and ultimately leads to increased complexity is good. As ecotechnology experiences increased learning effects and improved efficiency, it can be expected that *more-with-less* is possible and that human production goals can be achieved without large inputs of materials and high input technology, which will result in less pollution. The values intrinsic to technology have resulted in technological imperative that promotes a hard technology trajectory with a low level of dependence on natural systems. This has allowed high levels of human control and manipulation in meeting production goals, but at great costs. Utilising natural processes to achieve production goals through soft technology paths will requires a different interpretation and understanding of what Efficient, High-tech, Elegant and Self-perpetuating implies when alternative and potentially, environmentally benign options are considered. If technology is to be "brought under control," experts and decision makers must use their moral judgement ". . . at the source of technological development itself" (Brunk 1985: 126).

7.4.2 Constructive Technology Assessment

The concept of constructive technology assessment is significant in relation to the issues discussed in this thesis. The inherent goal of constructive technology assessment includes opening decision-making to all concerned stakeholders in order to steer the internal development of technology rather than having it pre-determined and imposed from forces external to the setting where it is being used (Schot 1992). Participatory and collaborative decision-making is essential. As experiments in innovative environmental management, the case studies exposed several factors promoting adoption of the ecotechnology. Users viewed the ecotechnology as a superior environmental management option and this was a key factor leading to its adoption. In addition, the unique site-level amenities and operational characteristics of the ecotechnology were significant and reveal some of the design elements that attracted users. A key element of these design elements, in relation to local level environmental management, was the necessity of wastewater management solutions that had fewer negative environment impacts than those associated with the standard conventional options. In fact, this seemed to compel the adoption more than anything and suggests that the soft, technical nature of the ecotechnology and its potential ability to improve the environment resonated with users in a culturally relevant fashion in contrast to the conventional options, which were rejected.

Findings from the cases studies where the CTWs were applied also reveal that the creation of collaborative settings allowed a social learning process to occur. Collaboration between key stakeholders, mainly the conservation authority and the provincial Ministry of Environment, legitimise the project. This acted to create a niche, which also allowed the municipal government's involvement and acted to decrease their initial fears regarding a departure from standard practice. Consequently, this resulted in a high level of learning by those parties who were involved. This is measured by the efforts of the municipal government to create and implement a planning mechanism to permit the CTWs in both cases. Change was achieved in terms of the broader acceptance of the ecotechnology and its legitimacy as a viable and effective option in environmental management.

Comparisons between the cases where the CTWs and the GBTTs were applied demonstrate that a tremendous amount of capacity can be built when enabling settings are created and a level of flexibility is available to those officials without fear of liability that extends into the future. Short of the ability of users to capitalise the GBTTs - and the required redundant backup systems - the current regulatory structure for regulating onsite sewage system under the OBC is very restrictive. These cases reveal a need to bridge the dissonance between the unique requirements of ecotechnology and the regulatory standards established to protect the environment and limit liability. Change in legal instruments may be needed to this end. Local level authorities need opportunities to increase their capacity in order to facilitate local innovation and to allow constructive technology assessment to occur. Although science-based safeguards certainly need to be in place, mechanisms need to be devised to promote local level experimentation.

Integrated planning and management provides a framework that may be appropriate to achieve the aims of constructive technology assessment. If processes and mechanisms can be established to set the rules of the game between stakeholders to resolve edge problems as they occur, this may provide a context for local level collaboration and experimentation in the development of innovative technology. In essence this is what was possible when the UTRCA, MOEE and local government worked together to implement the CTW technology. In spite of the initial uncertainties that existed, a venue for collaboration and social learning was created, which resulted in significant capacity building, and ultimately, change. This was not achieved in the case where the GBTTs were applied. In these settings, both the generic and substantive management functions were determined centrally and acted to restrict local level innovation, which constrained the projects. Generic management functions (*i.e.* management, regulations, approvals) as well as substantive management functions, or the technical interventions themselves, need to be allocated closer to the level where efforts to innovate are actually occurring (Mitchell 1990).

Strong regulation and other incentives are required to steer the development of sustainable technological options rather than regulations that are inflexible and act to constrain innovation and subsequent reliance on the 'best available' technologies that now dominate current markets. In this context, small-scale experimentation, transfer of information, training, collaboration, regulatory guidance and cost sharing measures are required. Approval mechanisms must enable settings where local level innovation can occur and novel technologies can be established in niches that permit social learning during the co-development of alternative forms of technology. This is critically important in relation to ecotechnology. The performance parameters and operational requirements of ecotechnology are unique and not well understood at this time in its development. In developing new forms of environmental management technology a wider peer-community that includes all stakeholders must be tapped during citizen-level initiatives to improve the environment.

The conceptual framework that developed in relation to this research is optimistic and suggests that society desires and is certainly capable of a planned transition away from the risk posed by modern industrial technology, towards alternatives that are harmonised with the planetary ecology. The framework is also normative, in a sense, and suggests that there are certain alternatives that will be more effective than others in accomplishing this transition. Certainly the transition towards cleaner forms of technology must be managed by competent experts; however, new forms of technology and the policies under which they are selected will not be effective over the long-term if applied mechanistically and with faith in instrumental reason alone. As environmental change and crisis become increasingly evident, the adverse trajectories that technological progress has taken must be critically examined. It is imperative that new technological directions are identified that can meet human production requirements while maintaining sustainable social interaction with the environment. This will inevitably require means that are technical and must incorporate a revised understanding of the technological imperative to bring technology in line with ensuring the security of the planetary ecology.

Appendices (1-10)

Appendix – 1 Summary of Methods

Method	Description/Justification	Source
	Source of Data	
Chain Sampling	Informants and other relevant source of data are identified beginning with the initial interview.	Neuman (1991)
Semi-structured interviews	Allows for the collection of qualitative verbal data from interviewees and provides the opportunity to probe into key areas as the interview proceeds.	Patton (1990); Cresswell (1994)
Document Review	Common qualitative data sources. Documents offer an objective data source not created for research goals and are not affected by the research process.	Merriam (1990); Robson (19930; Cresswell (1994)
Data source triangulation	Multiple data sources to confirm/triangulate findings. More effective than repetitive data collection and improves the validity of research through increasing the meaning of the data.	Stake (1995)
Initial grouping data according to conceptual framework	Assists in a preliminary organisation of the data. Themes, patterns and categories are formulated as they emerge.	Stake (1995)
	Interview Procedures	
Interviewer probing	Allows complete exploration of individual stories. Can lead into a deep exploration of critical and previously unexplored areas and concepts.	Neuman (1991); Stake (1995)
Symbolic Interaction	'Sense making' (*e.g.* clarification) is undertaken between the interviewer and interviewee to avoid mis-interpretation of questions and responses to increases question-response reliability.	Foddy (1993)
	Data Analysis Procedures	
Open coding	Simplifies the initial raw data into themes, patterns and categories into numerical or worded codes as they emerge. Process is 'open' to change as patterns evolve and develop; focussing, changing or adding new themes occurs in successive readings.	Neuman (1991); DeGraaf, Jordan *et al.* (1999)
Axial coding	Axial coding further organises the data putting less emphasis on the data and more on focussing, grouping and re-defining initial codes. Original codes are challenged and questioned.	Neuman (1991)
Selective coding	Cases illustrating themes are identified and compared and contrasted against other cases that have been coded and reduced. Final themes, categories and patterns are identified.	Neuman (1991)
Successive Approximation	Through repeated iterations and comparisons, concepts are developed that fit the evidence and "reveal features of the data." Analysis occurs as concepts are modified through repeated analysis and comparison with the evidence.	Neuman (1991)

Appendix – 2 Recruitment and Consent Forms

RECRUITMENT LETTER

<<Interviewee Name and Address>>

Gregory Rose
University of Waterloo
School of Planning
200 University Ave., Waterloo, ON. Canada
Date << >>

Dear <<Name>>:

Thank you for agreeing to participate in this research project. I have selected this case because the technology that has been implemented here is, for the most part, unique. I am interested in the circumstances regarding the planning and implementation of the technology.

The purpose of the research is to explore the constraints, barriers and opportunities in relation to the implementation of alternative technological innovations for wastewater treatment. Through my research, I want to describe what factors have been, and presently are, important during the planning and implementation process. I would hope that my research would have practical implications in the future for planning sustainable technology for wastewater treatment and recovery in Ontario as well as other parts of Canada.

As we discussed by telephone, I will arrive at your office for an interview on << date>> at <<time>>. The purpose of the interview is to obtain a more complete description of the circumstances and conditions related to the technology that you were involved in implementing. The interview should take approximately 60 minutes of your time and will be tape-recorded for subsequent transcription.

There are no known or anticipated risks associated with your participation in this study. In addition, your participation is entirely voluntary and you may decline answering any questions you do not wish to answer. *All information you provide will be considered confidential unless consent is received to manage the data otherwise*. Interview tapes and notes will be transcribed and entered onto my computer hard disk. Backup copies of the data will be stored on CD and will be inaccessible to anyone other than members of my thesis committee and myself.

I have enclosed a copy of the **interview consent form** for your participation in the interview. On the day that we meet, I will present you with an identical copy that I will ask you to sign. This research is being conducted for my doctoral dissertation through the School of Planning (Faculty of Environmental Studies) under the supervision of Dr. Murray Haight at the University of Waterloo. A scholarship from the **Social Sciences and Humanities Council of Canada** is supporting my research at this time. This research has been reviewed by, and received ethics clearance through, the Office of Research Ethics at the University of Waterloo.

If you have any questions about your upcoming interview, please do not hesitate to contact me at <<telephone number>> or by email at << gdrose@fes.uwaterloo.ca >>. If you have concerns resulting from your participation in this study, please do not hesitate to contact either Dr. Murray Haight at <<telephone number>> or Dr. Susan Sykes in Office of Research Ethics at <<telephone number>>.

Thank you for your assistance with this project.

Yours sincerely,

Gregory Rose
Ph.D. Candidate, School of Planning

CONSENT FORM

I agree to participate in an interview being conducted by Gregory Rose of the University of Waterloo, School of Planning under the supervision of Dr. Murray Haight. I have made this decision based on the information I have received in the attached letter and have had the opportunity to receive any additional details I requested regarding the study. As a participant in this study, I realise that I will be asked to take part in an interview of between 60 and 90 minutes and that I may decline answering any of the questions, if I so choose.

All information that I provide will be held in confidence and I will not be identified by name in the thesis, report or subsequent publications unless agreeing otherwise. I also understand that the name of the business or organisation where the technology has been proposed or implemented will not be identified except by fictional name.

I understand that I may withdraw this consent at any time by asking that the interview be stopped. I also understand that this project has been reviewed by and received ethics clearance through the Office of Research Ethics at the University Waterloo and that I may contact this office if I have any concerns or questions about my participation in this study.

Participant's Name: ____

Participant's Signature: ____

Name of Witness: ____

Signature of Witness: ____

Date: _________________________

GRATUITY LETTER

<<Interviewee Name and Address>>

Gregory Rose
University of Waterloo
School of Planning
200 University Ave. West
Waterloo, ON.
N2L 3G1

Date << >>

Dear <<Name>>:

I am writing to express my gratitude for your participation during our recent meeting and interview. I appreciate the many demands made on your time so I am grateful for the opportunity to have met with you.

As we discussed, my research project examines the barriers and opportunities to the adoption of sustainable technology. I expect to complete the study in late 2001 and I will provide you with an Executive Summary of the research at that time. However, if you have any questions regarding the progress of the research in the meantime, please do not hesitate to contact me at <<telephone number>> or through email at << gdrose@fes.uwaterloo.ca >>.

My research is being conducted for my doctoral dissertation through the School of Planning under the supervision of Dr. Murray Haight. A Social Science and Humanities Research Council of Canada scholarship is supporting my research at this time. The procedures related to my data collection have been reviewed by, and received ethics clearance through, the Office of Research Ethics at the University of Waterloo. If you have concerns resulting from your participation in this study, please do not hesitate to contact either Dr. Haight at <<telephone number>> in the school of planning or Dr. Susan Sykes in the ethics office at <<telephone number>>.

Again, thank you for your assistance with my research project.

Yours sincerely,

Gregory Rose
PhD Candidate

CONSENT FOR USE OF ATTRIBUTED QUOTATIONS

Project Title

EXPERIMENTS IN INNOVATIVE ENVIRONMENTAL MANAGEMENT: THE ADOPTION OF ECOTECHNOLOGY FOR WASTEWATER MANAGEMENT

Having previously been tape-recorded in an interview in December 2000 to September 2002 conducted by Gregory Rose of the School of Planning at University of Waterloo under the supervision of his advisor Dr. Murray Haight, I agree to allow selected quotations from the interview to be published in Gregory Rose's thesis and any subsequent scholarly publications. I also permit the quotations to be cited by name and affiliation.

I understand that this form is an amendment to the original consent form that I signed at the time of the interview. Additionally, I understand that the request to cite me – and other informants - as an interviewee is being made to increase the integrity of the research and to acknowledge individuals for their insights. However, I understand that I am under no obligation to agree to this request.

Additionally, I understand that this project (and this amended consent form) has been reviewed by and received ethics clearance from the Office of Research Ethics at the University Waterloo and that I may contact Dr. Susan Sykes in that office at <<telephone number>> or Dr. Murray Haight at <<telephone number>> if any questions or concerns regarding my participation in this study arise.

Participant's Name: ____

Participant's Signature: ____

Name of Witness: ____

Signature of Witness: ____

Date: _________________________

Gregory Rose
School of Planning – University of Waterloo

Appendix – 3   Research Interview Questions

Date:__________________

Location of Interview: _____________________________

Time Started: __________ Time Finished: ___________ Duration___________

Interviewee Profile

Name of Case Discussed: ____

Involvement of Interviewee: ____

Section I General/Introductory

1. What was your role in the planning and implementation of the wastewater management technology related to this project?

   ____
   ____

2. Can you tell me why the decision to select or explore this wastewater treatment technology was made?

   ____
   ____

3. Has it been a success and how do you measure that success - what are the metrics?

   ____
   ____

Section II Stakeholder Values

4. In your opinion, what are the advantages and disadvantages of this technology when compared to other available onsite options?

   ____
   ____

5. Do you expect that this technology will offer the business/organisation a competitive advantage? If so, what are those advantages?

   ____

Section III Project Design Activities

6. Based on your experience during the implementation, what do you believe were the barriers that constrained the implementation of this technology?

____

____

7. How were these barriers overcome?

____

____

8. Do you feel that the current approvals/regulatory framework encourages alternative technologies to be adopted by business and how did they specifically affect the implementation in this case?

____

____

9. How was the approval or permit obtained - what needed to be negotiated for approval?

____

____

10. Was cost savings, either short-term or long-term, a factor in the selection this technology?

____

____

Section V Technical

11. Can you tell me what level of treatment is achieved by this technology?

____

____

12. How integral is the system to the operation as a whole and is there a contingency for wastewater treatment?

____

Thank you very much for your time today

Appendix – 4 List of Informant Names & Affiliations

Informant Coding Scheme		Engineer-Architect-Consultant	EAC
Owner-Operator-Proponent	OOP	Local Government Official	LGO
Conservation Authority Official	CAO	Provincial Government Official	PGO

Code	Name	Affiliation
French Case Informants (CTW) n = 9		
CAO-1	Mr. Brad Glasman	Engineer - Upper Thames River Conservation Authority
OOP-2	Mr. Bill French	Owner - French Dairy Farm
OOP-3	Mr. Rudy Rauser	Local Farm Owner – Cooperated in Project Conception
LGO-4	Mr. Dave Hanley	Planner - Perth County Planning and Development Office
LGO-5	Mr. Don Hocking	Reeve – Fullarton Township
PGO-6	Mr. Murray Blackie	Agricultural Specialist – MOEE
PGO-7	Anonymous	Environmental Planner – MOEE
PGO-8	Anonymous	Agricultural Specialist – OMAFRA
PGO-9	Anonymous	Agricultural Specialist – OMAFRA
Luckhart Case Informants (CTW) n= 7		
LGO-10	Mr. Rob Leach	Health Inspector - Perth District Health Unit
EAC-11	Ms. Laura Jeffery	Wetland Engineering Consultant
OOP-12	Mr. Doug Luckhart	Owner - Luckhart Transport Ltd.
OOP-13	Mr. David O'Rourke	Owner - O'Rourke Transport Inc.
OOP-14	Mr. Michael Rich	Liaison Officer – National Research Council of Canada
CAO-15	Mr. Jeff Brick	Planner – Upper Thames River Conservation Authority
CAO-16	Ms. Karen Maaskant	Biologist – Upper Thames River Conservation Authority
YMCA Case Informants (GBTT) n= 6		
LGO-17	Mr. Mike Gianfrancesco	Environmental Health Manager – Region of Waterloo
EAC-18	Mr. Greg Allen	Engineering Consultant - Allen Kani Associates
OOP-19	Mr. Callum McKee	System Operator – YMCA
EAC-20	Mr. Charles Simon	Architectural and Planning Consultant
OOP-21	Ms. Moragh Hayes	Canada Trust Friends of the Environment Foundation
OOP-22	Anonymous	Selection Committee – YMCA
Waldorf Case Informants (GBTT) n= 7		
LGO-23	Mr. James Stiver	Planner – City of Vaughan
EAC-24	Mr. Andrew Hellebust	Engineering Consultant – EcoWerks Technologies Corporation
EAC-25	Mr. Lloyd Rozema	Wetland Engineering Consultant - AQUA Treatment Systems
OOP-26	Mr. Bob Pickering	Selection Committee – Waldorf
OOP-27	Mr. George Ivanoff	Selection Committee – Waldorf
OOP-28	Mr. Paul Sheardown	Selection Committee – Waldorf
Supplemental Informants (CTWs and GBTTs) n= 11		
CAO-29	Anonymous	Manager – Toronto and Region Conservation Authority
EAC-30	Mr. Alex Campbell	Onsite Waste Management Specialist
EAC-31	Ms. Rifka Khalilieh	Environmental Manager - The Body Shop Canada
EAC-32	Dr. Doug Joy	Engineer - Educator and Researcher University of Guelph
PGO-33	Comm. Gord Miller	Environmental Commissioner of Ontario (Wetland Biologist)
EAC-34	Mr. John Pries	Wetland Technologist (Engineer)
CAO-35	Mr. Steve Sauder	Project Planner - Upper Thames River Conservation Authority
CAO-36	Ms. Tracy Ryan	Conservation Advisor - Grand River Conservation Authority
CAO-37	Ms. Nancy Davy	Environmental Planner - Grand River Conservation Authority
PGO-38	Anonymous	MOEE – Green Industry and Program Development
PGO-39	Anonymous	MOEE - Wastewater Treatment Specialist (engineer)
PGO-40	Anonymous	MOEE - Watershed Management Advisor

Appendix – 5 Frequencies of NVivo Axial Codes

STAKEHOLDER ATTRIBUTES

Proposed Legislation	3
Regulatory Driven Motive	5
Rejection of Conventional	10
Competitive Advantage	15
Technology Skepticism	16
Selection Motive	26
Added-Value	31
Environmental Values	31
Resistance to Change	32
Institutional Constraint	59
Champion of Innovation	61
Organisational Constraint	117
Technology Impression	130
Technology Preference	146

DESIGN ACTIVITIES

Collaboration/Participation	20
Contingencies	23
Provincial Approval	28
Planning Instrument	30
Planning & Implementation	43
Local Approval	47
Regulatory Impediment	60
Legitimacy & Credibility	95
Support & Endorsement	100
Regulatory Issue	101
Caution & Concerns of Liability	115

IMPLEMENATION SETTING

Ease of Adoption	24
Operation and Management	83
Recovery & Reuse	125
Economics & Market	146

Axial Node Count = 29

Appendix – 6 Peer-Debriefing Survey & Tabulated Results

Preliminary findings validated in the peer-debriefing survey were compiled to establish five final findings. Tabulated responses from the peer-debriefing survey are presented here with each of the seven preliminary findings contained in the peer-debriefing survey.

PEER-DEBRIEFING RECRUITMENT FORM

«Name»
«Company»
«Address1»
«City»

Gregory Rose
University of Waterloo
School of Planning
200 University Ave. West
Waterloo, ON.
N2L 3G1

Date <<   >>

Dear «Name»:

I am writing in the hope that you will assist me to validate the findings that I have generated in my doctoral research by taking part in a Peer-Debriefing exercise. The intent of peer-debriefing is to validate the accuracy of the preliminary research findings. The objective of the research was to identify ***Factors that Promote and Constrain the Application of Ecological Wastewater Treatment Technology in Ontario***. The technologies investigated were constructed treatment wetlands for agricultural wastewater and greenhouse-based biological treatment systems for human wastewater.

The data set was collected between December 5, 2000 and September 4, 2001. During that time, forty individuals were interviewed in relation to the four case studies investigated. Findings from the investigation have been included in the Peer-Debriefing exercise (enclosed). I have also included a one-page background for each of the case studies: A, B, C and D.

The exercise consists of several short and summarised findings, to which, I ask that you respond and return to me in the pre-posted/pre-addressed envelope at the earliest time possible. Please feel free to call me at any time if necessary; my home telephone number is <<_>>. Your assistance and comment are most appreciated.

I can assure you that responses to this Peer-Debriefing exercise will be completely confidential and no names will be associated with returned comments.

Yours sincerely,

Gregory Rose
Ph.D. Candidate

PEER-DEBRIEFING PRELIMINARY FINDINGS (grouped by final findings 1-5)

Gregory Rose
School of Planning, University of Waterloo
January 21, 2002

Thesis Title: Experiments in Innovative Environmental Management

Please circle your affiliation

Owner-Operator-Proponent	Local Government Official	Provincial Government Official
Conservation Authority Official	Engineer-Architect-Consultant	

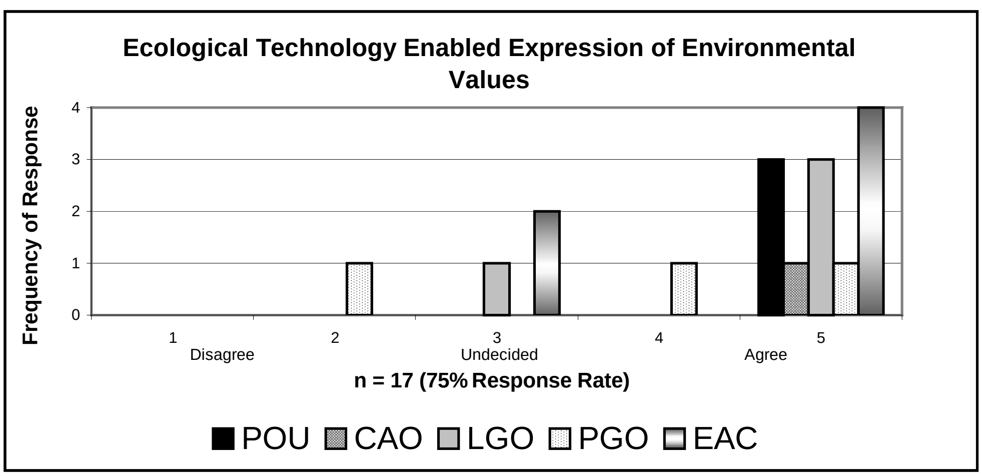
Finding - 1
Environmental Values Were a Motivating Factor

Ecological Technology Enabled Expression of Environmental Values (preliminary)

- The convention options for wastewater treatment were not congruent with the environmental values of either of the educational facilities. The decision to adopt the greenhouse treatment technology was made because it was considered to be an environmentally superior alternative and demonstrated environmental responsibility.

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting “0”.

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement



6% Disagree - 18% Undecided - 76% Agree

Finding - 2
Historical Perspective Gaps and Inertia Reinforce the Selection Environment

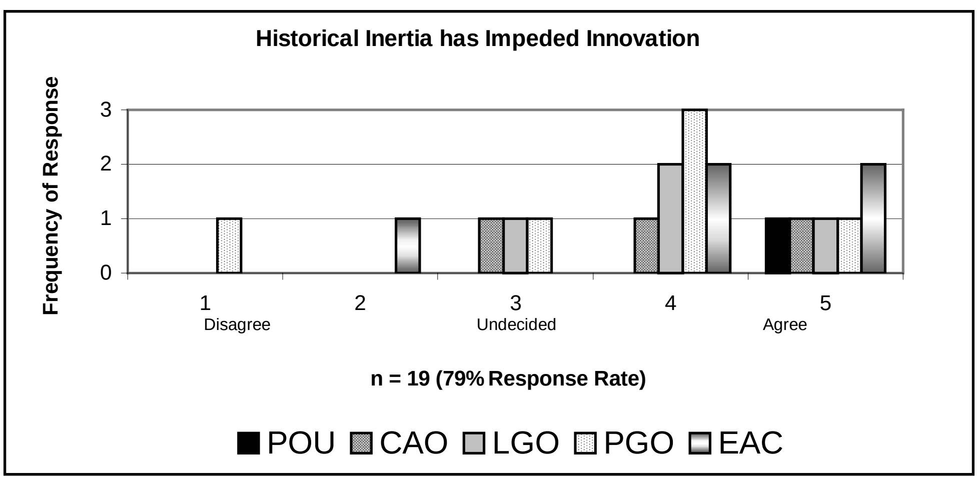
2a Historical Inertia has Impeded Innovation (preliminary)

- Dating back to the demonstration treatment wetland project in Listowel, Ontario (1980-1984), the Ontario Ministry of Environment (MOE) has never made a definitive assessment of the practicality and efficiency of treatment wetlands for agriculture.
- The historical unwillingness of the MOEE to innovate in the area of constructed treatment wetlands stems from bias seated in a traditional/conservative engineering culture that has emerged within the Ministry and has impeded innovation in this area.
- The MOEE has displayed discomfort and uncertainty with the unique performance and operational principles of treatment wetlands and has not encouraged innovation through establishing an approval framework that would enable advances in treatment wetland development while still ensuring protection of the environment.
- Currently no official guidelines exist with the exception of a MOEE authored position paper* outlining limited and restricted use of the treatment wetland technology.

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting "0".

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement

Ministry of Environment (1998). *Constructed wetlands wastewater treatment technology: Interim approach to review and approval of constructed wetlands wastewater treatment technologies under Ontario Water Resources Act*. Toronto, Ontario.



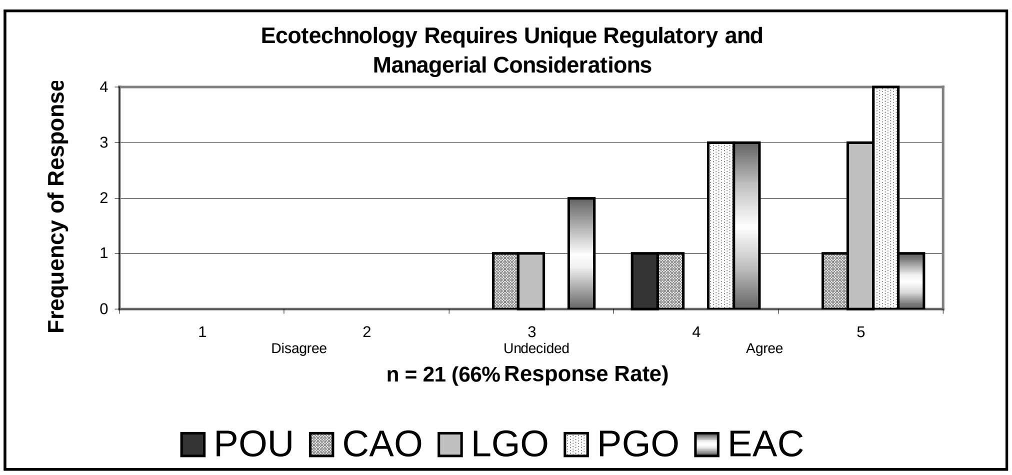
5% Disagree - 21% Undecided - 74% Agree

2b Ecotechnology Required Unique Regulatory And Managerial Considerations (preliminary)

- Comprised of predominantly natural components, the performance parameters and operational principles of treatment wetlands are dissimilar from the conventional options and pose an added level of complexity and uncertainty for regulatory officials.
- Ecological technologies are susceptible to insults such as disease, predation by pests and sensitive to toxic compounds. These factors necessitate that the technology fit the operational framework of the business and that there is full commitment by the user to engage in a unique management regime in order for the technical integrity of the system to be maintained and consistent water quality criteria achieved.

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting "0".

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement



0% Disagree - 19% Undecided - 81% Agree

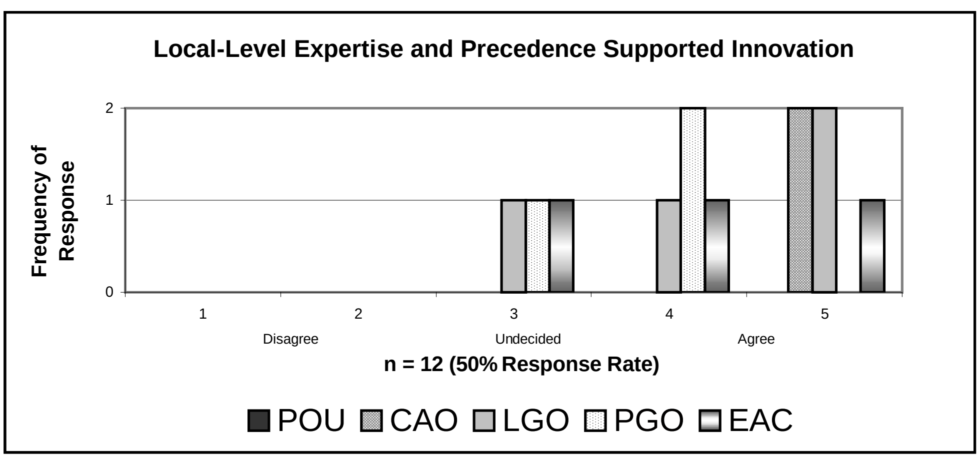
Finding - 3
Expert Involvement Legitimated the Ecotechnology and Built Local Capacity

3a Local Level Support of Innovation (preliminary)

- Although the prospect of an unfamiliar wastewater treatment technology was initially distressing for local officials they were willing to support innovation. The municipal planning department had no intention of stifling innovation and worked collaboratively with the Conservation Authority and the MOEE to enable application of the treatment wetland while ensuring that adequate safeguards were in place.
- During The Luckhart Case, the enactment of the Services Improvement Act (1997) was imminent and responsibility for sewage works of less than 10,000 litres/wastewater/day would be transferred to the local level. In anticipation, the MOEE gave full responsibility for the approval of the treatment wetland in The Luckhart Case to the Conservation Authority. The capacity that the Conservation Authority had built in previous collaboration with the MOEE, established their expertise in designing, building and monitoring the technology - they were trusted at this point by the MOEE and received full permission from local officials to implement the system in association with the truck washing facility.

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting “0”.

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement



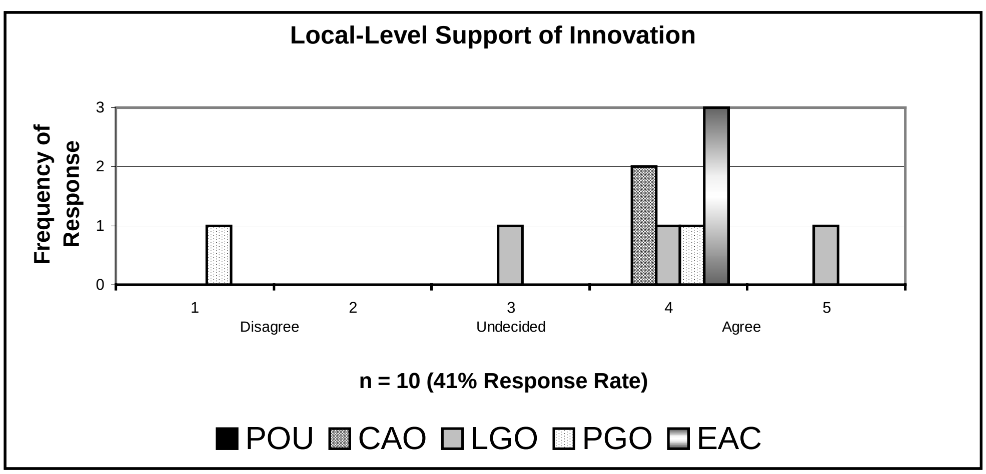
0 Disagree - 25% Undecided - 75% Agree

3b Local Level Expertise and Precedence Supported Innovation (preliminary)

- Initially, local officials were cautious and resistant to depart from standard agricultural wastewater management practices due to unfamiliarity with the innovative technology and concerns of potential liability. The collaboration built between the MOEE and Conservation Authority legitimise the treatment wetland technology, thereby reducing the apprehension of local officials and compelling them to devise a mechanism to permit it.
- During the application of the treatment wetland in The French Case, collaboration between the MOEE and the Conservation Authority enabled capacity to be developed in the design and operation of the technology.
- The precedence in application of the wetland in The French Case (1993) established confidence in the Conservation Authority from local officials and enabled the application of the treatment wetland in The Luckhart Case (1996) to proceed with minor local level hesitance, which was overcome through offering assurance that the business owner and Conservation Authority were working together to ensure the safety and integrity of the project.
- In a strategic move by the Conservation Authority, momentum was developed behind the project through initiating funding partnerships and a public relation campaign prior to consultation with local officials. This catalyzed local officials into developing a planning mechanism that would permit the treatment wetland.

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting "0".

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement



10% Disagree - 10% Undecided - 80% Agree

Finding - 4
Provincial Budget Reductions Impeded Innovation

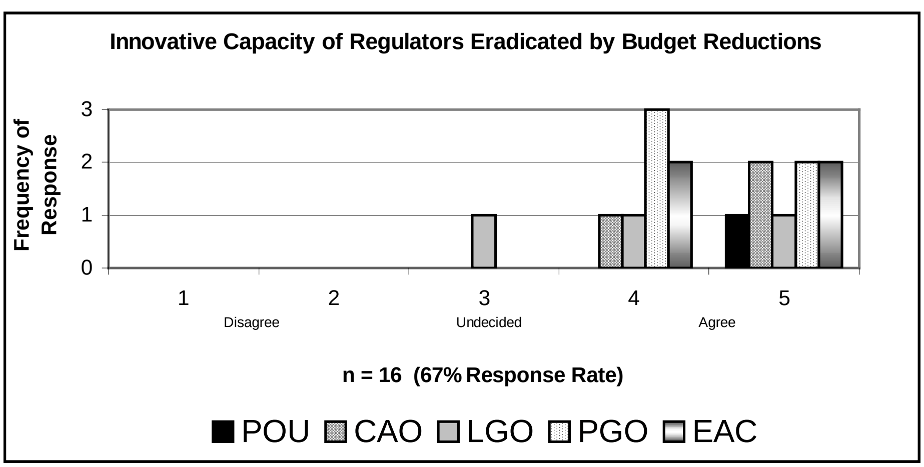
Innovative Capacity of Regulators Eradicated by Budget Reductions (preliminary)

- Under the MOEE's Clean Up Rural Beaches (CURB) program, circumstances were created, which included the availability of funding and a venue for innovation for the management of agricultural wastewater. During this time, the MOEE developed partnerships with conservation authorities and demonstrated the ability to collaborate in developing treatment wetlands for agriculture.
- In 1996, however, provincial government budget reductions eradicated the innovative capacity that the MOEE had built in the application of treatment wetlands for agriculture under the CURB program.
- In 1997, the MOEE management team that was delivering the Canada-Ontario Agricultural Green Plan's provincial study** to determine the practicality and efficacy of treatment wetlands was dismantled and no assessment resulting from monitoring put forward; the MOEE's research and development momentum in relation to treatment wetlands was effectively dissolved at this point.
- In spite of sustained interest by the agricultural community and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) in the treatment wetland technology, no official guidelines for their design or performance resulted from the various MOEE sponsored demonstration projects in Ontario.

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting "0".

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement

** Canada-Ontario Agricultural Green Plan (1994). *Research sub-program: Environmental monitoring of agricultural constructed wetlands – A Provincial Study*.



0 Disagree - 6% Undecided - 94% Agree

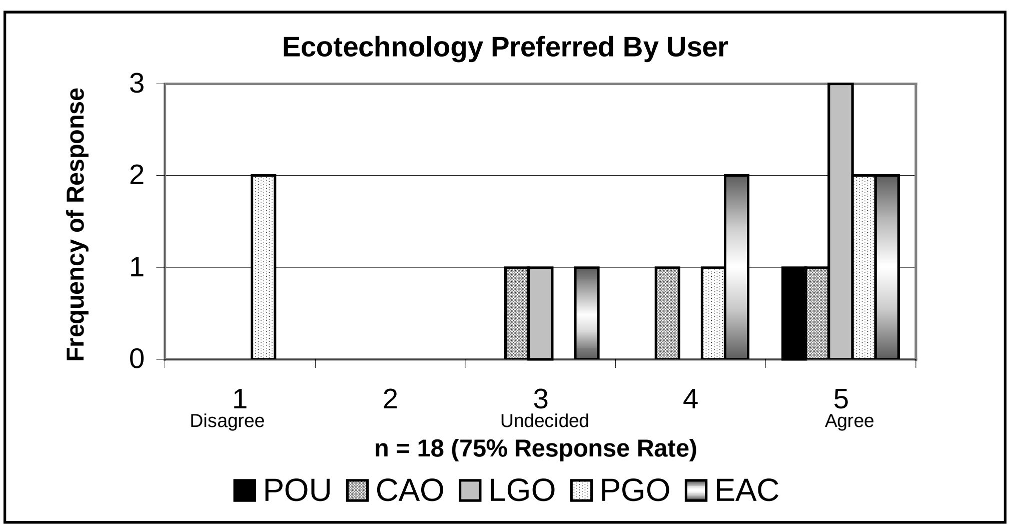
Finding - 5
Ecotechnology Preferred By Users

5a Alternative Technology Preferred By User (preliminary)

- From an operational standpoint, users considered treatment wetlands to be a more practical and environmentally superior technology because of their ability to treat wastewater as opposed to the conventional option: storage and land-spreading. It was also seen as a simpler and less expensive alternative to operate and maintain and was perceived, in The French Case to have a potentially longer life-expectancy than the conventional option.
- The owners in Cases A and B also preferred the treatment wetland because it offered added-value as an aesthetic amenity when compared to conventional options that were considered unsightly.
- Adoption of the treatment wetlands was also a strategic decision. In The French Case, it was adopted in anticipation of stricter regulations; in The Luckhart Case, it was adopted because the owner believed he could gain a competitive advantage through improving the company's environmental image (*i.e.*, 'greening').

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting "0".

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement



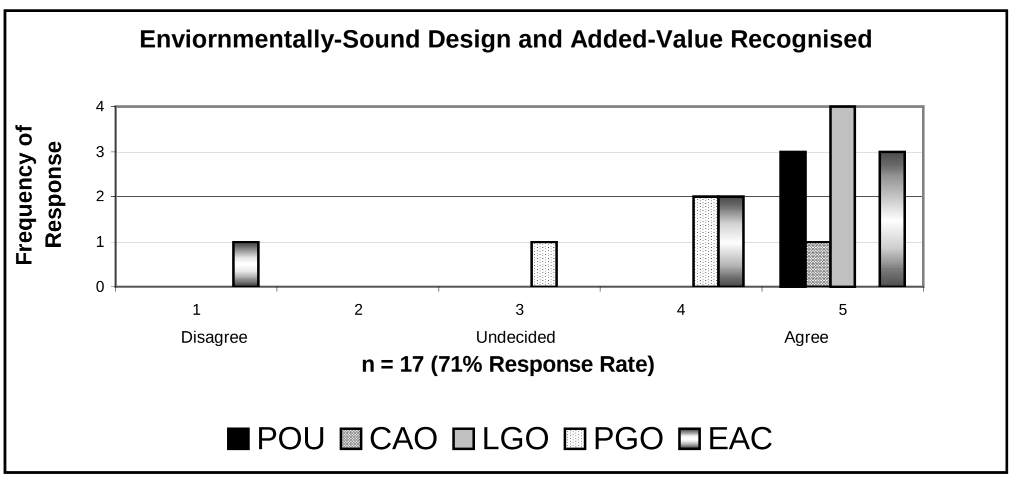
11% Disagree - 17% Undecided - 72% Agree

5b Environmentally Sound Design And Added Value Recognised (preliminary)

- The recycling of treated wastewater and reduction of energy-use was enabled through integrating the management of wastewater within the greenhouse's design, which allowed passive heating and cooling.
- The greenhouse treatment technology was adopted because it was capable of effectively treating and reusing wastewater in a greenhouse setting, which added value to each site through creating an aesthetically pleasant recreational area and providing a venue for educational programs.
- The greenhouse treatment technology also provided strategic advantages for each organization through its potential ability to attract clientele.

On the scale below, circle a number (1-5) that indicates your level of **Agreement** or **Disagreement** with this finding. Please Note: inability to comment can be indicated by selecting "0".

0	1	2	3	4	5
Cannot Comment	No Agreement		Undecided		Full Agreement



6% Disagree - 6% Undecided - 88% Agree

Appendix – 7 List of Peer-Debriefing Respondents

Peer-Debriefing Informants Contacted

Informant Coding Scheme

Owner-Operator-Proponent	OOP	Engineer-Architect-Consultant	EAC
Conservation Authority Official	CAO	Local Government Official	LGO
		Provincial Government Official	PGO

Code	Name	Affiliation
CAO-Original Interviewee	Mr. Brad Glasman	UTRCA – Engineer
OOP-Original Interviewee	Mr. Bill French	Owner – French Dairy Farm
LGO-Original Interviewee	Mr. Doug Vock	Township of Perth East
LGO-Original Interviewee	Mr. Dave Hanley	Perth County Planning and Development Office
PGO-Original Interviewee	Mr. Murray Blackie	MOEE – Agricultural Specialist
PGO-Original Interviewee	Anonymous Interviewee	MOEE – Environmental Planner
PGO-Original Interviewee	Anonymous Interviewee	OMAFRA – Agricultural Specialist
LGO-Original Interviewee	Mr. Rob Leach	Perth District Health Unit – Health Inspector
OOP-Original Interviewee	Mr. Doug Luckhart	Luckhart Transport Ltd. – Owner
OOP-Original Interviewee	Mr. Michael Rich	National Research Council of Canada – Liaison Officer
CAO-Original Interviewee	Mr. Jeff Brick	UTRCA – Planner
CAO-Original Interviewee	Ms. Karen Maaskant	UTRCA – Biologist
LGO-Original Interviewee	Mr. Mike Gianfrancesco	Region of Waterloo – Environmental Health Manager
EAC-Original Interviewee	Mr. Greg Allen	Allen – Kani Associates – Engineering Consultant
OOP-Original Interviewee	Mr. Callum McKee	YMCA – System Operator
EAC-Original Interviewee	Mr. Charles Simon	Architectural and Planning Consultant
OOP-Original Interviewee	Anonymous Interviewee	YMCA Learning Centre – Selection Committee
LGO-Original Interviewee	Mr. James Stiver	City of Vaughan – Planner
EAC-Original Interviewee	Mr. Andrew Hellebust	EcoWerks Technologies Corporation
EAC-Original Interviewee	Mr. Lloyd Rozema	AQUA Treatment Ltd. – Wetland Engineering
OOP-Original Interviewee	Mr. Bob Pickering	Toronto Waldorf School – Selection Committee
OOP-Original Interviewee	Mr. George Ivanoff	Toronto Waldorf School – Selection Committee
OOP-Original Interviewee	Mr. Paul Sheardown	Toronto Waldorf School – Selection Committee
EAC-Original Interviewee	Mr. Alex Campbell	Onsite Waste Management Specialist
EAC-Original Interviewee	Dr. Doug Joy	Educator University of Guelph – Educator/Researcher
PGO-Original Interviewee	Comm. Gord Miller	Environmental Commissioner of Ontario
EAC-Original Interviewee	Mr. John Pries	CH_2M HILL Gore & Storrie Ltd. - Wetland Technologist
CAO-Original Interviewee	Ms. Tracy Ryan	GRCA – Conservation Advisor
PGO-Original Interviewee	Anonymous	MOEE – Wastewater Treatment Specialist
PGO-Supplemental Peer	Anonymous	MOEE – Standards Development
PGO-Supplemental Peer	Anonymous	MOEE London Regional Office – Environmental Engineer
PGO-Supplemental Peer	Anonymous	OMAFRA – Environmental Management Specialist
PGO-Supplemental Peer	Anonymous	OMAFRA - Agricultural Specialist
EAC-Supplemental Peer	Anonymous	MMAH – Building Materials Evaluation Committee
PGO-Supplemental Peer	Anonymous	MMAH – Ontario Building Code Advisor
EAC-Supplemental Peer	Anonymous	Researcher Kemptville College (CTW Specialist)
EAC-Supplemental Peer	Anonymous	Private Consultant (GBTT Specialist)
EAC-Supplemental Peer	Anonymous	Private Consultant (GBTT Specialist)

Total Peer Debreifing Mailers Sent: (n=38)

Appendix – 8 List of Case Records

Case records consisted of formal and non-formal publications, documents, letters, memorandums and newspaper articles that that were identified and cited.

Record Number	Supplemental Case Records
1	UTRCA (1992). Talk of the Thames. Constructed Wetland to Treat Barnyard Runoff, Upper Thames River Conservation Authority.
2	Bader, A. 1993. Constructed Wetland in Fullarton First of Its Kind. The Mitchell Advocate, July 21: p. 2.
3	Record Special 1994. Nature His Waste Disposer. The Record, September 14: p. B12.
4	Shyplla, B. 1994. Artificial Wetland in Fullarton may hold promise for farmers. The Beacon Herald, September 9: p. 7.
5	Reid, B. 1995. Fullarton Farmer Surprised over Sudden and Widespread Interest in Wetland Project. The Beacon Herald, July 15: p. 9.
6	October 27, 1995, letter from Mountain, Mitchell, Hill, Monteith & Ritsma Barristers and Solicitors to Mr. Donald Feeney of the Township of Fullarton.
7	November 30, 1995, letter from Perth County Health Inspector Mr. Sean Morrison to Mr. Dave Hanly, Director Perth County Planning Office.
8	August 14 1995, letter from UTRCA official Mr. Jeff Brick to Mr. Dave Hanly, Director Perth County Planning Office.
9	July 24 1995, letter from UTRCA official Ms. Karen Maaskant to Mr. Dave Hanly, Director Perth County Planning Office.
10	Proposed Minimum Monitoring Schedule, Letter August 14, 1995, from UTRCA official Mr. Jeff Brick to Mr. Dave Hanly, Director Perth County Planning Office.
11	December 15 1995, letter from MOEE official Mr. William Armstrong to Mr. Dave Hanly, Director Perth County Planning Office.
12	OMAFRA Memorandum from OMAFRA official Mr. James Weeden to Mr. Dave Hanly, Director Perth County Planning Office & OMAFRA Memorandum from OMAFRA official Mr. Don Hillborn to OMAFRA official Mr. James Weeden.
13	September 8, 1992, The Corporation of the Township of Fullarton By-Law amendment 19-1992 to allow the CTW for temporary period of three years.
14	October 16, 1995, Notice of bylaw amendment. Donald Feeney, Clerk, Township of Fullarton.
15	June 2, 1992, letter from UTRCA official Karen Poel to Mr. Dave Hanly, Director Perth County Planning Office.
16	UTRCA (1996). Project Description: Luckhart Wastewater Treatment System. London, ON, Upper Thames River Conservation Authority.
17	Glasman, B. and L. Jeffery (1997). An Industrial Application for the Emerging Technology of Constructed Wetlands in Waste Water Treatment. London, ON, Upper Thames River Conservation Authority.
18	Greene, M. (1997). Perfectly Natural. In Today's Trucking May: 47-50.
19	Reid, B. 1996. Environmental Consciousness Drives Truckers Quest to Clean Water, Image. The Beacon Herald: p. 4.
20	Greene, M. 1996. Local trucking company meets Mother Nature halfway. The Mitchell Advocate: p. 6.
21	May 6, 1999, letter from Perth County Health Official Mr. Rob Leach to Ms. Carol Zimmer of the Perth County Land Division Committee.

Record Number	Supplemental Case Records
22	UTRCA (n.d.). Using constructed wetlands to treat wastewater from a truck washing facility. London, ON, Upper Thames River Conservation Authority.
23	Simon, C. (1995). The Environmental Learning Centre - A demonstration of sustainable design. In The Ontario Eco-Architecture Series 1.
24	Roe, J. 1994. YMCA's Environment camp to teach 'Earth Wisdom'. The Record, October 25: p. A1-A2.
25	Kitchener-Waterloo YMCA (n.d.). "The Kitchener-Waterloo YMCA: Environmental learning centre. Kitchener-Waterloo, Kitchener-Waterloo YMCA
26	Burtt, B. 1999. Treatment plant set living example. The Kitchener-Waterloo Record, Wednesday April 22: p. 4.
27	OCETA 2002. Eco Rem - Water Reclamation System. Retrieved February 2002, from http://www.oceta.on.ca/profiles/ecowerks/ecorem_tech.html.
28	EcoWerks Technologies Corporation (2002). What We Do.
29	Hellebust, A. (2001). Eco Rem Greenhouse Biological Sewage Treatment with Reuse at the Toronto Waldorf School. Proceedings of the Water Environment Association Technical Symposium 2001.
30	Adler, M. 2000. 'Living 'Machine' cleans, recycles 70% of schools toilet water. The Liberal (community newspaper for York Region), May 25: p. M1.
31	AQUA Treatment Systems 2000. Treatment Wetland Characteristics. Retrieved June, from http://www.aquatreatment.com.
32	Glasman, B. and W. E. Briggs (1996). Submerged Flow Wetland to Treat Wastewater from a Single Family Residence. London, ON, Upper Thames River Conservation Authority.
33	Glasman, B. and L. Jeffery (1997). An Industrial Application for the Emerging Technology of Constructed Wetlands in Waste Water Treatment. London, ON, Upper Thames River Conservation Authority.

Appendix – 9 Case Treatment Efficiencies

Table 7-1. Comparative Treatment Technology Efficiencies (Luckhart and Waldorf).

Ontario Building Code Effluent Quality Criteria and Provincial Water Quality Objectives				Case Studies			
Parameter	Provincial Water Quality Objective	MOEE Treatment Requirements: Private Sewage Works (Procedure F-5-1) (mg/L)	OBC Treatment Unit Effluent Requirements (mg/L)	French CTW	Luckhart CTW	YMCA GBTT	Waldorf GBTT
Average BOD_5 5-day biological O_2 demand	No Objective	Design Objective 15 Non-compliance 25	Secondary* 40 Tertiary* 15	14	20	N/A	13
Average TSS total suspended solids	No Objective	Design Objective 15 Non-Compliance 25	Secondary* 30 Tertiary* 10	N/A	16	N/A	5
Total Ammonia N $(NH_3^+ + NH_4^+)$-N Ammonia+Ammonium as N	0.02 mg/L	No Objective	No Objective	N/A	**8.6**	N/A	0.14
Total Nitrate Nitrogen $(NO_2^- + NO_3^-)$-N Nitrate and nitrate N	10 mg/L	No Objective	No Objective	0.01	N/A	N/A	**70**
TKN Total Kjeldahl as N	No Objective	No Objective	No Objective	9	23.1	N/A	1.2
Total Phosphorus	No Objective	No Objective	No Objective	2	8.91	N/A	5
E. Coliform	100 cfu per 100/ml	No Objective	No Objective	N/A	**0.03 cfu per 100/ml**	N/A	**119 cfu per 100/ml**

Notes:
* Maximum concentration based on 30-day averages in milligrams per Litre (mg/L).
Shading indicates the objective is exceeded.
cfu = coliform units

Sources: UTRCA (1992-2001); MMAH (1997); Eco-Tek Wastewater Treatments Inc. (1998); Hellebust (2001); MOEE (n.d.-a).

The Luckhart Case Constructed Treatment Wetland

Table 7-2. Performance Efficiencies Luckhart Case CTW.

Wastewater Characteristics	Influent to Marshes	Effluent	Efficiency
Average BOD_5	183 mg/L	20 mg/L	89%
Average TSS*****	158 mg/L	16 mg/L	90%
NH4 (Ammonia + Ammonium as N)	17.5 mg/L	8.6 mg/L	51%
TKN (Total Kjeldahl as N)	74.8 mg/L	23.1 mg/L	69%
Total Phosphorus	25.9 mg/L	8.91 mg/L	67%
E. coliform	3,800,000 cfu/day	2000 mg/L	> 99%
Fecal strep.	70,000 cfu/day	2500 mg/L	96%

Notes:
***** TSS was only collected in 1997 & 1998 since no flow was observed/measured leaving the vegetated filter strip. It can be assumed no solids leave the treatments system.
cfu = coliform units

Source: Upper Thames River Conservation Authority (2002).

The Waldorf Case Greenhouse-Based Treatment Technology

Table 7-3. Performance Efficiencies the Waldorf Case GBTT.

Wastewater Characteristics	Influent to Greenhouse*	Influent to Greenhouse*	Effluent	Effluent	Efficiency on mass basis**
Average BOD_5	192 mg/L	1,297 g/d	13 mg/L	34 g/d	97.4%
Average TSS	23 mg/L	155 g/d	5 mg/L	12 g/d	92.4%
$(NH_3^+ + NH_4^+)$-N (Ammonia+Ammonium as N)	88 mg/L	594 g/d	0.14 mg/L	0.4 g/d	99.9%
TKN (Total Kjeldahl as N)	107 mg/L	723 g/d	1.2 mg/L	3 g/d	99.6%
Total Phosphorus	5 mg/L	33 g/d	5 mg/L	13 g/d	62.0%
E. coli	3,853 million cfu/day		8 million cfu/day		99.8%

Notes:
* Grab sample after flow balancing and septic tanks prior to start of reuse.
** Mass reduction is used to assess performance because reuse reduces the volume of water discharged resulting in elevated concentrations.

Source: EcoWerks Technologies Corporation (2002).

The French Case Constructed Treatment Wetland

Comprehensive performance data not available.

The YMCA Case Greenhouse-Based Treatment Technology

No performance data not available.

Appendix – 10 Case Study Locations & Key Contacts

French Dairy Farm

William H. French
Mitchell, Ontario N0K 1N0

Design and Implementation
Upper Thames River Conservation Authority
1424 Clarke Road
London, Ontario N5V 5B9
http://www.thamesriver.org/

Luckhart Trucking Ltd.

PO Box 65
RR # 1, Sebringville, Ontario N0K 1X0
http://www.luckhart.com/

Design and Implementation
Upper Thames River Conservation Authority
1424 Clarke Road
London, ON. N5V 5B9
http://www.thamesriver.org/

YMCA Environmental Learning Centre at Paradise Lake

YMCA Environmental Learning Centre
3738 Hessen Strauss
RR #1, St. Clements
Ontario N0B 2M0

Design and Implementation
Dr. John Todd
Ocean Arks International
176 Battery Street, Suite 1
Burlington, VT USA 05401
http://www.oceanarks.org

Toronto Waldorf School

Toronto Waldorf School
9100 Bathurst Street #1
Thornhill, Ontario L4J 8C7

Design and Implementation:
EcoWerks Technologies Corporation
100 Arbors Lane, Unit A
Woodbridge, Ontario L4L 7G4
http://www.ecowerks.ca

Index

U

V

W

Z

Bibliography

Abbott, A. (1988). *The System of Professions*. Chicago, The University of Chicago Press.

Adamson, V. F. (1984). *Breaking the barriers: A study of legislative and economic barriers to industrial waste reduction and recycling*. Toronto, Canadian Environmental Law Research Foundation and Pollution Probe Foundation.

Alberta Environment (2000). *Guidelines for the approval and design of natural and constructed treatment wetlands for water quality improvement*. Edmonton, AL, Alberta Environment.

Allenby, B. R. (1994). Integrating environment and technology: Design for environment. In *The greening of industrial ecosystems*. B. R. Allenby and D. J. Richards (Eds.). Washington, D.C., National Academy Press**:** 137-138.

______ (1999). *Industrial ecology: Policy framework and implementation*. Upper Saddle River, N.J., Prentice Hall.

Anderson & Associates Inc. 2001. *Treatment wetlands*. Retrieved January 2001, from http://www.andassoc.com/projects/images/wetland1.

Ashford, N. (1993). Understanding the technical response of industrial firms to environmental problems: Implications for government policy. In *Environmental strategies for industry: International perspectives on research needs and policy implications*. K. Fischer and J. Schot (Eds.). Washington, D.C., Island Press**:** 227-310.

Auditor General of Canada (2001). *Report of the Commissioner of the Environment and sustainable development*. Ottawa, Office of the Auditor General of Canada and the Commissioner of the Environment and Sustainable Development.

Ayres, R. U. and L. W. Ayres (1996). *Industrial ecology: Towards closing the materials cycle*. Cheltenham, UK, Edward Elgar.

Bader, A. 1993. Constructed Wetland in Fullarton First of Its Kind (21 July). *The Mitchell Advocate*: p. 2.

Banks, D. and G. Heaton (1995). An innovation-driven environmental policy. In *Issues in Science and Technology* Fall 1995: 43-51.

Bansal, P. (1997). Business strategy and the environment. In *Business and the natural environment*. P. Bansal and E. Howard (Eds.). Oxford, Butterworth-Heinemann**:** 173-194.

Bartone, C. (1995). *Urban wastewater and sanitation: Responding to household and community demand*. Proceedings of the Human Face of the Urban Environment: Second Annual World Bank Conference on Environmentally Sustainable Development, September 19-21, 1994 in Washington, D.C., The International Bank for Reconstruction and Development-The World Bank.

Beck, M. B., J. Chen, A. J. Saul and D. Butler (1994a). Urban Drainage in the 21st Century: Assessment of new technology on the basis of global material flows. In *Water, Science & Technology* 30(2): 1-12.

Beck, U. (1992). *Risk society: Toward a new modernity*. London, Sage.

______ (1994). The Reinvention of Politics: Toward a theory of reflexive modernization. In *Reflexive Modernization*. U. Beck, A. Giddens and S. Lash (Eds.). Stanford, Stanford University Press.

Beck, U., A. Giddens and S. Lash (1994b). *Reflexive modernization: politics, tradition and aesthetics in the modern social order*. Stanford, California, Stanford University Press.

Beder, S. (1997). Technological Paradigms: The case of sewerage engineering. In *Technology Studies* 4(2): 167-188.

Beltrame, J. (2002). Fouling our Cities (29 July). Maclean's**:** 18-24.

Black, M. (1998). *Learning that works: A 20 year retrospective view on international water and sanitation cooperation*. Washington, UNDP - World Bank.

Bookchin, M. (1980). *Toward an ecological society*. Montreal, Black Rose Books.

Born, S. M. and W. C. Sonzogni (1995). Integrated environmental management: Strengthening the conceptualization. In *Environmental Management* 19(2): 167-181.

Bowen, G. and G. Ferguson (1989). *Overcoming institutional barriers and constraints to water quality management*. Proceedings of the AWRA Water Laws and Management Conference in Tampa, Fl., American Water Resource Association. September 17-22, 1989.

Brand, K.-W. (1997). Environmental consciousness and behavior: The greening of lifestyles. In *The international handbook of environmental sociology*. M. Redclift and G. Woodgate (Eds.). Massachusetts, Edward Elgar Publishing, Inc.**:** 204-217.

Briassoulis, H. (1989). Theoretical orientations in environmental planning: An inquiry into alternative approaches. In *Environmental Management* 13(4): 381-392.

Briscoe, J. (1993). When the cup is half full. In *Environment* 35(4): 7-37.

Brix, H. (1994). Use of constructed wetlands in water pollution control: Historical development, present status, and future perspectives. In *Water, Science & Technology* 30(8): 209-223.

Brix, H. and H. Schierup (1989). The use of aquatic macrophytes in water-pollution control. In *Ambio* 18(2): 100-107.

Brunk, C. (1985). *Professionalism and responsibility in the technological Society*. Waterloo, ON, Conrad Grebel College.

Burtt, B. 1999. Treatment Plant Sets Living Example (22 April). *The Kitchener-Waterloo Record*: p. 4.

Buttel, F. (1997). Social institutions and environmental change. In *The International Handbook of Environmental Sociology*. M. Redclift and G. Woodgate (Eds.). Northampton, MA, Edward Elgar**:** 40-54.

Buttel, F. H. (2000). Ecological modernization as social theory. In *Geoforum* 31: 57-65.

Callenbach, E., F. Capra, L. Goldman, R. Lutz and S. Marburg (1993). *Ecomanagement: The Elmwood guide to ecological auditing and sustainable business*. San Francisco, Berrett-Koehler Publications.

Canada-Ontario Agriculture Green Plan (1994). *Environmental monitoring of agricultural constructed wetlands - a provincial study (UTRCA funding proposal)*. London, Upper Thames Conservation Authority.

Capra, F. and G. Pauli, Eds. (1995). *Steering Business Toward Sustainability*. Tokyo, The United Nations University Press.

Clark, K. L. and J. Yacoumidis (2000). *Ontario's Environment and the Common Sense Revolution: A fifth year report*. Toronto, Canadian Institute for Environmental Law and Policy.

Cresswell, J. W. (1994). *Research design: Qualitative & quantitative approaches*. Thousand Oaks, Sage Publications.

______ (1998). *Qualitative Inquiry and Research Design: Choosing among five traditions*. Thousand Oaks, CA, SAGE Publications Inc.

Cresswell, J. W. and D. L. Miller (1997). *Validity (verification) in qualitative research: Perspectives, terms, procedures, and methodologies*. Unpublished manuscript. Department of Educational Psychology, University of Nebraska-Lincoln,

Cusworth, J. (1997). Institutional capacity building for rural development: A case study from Zimbabwe. In *Towards Sustainable Project Development*. F. Wilson (Eds.). Cheltenham, UK, Edward Elgar**:** 183-197.

DeGraaf, D., D. Jordan and K. DeGraaf (1999). *Programming for Parks, Recreation, and Leisure Services: A servant leadership approach*. State College, PA, Venture Publishing, Inc.

Denny, P. (1997). Implementation of constructed wetlands in developing countries. In *Water, Science & Technology* 35(5): 27-34.

Disco, C. (2002). Remaking "nature": The ecological turn in Dutch water management. In *Science Technology and Human Values* 27: 206-235.

Dosi, G. (1988). The nature of the innovation process. In *Technical Change and Economic Theory*. G. Dosi, R. Freeman, G. Nelson, G. Silverberg and L. Soete (Eds.). London, Pinter Publishers**:** 221-238.

Dunfield, A. and K. Lunman 2002. Grasshoppers Plague Province (24 July). *The Globe and Mail*: p. A7.

Dunlap, R. E. and W. R. Catton (1984). Commitment to the dominant social paradigm and concern for environmental quality. In *Social Science Quarterly* 65: 1013-28.

Eade, D. (1997). *Capacity-Building: An approach to people-centred development*. Oxford GB, Oxfam.

Eco-Tek Wastewater Treatments Inc. (1998). *Promotional Literature*. Langley, Canada.

EcoWerks Technologies Corporation (2002). *What We Do*.

Environmental Technology Evaluation Center (1997). *Accelerating Environmental Technology Implementation*. Civil Engineering Research Foundation Report.

Etzioni, A. (1967). Mixed scanning: A "third" approach to decision-making. In *Public Administration Review* 27: 385-392.

Everett, M. (1993). Engineers and Economic Conversion: A psychological perspective. In *Engineers and Economic Conversion*. P. L. MacCorquodale, M. W. Gilliland, J. Kash, P. and A. Jameton (Eds.). New York, Springer-Verlag: 41-67.

Fahm, L. A. (1980). *The Waste of Nations: the Economic Utilization of Human Waste in Agriculture*. Montclair, New Jersey, Allanheld, Osmun & Co. Publishers, Inc.

Farrell, M. (1996). Purifying wastewater in green houses. In *BioCycle*.

Foddy, W. (1993). *Constructing Questions for Interviews and Questionnaires: Theory and practice in social research*. New York, Cambridge University Press.

Fontana, A. and J. Frey (2000). The interview: Form structured questions to negotiated text. In *Handbook of Qualitative Research*. N. K. Denzin and Y. S. Lincoln (Eds.). Thousand Oak, CA, Sage Publications Inc.: 645-672.

Forster, D. and D. Southgate (1983). *Institutions constraining the utilization of municipal wastewaters and sludges on land*. Proceedings of the Proceedings of Workshop on Utilization of Municipal Wastewater and Sludge on Land in Riverside, CA, Department of Soil and Environmental Sciences, University of California, Riverside.

Friedmann, A., C. Zimring and E. Zube (1978). *Environmental Design Evaluation*. New York, Plenum Press.

Friedmann, J. (1984). Planning as social learning. In *People-Centred Development: Contributions toward theory and planning frameworks*. D. C. Korten and R. Klauss (Eds.). West Hartford, Kumarian Press: 189-194.

______ (1987). *Planning in the Public Domain: From knowledge to action*. Princeton, N.J., Princeton University.

Frijns, J. and M. Jansen (1996). *Institutional requirements for appropriate wastewater treatment systems*. Proceedings of the Workshop on sustainable municipal waste water treatment systems in Leusdan, the Netherlands, ETC in co-operation with WASTE.

Frosch, R. (1997). Closing the loop on waste materials. In *The Industrial Green Game: Implications for environmental design and management*. D. J. Richards (Eds.). Washington, D.C., National Academy of Engineering**:** 37-47.

Furedy, C. (1990). *Social Aspects of Solid Waste Recovery in Asian Cities*. Toronto, York University.

Gabriel, A. (1997). *Australian and regional co-operation Initiatives to promote cleaner production and waste Minimisation*. Proceedings of the OECD Proceedings: Cleaner Production and Waste Minimization in OECD and Dynamic Non-Member Economies in Paris, France, OECD.

Gandy, M. (1997). Postmodernism and environmentalism: complementary or contradictory discourses. In *The International Handbook of Environmental Sociology*. M. Redclift and G. Woodgate (Eds.). Massachusetts, Edward Elgar Publishing, Inc.**:** 150-157.

Gardner, G. (1998). Recycling organic waste. In *State of the World 1998*. L. Starke (Eds.). New York, WW Norton & Company**:** 97-112.

Gaye, M. and F. Diallo (1997). Community participation in the management of the urban environment in Rufisque (Senegal). In *Environment and Urbanization* 9(1): 9-29.

Gilliland, M. W. and J. Kash, P. (1994). Economic Conversion, Engineers, and Sustainability. In *Investing In Natural Capital: The ecological economics approach to sustainability*. A. Jansson, M. Hammer, C. Folke and R. Costanza (Eds.). Washington D.C., Island Press**:** 449-466.

Glasman, B. and W. E. Briggs (1996). *Submerged Flow Wetland to Treat Wastewater from a Single Family Residence*. London, ON, Upper Thames River Conservation Authority.

Glasman, B. and L. Jeffery (1997). *An Industrial Application for the Emerging Technology of Constructed Wetlands in Waste Water Treatment*. London, ON, Upper Thames River Conservation Authority.

Gouldson, A. and J. Murphy (1997). Ecological modernisation: Economic restructuring and the environment. In *The Political Quarterly* 68(5): 74-86.

______ (1998). *Regulatory Realities: The implementation and impact of industrial environmental regulation*. London, Earthscan Publications Ltd.

Government of Canada (2002). *Climate Change Plan for Canada*. Ottawa, Government of Canada.

Gray, B. (1985). Conditions facilitating interorganizational collaboration. In *Human Relations* 38(10): 911-936.

Green, M. B. and J. Upton (1995). Constructed reed beds: Appropriate technology for small communities. In *Water, Science & Technology* 32(3): 339-348.

Greene, M. 1996. Local Trucking Company Meets Mother Nature Halfway. *The Mitchell Advocate*: p. 6.

______ (1997). Perfectly natural. In *Today's Trucking* May: 47-50.

Greeno, J. L. (1994). Corporate environmental excellence and stewardship. In *Environmental Strategies Handbook*. R. V. Kolluru (Eds.). New York, McGraw-Hill**:** 43-64.

Griefahn, M. (1995). The role of government. In *Steering Business Toward Sustainability*. F. Capra and G. Pauli (Eds.). Tokyo, The United Nations University Press**:** 95-107.

Grimble, R. and M.-K. Chan (1995). Stakeholder analysis for natural resource management in developing countries. In *Natural Resource Forum* 19(2): 113-124.

Guterstam, B. (1996). Demonstrating ecological engineering for wastewater treatment in a nordic climate using aquaculture Principles in a Greenhouse Mesocosm. In *Ecological Engineering* 6: 73-97.

Guterstam, B. and J. Todd (1990). Ecological engineering for wastewater treatment and its application in New England and Sweden. In *Ambio* 19: 173-175.

Hajar, M. A. (1995). *The Politics of Environmental Discourse*. Oxford, Clarendon Press.

______ (1996). Ecological modernisation as cultural politics. In *Risk, Environment & Modernity: Towards a new ecology*. S. Lash, B. Szerszynski and B. Wynne (Eds.). London, SAGE Publications**:** 246-268.

Hajar, M. A. and F. Fischer (1999). Beyond Global Discourse. In *Living with nature*. F. Fischer and M. A. Hajar (Eds.). Oxford, University Press**:** 1-20.

Hanmer, R. (1997). *Policy approaches for promoting cleaner production and waste minimization in OECD member countries*. Proceedings of the OECD Proceedings: Cleaner Production and Waste Minimization in OECD and Dynamic Non-Member Economies in Paris, France, OECD.

Hanna, E., B. McMullan and P. McGrenere (2001). *A full scale, full-treatment constructed wetland for Cobalt, Ontario*. Proceedings of the 30th Annual WEAO Technical Symposium in Toronto, Ontario. April 1-3, 2001.

Hawken, P. (1993). *The Ecology of Commerce*. New York, HarperCollins.

Health Canada 2001a. *Canada Communicable Disease Report: Waterborne outbreak of gastroenteritis associated with a contaminated municipal water supply, Walkerton, Ontario, May-June 2000*. Retrieved August 2001, from http://www.hc-sc.gc.ca/hpb/lcdc/publicat/ccdr/00vol26/dr2620eb.html.

______ (2001b). *Waterborne Cryptosporidiosis Outbreak*. Ottawa, Health Canada.

______ 2001c. *West Nile Virus - The Facts*. Retrieved August 2001, from http://www.hc-sc.gc.ca/hpb/lcdc/publicat/info/wnv_e.html.

Hellebust, A. (2001). *Eco Rem greenhouse biological sewage treatment with reuse at the Toronto Waldorf School*. Proceedings of the Water Environment Association Technical Symposium 2001 in.

Henderson, K. A. and D. M. Bialeschki (1995). *Evaluating Leisure Services: Making enlightened decisions*. State College, PA, Venture Publishing.

Herbold, R. (1995). Technologies as social experiments: The construction and implementation of a high-tech waste disposal site. In *Managing Technology in Society: The approach of constructive technology assessment*. A. Rip, T. J. Misa and J. Schot (Eds.). London, Pinter Publishers**:** 185-195.

Herskowitz, J. (1986). *Listowel Artificial Marsh Project Report*. Listowel, Ontario, Ontario Ministry of the Environment.

Hudson, B. (1979). Comparisons of current planning theories: Counterparts and contradictions. In *Journal of the American Planning Association* 45(4): 387-406.

Irwin, A. (1995). *Citizen Science: A study of people, expertise and sustainable development*. London, Routledge.

Irwin, A., S. Georg and P. Vergragt (1994). The social management of environmental change. In *Futures* 26(3): 323-334.

Johnston, N. and A. Stokes (1995). *Waste Minimization and Cleaner Technology: An assessment of motivation*. London, Center for Exploitation of Science and Technology.

Kadlec, R. and R. Knight (1995). *Treatment Wetlands*. Boca Raton, Lewis Publishers.

Kay, J., H. Regier, G. Francis and M. Boyle (1999). An ecosystem approach for sustainability: Addressing the challenge of complexity. In *Futures* 31(7): 721-742.

Kemp, R. (1993). An economic analysis of cleaner technology: Theory and evidence. In *Environmental Strategies for Industry: International perspectives on research needs and policy implications*. K. Fischer and J. Schot (Eds.). Washington, D.C., Island Press**:** 79-113.

______ (2000). *Technology and Environmental Policy—Innovation effects of past policies and suggestions for improvement*. Proceedings of the OECD Workshop on Innovation and Environment in Paris, France. 19 June 2000.

Kemp, R. and J. Rotmans (2001). *The Management of the co-evolution of technical, environmental and social systems*. Proceedings of the International Conference Towards Environmental Innovation Systems in Garmisch Partenkirchen, Germany. 27-29 September 2001.

Kitchener-Waterloo YMCA (n.d.). The Kitchener-Waterloo YMCA: Environmental learning centre. Kitchener-Waterloo, Kitchener-Waterloo YMCA**:** 5.

Korfiatis, G. and P. Cheremisinoff (1994). Environmental technology and engineering. In *Environmental Strategies Handbook*. R. V. Kolluru (Eds.). New York, McGraw-Hill**:** 119-163.

Korten, D. (1984). People Centred Development: Toward a framework. In *People-Centred Development: Contributions toward theory and planning frameworks*. D. C. Korten and R. Klauss (Eds.). West Hartford, Kumarian Press**:** 299-309.

Langhelle, O. (2000). Why Ecological Modernization and Sustainable Development Should Not Be Conflated. In *Journal of Environmental Policy & Planning* 2: 303-322.

Lévêque, F. and A. Nadaï (2000). A firm's involvement in the policy-making process. In *Principles of Environmental and Resource Economics: A guide for students and decision-makers*. H. Folmer and H. L. Gabel (Eds.). Cheltenham, UK, Edward Elgar Publishing Ltd.**:** 235-263.

Levins, R., T. Awerbuch, U. Brinkmann, I. Eckardt, P. Epstein, N. Makhoul, C. Albuquerque de Possas, C. Puccia, A. Spielman and M. E. Wilson (1994). The emergence of new diseases. In *American Scientist* 82(1): 52-60.

Lincoln, Y. S. and E. G. Guba (1985). *Naturalistic Inquiry*. Beverly Hills, CA, Sage Publications.

Lindgren, R. D. and S. Miller (1997). *Ontario's Water Resources: The need for public interest reguation*. Canadian Environmental Law Association,
Great Lakes United,.

Living Machines Inc. 2002. *How It Works*. Retrieved from http://www.livingmachines.com/htm/how_works/step1.htm.

Lowe, E. (1996). Industrial ecology: A context for design decision. In *Design for the Environment: Creating Eco-efficient Products and Processes*. J. Fiksel (Eds.). New York, McGraw-Hill**:** 437-471.

Lyle, J. T. (1994). *Regenerative Design for Sustainable Development*. New York, John Wiley & Sons, Inc.

Ma, S. and J. Yan (1989). Ecological engineering for treatment and utilization of wastewater. In *Ecological Engineering: An introduction to ecotechnology*. W. M. a. S. Jorgensen (Eds.). New York, J. Wiley & Sons, Inc.**:** 185 - 217.

Mahoney, J. 2002. Drought Wounds Prairie Farmers (18 July). *The Globe and Mail*: p. A1.

Meadows, D. H., D. L. Meadows and J. Randers (1992). *Beyond the Limits*. Toronto, McClelland & Stewart Inc.

Meadows, D. H., Potomac Associates and Club of Rome (1972). *The Limits to Growth: A report for the Club of Rome's project on the predicament of mankind*. New York, Universe Books.

Merriam, S. (1990). *Case study research in education*. San Francisco, Jossey-Bass Publishers.

Miles, M. B. and A. M. Huberman (1994). *Qualitative data analysis*, Thousand Oaks: Sage Publications.

Miller, G. (2000). *The Protection of Ontario's Groundwater and Intensive Farming: Special report to the Legislative Assembly of Ontario*. Toronto, Environmental Commissioner of Ontario.

______ (2001a). *Having Regard*. Toronto, Environmental Commissioner of Ontario.

______ (2001b). *The lessons of Listowel*. Proceedings of the 30th Annual WEAO Technical Symposium in Toronto, Ontario. April 1-3, 2001.

Mitchell, A. 2002. Northern Nations Suffering Hottest Summer Yet (5 August). *The Globe and Mail*: p. A1.

Mitchell, B. (1986). The evolution of integrated resource management. In *Integrated approaches to resource planning and management*. R. Lang (Eds.). Calgary, The University of Calgary Press: 13-26.

______ (1989). *Geography and resources analysis*. London, Longman.

______ (1990). *Integrated water management: International experience and perspectives*. London, Belhaven Press.

______ (1994). Addressing "edge" problems in land water management in the Sokoto-Rima River Basin, Nigeria. In *Geoforum* 25(2): 133-143.

______ (1997). *Resource and environmental management*. Essex, England, Longman.

______ (1999). Personal communication November 4, 1999.

Mitchell, B. and M. Hollick (1993). Integrated catchement management in Western Australia: Transition from concept to implementation. In *Environmental Management* 17(6): 735-743.

Mitsch, W. and S. Jorgensen (1989). Introduction to ecological engineering. In *Ecological engineering: An introduction to ecotechnology*. W. Mitsch and S. Jorgensen (Eds.). New York:, J. Wiley & Sons, Inc.: 3-12.

Mitsch, W. J. (1991a). Ecological engineering: Approaches to sustainability and biodiversity in the U.S. and China. In *Ecological Economics*. R. Constanza (Eds.). New York, Columbia University Press: 428-448.

______ (1991b). Ecological engineering: The roots and rationale of a new ecological paradigm. In *Ecological engineering for wastewater treatment*. C. Etnier and B. Guterstam (Eds.). Gothenburg, Sweden, Bokskogen: 110-120.

______ (1998). Ecological engineering - the 7-year itch. In *Ecological Engineering* 10: 119-130.

MMAH (1997). 1997 Ontario Building Code. Code and Guide for Sewage Systems.

MOEE (1992). *1992 Status Report on Ontario's Air Water and Waste*. Toronto, Ministry of Environment and Energy.

______ (1993). *Integrating Water Management Objectives into Municipal Planning Documents*. Toronto, Ministry of Environment and Energy.

______ 1996. *Measures to Address Climate Change in Ontario Government Operations*. Retrieved January 2002, from http://www.ene.gov.on.ca/programs/3611e.pdf.

______ (1998). *Constructed Wetlands Wastewater Treatment Technology: Interim approach to review and approval of constructed wetlands wastewater treatment technologies under Ontario Water Resources Act*. Toronto, Ontario, Ministry of Environment and Energy.

______ (n.d.-a). *Determination of Treatment Requirements for Municipal and Private Sewage Treatment Works Discharging to Surface Waters (Procedure F-5-1)*. Toronto, Ministry of Environment and Energy.

______ n.d.-b. *Project Profile: Solar Aquatics System for Wastewater Purification*. Retrieved January 2002, from http://www.ene.gov.on.ca/programs/3354e29.pdf.

Mol, A. (1997). Ecological Modernization: Industrial transformations and environmental reform. In *The international handbook of environmental sociology*. M. Redclift and G. Woodgate (Eds.). Northampton, MA, Edward Elgar.

Mol, A. P. J. (2000). The environmental movement in an era of ecological modernization. In *Geoforum* 31: 45-56.

Murphy, J. (2000). Ecological modernisation. In *Geoforum* 31(1): 1-8.

Murphy, J. and A. Gouldson (2000). Environmental policy and industrial innovation: Integrating environment and economy through ecological modernization. In *Geoforum* 31(1): 33-44.

Nelson, R. R. and S. G. Winter (1977). In search of useful theory of innovation. In *Research policy* 6: 36-76.

______ (1982). *An evolutionary theory of economic change*. Cambridge, Massachusetts, Harvard University Press & Belnap Press.

Neuman, W. L. (1990). *Social research methods*. Needham Heights, Mass., Allyn and Bacon.

______ (1991). *Social research methods: Qualitative and quantitative approaches*. Boston, Allyn And Bacon.

Niemczynowicz, J. (1993a). New Aspects of Sewerage and Water Technology. In *Ambio* 22(7): 449-455.

______ (1993b). *Ways to Overcome Barriers Against Application of A 'New technical Paradigm' in Cities*. Proceedings of the Hydropolis: The role of water in urban planning - Proceedings of the International UNESCO-IHP Workshop in Wageningen, The Netherlands and Emscher Region, Germany, Backhuys Publishers, Leiden. March 29-April 2.

______ (1994). New Aspects of Urban Drainage and Pollution Reduction Towards Sustainability. In *Water Science and Technology* 30(5): 269-277.

OCETA 2002a. *Eco Rem - Water Reclamation System*. Retrieved February 2002, from http://www.oceta.on.ca/profiles/ecowerks/ecorem_tech.html.

______ 2002b. *Solar Aquatics System: Greenhouse-based wastewater treatment*. Retrieved April 2002, from http://www.oceta.on.ca/profiles/earthtech/icon.html.

O'Connor, D. R. (2002). *Report of the Walkerton Inquiry: The events of May 2000 and related issues*. Toronto, Ontario Ministry of the Attorney General.

Odum, H. T. (1971). *Environment, Power, and Society*. New York, Wiley-Interscience.

OECD (1995). *Principles in Practice*. Proceedings of the Proceedings of the OECD/DAC Workshop on Capacity Development in Environment in Rome. December 15.

OMAFRA 2001. *Nutrient Management Act 2001*. Retrieved July 2002, from http://www.gov.on.ca/OMAFRA/english/agops/nutrient_management_act_2001.pdf.

Palys, T. (1997). *Research Decisions: Quantitative and qualitative perspectives*. Toronto, Harcourt Brace.

Patton, M. Q. (1990). *Qualitative Evaluation and Research Methods*. Newbury Park, CA, Sage Publications.

Petak, W. J. (1980). Environmental Planning and Management: The need for an integrative perspective. In *Environmental Management* 4(4): 287-295.

Petts, J. (1994). Effective waste management: Understanding and dealing with public concerns. In *Waste Management and Research* 12: 207-222.

Pretty, J., I. Guijt, I. Scoones and J. Thompson (1992). Regenerating Agriculture: The Agroecology of low-external input community-based development. In *Making Development Sustainable*. J. Holmberg (Eds.). Washington, D.C., Island Press: 91-123.

Price, T. and D. Probert (1997). Role of Constructed wetlands in environmentally-sustainable developments. In *Applied Energy* 57(2-3): 129-174.

Pries, J. (1996). *Constructed Treatment Wetland Systems In Canada*. Proceedings of the Constructed Wetlands In Cold Climates Symposium in Niagara-on-the-Lake, Ontario, CANADA. June 4-5.

______ (2001). Water Works: Communities build wetlands to clean their water. In *The Ontario Technologist* 43(2): 12-15.

Pries, J., R. Borer, R. A. Clarke and R. Knight (1996). *Performance and Design Consideration of Treatment Wetland Systems for Livestock Wastewater Management in Cold Climate Regions in the Northern United States and Southern Canada*. Proceedings of the Second National Workshop, Constructed Wetlands for Animal Waste Management in Fort Worth, Texas, Texas A&M University, College Station, Texas.

QSR International (2000). NVivo NUD*IST for Qualitative Research. Victoria, Australia, Qualitative Solutions and Research.

Rapoport, A. (1984). *The technological imperative*. Proceedings of the University of Waterloo Conference on Philosophy and Nuclear Arms in Waterloo, ON. 28-30 September.

Record Special 1994. Nature his Waste Disposer (14 September). *The Record*: p. B12.

Rees, W. (1995). Achieving Sustainability: Reform or Transformation. In *Journal of Planning Literature* 9(4): 343-361.

Reid, B. 1995. Fullarton Farmer Surprised over Sudden and Widespread Interest in Wetland Project (15 July). *The Beacon Herald*: p. 9.

______ 1996. Environmental Consciousness Drives Truckers Quest to Clean Water, Image. *The Beacon Herald*: p. 4.

Rejeski, D. (1997). Metrics, Systems, and Technical Choices. In *The Industrial Green Game: Implications for environmental design and management*. D. J. Richards (Eds.). Washington, D.C., National Academy of Engineering**:** 48-72.

Rew, S. (1999). An Evaluation of Constructed Treatment Wetlands. School of Planning. Waterloo, University of Waterloo**:** 106.

Rich, G. (1993). *The Professional Practice of Urban and Rural Planning in Canada*. San Francisco, EMText.

Richards, D. J. and R. Frosch (1997). The Industrial Green Game: Overview and perspective. In *The Industrial Green Game: Implications for environmental design and management*. D. J. Richards (Eds.). Washington, D.C, National Academy of Engineering**:** 1-34.

Rip, A. and R. Kemp (1998). Technological Change. In *Human Choice and Climate Change: Resources and technology*, Battelle Press. 2**:** 327-400.

Rip, A., T. J. Misa and J. Schot (1995a). Constructive Technology Assessment: A new paradigm for managing technology in society. In *Managing Technology in Society: The approach of constructive technology assessment*. A. Rip, T. J. Misa and J. Schot (Eds.). London, Pinter Publishers**:** 3-12.

______, Eds. (1995b). *Managing Technology in Society: The approach of constructive technology assessment*. London, Pinter Publishers.

Robinson, M. L. 2002. *The Deccentralization of Private and Municipal Wastewater Treatment Through the Development of Constructed Treatment Wetlands Policy*. Retrieved September 2002, from http://www.unce.unr.edu/publications/Spec%20Pubs/SP-01-14.htm.

Robson, C. (1993). *Real World Research*. Oxford, UK, Blackwell Publishers Ltd.

Roe, J. 1994. YMCA's Environment camp to teach 'Earth Wisdom' (25 October). *The Record*: pp. A1-A2.

Rondinelli, D. (1993). *Strategic and Results-Based Management: Reflections on the process*. Ottawa, Canadian International Development Agency.

Rose, G. D. (1999). *Community-Based Technologies for Domestic Wastewater Treatment and Reuse: Options for urban agriculture*. Ottawa, International Development Research Centre, Cities Feeding People Series - Report 27.

Roseland, M. (1994). Ecological Planning for Sustainable Communities. In *Futures by Design: The practice of ecological planning*. D. Aberley (Eds.). Gabriola Island, B.C., New Society Publishers**:** 70-78.

Ryan, G. and R. Bernard (2000). Data Management and Analysis Methods. In *Introduction: The Discipline and Practice of Qualitative Research*. N. K. Denzin and Y. S. Lincoln (Eds.). Thousand Oak, CA, Sage Publications Inc.**:** 733-768.

Sanio, M., D. Burack and S. Siddiqui (1998). *Reuse of Urban Waste for Agriculture: An investment program for progressive action*. Alexandria, VA, World Engineering Partnership for Sustainable Development.

Schot, J. (1992). Constructive Technology Assessment and Technology Dynamics: The case of clean technologies. In *Science, Technology & Human Values* 17(1): 36-56.

Sewell Commission (1993). *New Planning for Ontario - Final Report*. Toronto, Sewell Commission on Planning and Development Reform in Ontario.

Shrivastava, P. (1996). *Greening Business: Profiting the corporation and the environment*. Cincinnati, Ohio, Thomson Executive Press.

Shumacher, E. F. (1973). *Small is Beautiful*. Triptree, Essex, Blond & Briggs.

Shyplla, B. 1994. Artificial Wetland in Fullarton May Hold Promise for Farmers (9 September). *The Beacon Herald*: p. 7.

Simon, C. (1995). The Environmental Learning Centre - A demonstration of sustainable design. In *The Ontario Eco-Architecture* Series 1: 56-61.

Smith, A. (1997). *Integrated Pollution Control*. Ashgate, Aldershot.

Sparkes, A. and K. Peattie (1998). The Sustainable Management Challenge for Local Government: Green revolution or business as usual? In *Greener Management International* 22: 62-72.

Stake, R. E. (1995). *The Art of Case Study Research*. Thousand Oaks, CA. USA, Sage Publications.

______ (2000). Case Studies. In *Handbook of Qualitative Research*. N. K. Denzin and Y. S. Lincoln (Eds.). Thousand Oak, CA, Sage Publications Inc.**:** 435-454.

Stauffer, J. (1999). *The Water Crisis: Finding the right solutions*. Montreal, Black Rose Books.

Stikker, A. (1997). Putting Systems Into Practice. In *Business and the Natural Environment*. P. Bansal and E. Howard (Eds.). Oxford, Butterworth-Heinemann**:** 221-238.

Strong, M. (1995). *The road from Rio*. Proceedings of the Human Face of the Urban Environment: Second Annual World Bank Conference on Environmentally Sustainable Development in Washington, D.C., The International Bank for Reconstruction and Development-The World Bank.

Tanner, C. C., J. P. S. Sukias and C. Dall (2000). *Construction wetlands in New Zealand - Evaluation of an Emerging "Natural" Wastewater Treatment Technology*. Proceedings of the Water 2000: Guarding the Global Resource Conference in Auckland, NZ. March 19-23.

The Water Foundation 2002. *FlowForms Gallery*. Retrieved December 2002, from http://www.waterflow.net/ffgallery.htm.

Tilley, F. (1998). The Gap Between The Environmental Attitudes And The Environmental Behavior Of Small Firms: With An Investigation Of Mechanical Engineering And Business Services In Leeds. Leeds, Leeds Metropolitan University.

______ (1999). The Gap Between the Environmental Attitudes and the Environmental Behavior of Small Firms. In *Business Strategy and the Environment* 8: 238-248.

Todd, J. and B. Josephson (1996). The Design of Living Technologies for Waste Treatment. In *Ecological Engineering* 6: 109-136.

Todd, J. and N. Todd (1994). *From Eco-cities to Living Machines: Principles of ecological design*. Berkely, CA, North Atlantic Books.

Trochim, W. M. K. 2001. *Likert Scaling*. Retrieved February 2002, from http://trochim.human.cornell.edu/kb/scallik.html.

UTRCA (1992). *Talk of the Thames*. Constructed Wetland to Treat Barnyard Runoff, Upper Thames River Conservation Authority.

______ (1994). *Project Update: Constructed Treatment Wetland Treatment System*. London, ON., Upper Thames River Conservation Authority.

______ (1996). *Project Description: Luckhart Wastewater Treatment System*. London, ON., Upper Thames River Conservation Authority.

______ (n.d.). *Using constructed wetlands to treat wastewater from a truck washing facility*. London, ON., Upper Thames River Conservation Authority.

Van Der Ryn, S. and S. Cowen (1996). *Ecological Design*. Washington, D.C., Island Press.

Van Osch, K. (1997). An Assessment of Farm Plans and Countryside Planning in Ontario. In *Environments* 25(1): 15-28.

Ventre, F. R. (1989). The policy Environment for Environment-Behavior Research. In *Advances in Environment, Behavior and Design*. E. Zube and G. Moore (Eds.). New York, Plenum Press. 2**:** 317-342.

Vergragt, P. and D. van Noort (1996). Sustainable Technology Development: The mobile hydrogen fuel cell. In *Business Strategy and the Environment* 5: 168-177.

Wackernagel, M. and W. Rees (1996). *Our Ecological Footprint: Reducing human impact on the earth*. Gabriola Island, BC, New Society Publishers.

Waltner-Toews, D. (1995). Changing Patterns of communicable Disease - Who's turning the kaleidoscope. In *Perspectives in Biology & Medicine* 29: 43-55.

______ (1996). An Agroecosystem Perspective on Foodborne Illnesses. In *Ecosystem Health* 2: 177-185.

Warner, D. B. and L. Laugeri (1991). Health for All: The legacy of the water decade. In *Water International* 16: 135-141.

WCED (1987). *Our Common Future*. Oxford, Published by Oxford University Press.

Welford, R. (1998). Corporate Environmental Management and Sustainable Development: Post-modern perspectives and the need for a critical research agenda. In *Business Strategy and the Environment* 7(1-12): 1-12.

______ (2000). *Corporate Environmental Management 3: Toward sustainable development*. London, Earthscan Publications.

White, G. F. and A. U. White (1979). Behavioral Factors in Selection of Technologies. In *Appropriate Technology in Water Supply and Waste Disposal*. C. Gunnerson and J. Kalbermatten (Eds.). New York, American Society of Civil Engineers: 31-51.

Winfield, M. and G. Jenish (1996). *The "Common Sense Revolution" and Ontario's Environment: An interim report*. Toronto, Canadian Institute for Environmental Law and Policy.

World Bank (1996). *The World Bank Participation Sourcebook*. Washington, D.C., The International Bank for Reconstruction and Development.

World Resource Institute, UNEP, UNDP and World Bank (1996). *World Resources: A guide to the global environment 1996-1997*. New York, Oxford University Press.

Yin, R. K. (1994). *Case Study Research: Design and methods*. Thousand Oaks, California, Sage Publications.