Ecological Planning of Water Reuse:
A Case Study of the Feasibility of Wastewater Reuse Facilities Re-Design, in Grant Park Shopping Centre, Winnipeg, Manitoba

By

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Abstract

Recycling of water in cities is a viable strategy to address anticipated water shortages, but this aspect of contemporary urban design has been under-examined. Considerable investigation of wastewater reuse in the planning discipline has been conducted on a theoretical level; however, a comprehensive study of a local scale application regarding the potential of a solar aquatic facility implemented in a shopping centre appears to be lacking. This practicum addresses the question " Is water reuse in a typical shopping centre redevelopment environmentally and socially beneficial, and economically feasible?" The structure of this research follows the ecological planning approach, and is based on a review of literature, interview results and conceptual design applied in a case study of Grant Park Shopping Centre (Winnipeg, Manitoba). An ecological framework, simultaneously incorporating the long-term environmental, economic and social values into urban planning and development, is the approach adopted.

Three challenges associated with the implementation of a solar aquatic facility in Grant Park Mall are the difficulties involved in designing the biological process treatment, high capital cost of the intervention and unfavourable public perception towards wastewater reuse. These issues are addressed in the conceptual design through the process treatment design, examination of the cost-effectiveness of the intervention, and suggestions for social programs. The conceptual design demonstrates that a solar aquatic facility is environmentally and socially beneficial and economically feasible where the long run (10 year period) is considered. These findings are supported by the key informants evaluating the conceptual design in a second round of interviews. With consideration to the ecological approach, the intervention in Grant Park Mall would be perceived favourably. A pilot project is recommended to reduce the high initial cost and test receptivity. A strategy to reduce the high capital cost of on-site sewage connection is also identified, but would require new and innovative municipal arrangements to share costs and benefits.

This practicum contributes to the literature, by introducing to planners, governmental officials and potential investors the on-site wastewater reuse, and facilitating the application of governmental permits. Research opportunities are identified to encourage further exploration of the topic. The two most important opportunities are the investigation of implementing a larger scale facility to treat additional wastewater from the surrounding neighbourhoods, and the examination of the current public attitudes and policies regarding wastewater reuse. The findings and recommendations are pertinent to on-site wastewater facilities in future developments, including enclosed shopping centres and other retail developments in Winnipeg as well as in other Canadian cities.

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Chapter One:
Practicum Introduction

1.1 Problem Statement

The planning, design and construction of urban infrastructures has historically lacked a strategy for the efficient use of water resources (Isliefson, 1998; Tyler, 1994). Environment Canada indicates that the usable water supply is being seriously depleted (Isliefson, 1998). Roodman and Lenssen (1995) state that buildings account for one-sixth of the world's fresh water withdrawals, and building infrastructures in modern cities are not "sustainable" in an environmental and economic sense. In the city of Winnipeg, with its average annual 1% increase in per capita water consumption and its slowly growing population[1], the water demand will exceed the ability of the Shoal Lake[2] Aqueduct to convey water to the city (City of Winnipeg a; b). Consequently, an expensive water supply or system expansion may become necessary in the near future.

Commercial and industrial water uses account for 40% of Winnipeg's total water expenditure[3], with an expected increase of 0.5% per annum (City of Winnipeg, 1994; City of Winnipeg a). Shopping centres are among the highest water consumers among commercial users (Cheremisinoff and Cheremisinoff, 1993). An enormous water consumption of shopping centres places a heavy load on the potable water supply and wastewater treatment utilities, as a mall with a floor area of 9,290 m^2 (100,000 ft^2)

[1] Population of the city of Winnipeg has increased 2. 07% from 1998-1999; 2.38% from 1999-2000.

[2] The City's drinking water originates in Shoal Lake.

[3] Commercial and industrial water use in the City of Winnipeg is not statistically separated. The actual percentage of water use by each sector cannot be determined (City of Winnipeg, d).

produces 39 m^3 (10,250 US gallons) of wastewater, and 5,900 grams BOD_5 per day[4] (Butler and Davies, 2000). Therefore, developing strategies to curb the ever-increasing water usage in shopping centres would delay the need of immediate expansion of the city's water system.

Tyler (1994; 2000a) argues that an ecological approach to development can simultaneously benefit environmental and human socio-economic systems, especially in commercial developments such as shopping centres which have long been criticized in regards to their economic sustainability[5]. Although there may be drawbacks and negative perceptions of solar aquatic facilities,[6] in general, this practicum will demonstrate that such facilities can help businesses to become more ecologically, economically and socially sustainable. Shopping centres have the potential for achieving these benefits with the use of wastewater reuse facilities, with relatively few negative aspects.

1.2 Objectives

Wastewater reuse issues have been studied through the ecological planning approach. The benefits and drawbacks of on-site wastewater facilities in Grant Park Mall (GPM) have been identified, concluding with a conceptual design scheme which has been developed to demonstrate the possibility of a more environmentally, economically and socially sustainable shopping centre.

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[4] BOD is an indicator of the concentration of organic substances in water. High BOD is perceived as a negative aspect for the environment, indicating large amounts of oxygen-consuming organic material is present in the water.

[5] The success of malls appears to be threatened by new forms of retail development such as the "big-box" developments (Yasuhiko and Tao, 1999). Details are provided in Chapter 4.1.

[6] A solar aquatics facility is one type of wastewater recycling system. This is a natural food chain and relying on aquatic plants to clarify the wastewater.

These goals can be generalized into five research objectives:

1. An examination of ecological design principles in relation to water reuse, through a literature review.
2. An examination of the potential benefits and disadvantages for wastewater reuse by studying the related water quality guidelines and public health issues.
3. An examination of the context of shopping malls, and a study of the feasibility of incorporating a wastewater reuse facility in Grant Park Mall (GPM) by examining the literature and conducting first round interviews.
4. A site analysis to further explore the suitability of wastewater reuse in GPM by collecting and analyzing information from the mall itself.
5. A conceptual design exercise, based on design criteria derived from the examinations, with the physical design and complementary calculations, demonstrating the positive environmental, economic and social benefits of wastewater reuse facilities in Grant Park Shopping Centre (GPM). Finally, the design was evaluated through a second round of interviews of key informants and the design is further developed.

1.3 Methods

Literature Review

Initially, the effort focuses on examining current literature on ecological planning and design. The literature review provides a theoretical discussion, to set the parameters that form the basis for Chapters Two, Three, and Four.

Ecological Planning Approach

The structure of this practicum follows the five steps of the ecological planning approach outlined by Steiner (1994).

Step 1: Identification of Planning Problems and Opportunities

The world faces many environmental, economic and social problems and opportunities, resulting in general planning issues. Chapter Two and Three discuss the general environmental problems of water shortage on a national and local scale.

Step 2: Re-definition of Planning Goals

There is a growing trend towards sustainable development and water reuse. These changes lead to the re-examination of various government jurisdictions in order to accommodate water reuse practice.

Step 3: Detailed Studies

This step examines the local situation in regards to the relationships between environmental, economic and social opportunities/constraints. In Chapter Four, the associated experts present their perspectives on the environmental, economic and social viability of a wastewater reuse facility in Grant Park Mall (GPM).

Step 4: Landscape Analysis at the Local Level

Landscape analysis involves the collection of site information and analysis of the physical, biological and social elements related to the planning site. In Chapter Four and Five, the environmental, economical and social issues of water reuse are examined on a local scale in the context of a shopping mall. The specific site information is collected and analyzed with the use of Isliefson's Opportunity/Constraint" model (1998).

Step 5: Conceptual Design

Designing consists of forming and arranging elements spatially, creating a visual image of conceptual ideas, creating more meaningful and practical responses to theoretical examinations. A conceptual design in Chapter Six produced a synthesis of the previous four ecological planning steps (in Chapter Two to Five). The design evaluates and proposes the most appropriate wastewater reuse facility to maximize positive impacts, and minimize negative impacts, environmentally, economically and socially.

Key Informant Interviews

Two rounds of key informant interviews were conducted. In the first set of interviews relevant facts were collected to inform the conceptual design proposal, as well, it was an opportunity to seek opinions on the perceived opportunities and constraints of Grant Park Shopping Centre being redeveloped using a sustainable water reuse system. The results of these interviews, along with information derived from the literature reviews and the site analysis, were used to establish the conceptual design criteria.

The second round of interviews sought opinions and attitudes from interviewees regarding the appropriateness of the proposed design concept for the GPM. This information helped in the elaboration of the final design. The records of the interviews are provided in Appendix C.

Cost-benefit Analysis

Three options for a solar aquatic facility[7] in Grant Park Mall are considered. A cost-benefit analysis (possible saving versus implementation costs) of the three options is undertaken. Cost-benefit analysis of the proposal for a solar aquatic facility assists potential investors, by informing them as to the alternatives and at what cost. They are guidelines for potential investors (Schmid, 1989). However, several issues are critical in a cost-benefit analysis of the GPM solar aquatic facility: determining the relevant alternatives, the primary benefits and costs, and the prediction of both physical quantities and prices.

Although the cost-benefit analysis guides the decision-making process, the final decision of whether or not to implement a solar aquatic facility may vary according to the environmental, economic and social preferences of the decision-makers (Irvin, 1978).

1.4 Limitations

Due to the broad nature of the field of ecological planning and the restricted time frame for the practicum, certain limitations have been imposed on this research study. While there are many other significant issues around the topic of sustainability in shopping centres, this practicum focuses on the benefits and feasibility of water re-use. In addition, the physical design and technical calculations presented in the practicum are from the perspective of a site planner and urban designer.

The available site information was limited due to the lack of specific inspections of wastewater composition and existing mechanical systems of Grant Park Mall. In

[7] Solar aquatic facility is one type of wastewater reuse systems.

addition, with the license-protected company, Living Machine Inc., further details related to the design and cost of a solar aquatic system/Living Machine[8] was unavailable. A representative of Living Machine Inc., Erik Alm (Personal Communication, July 2001), claimed that such information would have required prolonged effort for engineers and other technicians. For similar reasons, most of the assumptions made in the conceptual design need further refinements. Although renovation projects in shopping centres tend to be associated with considerable physical changes in order to accommodate their tenants, this practicum did not propose a major renovation in GPM due to the objectives of the research and time constraint.

In June 2001, following two months of research, I decided to expand the scope of the topic to include blackwater reuse along with the greywater reuse. It was indicated in the literature review that re-using both greywater and blackwater would generate far more environmental, economic and social benefits than reusing only greywater.

1.5 Overview of Chapters

Chapter One describes the overall structure and the purpose of the practicum.

Chapter Two outlines water shortage issues nationally and globally, introduces Tyler's ecological framework perspective, and discusses how wastewater reuse could address the water shortage issues, by employing the ecological design principles.

Chapter Three focuses the discussion of water shortage in the context of Winnipeg, examines the potential benefits/drawbacks of wastewater reuse through

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[8] A living machine is one kind of solar aquatic facility with an emphasis on using biological processes to clean up wastewater. This copy-righted term is used by John Todd as trademark for his company Living Machine Inc. Details are provided in Section 4.6.

literature review, and examines the barrier of institutional regulations in relation to water reuse.

Chapter Four outlines the existing context and issues of shopping centres, and continues the discussion about the potential benefits/drawbacks of a solar aquatic facility in GPM, from the perspective of key informants.

Chapter Five presents basic site information of Grant Park Shopping Centre by using Isliefson's opportunities/constraints model to inform a site analysis. The government regulations outlined in Chapter Three are further examined in GPM.

Chapter Six develops design criteria informed by the issues discussed in the previous chapters. The conceptual design of a wastewater reuse facility in GPM is then developed, addressing the process treatment and physical design of the facility.

Chapter Seven continues the conceptual design by conducting a cost-benefit analysis and suggesting social programs. The conceptual design is then evaluated by the interviewees.

Chapter Eight presents the conclusions and recommendations, and identifies issues for further research.

Chapter Two:

Ecological Frameworks and Ecological Design Principles in Respect to Water Reuse

As the available potable water quantity will soon exceed the current capacity in water conveyancing infrastructures to meet the continuously increasing water demand, water shortage appears to be an important issue to be addressed nationally and globally. Tyler (1994; 2000a; 2000b) suggests the ecological framework, which aims to integrate environmental, economic and social values into urban development decision-making. Through the study of literature, five ecological design principles are identified. This chapter will indicate how on-site wastewater reuse is an effective strategy to address water shortage issues, in part by meeting the criteria of the ecological design principles.

2.1 Toward an Ecological Framework Perspective

Water shortage is an urgent issue that must be addressed nationally and globally. Less than three percent of all the water on earth is identified as potable, while this number continues to shrink as a result of the pollution of rivers, lakes and groundwater (Hawken et al., 1999). Moreover, global climate changes have intensified droughts that have periodically devastated sub-continental areas. One of the clearest signs of water scarcity is the increasing number of countries that have insufficient water to supply their population. Despite the threat of future water shortages, many countries continue to use the highest-quality water for every task. No major water construction projects and supply strategies seem to be able to keep pace with the population growth rate and demand (Hawken et al., 1999).

Water consumption per capita in Canada is greater than that in any other country except the United States (Waller et al., 1998). As a result, many Canadian municipalities are facing, or will face, fresh water supply and wastewater management problems (Waller et al., 1998). It should be noted that less than 5% of all potable water produced in municipal water plants is used for drinking (Tyler, 2000b), but many analysts argue that no high-quality water should be used for a purpose that can tolerate a lower grade (Okun, 1997).

According to Tyler (2000a), Canadian urban environmental planning has gone through three significant phases over the past 20 years: Thematic Spatial[9]; Activity-based Regulatory[10]; and the Ecosystem frameworks. The latest phase, the Ecosystem Framework, attempts to integrate ecological considerations into urban planning and design. The ecological planning framework suggests simultaneously incorporating environmental, economic and social values into the decision-making process of urban development and redevelopment (Tyler, 1994; 2000a; 2000b; IUCN, 1991; WCED, 1987). The ideology of ecological framework is that "'everything is connected to everything else", in which planners should view the environmental, economic and social systems as an integrated, inseparable piece (Tyler, 2000b). Waller et al. (1998) also recognizes the need to adopt such an approach, refuting the long-held belief and widely

[9] The thematic spatial framework views human activities in the urban and regional environment as a matter of organizing the geographic distribution of compatible and incompatible types of land use. Examples are the legislative requirement for master plans based on land-use planning and zoning (Tyler, 2000b).

[10] Activity-based Regulation introduces tools that are intended to manage environmental behaviour. Examples are the establishment and enforcement of environmental quality standards for water, sewage and solid waste disposal (Tyler, 2000b).

held position that business values, environmental and social responsibility are incompatible.

2.2 Ecological Design Principles

Ecological design is defined as "any form that minimizes environmentally destructive impacts by integrating itself within living processes" (Van der Ryn and Cowan, 1996, p.8), and it is commonly perceived to be simply an effective adaptation to and integration with nature's processes. Five ecological design principles were established from the literature review to guide the conceptual design in Chapter Six (Van der Ryn and Cowan, 1996; Hough, 1995; Jacobs, 1994; Todd and Todd, 1994; Tyler, 2000b; Van Vliet, 1994; Von Weizsacker et al., 1998), with the final goal to create an ecological framework plan.

1. Reduction of the water consumption rate
2. Redevelopment of existing environmentally insensitive urban development
3. Respect for the natural process in living biological systems and in natural world
4. Promotion of the cost effectiveness in ecological investment
5. Promotion of encouraging environmental stewardship to the general public

Increasing the freshwater supply is not a sustainable solution to address water shortage; a practical strategy is to utilize the currently available water supply more efficiently (Hawken et al., 1999). On-site wastewater reuse has become a legitimate alternative to reduce the use of fresh water. Since only one-third of water used in urban areas requires potable quality water, two-thirds of the water usage could be replaced by purified wastewater (Okun, 1997). Most importantly, the implementation of an on-site wastewater reuse facility in an existing building can satisfy the five ecological design principles listed above.

1. Reduction of the water consumption rate

Conservation slows down the consumption rate by allowing a limited resource to be used for a longer period of time (Van der Ryn and Cowan, 1996). The practice of reuse can minimize the depletion of limited potable water.

2. Redevelopment of existing environmentally insensitive urban development

In the past urban development ignores environmental sustainability. While most groups are now aware of sustainable practices, its application has not been applied nor promoted enough in the development sector (Hough, 1995). Environmentally unsustainable infrastructures need to be renovated with ecological technology such as water reuse.

3. Respect for the natural process in living biological systems and in natural world

Todd and Todd (1994) stress that sustainability should be promoted by integrating living biological systems, and through respecting the laws of life in the natural world. Tyler (2000b) also mentions that the "ecological infrastructure of cities of the twenty-first century should incorporate the 'ultimate technology': biological life" (p.491). According to Jacobs (1994), there are two sorts of ecosystems: one created by nature, and one created by humans. Because of the complex inter-dependency of natural biological systems, both sorts of ecosystems are vulnerable and easily destroyed. The wastewater reuse facilities are designed according to the laws of the natural world, in an attempt to create an environment in which the living organisms can thrive.

4. Promotion of the cost effectiveness in ecological development investment

According to Von Weizsacker et al. (1998), reuse of resources can be environmentally friendly and profitable because sustainable development tends to reduce the cost involved in the disposal of wastes. The result can be a lesser threat to the environment and a lower cost for business and society, since they no longer need to pay for the damage done to the ecosystem. Moreover, an ecological design also implies practicality, efficiency, and cost-effectiveness, creating important economic benefits for water reuse facilities

5. Promotion of encouraging environmental stewardship to the general public

Environmental stewardship describes an ethic to respect the natural environment (Van Vliet, 1994). Water reuse practices may change personal attitudes towards the value of water, and encourages environmental stewardship to the public.

2.3 Introduction of Wastewater Reuse Practice

Wastewater is defined as "a combination of the liquid- or water-carried wastes removed from residences, institutions, and commercial and industrial establishments, together with such groundwater, surface water, and storm water as may be present" (Metcalf and Eddy, 1991, p.31). Untreated water contains numerous pathogenic, disease-causing micro-organisms, toxic compounds and nutrients, it is therefore necessary to remove or treat wastewater immediately from its source. According to Isliefson (1998), domestic wastewater can be categorized into blackwater and greywater; the solid wastes generated in toilets, kitchen sinks and dishwashers characterize blackwater, while greywater is produced from baths, showers, and laundries. In conventional buildings, blackwater and greywater streams are combined in a single waste stream and disposed of via sewers to municipal treatment plants. After the treatment of the raw sewage, the final effluent is released to a nearby river or other water source.

In contrast to conventional treatment of wastewater, the biological process with the solar aquatic facilities involves the removal of contaminants brought about by biological activity (Metcalf and Eddy, 1991; Todd and Josephson, 1996). The effectiveness of purifying water in solar aquatic facilities has proven to be equivalent to that of the tertiary treatment in conventional wastewater plants (Todd et al., 2001). After treatment, the water can be used for cleaning, waste removal, and indoor and outdoor yard/plant irrigation.

Solar aquatic facilities can be described as "biological water purification systems modeled after natural systems, utilizing microbes, algae, aquatic vegetation and solar energy to filter and breakdown nutrients, solids, bacteria and trace metals in wastewater" (Reiber, 1999, p.1). Generally in such a facility, wastes generated by the organisms of one tank flow through the pipes to become food for the organisms of another tank, with sunlight the primary source of energy (Todd et al., 2001). A specific kind of solar aquatic facility, a Living Machine, has been designed and licensed by John Todd (Todd, 2001). The treatment process of solar aquatic facilities will be further examined in the conceptual design presented in Section 6.2.

2.4 Chapter Two Summary

Water shortage is largely caused by the increasing demand of potable water and misuse of high quality water for every task. Wastewater reuse can potentially address the issue of water shortage and satisfy ecological design principles. The use of an on-site wastewater reuse facility reduces the water consumption rate, regenerates existing unsustainable development and its design follows biological processes in nature. The facility may also be a cost effective investment, and it can be used to encourage public environmental stewardship. The emergence of solar aquatic technology allows the practice of on-site wastewater reuse. In a solar aquatic facility, wastewater is purified and is reused for toilet flushing and plant irrigation.

Tyler's ecological framework is the major approach adopted in this practicum, and the five principles of ecological design inform the process of the investigation of environmental, economic and social issues of wastewater reuse in Chapter Three (Section 3.2) and Four (Section 4.5).

Chapter Three:
Potentials and Regulatory Barriers of Water Reuse in Winnipeg

Similar to many cities in Canada, Winnipeg is likely to have a water shortage problem in the future. Continuing the exploration of the potential of water reuse from the previous chapter, this chapter examines the literature on the use of solar aquatic facilities in terms of environmental, economic and social benefits and drawbacks for the city of Winnipeg. On the other hand, existing national, provincial and municipal codes and regulations related to on-site water reuse are discussed. These codes and regulations outline the specific quality standards of water required for a variety of purposes. Information on government funding programs has also been included.

3.1 Water Shortage Issues in Winnipeg

The city of Winnipeg has a reliable water supply from Shoal Lake[11] (City of Winnipeg a). However, hydrologists estimate that every individual in Winnipeg consume an average of 0.36 cubic metre (82 US gallon) of potable water per day (Cathy, Personal Communication, October 2001), and this demand for water is expected to exceed the capacity from existing water treatment facilities in the near future. To deal with the expected shortage of high quality of water, the City is implementing a water treatment plant.

[11] Shoal Lake is located approximately 160 km east of Winnipeg.

3.2 Implementation of Wastewater Reuse Facilities in Winnipeg

3.2.1 Environmental Issues

The wastewater reuse facility conserves water by using treated wastewater for irrigation/toilet flushing, in this way reducing the use of potable water and minimizing downstream water effects. An example is the South Burlington Sewage treatment facility, which is designed for zero discharge[12], treating up to 80,000 USG (303 m^3) of domestic wastewater every day (Table 3.1) (Todd, 1999). Another example is Ethel M Chocolates Factory in Nevada, which handles up to 32,000 USG (121 m^3) of industrial wastewater per day (Todd, 1999). As it will be discussed later, the site of Grant Park Shopping Centre has similar wastewater composition as South Burlington Sewage facility, and has a similar wastewater quantity per day as Ethel M Chocolates Factory.

Table 3.1: Performance of Solar Aquatic Facilities (Todd, 1999)

Contaminants	*Typical Composition of Untreated Domestic Wastewater (mg/L)*	*Treated Wastewater in a Solar Aquatic Facility (mg/L)*	*Treated Wastewater in South Burlington Living Machine, Vermont*
COD	250 – 500	Lower than 50 mg/L	31 mg/L
BOD_5	110 – 220	Lower than 10 mg/L	6 mg/L
Total Suspended Solids (TSS)	100 – 220	Lower than 10 mg/L	5 mg/L
Total N	20 – 40	Lower than 10 mg/L	2 mg/L

On-site water reuse has other environmental benefits. The wetland components of wastewater reuse facilities would enhance bio-diversity by providing habitat for migrating waterfowl and other wildlife. Solar aquatic facilities make use of natural

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[12] No wastewater is discharged to the public sewer systems.

biological treatment to clarify water instead of the conventional mechanical and chemical treatment used in wastewater treatment plants, further enhancing bio-diversity.

Furthermore, an on-site wastewater reuse facility presents some potential environmental threats to the urban landscape of Winnipeg. According to the Canadian Water and Wastewater Association (1997), the consequences of the failure of an on-site wastewater system may be direct, including the inadequate supply of treated water for toilet flushing and a backed-up sewer. The damage may also be long term, leading to the deterioration of water quality or the necessity of frequent repair or replacement of failed facilities. In addition, the damage may be off-site, such as contamination of surface or groundwater.

3.2.2 Economic Issues

Tyler (2000a) stresses that there is a degree of market receptivity for sustainable forms of development, but it is critical to identify the long-term benefits rather than engage in short-term economic thinking (1994). Benefits of on-site wastewater reuse include reduced fresh water demand, reduced wastewater discharge cost and increased revenue from the sale of aquaculture. Potable water used for toilet flushing can be completely substituted by reclaimed wastewater. Outdoor water use in Winnipeg can also be reduced significantly with the use of treated wastewater for irrigation, since the amount of water used for this purpose is significant (Hawken et al., 1999). Because the purified wastewater is relatively free of harmful materials and micro-organisms (Table 3.1), there is no need for further treatment in the municipal treatment plants, and the cost for sewage discharge can be reduced substantially. Besides, some of the vegetation produced in the solar aquatic facilities can be marketed to enhance economic gains. An example of this is the Master Food industrial wastewater treatment plant in Australia. This plant contains over 350 shelves of food products, generating income by selling organic foods and other product such as Uncle Ben's food (Todd, 1999). The facility is zero discharge, indicating that the cost for public sewage discharge is largely reduced.

If businesses are perceived to be "environmentally-friendly", they are likely to increase in popularity. Commercial industry has entered into a new phase in which a sustainable business is perceived as having a competitive advantage, and consumers tend to prefer goods and services delivered in an environmentally and socially responsible way (Myers, 1995). For example, the solar aquatics plant at Bear River in Nova Scotia is visited by appropriately 2000 tourists per year despite its remote location[13], and the facility generates a considerable amount of income with its increasing popularity (Bear River Solar Aquatics Wastewater Treatment Facility a). It is also expected that the Corkscrew Swamp Living Machine in Florida will have 4,300 visitors per day (Todd et al., 2001). As will be discussed later, the site of Grant Park Mall has florists that could make use of the plants and nursery stocks produced in the solar aquatic facility. The mall is located in an urban context, and is visited by an average of 600,000 shoppers per month (Appendix B 1), and may attract more shoppers given the level of interest in the Bear River treatment facility and Corkscrew Swamp Living Machine.

As the City of Winnipeg implements a water treatment plant, an increase in water costs is expected. As the environmental conditions worsen in the future, the charge for treating poor-quality water and discharging wastewater are likely to increase considerably

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[13] Annapolis County is the smallest municipality in Nova Scotia with 600 residents. It is 30 minutes from Digby and 2 hours to metro Halifax (Valleyweb.com a).

(Lehr 1986, Waller et al., 1999). Furthermore, there is a trend for municipal governments to move water and sewer treatment towards user-pay direct consumer charges. This would likely result in a further increase of water and sewage treatment charges in the future, and wastewater reuse may then be perceived more favourably (Waller et al., 1998).

There are economic drawbacks associated with on-site wastewater reuse. Potential investors in Winnipeg could be discouraged by the initial cost of a wastewater reuse facility and the lack of financial payback in the short run. Developers also seem to have doubts about the performance of the technology as well as the short-term economic benefits the facility may bring. Furthermore, such facilities require certain levels of maintenance that can be avoided if the wastewater is treated in municipal wastewater treatment plants (Waller et al., 1998). The owner of such a decentralized facility must ensure that technicians are available for ongoing operation and maintenance, and that the final effluent must be evaluated by a public or private body. These maintenance needs place additional costs on the facilities. All these drawbacks are supported by the interviewees.

3.23 Social Issues

Urban non-potable reuse of wastewater offers a number of social advantages to the citizens of Winnipeg. The social well-being of the community can be enhanced with the educational opportunities provided in the form of everyday visits and field trips of groups to visit the facility, learning about ecology. A case in point is the South

Burlington Living Machine, which is used as a teaching tool for 1000 students per year from different schools and universities in the region (Todd, 1999). Another example is the Darrow High School Living Machine in New York City, which incorporates the wastewater reuse into the school's curriculum as a hands-on academic laboratory for a variety of science, mathematics and art classes. As in Grant Park Shopping Centre, many primary, secondary schools are located within two miles, the proposed facility can contribute to the teaching programs in these schools similar to that in the Darrow School[14].

Environmental variety is important in the emotional and psychological development of children (Selman, 1981). A solar aquatic facility implemented in Winnipeg has potential to provide a rich recreational and educational environment for children in the neighbourhood. Furthermore, the facility can inform people in Winnipeg that an effective approach to deal with water issues involves adopting a new social ethic of conservation, recycling, and reuse (Waller et al., 1998). Ecological design shows citizens of the community the consequences of their sustainable living styles (Van Vliet, 1994). Consideration of ecological design practice around the water theme may lead people, step by step, to realize the inter-connectedness between people and nature - human beings rely on the good health of all living ecosystems for their survival. As a result, a change in public attitude may gradually aid in fostering a general Earth-care ethic.

The potential involvement of community members in a solar aquatic facility project could help them to establish a shared vision of environmental stewardship. The

[14] Details of how Darrow School incorporates the solar aquatic facility into its curriculum is provided in their website http://www.darrowschool.org/pages/learning_at.cfm

interaction between neighbours may be enhanced, leading to a stronger sense of community and a higher level of social stewardship. With a strong identity, a community is more likely to survive through environmental, economic and social hardships (Van Vliet, 1994).

On the other hand, there are certain social drawbacks to on-site wastewater reuse. According to Isliefson (1998), public acceptance is considered to be a critical implementation issue. This is related to society's and a particular community's opinion of the wastewater reuse technology and its willingness to accept potential changes. She states that obstacles are largely created by seemingly negative public attitudes and perceptions of wastewater reuse in Winnipeg. The perception is that freshwater is cleaner and more appropriate than reclaimed wastewater for all-purposes (Canadian Water and Wastewater Association, 1997). The generally unfavourable perception of wastewater reclamation results in limitations to its application in Winnipeg.

3.3 Barriers and Potentials of National, Provincial and Municipal Codes

Most jurisdictions in Canada do not have specific legislation that permits or disallows an on-site wastewater reuse facility, and they do not have any design or performance requirements for such systems (Canadian Water and Wastewater Association, 1998). Because wastewater reuse is a relatively new technology, the relevant government institutions appear to be reluctant to assume any risk and liability involved in these technologies (Canadian Water and Wastewater Association, 1998). The national regulations related to water reuse are described in Section 3.3.1, the provincial regulations are described in Section 3.3.2, and the municipal regulations are described in Section 3.3.3. Following that, the potential of overcoming institutional barriers are examined in Section 3.3.4.

3.3.1 National Regulations

Three guidelines at the national level have impacts upon the acceptance or rejection of a solar aquatic facility in Winnipeg (Table 3.2). These are the Guidelines for Canadian Drinking Water Quality (Health Canada, 1996)[15]; the Guidelines for Canadian Recreational Water Quality (Health and Welfare Canada, 1992); and the National Plumbing Code of Canada (National Research Council of Canada, 1995).

Table 3.2: Water Quality Standards from Different National Codes (Stidwill and Dumon, 1999)

Water Quality Parameter	Canadian Drinking Water Quality	Canadian Recreational Water Quality	Unrestricted Urban Reuse Criteria for Toilet Flushing by USEPA[16]
pH	6.5 - 8.5 mg/L	6 – 9 mg/L	
Turbidity[17]	Lower/equal to 1 NTU	Lower/equal to 50 NTU	2-5 NTU
Coliform	Not detectable	200 E. Coliform per 100mL	
Colour	Lower/equal to 15 TCU		
Iron		Lower/equal to 0.3 AO	1 mg/L
Manganese		Lower/equal to 0.05 AO	0.5 mg/L
Oil and Grease	50 – 100		

Note: NTU = nephelmetric turbidity unit, TCU = true colour unit, AO = aesthetic objective

[15] Four potential categories of reuse are identified: Potable (drinking and cooking), Human Contact (bathing, house cleaning), Indirect Uses (toilet flushing), and Irrigation (Canadian Water and Wastewater Association, 1997).

[16] The United States Environmental Protection (1992) developed an unrestricted urban reuse category, which may be referenced by relevant government departments in Canada in the consideration of granting permits for any water reuse system.

[17] An acceptable turbidity level is associated with both health and aesthetic considerations. High levels of turbidity can prevent the growth and activity level (disinfection) of micro-organisms and bacteria.

The Guidelines for Canadian Drinking Water Quality (Table 3.2)

The guideline states that every water outlet in the Canadian domestic environment (faucet, toilet, hose bib, etc.) should meet high quality standards to ensure safety. Nonetheless, these guidelines are intended to apply only to drinking water supplies. As indicated in Section 2.1, this high level of water quality need not be applied to all levels of water consumption as it now is in most cases. Governments are already aware of the necessity to be flexible in differentiating in the quality of water used for different purposes.

The Guidelines for Canadian Recreational Water Quality (Table 3.2)

Recreational water use is defined as any activity involving the intentional or accidental immersion of the body. The guidelines are intended to apply to surface water that is used for recreational purposes. The recreational guidelines set out quality parameters for surface water used for recreational purposes, which could be applicable to the usage of reclaimed water. These guidelines could be considered as the minimum water quality standards to be met by an on-site wastewater reuse facility. Therefore, if the treated water can satisfy the quality stated in these guidelines, the treated water should be permitted to be discharged directly to surface waters. Consequently the fountain and other landscape design proposed in the final design concept in Chapter Six may be allowed (Appendix D 5.1; D 5.2). Generally six water quality parameters are evaluated in determining the quality of wastewater (Table 3.2).

The National Plumbing Code of Canada

This Code requires every potable water system to be connected to a public or private potable water supply system (Provisions of National Plumbing Code 1.6.3), and prohibits the discharge of non-potable water to any fixtures where a potable supply is available[18] (Provisions of National Plumbing Code 7.3.2). In a solar aquatic facility, part of the potable water distribution system would be connected to a non-potable water supply, and some outlets from the non-potable system would discharge into the fixtures described in 7.3.2. As a result, the use of an on-site wastewater reuse facility appears to conflict with these plumbing code requirements (Waller et al., 1998). However, the Canadian Water and Wastewater Association (1997) notes that under Section 1.4 a wastewater reuse facility is acceptable if it can meet the level of performance required by the Code, along with evaluation of its past performance[19]. Section 1.4, therefore, builds some flexibility into the Code, allowing the Code to be interpreted more favourably vis-a-vis wastewater reuse.

3.3.2 Provincial Regulations

The requirements for public potable water systems in the city of Winnipeg are administered by Manitoba Environment and Health (City of Winnipeg a). Manitoba Environment generally follows the Guidelines for Canadian Drinking Water Quality and

[18] Wastewater can not be discharged into a sink or lavatory, a fixture into which an outlet from a potable water system is discharged, or a fixture that is used for the preparation, handling or dispensing of food, drink or products that are intended for human consumption (Provisions of National Plumbing Code 7.3.2, 1995)

[19] This section specifically allows alternate materials, appliances, systems, equipment, methods of design and construction procedures, if there is evidence that the proposed equivalent will provide the level of performance required by the Code, and this equivalence is demonstrated by past performance, test or evaluation.

the Guidelines for Canadian Recreational Water Quality (Canadian Water and Wastewater Association, 1997).

Public health concerns continue to be the most impermeable barrier to on-site wastewater reuse because of the risk of waterborne disease. Inadequate wastewater treatment, excessive human exposure and water contamination must be prevented (Canadian Water and Wastewater Association, 1997; Waller et al., 1998). However, it seems to be difficult to set up quality parameter. Even when coliform populations[20] are acceptable, viruses and pathogens such as Giardia and Cryptosporidium may remain in treated water. According to general provincial health standards, treated wastewater is safe for human contact because it is relatively low in pathogens, toxins, suspended and organic solids. Treated water in open public places should be low in organic solids, and low in BOD_5 and COD[21] to reduce the chance of odour (Table 3.1).

Based on case-by-case approval by the Manitoba health officers, most existing health regulations inherently provide a certain degree of flexibility in meeting required standards. Issues that must be addressed to obtain a permit include on-site proper treatment and storage of purified wastewater, satisfactory water quality, microbiological level and aesthetics. Manitoba public health officials have the authority[22] to reject any application for an on-site wastewater reuse facility that they deem to be a threat to public health. The Chief Environmental Health Officer, Senior Public Health Engineer and the

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[20] To evaluate the micro-organisms, the total coliform concentration is used to indicate whether or not water is suitable for human consumption.

[21] COD is an indicator of the concentration of organics in water, and the COD test measures the chemical oxidant needed to break down organics.

[22] Provincial and territorial Public Health Acts

Manager of Environmental Contaminants/Waste Disposal, would review the proposed wastewater reuse facility and make recommendations on the suitability of the facility on site. Other factors considered by the health officials include meeting zoning, planning, and building requirements, and preparing resources for monitoring, sample collection and laboratory testing. Furthermore, an on-site water reuse system would also be subject to the approval of public health officials under the following Sections of the legislation: S. 330/88 - Water Supplies and Water Works, S. 331/88 - Sewerage and Sewage Disposal.

Plumbing/Building Codes Section 330/88

The Manitoba provincial plumbing codes were established based on the 1995 National Plumbing Code with minor amendments, resulting in the Manitoba Code presenting similar barriers to on-site water reuse systems. However, no other specifically legislated barriers to on-site wastewater reuse facilities are identified in Manitoba's regulations. Building Codes may specify certain minor design restrictions that must be followed, including the height of infrastructure, choice of materials and design dimensions.

Sewerage and Sewage Disposal Section 331/88

"Wastewater" as all spent water from a community (City of Winnipeg, 1995). Similar to most provinces, the sewage of any building in Winnipeg must be drained into a private sewage disposal system or a public sewer (Private Sewage Disposal Systems and Privies Regulations; Manitoba Regulation 95/88R; S.7). Section 20 of the same regulation allows for "the installation of alternative private sewage disposal systems subject to such terms and conditions that may be required by the Minister." The flexibility in these regulations is valuable because it increases the chances of gaining approval for the facility.

Manitoba Environment Act

Cliff Lee (Personal Communication, July 2001), Environment Act administrator, indicates that although the installation of sewage treatment systems, such as lagoons, requires application of a provincial licence, the Act does not mention a solar aquatic facility in an urban commercial setting. He adds that a case-by-case study would be conducted. The developer needs to submit information related to the design and the facility's potential influence on the surrounding environment. A preliminary evaluation would be conducted to determine if further investigation is necessary. Lee states if the Manitoba Health has investigated the proposed facility in enough detail, provincial licence application may be omitted.

3.3.2.1 Funding Programming

Two provincial funding sources - Sustainable Development Innovations Fund and Waste Reduction and Pollution Prevention Fund - are available for private organizations and businesses (Manitoba Conservation's Sustainable Development Web site a). The funding aims at experimenting with ecologically sustainable interventions.

The Sustainable Development Innovations Fund (SDIF) provides funding for the promotion and implementation of environmental innovation and sustainable development projects. The SDIF funding is intended to support the demonstration of new environmental innovation preventing waste and pollution, while not yet funded by existing programs. The funding project should stimulate economic development and diversification to improve the quality of life and strengthen community identity.

The Waste Reduction and Pollution Fund (WRAPF) is a two-year funding program assisting projects that aim at waste reduction and pollution prevention. According to Jim Ferguson (Personal Communication, August 2001), a representative of the Manitoba Conservation and Pollution Prevention Branch, the maximum amount of funding is $50,000. Recipients may receive the full amount in a year, or split the total amount over two years. The funding project should promote the environmental and economic benefits of reducing waste, and be capable of educating communities in Manitoba.

3.3.3 Municipal Regulations

Municipal By-laws

At the municipal level, certain by-laws related to sewage disposal could be interpreted as barriers to on-site wastewater reuse. However, since most of the municipal by-laws do not specifically prohibit water reuse, their openness to interpretation may be favourable to reuse applications. The City of Winnipeg by-law requires that all wastewater be directed to a sewer (Part 4, S. 11). This by-law, as with the provincial sewage disposal regulation, could be interpreted as a barrier to on-site reuse of water.

Zoning By-Law

The current zoning by-law in Winnipeg does not mention solar aquatic facilities. Any developers interested in implementing such facilities on their site must apply for a permit from the City. Details are provided in Section 5.5.

3.3.4 Potential of Overcoming Regulatory Barriers

Since on-site wastewater reuse technologies are relatively new and thus uncommon, most of the national, provincial and municipal regulations on water quality/sewage discharge may have an affect on the wastewater reuse facilities' application in Winnipeg. The lack of detailed regulations, criteria and experience specifically addressing wastewater reuse, all result in obstacles to its implementation (Waller et al., 1998). The current case-by-case procedure for approval of wastewater systems has its advantages; since it is flexible enough to allow for such experimentation while ensuring that public health is protected. However, a drawback is that the chances of granting permits are partially dependent upon the government's knowledge, interpretation and attitude towards the technology. Despite the perceived barrier, the frequency and variety of successful wastewater reuse facilities documented in the literature suggest that the implementation barrier identified above can be overcome. Currently, there are three prominent precedents of solar aquatic facilities in Canada: Bear River Solar aquatic facility in the municipality of Annapolis, Nova Scotia, Beaverbank Villa system in Halifax, and the Body Shop in Toronto. It is important to note that as long as the existing regulations provide room for innovation, there is no absolute barrier to on-site water reuse (Canadian Water and Wastewater Association, 1997).

On the other hand, there are many issues that the investors must negotiate with relevant government agencies. The most important ones are the reductions of sewer charges and potable water cost, specific ownership of sewer lines, liability, and forms of government assistance. If the parties cannot reach agreements, the project could be terminated (Waller, 1998). Therefore, mutual support and co-operation between the private investors and the relevant government agencies are essential to the successful implementation of on-site wastewater reuse.

3.4 Chapter Three Summary

The current water plant infrastructure will not be able to handle the increasing water demand of people in Winnipeg, and the on-site wastewater reuse could potentially address this issue. The use of solar aquatic facilities would be beneficial to the environment by reducing the demand for fresh water, resulting in less pressure on existing water and wastewater treatment plants, and providing habitat for wildlife. However, there are environmental threats in case of treatment system failure. The facilities could also bring about economic gains by substituting treated water for potable water in toilet flushing and plant irrigation, but the investors may be discouraged by the capital and maintenance costs. There are also social benefits to the citizens of Winnipeg, as the solar aquatic facilities could provide educational opportunities for the general public, and enhance the interaction between neighbours with community participation. Nevertheless, the generally unfavourable public perception of wastewater reclamation results in limitations to its application in Winnipeg.

Government regulations may create barriers to on-site wastewater reuse facilities. Currently most Canadian jurisdictions do not have specific legislation that permits or disallows the facilities. On the national level, the Guidelines for Canadian Recreational Water Quality appears to be most applicable to the facilities, and the treated water in the solar aquatic facility should be permitted to be discharged directly to surface waters if its quality can satisfy these particular guidelines. Furthermore, the facility might benefit from the ambivalence of the National Plumbing Code of Canada, which allows the use of such a facility if it can meet a required level of performance. At the provincial level, public health concern may present a barrier, as wastewater with inadequate treatment and excessive human exposure could lead to human disease. Based on a case-by-case approval, Manitoba public health officials can reject any facility's proposal, but most regulations provide some degree of flexibility in meeting required standards. This flexibility may be advantageous to the wastewater reuse practice, but the chances of being granted a permit might be dependent upon the government's attitude towards such facilities. The most important factor in successful implementation of solar aquatic facilities is the mutual support of investor and relevant government agencies.

The environmental, economic and social benefits/drawbacks identified in Chapter Three will be applied in the formation of the design criteria in Chapter Six, and will be demonstrated through the conceptual design in Chapter Six and Seven. The interviews conducted in Chapter Four further examine the environmental, economic and social issues related to the use of a solar aquatic facility, and indicate the benefits the facility can bring to a shopping centre.

Chapter Four:
Feasibility of Ecological Redevelopment[23] in Shopping Centres

The existing context of shopping centres is examined, and the site of Grant Park Shopping Centre is introduced as a typical shopping centre in Canada. The suitability of a solar aquatic facility in Grant Park Shopping Centre is further examined from the perspective of key informants representing different professional disciplines. Through the interviews, the environmental, economic and social issues of wastewater reuse in Grant Park Shopping Centre are identified, and desirable criteria for the conceptual design are developed.

4.1 Design Trends of Shopping Centres

A brief history of the development of shopping centres indicates how designers have responded to the trends of retail business and preferences of customers, and the conceptual design of this practicum should respond to the trends of retail business and customers' preference. This particular section is adapted from Buxton (1995), Gosling and Maitland (1976; 1985; 1990) and Rowe (1991).

A typical Canadian shopping centre is defined as "a group of commercial establishments, planned, owned, and managed as a unit, usually located in an outlying or suburban territory, with off-street parking provided on the property, " (City of Winnipeg (1973, p.5). According to Maitland (1985; 1990), design of shopping centres can be

[23] Ecological redevelopment refers to the redevelopment of existing infrastructure with consideration of ecological aspects of design.

divided in four phases roughly representing four periods. Phase one malls (1950-65) consisted of a cluster of separate buildings, and were open to the surrounding environment. Phase two malls (1965-75) became enclosed buildings with pedestrian-only streets to separate shoppers from the inconsistent outdoor weather. The typology of building form was the "I" and "L" shaped layout with anchor stores at each end. Tremendous capital was spent on the interior space, but the plain exterior wall left a negative presentation to the neighbourhood, and there was a lack of environmental or ecological concern. Phase three (1975-85) malls had increasing variations in building design, and many landscape features were used in interior decorations. The increasing scale of malls also led to the increasing the number of anchor stores in a mall. In response to the energy crisis, a reduced use of natural resources with the use of skylights and glassed-framed central courtyard in mall design was evident.

Phase four shopping centres (1985 - Present) generally were larger with more elaborate design feature to attract shoppers. Older urban shopping centres were frequently redeveloped, with a combination of expansions, enclosures, re-tenanting and renovations. Existing malls are situated in a known market, with fewer zoning or environmental regulatory problems. Such renovation also tends to involve lower financial costs than the construction of new structures. New design concepts such as elaborating a central public courtyard, creating more pedestrian-friendly environment and enhancing physical connection to the surrounding neighbourhood made shopping centres more socially viable.

On the other hand, shopping patterns have changed over the last ten years. There appears to be a growing issue of economic sustainability due to changing shopping patterns over the last ten years (Buxton, 1995; Sawatzky, 1999; Shindleman, Personal Communication, February 2001). "Big-box" developments, such as Superstores, and other shopping methods such as TV shopping and on-line shopping are able to sell a variety of goods at lower prices than retail stores in shopping malls (Jones and Simmons, 1993). The growing prosperity of new retail formats implies that a considerable portion of sales formerly belonging to the shopping malls has been taken away. The successful reuse of existing shopping centres is critical, as they have become the focal points for shopping, business offices, recreational establishments and social spaces for communities (Buxton, 1995). In order to maintain economic viability, shopping centres attempt to improve their physical environment to attract more customers. Recently built or renovated malls incorporate themes[24] of entertainment to improve their financial situation.

4.2 Potential of Wastewater Reuse

A substantial number of new or recently renovated shopping centres incorporate many landscape features such as plant species and large-scale fountains to create outdoor environmental themes in their interior (Figure 4.1, 4.2). The large amount of fresh water used everyday implies that there is potential for the use of reclaimed wastewater to substitute the use of potable water. An example is at Disney World, approximately three million US gallons (11,000 m^3) of reclaimed water per day in the Disney World theme parks is used for fountains, golf courses and landscape irrigation (Waller et al., 1998;

[24] Shopping malls are built or renovated in a way attempting to create the illusion of a dream city (theme) through its design. The objective is to attract more customers and serve as a recreational centre.

Warren, Personal Communication, February 2001). Other shopping centres employing similar water reuse systems include Porter Square Shopping Centre in Massachusetts and the Eco-Wal-Mart in Kansas.

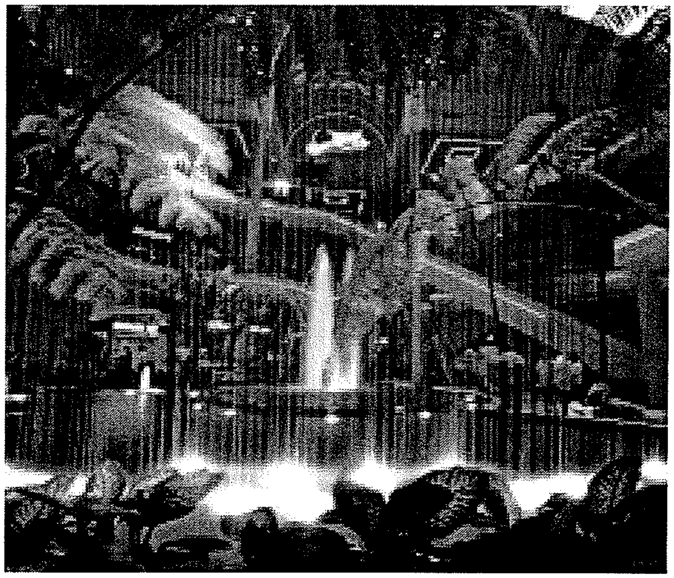

Figure 4.1: South Bay Galleria, California (Rathbun, 1986, p.21)

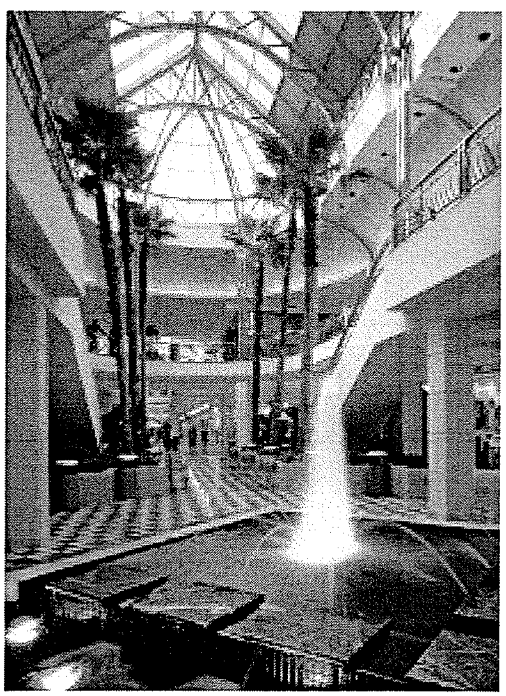

Figure 4.2: Tysons II Galleria, Chicago (Rathbun, 1990, p.48)

Porter Square Shopping Centre in Boston built in 1960, is an example of a shopping centre renovated in 1999 to incorporate greywater reuse systems (Elaine Construction Company a). Wal-Mart opened three "Eco-Marts" in the U.S. in 1993, incorporating greywater recycling systems, collecting greywater and stormwater from the building and parking lot, which they treat in a detention pond and reuse for landscaping. According to Eco-Mart (a), the water reuse systems proved to be successful both environmentally and economically. In addition, an education centre called an "Eco room" was built on site to educate and encourage the public to implement urban ecological principles. Wal-Mart promotes its three Eco-Marts across America and aims at developing a healthy attitude toward environmentally and socially- friendly "green" businesses. Furthermore, Tom Seay, Wal-Mart's vice president for real estate, states that sales are significantly higher in Eco-Marts than that in other regular branches (Pierson, 1995). Therefore, it is evident that there are potentials for shopping centres to implement water reuse.

4.3 Case Study: Context of Grant Park Shopping Centre

Grant Park Shopping Centre in Winnipeg represents many characteristics typical of shopping centres in Canada (Figure 4.3, Appendix B 2). The mall can be described as a phase two mall because of the I-shaped dumbbell layout with anchor stores at both ends. The mall was built in 1963, the period between the 1950s and 1980s in which most Canadian malls were built (Yeates, 1998). Grant Park Shopping Centre currently has 36,800 square metre gross floor area, a size within the definition of a community level nucleation with 18,600 to 93,000 square metre (200,000 to 1,000,000 ft^2) of gross floor area (Yeates, 1998). The parking index for the mall is 6.8[25], similar to the typical 1 to 3 gross floor area to parking area ratio in a mall. In addition, similar to other Canadian shopping centres, the main tenants of Grant Park Mall (GPM) are chain retail stores, restaurants, laundromat and offices (Details of tenants are provided in Appendix B 5). The mall was renovated and expanded in 1989, when a second story was added for offices on the west wing of the mall. The renovation transformed the mall into a late phase three mall. The proposed facility with the ecological theme would transform GPM into an avant-garde environmentally and socially-friendly phase four shopping centre.

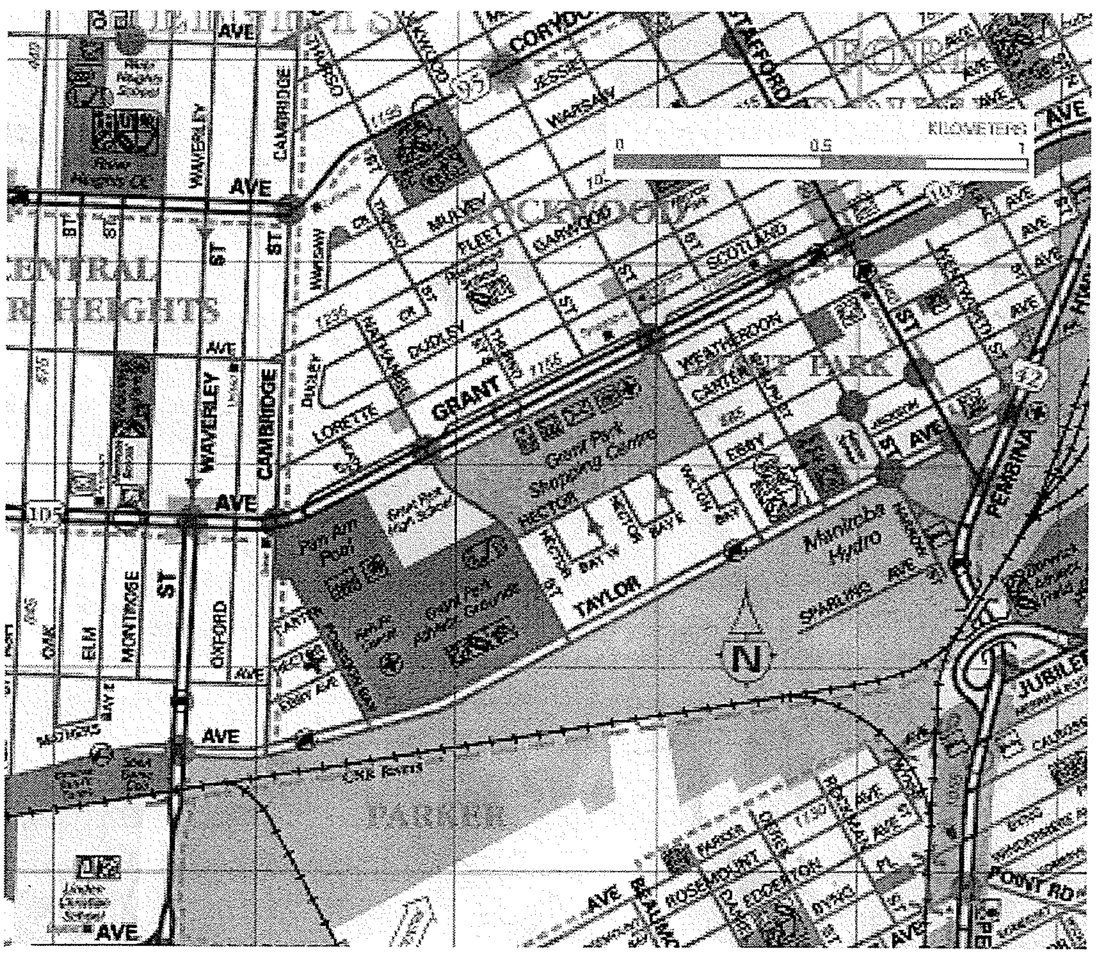

Figure 4.3: Site Map of Grant Park Shopping Centre (Sherlock's City Map, 1998)

[25] Parking Index is defined as the number of car parking spaces per 1000 square feet of gross leasable area.

Similar to many Canadian shopping malls, GPM seems to have the problem of environmental and economic sustainability. Currently the mall uses 55,200 cubic metres of potable water every year, contributing to the future water shortage issue in Winnipeg (Details are provided in Section 7.1.1.1). The number of shoppers decreased 15% between 1999-2000, with a current average of 110,327 shoppers per month (Appendix B 1). Furthermore, there have usually been vacancies in the last five years, indicating the negative economic health of the mall. Currently (summer 2001) there are four vacant spaces (with one occupying the size of three typical retail stores), and some major magnets (Wal-Mart and Royal Bank) have moved out (Figure 4.4). The new Zellers will

Figure 4.4: Vacant Space, Former Royal Bank (Summer, 2001)

likely attract fewer customers than the former Wal-mart, leading to a probable decrease in traffic flow (Warren, Personal Communication, February 2001). Moreover, the mall has been challenged by strip malls in the surrounding area, particularly by "big-box" development on Kenaston Highway and possible future "big-box" development to the south on Taylor Avenue. The mall also has social issues that need to be addressed. The appearance of the mall on the south side (back side) has a negative presentation to the neighbourhood, and the mall makes little attempt to integrate with this neighbourhood (Figure 6.10).

Responding to the emerging environmental theme of phase four malls to reduce the use of resources, wastewater reuse may be a next step for malls to improve their environmental sustainability. With the decline in the number of new malls, the proposed redevelopment of Grant Park Shopping Centre tends to be appropriate. Given its central location, there appears to be considerable opportunity for GPM to be renovated to become more environmentally, economically and socially sustainable. Shindleman (Personal Communication, February 2001) states that the population within the trade area of Grant Park Mall is large enough to continue to sustain a shopping mall; 78,060 reside within the trade area[26], 38,415 within the primary trade area. The mall is located in an urban area, with easy accessibility to Pembina Highway. Furthermore, an ecological redevelopment project in GPM would likely draw public attention, which could further promote the concept of ecological design and wastewater reuse to other areas in Winnipeg. For these reasons Grant Park Shopping Centre is chosen for the case study, as the mall has the potential, following renovation, to be more sustainable environmentally, economically and socially.

Since the original design of GPM followed the trend of the shopping centre development, it is important that the proposed intervention at Grant Park Mall should

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[26] The trade area is defined as "the area from which is obtained the major portion of the continuing patronage necessary for steady support of the shopping centre" (City of Winnipeg, 1973, p. 43). A community shopping centre normally attracts business from within a two mile radius, with not more than 5-10 minutes driving time (City of Winnipeg, 1973; Shindleman, personal communication, Feb, 2001). Primary trade area is defined as an area one mile distance from a shopping mall.

respect the design evolution of malls, and address the current trends affecting malls, as well as the issues of environmental, economic and social sustainability. Other design concepts used in phase four malls such as the integration with surrounding neighbourhoods, addition of new tenants' space and elaboration of central courtyard should also be considered in the physical design of a solar aquatic facility.

4.4 Wastewater Reuse Facilities' Implementation in Malls: Interviews

The interviewees were four key informants, drawing on their expertise and in a position to promote and implement such proposals. Interviewees included a site manager at Grant Park Mall, an urban designer, a developer and a site manager of an existing wastewater reuse facility. The interviewees were questioned regarding their attitude toward relevant trends and basic industry positions on wastewater reuse innovation in a shopping centre such as Grant Park Shopping Centre. The participants generally discussed the opportunities and constraints in improving the environmental, economic and social sustainability of mall with the intervention. The interviews also explored what considerations/criteria are important in regards to the design of a wastewater reuse facility in a mall, and how these criteria can be demonstrated effectively in a conceptual design (Details of research process and interview records are provided in Appendix A 3; A 4; A 5).

4.4.1 Environmental Issues

Both the designer and the site manager of the existing wastewater facility recognized that if a solar aquatic facility is successfully implemented in GPM, the investors would be doing an "ecological service", creating an overall healthier physical urban environment. They both agreed that a wastewater reuse facility could promote bio-diversity and encourage wildlife habitat in Winnipeg's urban areas. The designer claimed that not only the mall itself, but also its surrounding physical environment would be enhanced.

Both the developer and the GPM site manager stated that the environmental benefits of on-site wastewater reuse would be a significant aspect of conservation in general. Although both the developer and the GPM site manager did not perceive any negative environmental effects brought about by wastewater reuse, the designer was concerned about several issues related to its implementation at Grant Park Mall. He was aware of the public health restrictions and zoning regulations prohibiting wastewater reuse in an urban area. Other design and technical problems that needed to be addressed included adequate space for the treatment process of wastewater, the solar access of the wastewater reuse facility, and quality of treated wastewater up to an acceptable level. The GPM site manager raised the critical technical issue that GPM, similar to most malls in urban areas, contains many sewer outlets. These outlets connect directly to the city sewer line on the public streets (Hector Avenue), as opposed to being collected in a central sewer line. The existing pattern of sewer lines complicates the collection of sewage for on-site treatment.

4.4.2 Economic Issues

According to the developer, not only will the wastewater reuse bring about long-term benefits such as lower fresh water consumption, but also has the potential to attract environmentally-friendly tenants and shoppers. He also believed that by being environmentally and socially responsible, the good-will of the developer would be promoted. The site manager of the existing wastewater facility claimed that the facilities are supposed to be self-sustaining, with maintenance requirements being kept to a minimum.

While the designer suggested that the cost of the facilities must be reasonable, the developer and the GPM site manager had more concerns about its cost-effectiveness. According to the developer, if a wastewater reuse facility is built in a new development, a mall's owner will pay for the capital cost of the facility, and partially increasing the rental price to relieve the capital cost. The use of a solar aquatic facility tends to be more difficult in a retrofit situation such as Grant Park Shopping Centre, as the mall owner must pay for the facility's cost, but he could not raise the rents significantly. Without the tenants sharing in the cost of the installation and maintenance, the facility could not be realized. Consequently, a mall's owner and tenants must be convinced that their investment is cost-effective. The GPM site manager explained that the cost of the facility's construction seemed incapable to be recovered in a short period of time. Since the savings in fresh water and sewer costs are relatively low, the tenants might be reluctant to accept a substantial increase in rent to offset the capital cost.

Both the developer and the site manager of the existing wastewater facility expressed hesitancy in accepting the proposal of a solar aquatic facility due to the lack of precedents of wastewater reuse in a mall context. The developer was also concerned about the potentially high maintenance costs, and an insufficient number of technicians for day-to-day operations and emergency repairs. He added that if there are no physical constraints prohibiting the use of conventional sanitary systems, any innovative system might have difficulty receiving consideration.

The GPM site manager raised other issues that would lead to a substantial rise in capital cost. The construction work involved in such intervention appears to be complicated and expensive, since workers need to dig into the existing sewer line gallery to add any necessary new sewer collection lines[27]. The prolonged construction work is likely to cause inconvenience, which is perceived as unfavourable for any tenants and mall owners.

4.4.3 Social Issues

Since the mall attracts a large crowd every day, the designer felt that the facility would be very effective in terms of educating and encouraging the public to recycle wastewater. If successfully implemented, a wastewater reuse facility would have a positive influence on the neighbourhood, creating a sustainable community in the long run. The designer and the developer agreed that such innovation would encourage tenants, and shoppers to participate recycling-related programs.

The site manager of the existing wastewater facility stated that many business groups in society should undertake the responsibility of educating the public, particularly in the case of shopping centres, because of their tremendous impact on communities. He stated that children would have an opportunity to learn about natural systems in their neighbourhood, assisting them in becoming environmentalists in the future. According to

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[27] Sewer line galleries, if well designed, should be built with adequate space for upgrading and maintenance purpose. In the case of Grant Park Mall, the current sewer line gallery is not built to accommodate these functions, as it is buried 3 m under the ground below grade.

the developer, the intervention would allow people to see how wastewater reuse need not be limited to residential settings but could also be applied to settings such as commercial enterprises. He claimed that "the thinking outside the box" approach would change the attitude of tenants, shoppers and general public toward the value of recycling. Furthermore, the designer felt that new forms of public space could also be created in the mall, helping to generate more social interaction.

Both the designer and the GPM site manager agreed that most people in Winnipeg are not ready for wastewater reuse. The general public does not understand the value of recycling wastewater; neither do they know how to achieve it. The GPM site manager mentioned that, unlike some parts of the U.S. where this is an urgent shortage of fresh water, the abundance and low costs of Winnipeg's fresh water discourages people from reusing wastewater. The GPM site manager concluded that the idea of recycling wastewater would be difficult to "sell" to the public.

4.4.4 Criteria for Conceptual Design

According to the designer, some basic architectural design concepts are essential for the conceptual design of the wastewater reuse facility in GPM. Similar to an urban design project, the design must show that the treatment facility is technically sound and aesthetically pleasing in the context of GPM and the surrounding neighbourhood. Other related issues include what form the components of a solar aquatic facility would take, where these components would be located, and how it would relate to the existing fabric of the mall. Furthermore, features such as ponds, fountains, and wildlife habitats may need to be explored in the design.

On the other hand, the designer stated that the process of treatment should be identified. Other related technical issues include the location of the new wastewater collection line and reused water distribution line, and the designated volume of wastewater treated on site. Negative environmental issues such as odour and unsightly treatment processes should be kept to a minimum. The conceptual design could be presented in the form of performance specifications, indicating benefits and regulations.

The site manager of the existing wastewater facility stated that the promotion of wildlife should be given due consideration in the design process. The design also needs to address how the different components of a wastewater reuse facility are made accessible to the public. In addition, the treatment process ought to be designed so as to achieve self-sustainability with minimal maintenance requirement.

A cost-benefit analysis is critical for developers and tenants and must be presented in a form that can be easily understood. Estimated figures (e.g. capital cost/savings) along with appropriate calculations tend to be significant, and explanation of these figures is equally important. Other related issues in the conceptual design include research on available government funding and other kinds of government assistance in support of such innovative experimentation.

The GPM site manager stated that the owner of the mall would prefer to look at relatively accurate figures for the capital cost and potential savings. The design needs to demonstrate that the facility is aesthetically pleasing and fits in with the existing mall, by employing simple block diagrams in the design report. Preferably the facility would be designed to occupy a minimum amount of ground floor, due to the high value of interior tenants' space and exterior parking space. Relocating and re-sizing the existing tenant's space should be kept to a minimum. The design also needs to demonstrate the location of new wastewater collection line and their connection to the new wastewater reuse facility.

4.4.5 Evaluation of Conceptual Design

To create a satisfactory proposal for a wastewater reuse facility in Grant Park Shopping Centre, the designer stated that the conceptual design ought to be aesthetically pleasing. The facility should be economically feasible with relatively affordable initial capital, operation and maintenance costs. In addition, the preliminary design of the treatment facility should be technically sound with few physical disadvantages such as mechanical problems and odour.

The site manager of the existing wastewater facility suggested that the conceptual design would be perceived favourably if it would demonstrate how the facility could become self-sustainable, generating a substantial increase in number of visitors without raising the cost of rental space significantly.

For the proposal to be appealing, the developer stressed that the capital cost must be reasonable, preferably with financial assistance from government funding or government leverage. He stated that the savings from the reduced fresh water consumption and sewage charges would be directly weighted against the capital cost, maintenance and energy cost for the facility.

The GPM site manager claimed that the payback period of any investment in malls is generally between five to ten years, preferably not more than five years. The life span of a wastewater reuse facility is also a significant factor, since a mall owner projects a profit from a solar aquatic facility after the payback period. Preferably the capital costs could be met within the five-year loan to make the investment worthwhile.

The concerns of the interviewees regarding the design criteria for the proposed intervention, will form part of the basis of the criteria for the conceptual design in Chapter Six.

4.5 Chapter Four Summary

A brief history of the shopping centre development indicates how designers have responded to the trends of retail business. Phase two malls became enclosed buildings with a negative presentation to the neighbourhood. Phase three malls reduced the use of natural resources, while included many landscape features in interior decorations. In phase four, many older urban shopping centres were redeveloped, with more pedestrian-friendly environment and increasing physical connection to the surrounding neighbourhoods. The rise of new retail forms and shopping lifestyles led to the issue of economic sustainability in shopping centres. Many phase four malls develop environmental themes in their interior by incorporating landscape features, resulting in a significant increase in water consumption. Consequently, there is potential for implementing water reuse in malls to reduce potable water consumption on a daily basis and to create an ecological theme in the mall. Grant Park Shopping Centre in Winnipeg shares many characteristics typical of shopping centres in Canada. The mall also faces the environmental issue of enormous water consumption, economic sustainability, and social issue related to its negative visual presentation to the neighbourhood.

The environmental, economic and social issues related to a solar aquatic facility implemented in GPM were examined. From the perspective of the four key informants, there was agreement as to the environmental and social benefits of such intervention, but there were concerns about the inefficiency of the solar aquatic facilities in treating wastewater as well as its associated public health issues. In particular, the existing diverse sewer line outlets present a problem in collecting the sewage for treatment. Although there were positive comments in regard to the economic gains, the interviewees were concerned about its cost-effectiveness in the mall retrofit context. The interviewees also expressed their views about the criteria that should be emphasized in the conceptual design. Some important criteria include the design "fitting" into the existing mall, satisfying public health concerns, calculating capital costs and savings. Furthermore, the interviewees stated that the implementation of wastewater reuse facilities in GPM would be perceived favourably if the conceptual design could demonstrate that the facility was technically-sound and affordable with a short term loan.

In discussing environmental, economic and social issues of intervention in GPM through the interviews, many aspects presented in the ecological design principles (Section 2.2) and the literature review (Section 3.2) were reinforced. As indicated in Chapter Six, the proposed intervention at Grant Park Mall will address current issues affecting malls. Furthermore, the concerns of the interviewees regarding environmental, economic and social issues, and design criteria for the proposed intervention, will form part of the basis of the criteria for the conceptual design in Chapter Six.

Chapter Five:
Site Analysis of Grant Park Shopping Centre

The site analysis of Grant Park Shopping Centre employs Isliefson's "Opportunity/Constraint" model (1998), which is designed to identify the types of data that need to be collected to facilitate a preliminary assessment of water reuse feasibility at GPM. The general site characteristics of GPM, planning issues associated with water reuse in GPM, and current maintenance/monitoring programs of the mall are examined. Moreover, one of the government regulation areas discussed in Chapter Three, zoning regulations is further researched in the context of GPM.

There is limitations of data collection in the site analysis related to the lack of professional mechanical inspections of GPM and a lack of biological studies of its wastewater characteristics. More in-depth inspection would be essential if a solar aquatic facility is to be implemented. The following information is laid out according to the format suggested by Isliefson (1998).

5.1 General Facilities Information

Two aspects of the site must be examined. (1) General Facility Information involves the examination of characteristics and function of the building. (2) Current Water Usage investigates the types and patterns of water usage for the building, and the potential for wastewater reuse. The information is organized in Table 5.1 and discussed in Section 5.4.

Table 5.1: General Facility Information

	Issue	Considered
General Facility Inform-ation	Address	1080-1120 Grant Avenue
	Age of Building	38 years old (1963)
	Level of nucleation[28]	Community scale (between the community and regional scale)
	Number of Floors	2 story high
	Site Area	126100 m^2 (1,357,100 ft^2)
	Building Area	35,100 m^2 (377,700 ft^2), 6th largest in Winnipeg
	Parking Area	94,710 m^2 (1,019,400 ft^2), but changes are expected continually.
	Parking Index	6. 8
	Gross Floor Area	36,800 m^2 (396,100 ft^2), including on-site free-standing restaurants and gas station.
	Gross Leasable Floor Area	34,900 m^2 (375,000 ft^2)
	Other Gross Floor Area	1,960 m^2 (21,100 ft^2)
	Building Function(s)	Retail, restaurants, food court, offices. Building functions continue to change, but retail typology/variety remain relatively consistent.
	Total Number of Tenants	Currently 51 retail outlets, 17 offices
	Expected Remaining Useful Life of the Building	30 – 50 years, depending on its economic sustainability.
	Current Maintenance Practices	Ongoing minor maintenances take place in the mall.
	Future Occupancy and Use Plans	Tenants change continually.
	Major Renovation Plans	A major renovation took place in 1989 involving the change of tenants, addition of skylight and central sitting space.
	Contractors Serving Facility	Smith Carter Architectural. Co. Ltd.
	Number of Neighbourhoods within Trade Area	Primary Trade Area: 13 Secondary Trade Area: 22
Current Water Usage	Quantity of Water Used (total in year 2000)	55,100 m^3 (14,560,000 USG)
	Peak Demand Factors	Increase of shoppers during special seasons.
	Present and Projected Water Costs	Present Water Costs: $ 38,100 per annum Projected Water Costs: $ 42,900 per annum
	Types of Water Uses	Toilets, urinals, faucets, food preparation, food production, laundry, plant irrigation
	Sources of Wastewater	17 toilets (2 public and 15 private washrooms in individual retail stores), sinks, cooking (3 restaurants in food courts, 1 in bookstore, 2 individual restaurants), laundromat (1) Wastewater source changes with the continual change in tenant mix.
	Quantity and Quality of Wastewater from Each Source (consistency of these quantities)	Information unavailable, but weekly or seasonal fluctuations may be experienced.

Note: No specific comments are made on these aspects in this section.

5.2 Planning Issues

Planning issues are considerations including the protection of public health, environmental degradation prevention, avoidance of public nuisance, and meeting

[28] Shopping nucleations are generally classified into three categories according to their scale (Yeates, 1998):
-Neighbourhood nucleation, including traditional shopping streets (gross floor area: 50,000 - 20,000 ft^2)
-Community level shopping centres (gross floor area: 200,000 – 500,000 ft^2)
-Regional shopping centres (gross floor area: 500,000 - 1 million ft^2)
-Major regional shopping centres (gross floor area: more than 1 million ft^2)

requirements of users, regulatory compliance and public acceptance. In order to satisfy planning, building and plumbing regulations, the physical, chemical and microbiological wastewater characteristics of the mall, as well as aspects related to municipal regulations, are examined. The information is organized in Table 5.2 and discussed in Section 5.4.

Table 5.2: Planning Issues

Issue	**Item**	**Considered (Concentration/mL)** (Metcalf and Eddy, 1991)
Public Health	Bacteria:	
	*Salmonella	1 - 10^2/mL
	*Shigella	Information unavailable.
	*Total Coliforms	$10^5 – 10^8$/mL
	*Fecal Coliforms	10^7-10^9/mL
	Other Organisms:	
	*Fecal streptococci	10^3 - 10^4/mL
	*Enterococci	10^2 - 10^3/mL
	*Pseudomonas aeroginosa	10 – 10^2/mL
	*Clostridium perfringens	10 – 10^3/mL
	*Mycobacterium, Tuberculosis	Information unavailable.
	Protozoa:	
	*Entamoeba histolytica	Information unavailable.
	*Giardia lamblia (Giardia cysts)	0.1 - 100
	*Crptosporidium cysts	0.1 – 1
	Helminth ova (parasites)	0.01 – 1
	Viruses:	
	*Polio	Information unavailable.
	*Hepatitis A	Information unavailable.
	*Norwalk	Information unavailable.
	*Rotavirus	Information unavailable.
	*Enteric virus	10 – 100/mL
	Chemical Parameters	
	Anions:	
	*Bicarbonate (HC03)	50 - 100/mL
	*Carbonate (C03)	0 - 10/mL
	*Chloride (CI)	20 - 50/mL
	*Nitrate (NO3)	20 - 40/mL
	*Phosphate (PO4)	5 - 15/mL
	*Sulfate (SO4)	15 - 30/mL
	Cations:	
	*Calcium (Ca)	6 - 16/mL
	*Magnesium (Mg)	4 - 10/mL
	*Potassium (K)	7 - 15/mL
	*Sodium (Na)	40 - 70/mL
	Other Constituents:	
	*Aluminum (AI)	0.1 - 0.2/mL
	*Boron (B)	0.1 - 0.4/mL
	*Fluoride (F)	0.2 - 0.4/mL
	*Manganese (Mn)	0.2 - 0.4/mL
	*Silica (SiO2)	2 - 10/mL
	*Total alkalinity (CaCO3)	60 - 120/mL
	*Total dissolved solids (TDS)	150 - 380/mL
	*pH	Information not available
	*Phosphorus	Information unavailable.
	*Total Salts	Information unavailable.

Issue	Item	Considered (Concentration/mL) (Metcalf and Eddy, 1991)
Cont-Amin-Ants	Solids, total (TS)	350 – 720
	Dissolved, total (TDS)	250 – 500
	Total Suspended solids (TSS)	100 – 220
	Settleable solids	5 – 10
	Biochemical oxygen demand, mg/L: 5-day, 20 C (BOD5, 20 degree Celsius)	110 – 220
	Total organic carbon (TOC)	80 – 160
	Chemical oxygen demand (COD)	250 – 500
	Nitrogen (Total N)	20 – 40
	Phosphorus (Total P)	4 – 8
	Chlorides	30 – 50
	Sulfate	20 – 30
	Alkalinity (as CaCO3)	50 – 100
	Grease	50 – 100

Note: National, provincial codes/ regulations partially address the amount of organisms and nutrients allowed in the reclaimed water (Details are provided in Section 3.3).

Issue	Item	Considered (Concentration/mL)	Comments
Public Exposure	*Body Contact *Inhalation *Ingestion	Although the open tanks are accessible to the shoppers, the proposed physical design discourages direct human contact with wastewater when its quality does not satisfy the safety standard. Precautionary signs will be put up to discourage contact. Potential inhalation and ingestion issues do not present a problem.	The Guidelines for Canadian Recreational Water Quality would be applicable (Details are provided in Section 3.3.1)
Environment	Nutrient Levels and Salt Concentration	Information unavailable.	Control of nutrient and salt level determines potential for plant damage.
	Ground Water and Surface Water Contamination	The reused wastewater will not have any physical contact with the ground water or surface water, and contamination will not occur	Risks of contaminating ground and surface water should be minimized.
	Plant Damage	Health of plants is crucial as they are used to purify wastewater and generate revenue. Detailed studies will be carried out to prevent plant damage in the design stage of the solar aquatic facility.	Potential plant damage should be considered when irrigation is involved.
Building and Plumbing Codes	Conformity with local codes and regulations	No specific codes or regulations are imposed on the use of a solar aquatic facility. Details are provided in Section 3.3.2.	--
Sewer Utility By-laws	Conformity with local by-laws	No specific codes or regulations are imposed on the use of a solar aquatic facility. Details are provided in Section 3.3.3.	--
Infrastru-cture[29]/ Public Works	Treatment Measures	Treatment process and measure of solar aquatic facility must be identified. Details are provided in 6.3.1.2.	Suitable treatment measures should be set up for the whole biological process.
Zoning	Conformity with local zoning ordinances	Conditional use, variance or accessory use permits must be applied for. Details are provided in Section 5.5.	If wastewater reuse facility is in conflict with local zoning by-law, a variance or rezoning is required.

[29] Both internal (e.g. pipes, storage facilities) and external (e.g. sewer systems) infrastructures are considered in the wastewater reuse facility.

5.3 Water Reuse Options

The public health protection aspects involve the investigation of the mall's operating and monitoring systems for the wastewater reuse facility. The Operating and Maintenance Requirements involves the examination of operability, including inspection to ensure consistent water quality, space and location requirements of the wastewater reuse facility and minimum waste production during operation. The information is organized in Table 5.3 and discussed in Section 5.4.

Table 5.3: Water Reuse Options

Issue	Item	Considered
Reuse Possibilities	Uses of potable water which could be replaced with wastewater	Urinal and toilet flushing, plants irrigation, wetland.
	Quantity required (average demand) which could be met with treated wastewater per annum	23,200 m^3 (6,129,000 USG)
	Quality required for each water use which could be met with wastewater	Information unavailable.
	Stability of each water use which could be met with wastewater	Despite the continual change of tenants, water use is relatively consistent, since the number and types of retail establishments in a mall is consistent.
Pre-Design Considerations	Public Health Protection *Suitable treatment measures (and appropriate disposal of waste products)	The proposed solar aquatic systems will provide suitable treatment to ensure public health. Details are provided in 3.2.1.2.
	*monitoring of wastewater sources	On-site manager will inspect and monitor the wastewater reuse system regularly.
	*inspection program established and use of professional plumbers	Information unavailable.
	* labelling and use of different piping material for potable and non-potable components	Information unavailable.

Issue	Item	Considered
	Operating and Maintenance Requirements	
	*adequate storage facilities for treated wastewater (including emergency storage)	The storage facilities are important components to attract shoppers. Adequate space will be provided.
	*suitable conveyance and distribution network	The existing sewer lines are diversified, making the installation of a new distribution network difficult. The existing piping gallery has insufficient space to make changes. Expansion of the piping gallery to install new wastewater collection line may be necessary for the building of a solar aquatic facility.
	*disposal of waste products	All waste products in the whole process will be either recycled, sold through sales or carefully discarded.
	*instrumentation/control systems for monitoring treatment	All the control, monitoring, and backup inspection will be carried out regularly.
	*alternative disposal facilities	In case of systems failure, the conventional sewer system will be used to treat the sewage.
	*estimate of service life	A solar aquatic facility has a life span of 20 years.
	*flexibility of piping and pumping facilities to permit rerouting to alternative disposal	Flexibility of the piping system is essential to accommodate the change of tenant and their space needs.
	*operator training program	Since the facility is self-sustaining, it is relatively easy to operate, but operator training programs still appears necessary.

Note: No specific comments are made on these aspects in this section.

5.4 Analysis of Site Information

The Grant Park Shopping Centre was built 38 years ago. It has 35,100 m^2 leasable floor area and over 93,000 m^2 of parking area. The result of the site analysis indicates that there could be a major saving in water supply and sewage discharge fee with the solar aquatic facilities. The mall produces 55,000 m^3 of wastewater every year, and a large portion of the current water cost ($ 23,200 per annum) and sewer charge ($54,200 per annum) could be reduced, and these savings would be magnified with the potential increase in numbers of shoppers and tenants. It is also important to note that since the mall has a long life span (30 to 50 years), the accumulated fresh water and sewer charge savings would be substantial in the long term. The proximity to twenty-two residential neighbourhoods, within a two-mile distance of the mall, implies that there is potential to attract a considerably larger number of shoppers to the mall with a suitable intervention. Furthermore, the domestic wastewater produced in Grant Park Mall is much easier to handle than the typical waste occurring from industrial and manufacturing processes.

On the other hand, the main barriers associated with water reuse in GPM are mainly associated with the complexity of system maintenance, permits required from relevant government departments, and the installation of new sewer lines. The existing mechanical systems and maintenance services of the mall are not particularly designed for the easy implementation of an onsite wastewater reuse facility. Potential difficulties may be encountered when the existing sewer lines are altered. The ongoing technical inspections and monitoring programs could also be perceived as costly. Certain permit applications are also necessary from relevant government agencies, resulting in another barrier to implement a wastewater reuse facility in GPM.

The site information collected in the site analysis will form part of the basis of the conceptual design in Chapter Six (Appendix D 5).

5.5 Zoning Designation of Grant Park Shopping Centre

Grant Park Mall is zoned as CR in the document "Plan Winnipeg 2010" (City of Winnipeg, 1994)[30], Section 5A-27-30. CR is a designation for regional shopping centres (Figure 5.1).

[30] The most recent draft "Plan Winnipeg…2020" does not indicate the designated sites for shopping centres in their proposed landuse map.

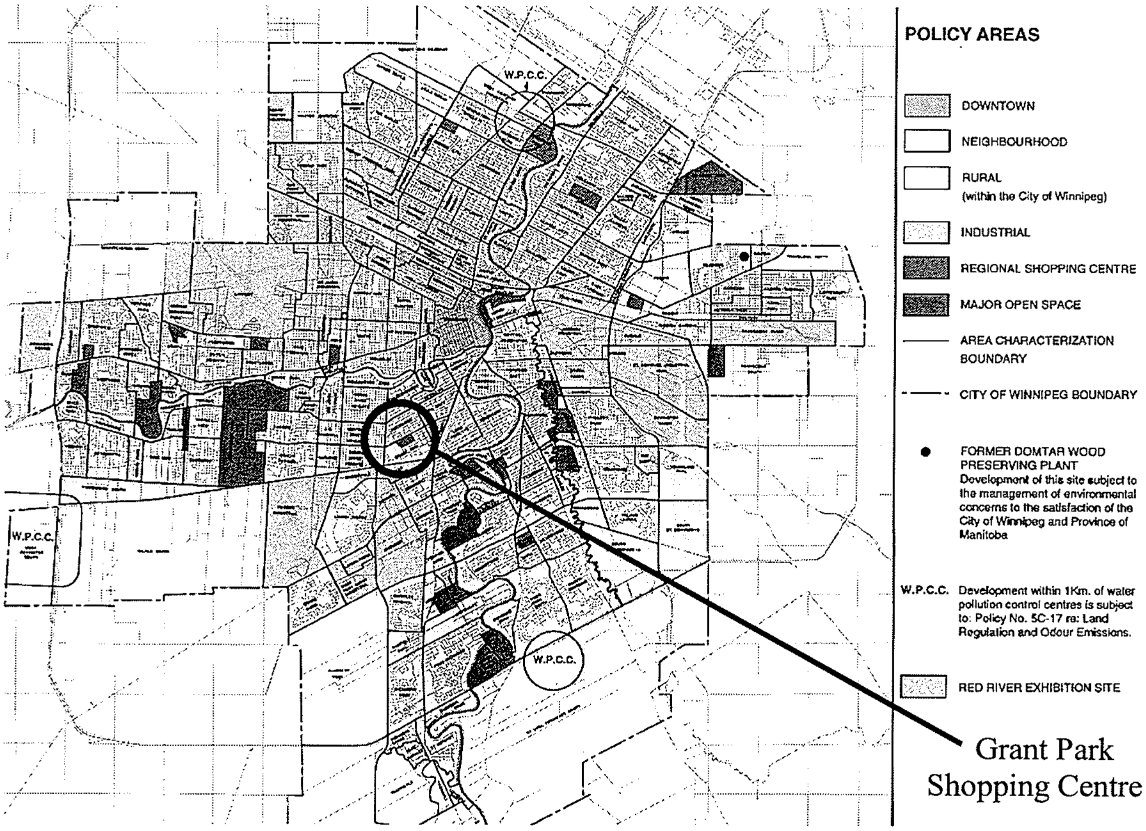


Figure 5.1: Zoning map of Winnipeg Regional Shopping Centres (Adapted from Plan Winnipeg, 1994)

The Commercial District By-Law Section No. 6400/94 also needs to be employed in order to obtain permission to install a wastewater reuse facility. Although the By-Law does not specifically address the case of a solar aquatic facility, several sections may have an influence on the position of local planners and city councillors in their consideration of granting permission for such an innovation. Any facilities related to a public utility are permitted in the designed regional shopping centres, except for sewage treatment[31]. However, this particular section seems to prohibit the City from building a "public sewage treatment plant" in shopping centres, but does not address the case of a

[31] The City usually refers to "sewage treatment" as a large-scale municipal treatment plant.

developer building a private treatment system on a property belonging to him the CR zone. In addition, Section No. 6400 states that "landscape production", including greenhouses or nurseries, the production and sale of plants and landscaping materials, are not permitted in the CR zone. However, shopping centres are permitted to incorporate a park, recreational centre and recycling depot. These establishments appear to be relevant to a solar aquatic facility. Packaged plants, flowers and landscaping supplies can also be sold in shopping centres CR. Furthermore, several home centres in Winnipeg, such as Home Depot and Canadian Ties, contain greenhouse structure for nursery and sales of plants and other landscape products. Therefore, a solar aquatic facility may be allowed to built. According to Hodge (1998), the purpose of municipal planning or development control bylaws is to disallow certain "inappropriate" developments in a particular area. When a specific development is not mentioned, it is not prohibited, indicating that its permission is dependent upon case-to-case review. Application for a conditional land use permit, an accessory use and/or a variance appears to be necessary.

In applying for a permit, there is a requirement for plans and supporting information, with sufficient detail, to adequately describe the development (City of Winnipeg e). All submitted plans and information are reviewed and evaluated by the Zoning and Permits Branch of the Planning, Development and Inspections Division of the Planning Property and Development Department, to determine if the material is sufficient to file the application.

5.5.1 Rezoning Applications

After an application is filed, the development proposal must go through the following process. A community committee public hearing is held. All parties whose interest may be affected by the development will be notified, to enable them to participate in the hearing on a voluntary basis. Everyone in the hearing is given opportunity to make presentations supporting or objecting to any aspects of the proposal. In the community committee meeting three councillors vote for approval or rejection of a proposal. Then the proposal is considered by the standing Committee on Property and Development and the Executive Policy Committee (EPC). Eventually the City Council considers first, second and third readings of the enabling bylaw amendment; all city councillors vote to approve or reject the application.

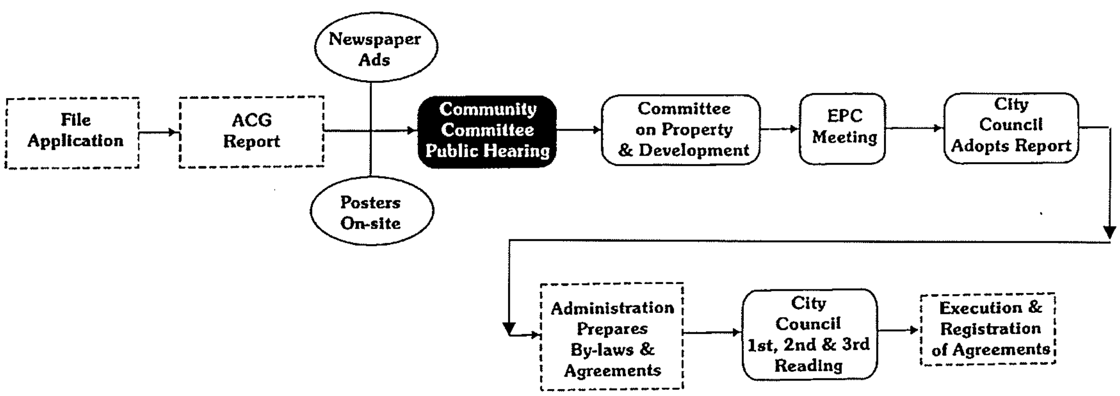


Figure 5.2: Rezoning Application (DS Lea Consultant Ltd. a)

5.5.2 Variance Application

According to Hodge (1998), variances introduce a degree of flexibility in zoning by-laws, where there may be unusual conditions that affect a development. However, a variance only allows for a change with minimal effect on surrounding properties, i.e. “minor variance”, and is expected to confer no special advantage on the applicant.

A relatively similar but shorter process would occur. After the filed application, a public hearing would be conducted, in which councillors would vote for final approval.

With the approval the application is required to pass through the Committee on Property and Development for administrative purposes. For appeal, the Board of Adjustment in Winnipeg would examine all the submitted evidence and decide to accept or reject the appeal (McCandless, Personal Communication, September 14, 2001).

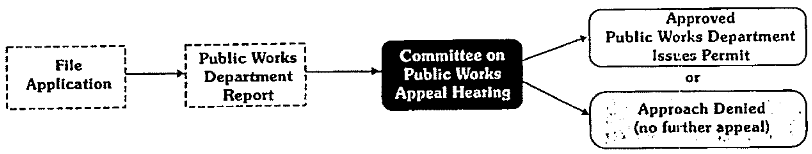


Figure 5.3: Variance Application (DS Lea Consultant Ltd. a)

5.5.3 Accessory Use Applications

According to the Zoning By-law Section No. 6400 (1994), an accessory use is a non-essential, unnecessary and incidental use of land, which is nevertheless desirable. Applicants can simply submit the application forms to Zoning and Permits Branch of the Planning, Development and Inspections Division of the Property and Development Department and request a permit. The process tends to be the simplest than conditional use or variance applications.

5.6 Chapter Five Summary

The site analysis of Grant Park Shopping Centre was conducted based on Isliefson's "Opportunity/Constraint" model, which identified the types of data required to study the suitability of wastewater reuse facilities in GPM. The long-term benefits of implementing a solar aquatic facility in GPM are associated with the potential savings in water supply and sewage discharge fee. The proximity of the mall to twenty-two residential neighbourhoods indicates the potential of attracting a considerably larger number of shoppers with the intervention and tremendous educational opportunities.

The main barriers of water reuse in GPM are associated with the complexity of system monitoring and maintenance, and the installation of new sewer collection lines. Another difficulty, examined in detail in Section 3.3, is that the owner of a wastewater reuse facility must obtain permission from relevant government agencies. Of particular interest is the Winnipeg zoning by-law, while one specific section implying the possibilities of permitting a wastewater reuse facility, another section implying the rejection of such a facility. Consequently, conditional use, variance or accessory use permits must be applied for.

The information collected in the site analysis reinforced the discussion in the literature review and interviews associated with the potential of implementing water reuse in GPM. The site analysis provides much of the necessary site information for the "Process Engineering" and "Economics" sections of the conceptual design in Chapter Six and Seven.

Chapter Six:
Conceptual Design of a Solar Aquatic Facility in Grant Park Mall

This chapter develops design criteria for the conceptual design based on the discussion and findings of the previous chapters (Chapter Two to Five). The physical design of the components and the six steps required in the treatment process are outlined: The quantity of wastewater that needs to be treated is indicated, the process of the treatment of wastewater is outlined and the physical design of the components required to carry out this process is described. The existing sewer system is evaluated in terms of what changes and upgrading are required in implementing the facility. Consideration of the ecosystems is given in the form of plants and animal species incorporated in the treatment system. The final physical design indicates how all these components are put into place within the existing fabric of the mall. It is important to note that the original conceptual design was modified following suggestions of the interviewees in the Second Round of Interviews and upon further examination of the subject matter.

Tyler (2000a, p.20) argues that "there is a significant need for urban ecology demonstration projects to make urban ecological design and planning a reality, not just a normative theoretical concept." She adds that urban ecology is "as much a design problem as it is a planning issue." The understanding of biological process, physical design, cost-benefit analysis and potential social issues associated with an on-site wastewater reuse facility are critical for planners, because it would be the responsibility of planners to explain to government officials and communities in public meetings the general concept and benefits/drawbacks of such technology.

The conceptual design of a solar aquatic facility in GPM offered here aims to demonstrate the potential environmental, economic and social benefits that would be achieved through such an intervention. The design also attempts to illustrate how the negative aspects associated with the use of a solar aquatic facility can be reduced, and potentially outweighed, by the positive affects. The design is meant to be preliminary, and easy for planners and urban designers to understand. In order to make the conceptual design more convincing, the present design proposal includes simple and technically sound information, using relatively reliable figures.

6.1 Development of Design Criteria

The three most significant challenges identified in Chapter Two and Five related to the implementation of a solar aquatic facility in GPM are:

1. The difficulties involved in the collection, process treatment of wastewater and distribution of treated water
2. The high initial capital cost of implementing a solar aquatic facility and payback period
3. The negative unfavourable public perception about wastewater reuse

These three major issues will be addressed in the conceptual design through the design of the solar aquatic facility process treatment ("Process Engineering"), the investigation of the costs/saving associated with the intervention ("Economics"), and the suggestions of local educational programs informing the public about the water reuse technology ("Social Programs"). The detailed criteria for the conceptual design in Table 6.1 have been developed from the issues discussed in Chapter Two to Chapter Five. These include ecological design principles, regulatory barriers to wastewater reuse, general shopping mall context, findings from the interviews and specific GPM site conditions.

Table 6.1: Conceptual Design Criteria

Conceptual Design for Environmental Benefits – Process Engineering

- Evaluation of Design Wastewater Flowrates
    - Evaluating designated quantity of wastewater treated
- Development of Treatment Process Flow Diagram
    - Designing and describing overall water purification and reuse process
- Preliminary Sizing of Treatment Components
    - Assessing appropriate system components
    - Calculating required sizing of system components
- Development of a Facility's Site Layout
    - Responding to existing sewer and piping systems
    - Evaluating mechanical layout of the collection and distribution of wastewater
    - Increasing visibility from the streets
    - Corresponding to existing mall's retail fabric
    - Selecting appropriate location and orientation of system components
    - Choosing appropriate plants, wildlife habitats
    - Responding to Trends of Shopping Centres
        - Developing an ecological theme in the mall
        - Minimizing relocation/resizing of existing tenant

Conceptual Design for Economic Benefits

- Cost
    - Design and construction
    - Operation and maintenance
- Savings
    - Water consumption and sewer charge
    - Merchandising of by-products
- Preliminary Cost-benefit Analysis
    - Short-term (5 years)
    - Longer-term (10 years)

Conceptual Design for Social Benefits

- Social Programs
    - Designing facility as a sustainable educational centre
    - Establishing mall as a community recycling centre
    - Promoting community involvement
- Integration with Community
    - Corresponding to surrounding neighbourhood (addressed in "Facility's Physical Layout")
    - Creating new social space (addressed in "Facility's Physical Layout")

6.2 Process Engineering

The preliminary physical design of a solar aquatic facility consists of six tasks (adapted from Metcalf and Eddy, 1991). The detailed calculations involved in this section (6.2) are laid out in Appendix C 1. This section on process engineering is divided into six parts.

- Evaluation of Design Wastewater Flowrates (Section 6.2.1)
- Development of Treatment Process Flow Diagram (Section 6.2.2)
- Preliminary Sizing of Treatment Components (Section 6.2.3)
- Addition of Mechanical Piping System (Section 6.2.4)
- Selection of Plants and Animals (Section 6.2.5)
- Development of Facility's Site Layout (Section 6.2.6)

6.2.1 Evaluation of Wastewater Design Flowrates

The wastewater flowrates indicates the average amount of wastewater produced in a day. The flowrates is one of the most critical pieces of information, as it has tremendous impact on the design decisions to be made in the later tasks. . The designed flowrates is the amount of fresh water consumed by retail establishments, shoppers and employees, with the exclusion of unaccounted water loss that does not reach the wastewater system (e.g. leakage from water mains and service pipes) (Metcalf and Eddy, 1991). Without detailed technical evaluation, the wastewater production can be estimated from the potable water consumption of Grant Park Mall. According to Metcalf and Eddy (1991), appropriately 15 - 40% of the water withdrawn from the water supply system does not reach the sewer system. The following assumptions are made in the estimation of supplied potable water that does not make it into wastewater category.

1. Number of retailers using water in the manufacturing process - 10% (Details of tenants including restaurants are provided in Appendix B 5)
2. Water for plants irrigations - 3%

3. Potential leakage given the age of the mall (28 years) - 2%

85% of the water recorded by the water meter is estimated to become wastewater. Consequently, the design flowrates is 156 m^3 per day (Table 6.2).

6.2.2 Development of Treatment Process Flow Diagram

According to Metcalf and Eddy (1991), a treatment process flow diagram is a graphic representation of particular combinations of unit operations and processes. Depending on the constituents of wastewater that must be dealt with, different flow diagrams can be developed by combining different unit operations and biological processes. Before the development of a treatment process flow diagram, it is essential to present the five basic principles associated with solar aquatic technology as synthesized by Ramjohn (1999).

1. The foundation of a solar aquatic facility is microbial communities. Many microbial communities are used as catalysts to initiate a number of other biological reactions, while the others are used in the facility as food for organisms of a higher order.

2. The fundamental source of energy is sunlight, initiating photosynthesis. A diversity of vegetation are used, particularly the higher order species. Plants such as water hyacinth stimulate microbial reactions on root systems, leading to increased nutrient uptake and efficiency in the overall biological process.

3. Three or four sub-ecosystems should be designed as parts of the entire solar aquatic facility, since diversity is the key to the reduction of toxins and pathogens. These ecosystems should be placed in separate tanks but the tanks should be connected to each other to allow wastewater flow. All biological tasks provided by the species have a role in the overall functioning of the facility and therefore should be identified and utilized.

4. The concept of natural ecosystem - nature being capable of adapting to a changing environment - is inherent in a solar aquatic facility. When a solar aquatic facility begins to operate, an operator needs to make a series of control adjustments to the ecosystem (e.g. reducing light, changing flow rate, introducing other biological species) in order to improve efficiency of the overall facility. The experimentation period also enables the species to adapt to their new living environment.

5. A sufficient supply of mineral nutrients (e.g. carbon, phosphorus, nitrogen) must be maintained by controlling wastewater flow. Micro-organisms and bacteria use a variety of minerals (e.g. phosphate, iron dioxide and sulfide) to metabolize nutrients.

Based on these five design principles, similar biological components and treatment processes were designed in many solar aquatic facility/Living Machines in the world (Appendix D 1). In this case study, six biological components and processes of a solar aquatic facilities/Living Machines have been selected for use in GPM and the treatment process flow diagram is developed (Figure 6.1). The explanation of the overall process is adapted from Todd (2001) and Ramjohn (1999). (The sources of the components illustrated is the Living Machine Inc. website, http://www.livingmachines.com/htm/machine.htm)

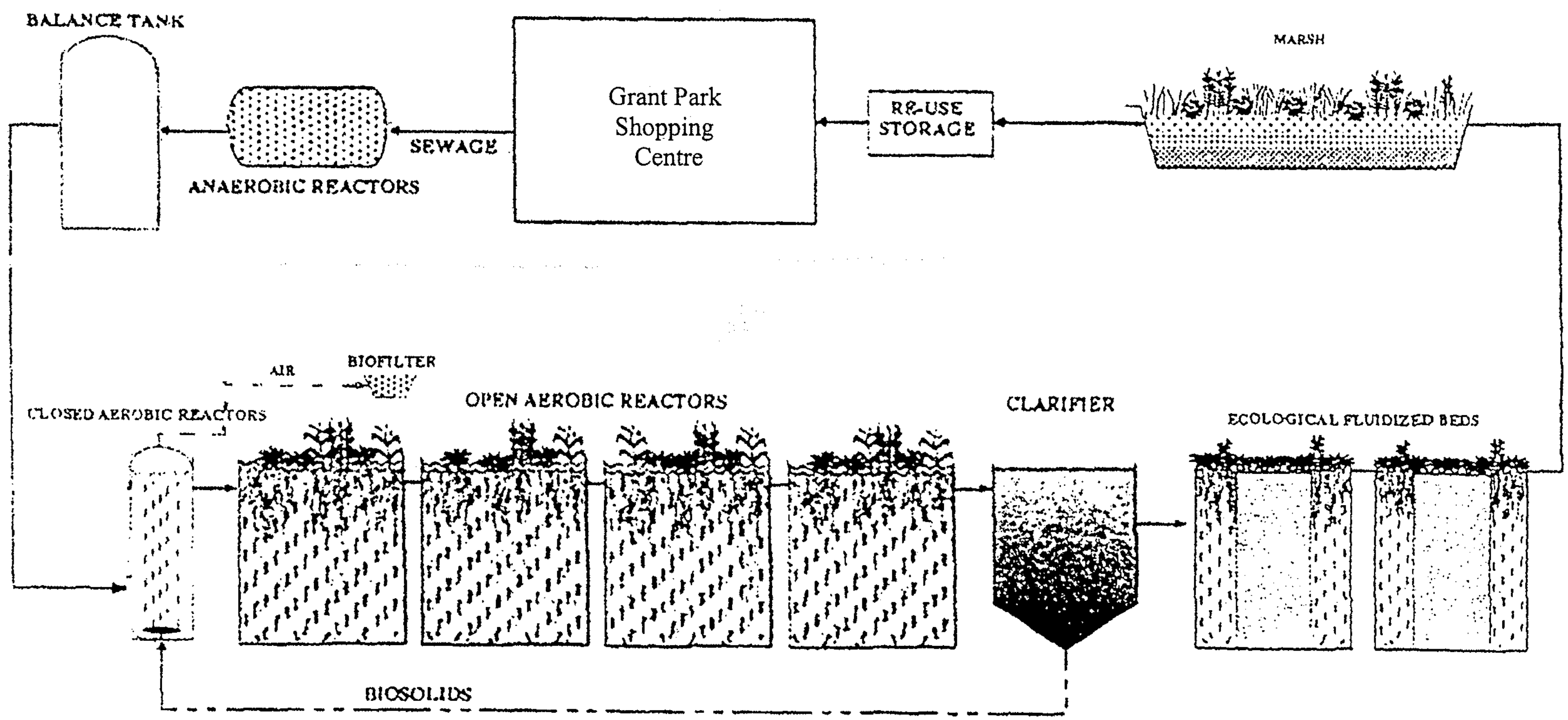


Figure 6.1: Treatment Process Flow Diagram for Grant Park Shopping Centre

1st Component: Anaerobic Reactor

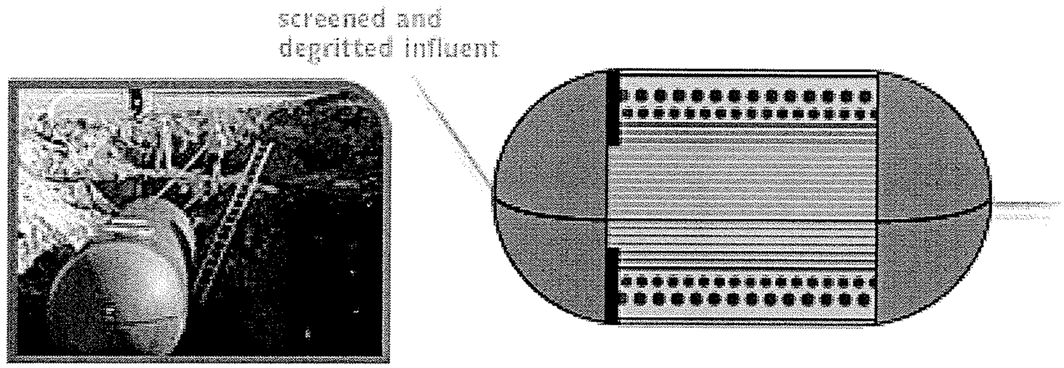


Figure 6.2: Anaerobic Reactor (Todd et al., 2001)

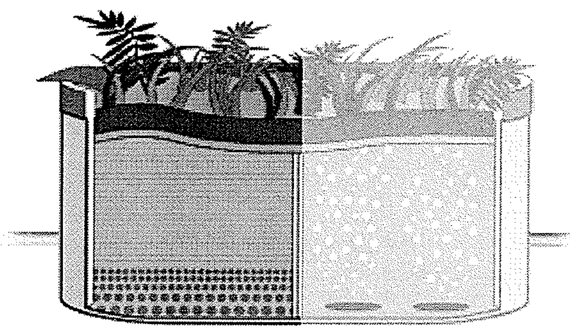
The raw wastewater enters the solar aquatic facility at the anaerobic reactor, which is underground outside of the main structure. Similar to a septic tank but with additional features designed to enhance treatment; the reactor removes inorganic grit (e.g. sand, plastics) with the use of large screens[32]. The purpose of this filtering is to remove large particles - hair, lint, fats, grease, etc. Sedimentation also takes place, in which suspended particles settle. This reactor becomes a primary sedimentation basin, and only the liquid portion is allowed to move forward to the following treatment component. Anaerobic bacteria – microbes that respire without oxygen – convert organic wastes into ammonia, methane and organic acids. Consequently, organic material and inorganic solids in the wastewater are significantly reduced, and the BOD content[33] is reduced by approximately 50% of its initial value. To control odour, the gases produced during the process pass through an activated carbon filter before being released from the reactor.

[32] Generally two types of filters are used: screen filters, and sand or gravel filters

[33] An index of the amount of organic material. Details are provided in footnote no. 4 and glossary

A balanced tank/equalization chamber (optional) is used to maintain a balanced flow of sewage entering the facility (nutrients) and a sufficient amount of bacteria (consumers of nutrients). The operator monitors this chamber and changes the influent flow. Organic sludge settled on the bottom of the chamber is removed and pumped into the closed aerobic tank.

2nd **Component**: Closed Aerobic Reactor



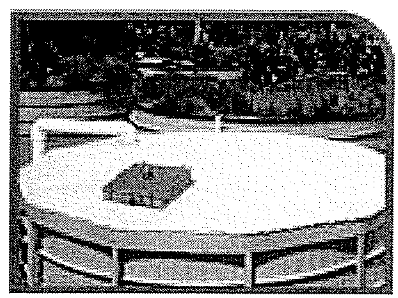


Figure 6.3: Closed Aerobic Reactor (Todd et al., 2001)

Large pumps and diffusers aerate the wastewater. The process of aeration - the addition of dissolved oxygen into the wastewater - takes place in the tanks and enables bacteria to consume nitrogen[34] and other nutrients. The reactor controls the level of the oxygen and prevents anaerobic conditions. The wastewater is circulated inside to speed up the growth and "workability" of micro-organisms. During the process of denitrification taking place in the tank, bacteria "breathe" the oxygen component of these nitrogous compounds, "breathe out" gaseous nitrogen and hence remove the nutrients from the incoming wastewater. This nitrogen gas is

[34] Denitratization is a process converting nitrogen (NO3) to nitrogen gas (N2O and N2), which bubbles out of the solution.

collected and eliminated through an odour filter and control device (a plant biofilter). BOD_5 is reduced by 90% of the initial value.

Biosolids from the clarifier (4th Component) and nitrified water from the final open aerobic reactor (3rd Component) are recycled back into the closed aerobic reactor to further the purification process.

3rd Component: Open Aerobic Reactors (Solar Tanks)

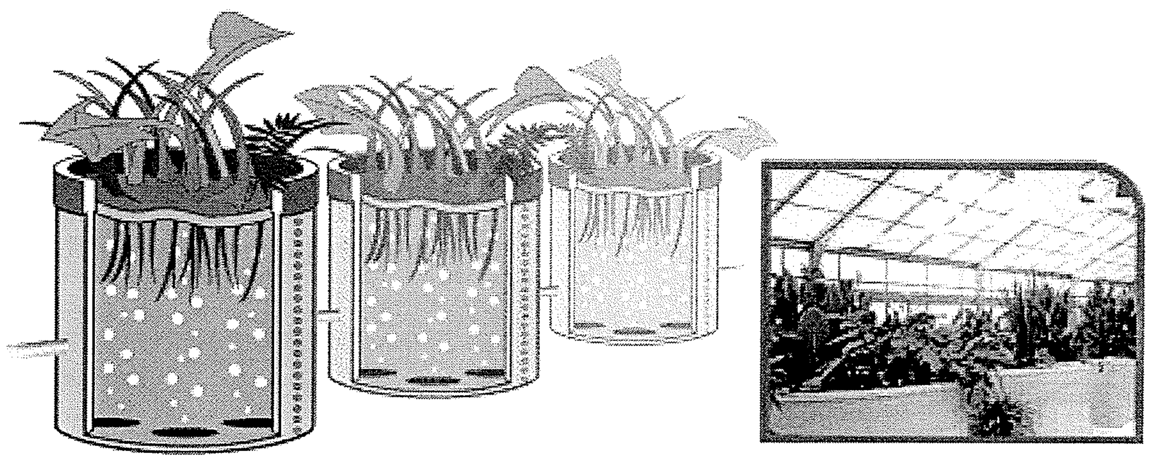


Figure 6.4: Open Aerobic Reactor (Todd et al., 2001)

These tanks are the most visible component of a solar aquatic facility, and the final process of heavy aeration takes place in the open aerobic reactors. A number of large cylindrical tanks are placed in a series of rows, with 3 - 12 tanks per row depending on the volume of influent, and each row is called a "train". Each tank may vary in diameter and height, depending on the overall design of the facility. Wastewater is directed through these tanks containing algae, plankton, fish and other aquatic species to create a natural food chain. Tanks with algae feed on nutrients in water, plankton feed on the algae, fish and mussels feed on algae and plankton.

The top of the reactors is covered with aquatic plants, which are suspended by wire mesh stretched over the tanks. The primary function of the plants is to provide habitats for large numbers of protozoa, micro-invertebrates, microbial populations, aquatic bacteria, insects and fish. These various life forms remove nitrogen, phosphorus, TSS, fecal coliform, heavy metals and other constituents. The secondary function of plants is to remove nutrients, destroying pathogen and to control gas exchange. Algae use carbon dioxide or bicarbonates as a source of carbon, and they also consume phosphate and nitrogen (ammonia or nitrate). Protozoa are single-celled aquatic animals which digest bacteria and algae. It is worth noting that major nitrogen reactions in water hyacinth include nitrification [conversion from ammonia (NH_4) to nitrate (NO_3)] and denitrification [conversion from nitrate (NO_3) to nitrogen gas (N_2)]. The nitrification process usually takes place when an adequate dissolved oxygen level is provided to support the activity of nitrifying bacteria. Nonetheless, as the number of plants increases, the oxygen level is lowered and anoxic conditions are created, the denitrification process would take place instead of the nitrification process. Consequently, the open aerobic reactors complete the nitrification and denitrification process by reducing BOD_5 to a satisfactory level. In addition, the plant covered reactors create a garden-like impression contributing aesthetically to the overall Grant Park Shopping Centre.

4^{th} **Component**: Clarifier

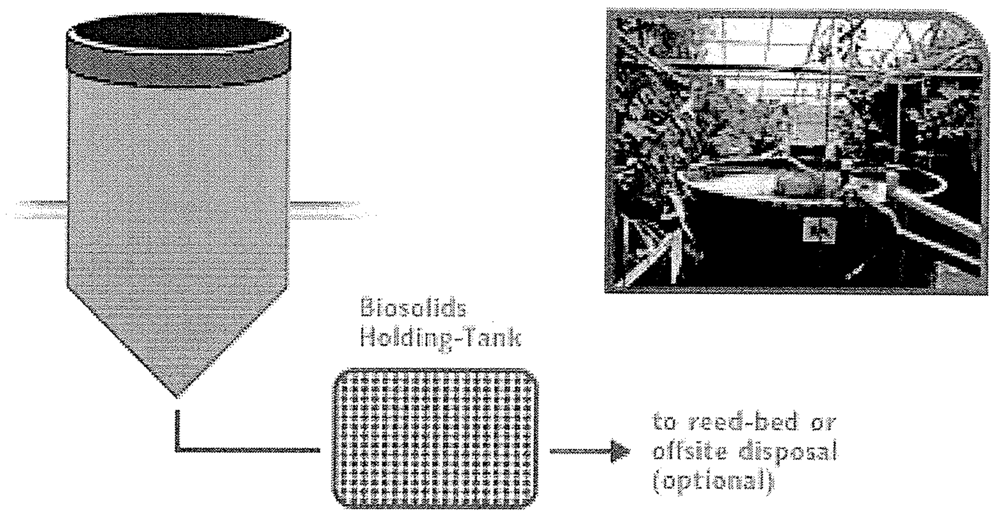


Figure 6.5: Clarifier (Todd et al., 2001)

The clarifier is a cone-shaped tank designed to allow wastewater to pass through it. Inside the tank there is a baffle structure that separates purified water on top from a layer of sludge formed by colonized bacteria. The composition of the influent at this stage is mainly liquid with small amounts of suspended solids and undissolved materials, and the clarifier further separates the microbial communities and remaining solids from the treated wastewater. Non-aerated water is filtered to the next reactor, while the remaining solids settle and are pumped back to the closed aerobic reactor (2^{nd} Component) for further purification. Cyclops and other organisms live in the wastewater and they are useful in further purifying the wastewater and forming a food chain with other species.

5th Component: Ecological Fluidized Beds (EFBs)

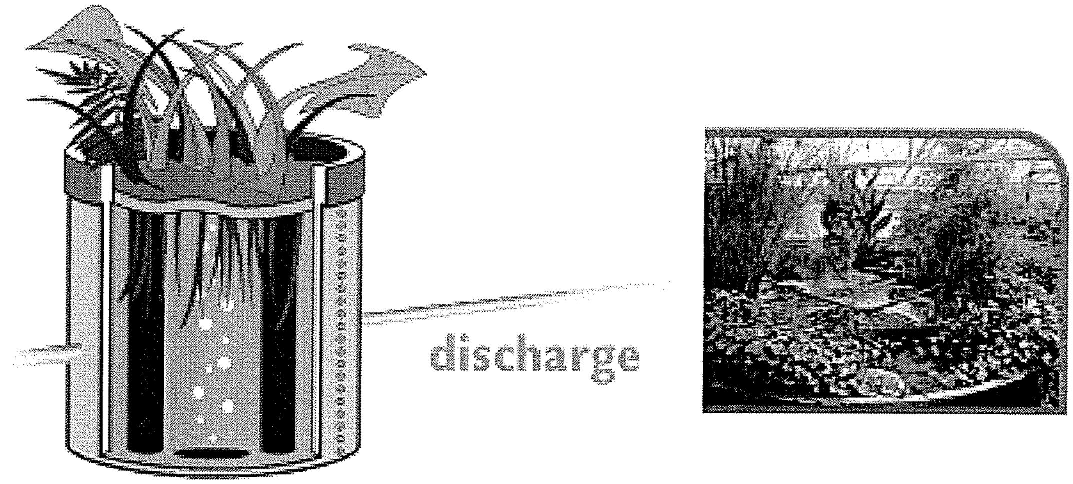


Figure 6.6: Ecological Fluidized Beds (Todd et al., 2001)

Two options are available after the wastewater leaves the clarifier. To further reduce TSS, the wastewater may be passed through a micro-screen or a coarse-grained gravel marsh. Both methods would result in a reduction of smaller suspended solids.

The Ecological Fluidized Beds are filled with light rock media. Wastewater is circulated through different habitats in these beds filled with diversified organisms, to remove organic materials and nutrients. During the aerobic operation, pumps are used to raise the wastewater from the bottom of the fluidized bed to the surface, where the water flows down through the bed. This process aims to facilitate the nitrification and denitrification process, and to nitrify any remaining ammonia in the treated water. Again, vegetation is planted on top of the fluidized beds, and benthic organisms graze the surface. When the wastewater is discharged from the EFBs, it is suitably purified for reuse in toilet flushing and plant irrigation. The quality of treatment achieved in the solar aquatic facilities is evident in the removal of 90% COD, 95% BOD, 95% TSS and 75% of total N removal (Table 3.1).

6th Component: Constructed Wetland

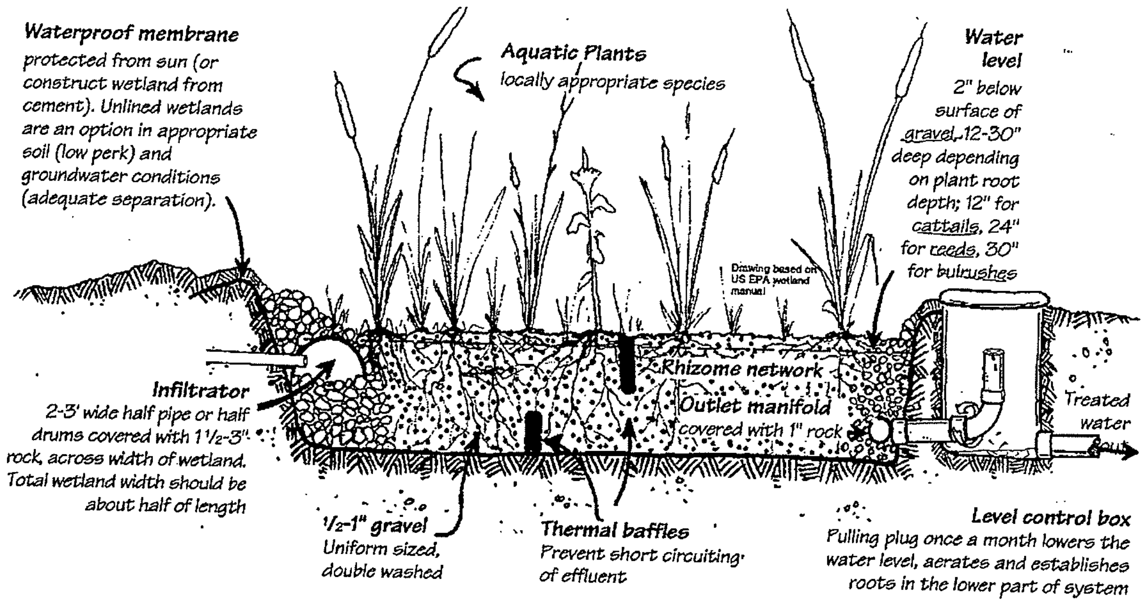


Figure 6.7: Artificial Wetland (Ludwig, 2000, p.23)

An artificial wetland (optional) is incorporated into the solar aquatic facility. Gravel and small stones are piled approximately 7.5 cm (3 ft) deep and plant species adapted to live in the open aerobic tanks can be used in the wetland. Such a wetland attracts wildlife and further promotes bio-diversity.

6.2.3 Preliminary Sizing of Treatment Components

After the development of the treatment process flow diagram, the next step is to determine the appropriate number and size of reactors required to carry out the necessary biological process. Erik Alm (2001), a representative of Living Machines Inc., states that they designed a system to treat a wastestream having a similar flowrates to that of Grant Park Shopping Centre. A total of 8 reactors were used. Alm (2001) assumes that the total retention (residence) time is approximately 2.5 days. In order to find out a rough capacity (which can be translated into a rough calculation of area) it is necessary to multiply the wastewater flow by 2.5 and figure out the dimensions of 8 cylindrical reactors, approximately 3.7 m (12 ft) high, to accommodate such capacity. However, it is important to note that the number and size of reactors may be different following detailed engineering evaluation.

Dimensions of each reactor: Diameter: 4 m (13 ft), Height: 3.8 m (12 ft)

Nonetheless, the design of Grant Park Shopping Centre Solar Aquatic Facility needs to have reactors with a height of 2.4 m (8 ft) to increase visibility for shoppers. As a result, some of the reactors have double the number of cylinders. Some reactors have a height of 2.4 m and a diameter of 3.9 m (12.8 ft). The dimensions of reactors and flow summary are provided in Table 6.2.

Table 6.2 Grant Park Mall Solar Aquatic Facility Flow Summary

Process Summary: Components	Number	Total Volume (m^3)	Height (m)	Diameter (m)
Closed Reactors	1	48.5	3.8	4.0
Open Reactors	8	194	2.4	3.9
Clarifiers	2	48.5	2.4	3.9
EFB's	2	97	3.8	4.0
Total	**13**	**388**		

6.2.4 Wastewater Collection Line and Reused Water Distribution Line

Currently the sewage produced from GPM is discharged at 11 different locations (Appendix B 3). Therefore, there is a need to design and build a new wastewater collection line to collect the sewage before it reaches the city sewer line (Appendix D 2). It is recommended that the new sewage line be directed to the solar aquatic facility through gravity (Butler and Davies, 2000). Since the existing sewage lines are 3 m (10 ft) below the ground, the new main wastewater collection line must be buried deeper than 3 m to accommodate the 1% gradient (Figure 6.8).

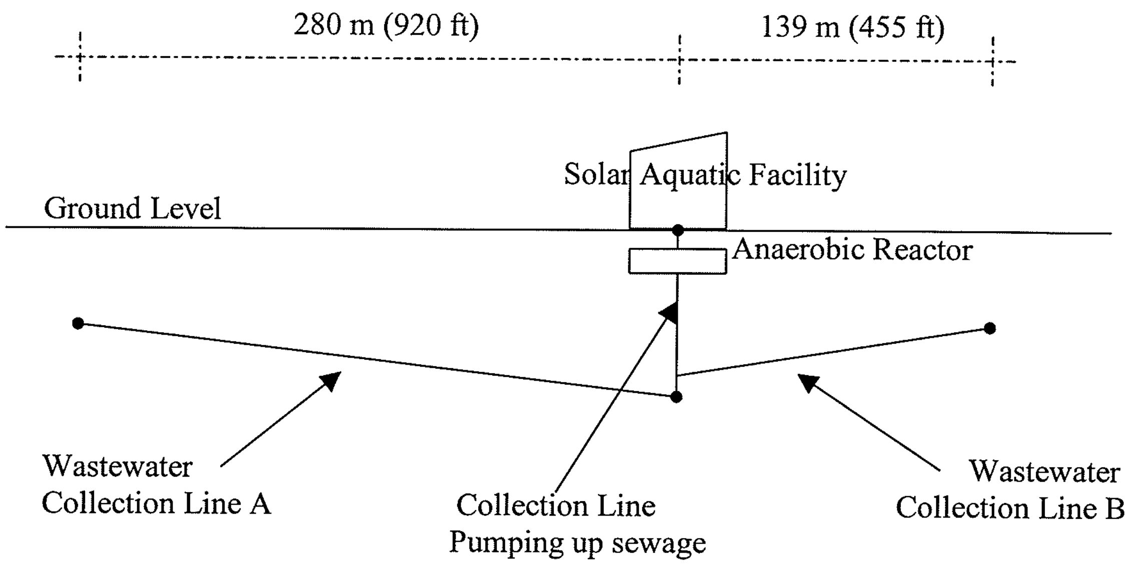


Figure 6.8: Gradient of Wastewater Collection Line

Wastewater collection line A and B are both ends of the same main wastewater collection (Figure 6.8). The new depth of wastewater collection line A is calculated to be 5.9 m (19.2 ft). Therefore, one end of the wastewater collection line will be buried at 3 m (10 ft) and will slope with 1% gradient. The wastewater collection line A will be 5.9 m deep when it reaches the solar aquatic facility from where the sewage will be pumped up to the surface level for treatment.

The new depth of wastewater collection line B is calculated to be 1.4 m (4.6 ft). Therefore, the other end of the wastewater collection line will also be buried at 3 m, and its depth will be 4.5 m (14.6 ft) when it reaches the solar aquatic facility, from which the sewage will be pumped to the surface level for treatment.

Reused Water Distribution Line

A "reused water" distribution line must be installed to supply the treated wastewater to the designated bathrooms (Appendix D 2).

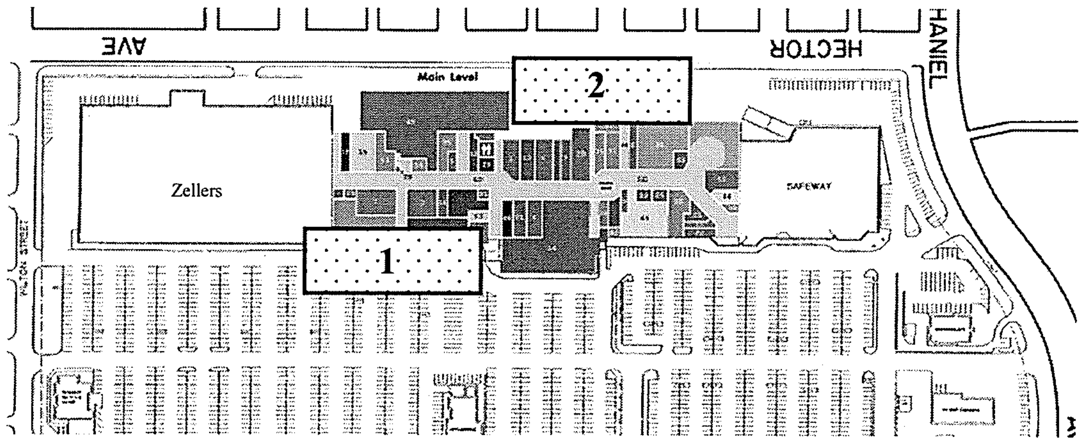
6.2.5 Selection of Plants and Animals

The plants used to cover the open aerobic reactors are often tropical, sub-tropical and temperate wetland species that have been tested and found effective in purified wastewater, while providing an optimal habitat for other species (Appendix C 1). They have shown remarkable nutrient uptake capability for both P and N compounds (Ramjohn, 1999). Furthermore, the specific plants are selected for their ability to produce large masses of hair-like roots. The water hyacinth is valuable in the solar aquatic facility, as it can reduce physiochemical and bacteriological elements effectively (i.e. BOD_5, COD, acidity, NO_3, PO_4, coliform, etc.) (Tripathi & Shukla, 1990).

6.2.6 Development of a Facility's Site Layout

"Facilities site layout" describes the spatial arrangement of the physical facilities. A series of design decisions are considered regarding the locations of the solar aquatic facility in the mall. Each option considers the environmental, economic and social benefits/drawbacks, the alternative that simultaneously benefits all three aspects the most are recommended, as Tyler (1994; 2000a; 2000b) discussed in Section 2.1.

Potential Orientation of a Grant Park Mall Solar Aquatic Facility



Option 1: North Side (Figure 6.9)

- Tremendous energy loss - low efficiency for solar aquatic treatment
- Greater distance to sewer outlets (Appendix B 3)
- Higher visibility – More attention from the visitors
- More shoppers using the solar aquatic facility – higher educational value

Option 2: South Side (Figure 6.10) (Recommended)

- South solar orientation - more efficient for solar aquatic treatment
- Shorter distance to sewer lines (Appendix B 3)
- Un-utilized space available for the building of new facility
- Greenhouse facing neighbourhood: creating intimate relationship with neighbourhood
- Renovation less disturbing to the existing retail fabric in the mall
- Improvement on the existing dreary service character of south side

Figure 6.9: North Side of Grant Park Mall

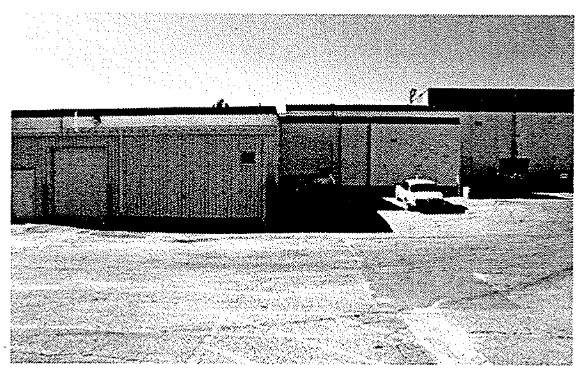
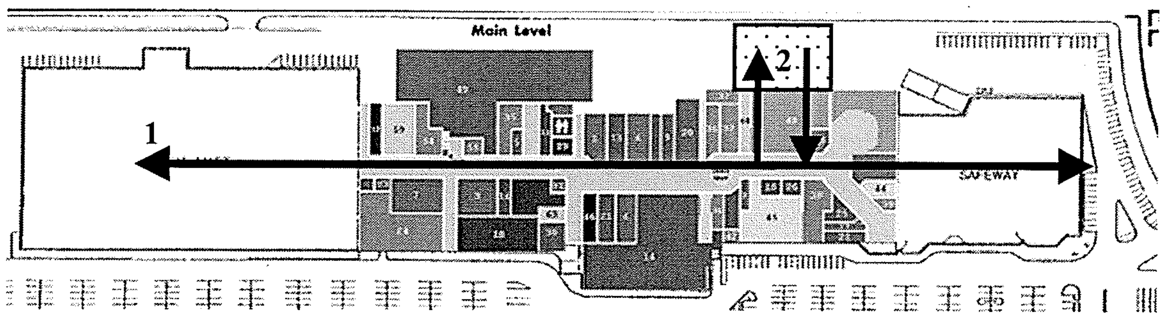


Figure 6.10: South Side of Grant Park Mall

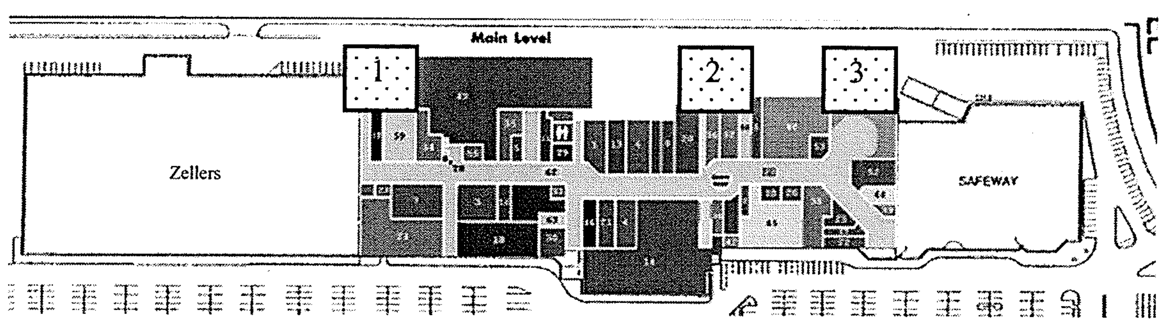
Designated Circulation Path



Option 1. Existing Layout
- I - shaped
- Linear circulation path
- Greater perceived mall distances between anchors

Option 2. Proposed Layout (Recommended)
- L - shaped or T - shaped
- Circular circulation path
- Shortened perceived mall distance between anchors

Location of Solar Aquatic Facility in Relation to Anchor Stores



Option 1. Adjacency to Cinema/Zellers (Figure 6.11; 6.12)
- Attracts many visitors existing space very popular
- Difficult to attract shoppers from the opposite end
- Lowest cost for the wastewater collection line
- Close to major bathrooms, higher educational value
- Limited amount of space for the facility and new retail

Option 2. Adjacency to Central Courtyard (Recommended) (Figure 6.13; 6.14; 6.15; 6.16)
- Existing skylight for the proposed vegetation (Figure 6.13)
- Middle point of the mall to attract shoppers from left or right wings
- Relatively low cost for the wastewater collection line
- Near the most important space in the mall - central courtyard
- Shortened perceived distance for the mall
- Near an existing unplanned pathway is present in that location (Figure 6.15)
- Opportunities for watering the plants in the courtyard

Option 3. Adjacency to Food Court/Safeway (Figure 6.17; 6.18)
- Attract many visitors because the space is popular now
- Difficult to attract shoppers from the opposite ends
- Highest cost for the wastewater collection line
- Servicing to Safeway is affected

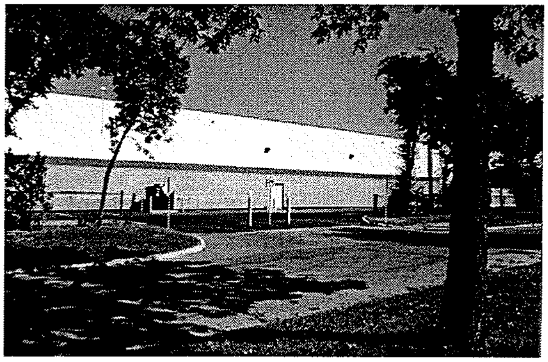


Figure 6.11: Adjacency to Cinema/ Zellers (Exterior)

Figure 6.12: Adjacency to Cinema/ Zellers (Interior)

Figure 6.13: Adjacency to Central Courtyard (Exterior)

Figure 6.14: Adjacency to Central Courtyard (Interior)

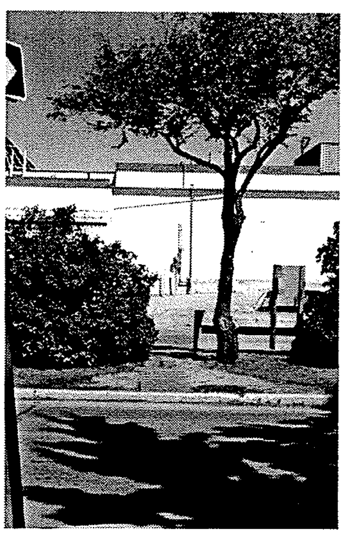


Figure 6.15: An existing (unplanned) pathway

Figure 6.16: Skylight in central courtyard

Figure 6.17: Adjacency food court/ Safeway (interior view)

Figure 6.18: Adjacency to Food Court/ Safeway (exterior view)

The photos of the chosen location are provided in Appendix B 4.1; B 4.2; B 4.3, and the preliminary design concepts of the physical layout of the solar aquatic facility in GPM are provided in Appendix D 3 and D 4, while the final physical layout is provided in Appendix D 5.

6.3 Environmental Benefit

The environmental benefits brought about by a solar aquatic facility are evident through the conceptual design. The living eco-systems created in the facility provide habitats for many regional plant and animal species, which are generally difficult to survive in urban areas. The designed process treatment is technically sound and it satisfies the design criteria. With the use of a solar aquatic facility, 156 m^3 (41,000 USG) per day of wastewater produced in the mall every day is treated on site without causing any pollution, reliving the pressure from local water and wastewater infrastructure. Furthermore, the most significant principle of a solar aquatic treatment is to work with nature; creating a natural food chain, relying on the sun as an energy source, and on photosynthesis and other biological reactions as methods of treating wastewater. All the biological processes taking place in the biological reactors are environmentally beneficial, and such treatment processes also follow the ecological design principles mentioned in Section 2.2.

The vegetation and landscape features included in the facility site layout create an ecological theme for Grant Park Shopping Centre, providing an "all-season mini-park" inside the mall. The conceptual design demonstrates that many important concerns of public health and relevant government departments are being addressed. Odour is eliminated by a bio-filter, and the toxic compound, nutrient, pathogens and other micro-organisms in the wastewater are greatly reduced. Treated water, which should be capable of satisfying the quality standards of the Guidelines for Canadian Recreational Water Quality described in Section 3.3.2, should be allowed to be discharged to surface waters in the fountain and flowerbed in the final design concept (Appendix D 5.1; D 5.2). Besides, no chemicals are added to the overall process treatment. In conclusion, the solar aquatic facility implemented in Grant Park Shopping Centre appears to be environmentally beneficial.

6.4 Chapter Six Summary

The design criteria were developed according to: ecological principles outlined in Chapter Two; the environmental, economic and social benefits/drawbacks, government regulations and, shopping centre trends in Chapters Three and Four; and the site analysis in Chapter Five. The design criteria were divided into three parts, each part used to demonstrate a particular aspect of the overall conceptual design.

Process engineering aimed at designing a process treatment in a solar aquatic facility that is technically sound and satisfies the design criteria. The treatment process is divided into six tasks. The quantity of wastewater was estimated to be 156 m^3 per day, and the facility was then designed to handle such a quantity. The treatment process flow diagram was developed following the study of the principles of solar aquatic technology and the essential biological treatment components. The six treatment components were recommended, including a closed anaerobic reactor, open aerobic reactors, clarifier, ecological fluidized beds and constructed wetland. The goal is to create a natural chain to use micro-organisms to purify the water, and use plants and animal species to consume the mico-organisms. In order to "fit" in GPM, several reactors were specifically designed, mainly in regards to height, width and location. In addition, a wastewater collection line and reused water distribution line were designed to alter the existing sewer discharge and water supply systems for treatment and distribution purposes. Specific plants and animal species were suggested, based on their suitability and capacity of adapting to the nature of the wastewater in the tanks during and after the treatment. In the last part of this section, the development of facility site layout, the existing fabric of the mall and that of the surrounding neighbourhood were carefully investigated in order to have the proposed solar aquatic facility fit the existing context. The physical design also aimed at selecting the most appropriate location, and physical form, to optimize to the living condition of the micro-organisms and plants in the facility, to attract a maximum number of visitors and enhance the physical relationship between the mall and the surrounding neighbourhood.

Chapter Seven:
Economic and Social Programs

An extensive cost-benefit analysis is conducted to estimate the costs and savings associated with the implementation of a solar aquatic facility. Three levels of intervention are identified and evaluated, and recommendations are made according to their relative profit/deficit. The social programs presented provide an educational opportunity for wastewater reuse and conservation for the surrounding communities. A second round of interviews is conducted to evaluate, for the last time, the feasibility of a solar aquatic facility in Grant Park Shopping Centre, based on the presented conceptual design.

7.1 Economics

A preliminary economic analysis has been made of possible cost savings versus implementation costs associated with wastewater reuse systems in Grant Park Shopping Centre. The detailed calculations involved in this section (7.1) are documented in Appendix C 2.

7.1.1 Cost

7.1.1.1 Design and Construction

According to Alm (2001), with a capacity to process 40,000 USG of wastewater per day (gpd), a Living Machine is estimated to cost $726,750 CAN ($475,000 US) in capital construction cost with a 20% discrepancy[35]. He adds that solar aquatic facility design services tend to be charged at an additional 15% of the total capital construction cost, which is $109,012 Can ($71,250 US). Consequently, the design and construction cost of a solar aquatic facility make up the largest component in the capital cost.

7.1.1.2 Operation and Maintenance

According to Alm (2001), the operation and maintenance cost per annum for a 40,000 gpd Living Machine is estimated at $76,500 Can ($50,000 US). This includes all labour (administrative and operational), electricity, gas, parts, testing equipment, monitoring and sludge handling. The maintenance cost of the Bear River solar aquatic facility is included as a reference for the distribution of cost items (Appendix C). Nevertheless, it is important to note that the designed capacity of the Bear River solar aquatic facility is 18,000 US gpd, while that of Grant Park Mall is almost triple at 41,338 US gpd.

7.1.1.3 Wastewater Collection and Reused Water Distribution Line

Width of the wastewater collection line is 8 - 10 in.[36], ABS[37]

Total Cost of wastewater collection line is $ 318,000

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[35] The price of a solar aquatic facility/Living Machine is not determined by the design flowrates of wastewater, but by the number of reactors required to treat the designated quantity and quality of water. The price estimated in this practicum may be adjusted with further evaluations by engineers.

[36] According to the GPM site manager, the size of the wastewater collection line on either end should be a minimum of 7 inches, and its size must get larger with the accumulation of more sewage along the same wastewater collection line, a maximum of 10 inches. However, the calculation is simplified, as the length required for 7 - 10 inches respectively is unknown. He also recommended the new water piping material be copper, with a3 ½ inch diameter.

[37] ABS is commonly used for sewer lines because it has more strength and durability than cast iron. Winnipeg building codes also require users to use ABS for sewer lines.

Reused Water Distribution Line

Width of the Reused Water Distribution Line is 3 ½ inches, Copper

Total Cost of reused water distribution line is $ 21,100

Excavation Fee

According to Ted Wilson (Personal Communication, August 2001), a representative of the City of Winnipeg's Water and Waste Department, Engineering Section, the excavation for a 20 cm (8 in) Wastewater collection line at 6 m (20 ft) in depth is $12,000.

A total of $35,100 would be spent on the wastewater collection line, reused water distribution line and excavation. They make up the second largest component of the whole capital cost.

7.1.1.4 Greenhouse Construction Cost

According to Mike Willis (Personal Communication, August 2001), a representative of HGS, a wholesale greenhouse construction company, an estimated per-footage cost for an all season greenhouse attached to a building, is \$25.4 per ft^2 if its size is smaller than 2,400 ft^2.

The greenhouse construction cost is: 2,400 ft^2 greenhouse x \$25.4 = \$ 61,000

7.1.1.5 Net Amount of Retail Space

Since part of the existing retail space is proposed to be eliminated, the opportunity cost[38] for this space would have to be calculated. According to the developer, the annual rent in GPM is estimated to be $50 per square foot. On the other hand, along with the building of a greenhouse for the solar aquatic facility, an additional structure is attached

[38] Opportunity cost is the amount of rent that would have been received if the space were leased to tenants.

to the greenhouse to provide new retail space in the mall. A new mini-golf course is also planned.

Net increase in retail space in summer time (6 months) is 2100 ft^2

Net decrease in retail space in winter time (6 months) is 2400 ft^2

Net deficit in rent per annum is $ 7,725

7.1.1.6 Interest

According to GPM site manager, the target for such an intervention would be a 5-year payback period with a 5-years loan, although the developer claimed that a 10-year or 20-year payback period might be used because of the lifespan of a solar aquatic facility. Both 5 and 10 -year mortgages are considered here. The annual loan payments are calculated by the mortgage calculators provided by Mortgage-calc.com (a).

7.1.2 Savings

7.1.2.1 Reduced Water Consumption

An estimated fifty-four percent of the total commercial water consumption[39] can be replaced with recycled wastewater. Consequently, freshwater consumption would be reduced by 54%.

Total reduced freshwater consumption per annum = $19,640

[39] Commercial water consumed percentage: WC flushing: 35%, Washing/bathing: 26%, Urinal flushing 15%, Food preparation/drinking: 9%, Laundry: 8%, Washing-up: 2%, Car washing/garden use: 4%, Others 1% (Butler & Davies, 2000). WC flushing (35%), Urinal flushing (15%) and Car washing/garden use (4%) can be replaced by treated water.

7.1.2.2 Reduced Sewer Charge

Since the wastewater treated would not be fully used in the mall, especially in the winter when the constructed wetland and the mini-golf course are not used, discharge to the city sewer line is necessary. Nevertheless, the quality of the treated water would be equivalent to that with tertiary wastewater treatment. It is assumed that the City of Winnipeg is willing to provide a 90% discount from its usual sewer charge.

7.1.2.3 Merchandising of By-products

Plants/aquaculture: The organic gardening that occurs in the solar aquatic facility involves a host of marketable flowering plants, foliage, shrubs and trees, duckweeds and vascular plants in the greenhouse. Potential revenue calculated for the South Burlington solar aquatic facility, with a capacity 370 m^3 (85,000 US gpd), is $99,840 to $179,712 (CAN) per annum (Ramjohn 1999). The proposed solar aquatic facility, treating half of the volume of wastewater treated in the facility in this practice (156 m^3), is estimated to produce plants worth approximately $69,888. On the other hand, the mall owner may negotiate with the City about them buying off the surplus produced in the GPM greenhouse in order to support the sustainable development of GPM.

Other By-products: The residual sludge leftover in the process of clarifying wastewater is a commercially viable fertilizers. Animals produced in a solar aquatic facility: snails, mussels, fish, crayfish and other ornamental aquatic species, all have resale value (Ramjohn 1999).

7.1.2.4 Rental Increase

According to the developer, the existing tenants should be willing to pay an additional \$1.00 – \$1.50 per square foot per month to support the intervention, because the intervention probably would boost up the sales in the GPM with the increase of shoppers. The following example assumes that 80% of the mall is leased out, and a \$1.00 per square foot rental increase is applied.

Gross leasable floor area (375,000 ft^2) x 80% = 300,000 ft^2

Additional rent per annum: 300,000 ft^2x \$ 1.00 / ft^2= \$ 300,000

7.1.3 Cost-Benefit Analysis

In the cost-benefit analysis, three intervention options are examined (Details are provided in Section 7.3).

Option A: No Intervention (Status Quo)

Option B: Solar Aquatic Facility - Service Depot

Option C: Solar Aquatic Facility – Educational Centre (Integrated with the mall)

The first option involves an analysis with no intervention; therefore, costs identified are those currently paid by the mall. The second option is to build a solar aquatic facility as a service depot for the mall, with no further design for integrating the facility with the existing mall. The facility would not be accessible to the public, and the benefit of the facility is mainly environmental and economical in potable water usage and sewage charge savings. The capital cost of the facility is weighted against the potential savings. The third option involves a more elaborate design integrating the existing mall with a solar aquatic facility, making the facility an educational centre with direct accessibility to the shoppers. In addition to its educational and environmental benefits, there is a potential for additional revenues generated by the new retail outlets.

7.1.3.1 Review of Total Cost and Savings of Three Options

The cost and revenues of all the items identified from 7.1.1 and 7.1.2 is listed in the following.

Total Cost and Savings of Three Options

	Items	Option A *(No Intervention)*	Option B *(Solar Aquatic Facility as Service Depot)*	Option C *(Solar Aquatic Facility as Educational Centre)*
Total Cost	1. Capital Cost			
	- *Solar Aquatic Facility*	-	$ 726,750	$ 726,750
	- *Design Service*		$ 109,012	$ 109,012
	- *Greenhouse structure*		$ 60,960	$ 60,960
	- *Wastewater Collection Line*		$ 317,625	$ 317,625
	- *Excavation*		$ 12,000	$ 12,000
	- *Reused Water Distribution Line*		$ 21,075	$ 21,075
	- *Project administration*[40]		$ 1,000	$ 1,000
	- *Additional renovation*		-	$ 500,000
	- *Potential Government Funding (Waste Reduction and Pollution Prevention Fund)*		$-50,000	$-50,000
	Sub-total		$ 1,198,422	$ 1,698,422
	Mortgage *(Compound Interest: 8% for 5 years loan*[41]*)*	-	$ 291,600 /yr. $ 24,300 /mon.	$ 413,300 /yr. $ 34,440 /mon.
	Mortgage *(Compound Interest: 8% for10 year loan)*	-	$ 174,500 /yr. $ 14,540 /mon.	$ 247,200 /yr. $ 20,600 /mon.
	2. Total Maintenance Cost per annum	-	$ 76,500	$ 76,500
	3. Net Amount of Tenant Space Rental per annum	-	-	$ 7,700
	4. Reduced Water Consumption	-	$ 15,400	$ 15,400
	5. Reduced Sewer Charge	-	$ 48,800	$ 48,800
Savings/ Revenue	6. Horticultural Sale	-	$ 69,900	$ 80,000[42]
	7. Rental Increase	-	$ 75,000[43]	$ 300,000

[40] Administration cost includes all the application, public meeting and technical inspection fees associated with obtaining the approval from government departments. According to Ferguson (2001), the application fees for an on-site wastewater reuse facility is estimated to be $1,000.

[41] The annual mortgage payments for each of the three options were calculated by the mortgage calculators provided by Mortgage-calc.com (a).

[42] Additional revenue is expected from the additional flowerbeds included in the overall mall intervention (Appendix J & K).

[43] Since the solar aquatic facility is not accessible to the public, the overall advertised effect of being "environmentally friendly" would then reduced. Therefore, only a $ 0.25 per ft^2.rental increase has been applied.

7.1.3.2 Cost-Benefit Analysis (5 Years Loan)

	Items	Option A *(No Intervention)*	Option B *(Solar Aquatic Facility as Service Depot)*	Option C *(Solar Aquatic Facility as Educational Centre)*
Total Cost	1. Mortgage	-	$-*1,458,000*	$-*2,066,500*
	2. Total Maintenance Cost	-	$-382,500	$-382,500
	3. Net Amount of Tenant Space			$ -38,500
	4. Water Consumption	$-77,000	-	-
	5. Sewer Charge	$-244,000	-	-
Total Revenue	6. Horticulture Sales	-	$ 349,500	$ 400,000
	7. Rental Increase	-	$ 375,000	$ 1,500,000
	Net Profit	-	-	-
	Net Deficit	**$ 321,000**	**$ 1,116,000**	**$ 587,500**
	Net Deficit (compare to Option A)	-	**$ 795,000**	**$ 266,500**
	Recommended Option	#1	#3	#2

Note: "-" indicates cost, "+" indicates profit. Inflation and discrepancies are not considered

The recommended option is Option A with least deficit. Detailed analysis are discussed in Section 7.1.4.

7.2.3.3 Cost-Benefit Analysis (10 Year Loan)

	Items	Option A *(No Intervention)*	Option B *(Solar Aquatic Facility as Service Depot)*	Option C (Solar Aquatic Facility *as Educational Centre)*
Total Cost	1. Mortgage	-	$-1,745,00	$-*2,472,000*
	2. Total Maintenance Cost	-	$-765,000	$-765,000
	3. Net Amount of Tenant Space per annum			$ -77,000
	4. Water Consumption	$ -154,000	-	-
	5. Sewer Charge	$ -488,000	-	-
Total Revenue	6. Sale of Horticulture	-	$ 699,000	$ 800,000
	7. Rental Increase	-	$ 750,000	$ 3,000,000
	Net Profit	-	-	**$ 486,000**
	Net Deficit	**$ 642,000**	**$ 1,061,000**	-
	Net Profit (compare to Option A)	-	-	**$ 1,128,000**
	Net Deficit (compare to Option A)	-	**$ 419,000**	-
	Recommended Option	#2	#3	#1

The recommended option is Option C with the most profit. Detailed analysis are discussed in Section 7.1.4.

7.1.4 Economic Benefits

The major components of the capital cost are the design and construction fee of a solar aquatic facility in GPM ($835,800). The second major component of the capital cost is the installation of the wastewater collection line, $339,100, which accounts for 28% of the total capital cost for Intervention Option B and 20% of the total capital cost for Intervention Option C. The high cost of wastewater collection line seems to be perceived unfavourably. The proposal for a solar aquatic facility (Option B and C) presents a noticeable economic disadvantage with a five-year mortgage, since capital cost cannot be recovered in 5 years. However, over a ten years investment period, option C is capable of recovering the initial cost of the facility. Moreover, Option C provides the most attractive intervention of the three options with a ten years loan, and is therefore recommended (see Appendix D 5).

As the GPM site manager stressed, since the investment in a solar aquatic facility cannot be paid back with a 5 years loan, it may be difficult to implement – the GPM owner may be discouraged by the slowness of the investment payback. It is also important to note that the public funding identified in the calculations may not be provided, meaning it could take even longer to recover the capital cost of the facility in GPM, and create a further potential barrier for such an intervention. As a result, the implementation of solar aquatic facility appears not to be economically feasible in a short term (5 year) but seems to be promising with a long-term loan (10 years).

As part of the limitations of this practicum described in Section 1.4, the investigation of Grant Park Shopping Centre redevelopment has been limited to the introduction of a solar aquatic facility. However, it is relatively common to have multimillion dollars spent on moderate to large-scale renovations of older malls. For example, $30 million was spent on the 1999 renovation of the St. Vital Shopping Centre in Winnipeg. Therefore, if the installation of a solar aquatic facility is incorporated into a moderate to large-scale renovation project, the investment in the facility would require only a small fraction of the total investment, and this might encourage investors to a greater degree. Moreover, in this practicum the projected increased revenue generated from an increased number of customers frequenting the mall after the renovation could not be reasonably estimated in the preliminary cost-effective analysis. The inability to predict this increased source of revenue makes the proposal appear less attractive. Nonetheless, the facility site layout in Section 6.2.6 demonstrates an ecological theme in GPM that could help to attract more shoppers and visitors. The increase of retail sales in the mall as a result of the solar aquatic facility could be significant, helping the mall to become more competitive in the retail market, as discussed in Section 4.1.

7.2 Social Programs

7.2.1 Suggestions of Social Programs

On-Site Solar Aquatic Educational Program

The solar aquatic facility is intended to serve as an educational centre, educating the public as to the value of recycling and reusing wastewater. The main part of the solar aquatic facility is separated from the mall by a glass wall, with a description of the biological process taking place inside the reactors and the potential savings produced by the system. Community members, students or tourists visiting the facility may participate in an on-site tour, in which staff gives a detailed explanation of the system components and the treatment process.

Co-operative Post-Secondary School Research Program

The facility could also serve as a research laboratory for students in post-secondary institutes in Winnipeg such as University of Manitoba and Red River College. The related research subjects could include environmental engineering, biological sciences, and plant ecology and food science. Such research and demonstration projects could form an important basis for public information, and for future policy and planning decisions made by the municipal government related to wastewater reuse.

Neighbourhood Recycling Program

Waste minimization and recycling could be promoted in Grant Park Shopping Centre with a series of recycling programs. Currently the mall is one of the local recycling centres and it could be developed into a major recycling centre, including recycling bins for papers, glass bottles and other recyclable materials (South Winnipeg Neighbourhood News, 2001). Medium to large-scale recycling events could be carried out seasonally in Grant Park Shopping Centre. In these events, other environmentally-conscious groups, such as the Fort Whyte Centre and Manitoba Prairie and Tall Grass Museum, could be invited to provide additional information on the importance of preserving of the natural environment.

7.2.2 Social Benefits

Public acceptance of recycled wastewater largely depends on the timing and quality of programs for public consultation and information on the potential benefits and drawbacks (Isliefson, 1998). Notifying community members and potential shoppers about the intervention is essential in obtaining support for developing a solar aquatic facility in GPM. It is important to show the potential consumers that treated wastewater or the service/products associated with treated wastewater will not endanger their health. The social programs suggested for Grant Park Shopping Centre would provide major educational opportunities for the various communities, and could result in community members changing their negative attitude about wastewater reuse, and gradually leading them to adopt ecologically sustainable lives.

Communities within one or two miles would benefit directly from the addition of a solar aquatic facility in GPM (Figure 7.1,7.2; Appendix C 3), and communities within three miles may also be benefited, according to the developer.

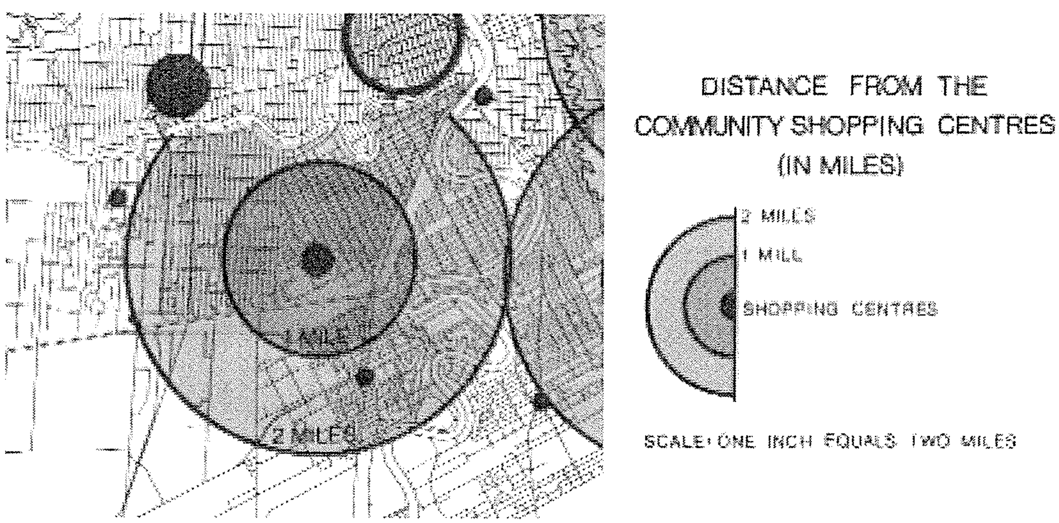

Figure 7.1: The "Two Mile" Trade Area of Grant Park Mall (City of Winnipeg, 1973)[44]

[44] It is worth noting that although Figure 7.1 and 7.2 are 18 years old but they are till applicable.

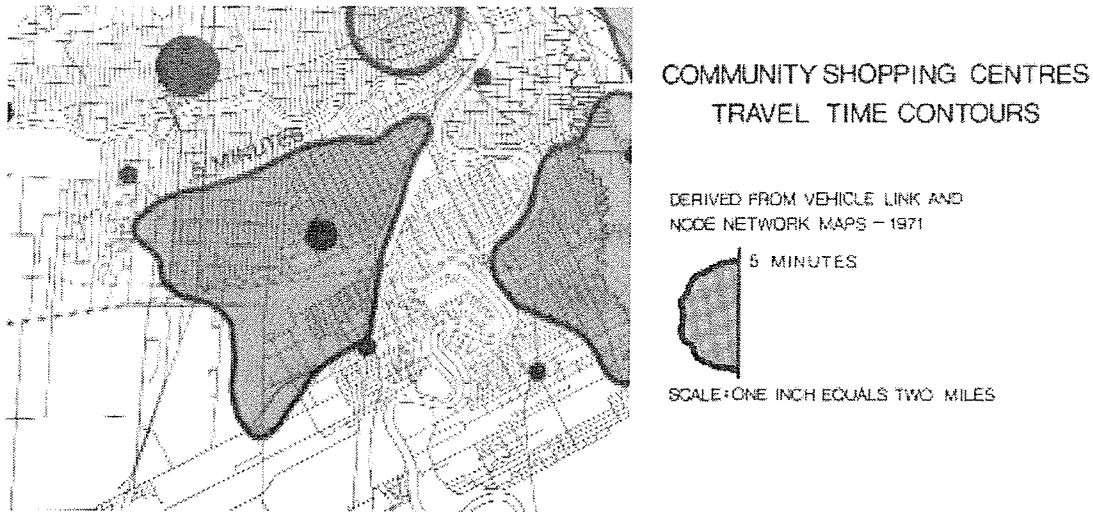

Figure 7.2: Grant Park Mall Travel Time Contours (City of Winnipeg, 1973)

The community members from these neighbourhoods may actively learn and become involved in the design, construction and maintenance of the solar aquatic facility on a voluntary basis. The tasks that they can undertake include nursing the plants produced in the facility, delivering information to shoppers about wastewater recycling, and carrying out occasional larger scale recycling events. Through their active participation in the operation, volunteers would have an opportunity to interact more with other community members, fostering a stronger sense of community. Furthermore, the community participation could further lower the maintenance cost of the solar aquatic facility, while the mall owner may allow the community to use GPM as a community centre.

The proposed solar aquatic facility in GPM also provides other social benefits. The facility site layout in Section 6.2.6 significantly integrates the surrounding neighbourhoods with the mall (Appendix D 5.1; D5.2; D 5.3). Public space is also expanded both inside and outside the mall, encouraging the interaction of neighbourhoods. The improved social orientation of the mall would enhance the relationship between the shopping centre and the surrounding communities. In addition, the facility could help to stabilizing the neighbourhood. Suburbanization continues in the city of Winnipeg; the population residing within the 2 mile zone of GPM has decreased considerably in recent years. The intervention would encourage community members to use Grant Park Mall more frequently, and hence encourage them to stay in the general neighbourhood. The intervention would therefore create a stabilizing affect on the local communities in the urban area. In conclusion, the solar aquatic facility appears to be beneficial socially.

7.3 Proposed Pilot Project

Before a full-size solar aquatic facility is implemented, a small-scale experimental pilot project on site is recommended. The project would aim at investigating the suitability, efficiencies and technical problems of a full-scale solar aquatic facility implemented in the mall. Micro-organisms, bacteria, plant and animal species would be studied in regards to their survival rate, productivity and adaptability to the unique site environment. Other important issues needed to be examined could include odour control and the final effluent quality meeting the national and provincial codes. Problems detected in the experimental period could then be addressed. Furthermore, the pilot project can examine to what extent the biological reactors in the facility could be open to the public, with consideration of significant issues such as safety and the prevention of vandalism.

With a pilot project, the reduced potable water demand, sewer discharge fee, maintenance fee and increased sales in GPM could be evaluated to examine if the intervention meets the expectation financially. A decision could be made by the mall owner and tenants as to whether a full-scale facility would be implemented, and whether additional investment would be necessary. The pilot project could help to boost the investors' confidence. In addition, the pilot project provides an opportunity to examine the public reaction to such innovation. As mentioned by the developer, the pilot project could draw attention from the public and the media, to generate public interest and support for the full scale implementation of a solar aquatic facility in GPM. With the promotion of the media, the people in Winnipeg could learn more about the water reuse practice and potentially change their attitudes toward wastewater reuse.

The pilot project is recommended to handle the wastewater from two sewer lines of the mall (Appendix D 6). The capacity of the experimental solar aquatic facility would be appropriately one-sixth of that in a full-scale facility.

7.4 Evaluation of Conceptual Design: Interviews

The conceptual design proposal was evaluated by the interviewees by examining the issues/criteria identified in the first interviews. Potential suitability was evaluated on criteria related to the improvement of ecological, economic and social sustainability. The suggestions for further study (Section 8.2) are also derived in part from the findings and feedback regarding the conceptual design. Interviewees for the second round of interviews were the same as those in the first. In general, the evaluation by the interviewees of the conceptual design resulted in suggestions for improving the quality of the physical design and the accuracy of the cost-benefit analysis.

The GPM site manager had no specific comments on the biological process of the designated solar aquatic facility and its associated social benefits, but he was very concerned about the results of the cost-benefit analysis. He stressed that the mall was not built to accommodate an on-site wastewater reuse facility, and the cost involved in the wastewater collection line installation is potentially high, while such cost is eliminated if a solar aquatic facility is built in a new mall. The Grant Park Mall site manager is satisfied with the proposed location of the solar aquatic facility because this is an under-utilized area and requires relatively shorter wastewater collection lines to intercept all the current sewer outlets. However, he felt that the facility location would make it difficult for delivery and service trucks. Moreover, the Grant Park Mall site manager identified some practical implementation problems. He stated that it would be difficult to modify the existing sewer line and to persuade the developer to invest with longer than a five-year loan. It could also be difficult to obtain approval of rental increase from tenants. In conclusion, the Grant Park Mall site manager felt that such a proposal is not feasible in Grant Park Shopping Centre.

The designer understood the fundamental principles of the solar aquatic facility and made no additional comments regarding the environmental and social benefits of the facility. He was very concerned about the physical design of the facility in the mall. As mentioned in Section 7.1.2, he stated that there are two approaches to introduce a solar aquatic facility in Grant Park Shopping Centre. The educational value for the second approach (Option C – solar aquatic facility as educational centre) is remarkable, with its potential for boosting the number of shoppers. In conclusion, the designer believed that a solar aquatic facility in Grant Park Shopping Centre is feasible because the economic and financial cost could be outweighed by many environmental and social benefits compounded with the additional savings of water consumption and sewer discharge.

The developer appreciated the environmental benefits associated with the biological process of the solar aquatic facility. He claimed that the social benefit of the solar aquatic facility is so significant that the neighbourhoods benefiting from the solar aquatic facility should be estimated to include those within three miles of the mall. The developer believed that the proposal is favourable and feasible even if the payback period is ten to twenty years. He explained that being environmentally-friendly is a local, national and global trend, and having such a reputation could be very profitable to a shopping mall.

In the evaluation of the feasibility of solar aquatic facility in Grant Park Shopping Centre based on the presented materials, a range of opinions were offered on the feasibility of intervention. The GPM site manager felt that such a proposal is not feasible because of the lack of short-term economic payback. However, the designer, and particularly the developer believe that the proposal is feasible, since it brings so many environmental and social benefits to the mall, communities and the business itself. The developer stressed that inability of payback with short-term loan should not be overlooked, since a long-term investment would likely to be considered with such proposal.

7.5 Chapter Seven Summary

A cost-benefit analysis was used to evaluate the economic feasibility of a solar aquatic facility in Grant Park Shopping Centre. Costs are weighed against the potential revenue and savings. Within the capital cost, the design and construction fee of a solar aquatic facility and the installation of a wastewater collection line are the major components. It is worth noting that the second major component of the capital cost is the installation of the wastewater collection line ($339,100) and such cost seems to be perceived unfavourably. On the other hand, the rental increase ($75,000 or $300,000) and reduced water supply/sewer discharge ($68,000) are the major components in the revenue columns. Out of the three options of intervention, option C – the solar aquatic facility as educational centre – was recommended in the longer term loan (10 years) because of its potential profits. Nonetheless, the cost-benefit analysis indicated that neither intervention options (B or C) were economically feasible because of its inability to realize a profit in the short term (5 years).

Three social programs - on-site solar aquatic educational program, co-operative post-secondary school research program, and neighbourhood recycling program - were suggested for Grant Park Shopping Centre along with the solar aquatic facility. The associated social benefits and educational opportunities that the facility and the social programs could bring are significant, and could alter the unfavourable public impression of wastewater reuse and help people to adopt a sustainable way of life. Furthermore, the proposed pilot project provides an opportunity to experiment the solar aquatic facility in GPM and test the response of the public to water reuse.

Interviewees' evaluation of the conceptual design resulted in suggestions for improving the quality of the physical design and the accuracy of the cost-benefit analysis, and comments on the feasibility of the facility at GPM. The Grant Park Mall site manager who was interviewed stressed that the wastewater collection line is too costly, and the lack of short-term payback was discouraging. The designer claimed that the intervention would be perceived favourably if the concept design is elaborated and incorporated into the existing fabric of the mall and the neighbourhood. The developer was also supportive of the proposed intervention, given the potential profits that might be generated in 10 or 20 year period.

The conceptual design has been presented in Chapter Five and Seven. Other significant areas that have not yet been researched, along with some of the suggestions from interviewees about the further research, are provided in the recommendations in the final chapter.

Chapter Eight:
Conclusions and Recommendations

8.1 Conclusions

The shortage of water seems to be evident in the future with the current unsustainable practice of urban development. Despite the seemingly abundant supply of potable water from Shoal Lake, increasing water demand in the city of Winnipeg points to the probability of an inadequate water supply provided by the existing water infrastructure. The City is implementing a water treatment plant, but widespread implementation of on-site water reuse in urban areas appears to have potential in addressing this problem. The wastewater reuse concept offers many environmental benefits, including the relief of existing water and wastewater infrastructure, and provision of wildlife habitats. Water reuse also provides economic advantages to a commercial business, including a substantial reduction in potable water demand and sewer service needs, and positive public relations. Furthermore, communities would benefit socially as community members would learn about environmental stewardship and potentially adopt a sustainable lifestyle. However, the regulations from national, provincial and municipal codes may also pose to barriers for water reuse implementation, in particular the Guidelines for Canadian Drinking Water Quality and the National Plumbing Code of Canada. However, based on a case-to-case examination, the relevant agencies tend to interpret the regulations with some degree of flexibility, which could favour the wastewater reuse facility application.

Shopping centres are one of the more intensive consumers of potable water among commercial buildings, the 1970s energy crisis led to the re-design of malls that aimed at reducing the use of resource. Environmental themes have been introduced in many malls with increasing use of vegetation and landscape features. The enormous amount of money spent on irrigating vegetation and removing wastewater indicate the potential of wastewater reuse in the mall context. Furthermore, wastewater reuse in a mall were tended to be supported by the key informant interviews because it provides substantial environmental and social benefits, but they remained doubtful about its cost-effectiveness in a retrofit situation. The site analysis further examined the current situation in Grant Park Shopping Centre and its potential for wastewater reuse. The conceptual design in Chapter Six and Seven aimed at demonstrating the environmental, economic and social benefits of wastewater reuse in GPM, with criteria derived from the issues examined in Chapter Two through Five.

There are three most significant challenges associated with the implementation of a solar aquatic facility in GPM: the difficulties involved in the collection, biological treatment and distribution of treated water, the high capital investment associated with the proposed intervention and the negative public perception on water reuse. These three issues were demonstrated and addressed in the conceptual design through the design of the solar aquatic facility process treatment, examination of the cost-effectiveness of the intervention, and suggestions of local educational programs. In addition, a pilot project in GPM could contribute to address the three barriers. The technical problems that may be encountered in a full-scale solar aquatic facility in GPM could be investigated. All the costs and revenues associated with the intervention could be evaluated as to whether or not the intervention meets the expectation financially. Such a project could also generate public support for the intervention, leading to more favourable public perception towards such technology.

Regulatory barriers related to water reuse also need to be addressed. Mutual support and co-operation between the GPM owner and the relevant government agencies are essential to the successful implementation of a solar aquatic facility in GPM. Moreover, mutual support between the GPM owner and the surrounding communities in realizing the intervention would generate wider benefits. Through active community participation in the operation, the maintenance cost for the facility and incidents of vandalism could be reduced, while the mall owner may allow some community and educational activities to take place in GPM, encouraging more social interaction and fostering a stronger sense of community.

In response to the research question, the findings supported that the intervention Option C proposal is environmentally and socially feasible through the conceptual design, the short-term economic disadvantage may result in a significant obstacle for the implementation of a wastewater reuse facility in GPM. Nonetheless, as Tyler (1994, 2000a; 2000b) emphasizes in the ecological framework, all ecological design projects should be evaluated simultaneously in terms of long-term environmental, economic and social benefits/drawbacks. In this way, the proposal for a solar aquatic facility in Grant Park Shopping Centre would be perceived favourably. The seemingly most appropriate time to implement a solar aquatic facility is when a medium- to a large-scale renovation next occurs in Grant Park Shopping Centre. Particularly if and when a major tenant such as the Cineplex Odeon Theatres move, this space would be well suited for a solar aquatic facility, because of its location and size[45]. The capital cost could be considerably reduced if there are other ways of collecting wastewater from GPM, given the high cost and technical difficulties involved in the wastewater collection line installation. One approach is to extract wastewater directly from the city sewer line on Hector Avenue.

Expanding consideration "beyond the site", there is a potential for implementing a larger scale solar aquatic facility to treat all the sewage in the city sewer line on Hector Avenue (Appendix B 2). For the successful implementation of such a project, the affected parties, including the surrounding neighbourhoods, school, churches, commercial enterprises (including GPM) and government officials would have to be actively involved. The sharing of cost and responsibility during the negotiating process, construction and management of the facility could lead to greater economic and social benefits. Such an approach would realize the ideology of the ecological framework "everything is connected to everything else" (Tyler, 2000b), in which every party is willing to collaborate and the government would relax regulatory barriers, and devising a system of fees and charges accordingly.

There appears to be considerable opportunity for wastewater reuse in shopping centres in the future. As mentioned in Section 3.1, as water shortage and pollution problems gradually become severe, the cost of potable water and municipal sewage treatment may increase substantially, encouraging on-site wastewater reuse. Also, as solar aquatic technology becomes more common and less expensive, wastewater reuse would then represent a cost-competitive strategy vis-à-vis the conventional potable water supply system and public sewer system. With increased exposure to water reuse projects,

[45] The advantage of building a solar aquatic facility at this location include shorter reused water distribution line necessary, and closer to a major tenant – Zellers.

the general population is likely to develop a more positive perception towards wastewater reuse, which in turn would encourage water reuse projects in shopping centres and other retail buildings.

It is worth noting that the municipal government and commercial developers are key players in any such innovation. This document is expected to serve as a resource for all of the stakeholders who have an interest in the planning, design, and management of wastewater infrastructure. Furthermore, this document can inform planners and municipal government officials of the feasibility of an on-site wastewater treatment facility in a commercial retail setting, which they may facilitate by creating more flexible recycled water quality regulations and zoning by-law. This practicum may help the City of Winnipeg to produce a brochure to promote the introduction of such an innovation to shopping mall owners. This in turn would assist mall owners to make the necessary applications for permits. Moreover, the conceptual design could also serve as guidance in further examination of the detailed planning, architectural and engineering issues associated with a solar aquatic facility when it is implemented. In summary, the analysis, findings, design proposal and conclusions should be of interest to the following groups:

University of Manitoba, Department of City Planning
University of Manitoba, Department of Civil Engineering
International Institute for Sustainable Development (IISD)
City of Winnipeg Water and Waste Department
City of Winnipeg Planning Property and Development Department
Fort Whyte Centre, Winnipeg
Architectural, Urban Design and Engineering companies
Colliers Pratt McGarry Realty
Shindico Realty Inc.

This practicum is intended to provide information and stimulate discussion on innovative wastewater reuse and its potential to address some of the infrastructure problems that Canadian municipalities and existing shopping centres are currently facing. Achieving the objective of sustainable development on a global scale is dependent upon the success of implementing ecologically sustainable designs at the community level. The successful implementation of water reuse in shopping centres would also encourage similar practices in the city of Winnipeg and other cities and countries. However, it is important to note that urban sustainability is difficult to achieve, based on current local, national and global rates of water consumption, and the prevalence of unsustainable urban development practices. The proposal presented in this practicum, on its own, cannot solve contemporary national and local sustainability problems, but it can provide a step in developing an urban renewal model in which water reuse is taken into consideration, as standard practice in urban development in the future.

8.2 Suggestions for Further Study

To promote on-site wastewater reuse as a viable water management option for existing shopping centres and other building types, both in terms of individual building efficiencies and the overall urban development sustainability, further extensive research is necessary. The following twelve research opportunities have been identified to encourage further exploration of how best to promote and implement on-site wastewater reuse, as an alternative, ecologically sustainable, urban redevelopment strategy.

- Researching further the national and global potential of water reuse, to demonstrate, if widely implemented, whether or not it could provide a solution to potential fresh water shortage in the future.
- Further examining current public attitudes and public policies regarding wastewater reuse.
- Recommending how the existing federal, provincial and municipal regulations and codes should be changed to provide a greater degree of flexibility in permitting an on-site wastewater reuse facility.
- Researching the public awareness and acceptance of wastewater reuse
- Replacing municipal sewage treatment plants with solar aquatic facilities in suburban areas, through an evaluation of their environmental, economic and social benefits and drawbacks.
- Proposing the incorporation of a solar aquatic facility in new shopping malls and buildings.
- Identifying the use of solar aquatic facilities in different types of buildings (e.g., office complexes, industrial factories, recreational facilities.)
- Investigating the other methods of collecting the wastewater from GPM.
- Refining many of the assumptions made in the conceptual design, most notably: wastewater quantity, design flowrates, cost of solar aquatic facility and additional renovation, and revenue from the merchandising of plants.
- Investigating the possibility of implementing a larger scale solar aquatic facility to treat wastewater from the neighbourhood through the city sewer line on Hector Avenue.
- Identifying better means for incorporating solar aquatic facilities with the overall aesthetic quality of buildings and sites.
- Conducting a study of the implications for settlement patterns (such as residential subdivisions, and commercial land use patterns) as a result of implementing solar aquatic systems in residential communities or commercial areas.

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Appendix A: Research Process and Interview Records

Appendix A 1: Ethic Approval for Personal Interviews

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Office of Research Services
244 Engineering Building
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APPROVAL CERTIFICATE

07 June 2001

TO:	**Kevin Yim** Principal Investigator	(Advisor D. Van Vliet)
FROM:	**Wayne Taylor, Interim Chair** Joint-Faculty Research Ethics Board (JFREB)	
Re:	**Protocol #J2001:047** **"Ecological Planning of Greywater Reuse: A Case Study of the Feasibility of Greywater Facilities in Grant Park Shopping Centre"**	

Please be advised that your above-referenced protocol has received human ethics approval by the **Joint-Faculty Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement. This approval is valid for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Appendix A 2: Consent Form for Interviews

This study is being conducted in order to examine the possibilities and constraints of the implementing an on-site wastewater reuse system in Grant Park Shopping Centre. The information gained from this interview will contribute to the identification of issues associated with implementing this proposal. This study is being conducted by Kevin Yim as a requirement to fulfill the graduate requirements from the Master in City Planning degree from the University of Manitoba. This practicum work is being supervised by Dr. David van Vliet of the Department of City Planning, Faculty of Architecture at the University of Manitoba.

Within this interview you will be asked to answer or comment on five questions regarding the use of greywater systems in shopping centres. With your permission, this interview will be audio taped so that analyzing the material at a later date will be completed with greater ease and efficiency. The anticipated length of the interview will be 20-30 minutes. It is important to note that your participation is voluntary. If at any time a portion of this interview makes you feel uncomfortable in any way, you may choose to terminate the interview. Also, if you have any questions or concerns during the interview feel free to ask the interviewer at any time.

Your identity will be kept as confidential as possible. This means that your name, your position, your organization's name, and any other information that may disclose your identity will not be included in the final report of this study. Please be aware that your identity may become identifiable in the final report.

If you are interested in viewing the final report, it will be made available for you to read in October 2001. This work will be published as a practicum and will be placed in the Architecture and Fine Arts Library at the University of Manitoba. This information may also be considered for future publication within planning journals by the researcher.

The study has been approved by the University of Manitoba's JFREB, and any complaint regarding a procedure may be reported to the Human Ethics Secretariat (474-7122), or to the Head of the researcher's department (474-7352) for referral to the Research Ethics Board. If you have any questions or concerns after this interview is completed, please feel free to contact Dr. David Van Vliet through myself at 1-204-275-5618, 1187 Chancellor Drive, Winnipeg, MB, Canada – R3T 4T6.

Thank you for giving your time to participate in this interview. Your responses are very valuable to this research project and are greatly appreciated.

I, ____, give Kevin Yim permission to use the information gathered during this interview under the conditions stated above for the purpose of researching the possibility and constraints regarding the implementation of wastewater reuse systems in shopping centres.

Date ______________________________________

Respondent's Signature ____________________________

Researcher's Signature ____________________________

Appendix A 3: Discussion of Changes Made During First and Second Round of Interviews

Original Questions in First Round of Interviews

Q1. How familiar are you with the concept of greywater recycling?
Q2. Do you support the use of a greywater facility in a mall context? Why, or why not?
Q3. What do you perceive as the environmental, economic and social benefits and/or drawbacks of incorporating greywater facilities in a mall? (Please be as specific and detailed as possible)
Q4. What would be the most important considerations/criteria you would reference as regards the design of greywater facilities?
Q5. How do yon think those criteria can be realize/demonstrated in a conceptual design exercise?
Q6 How would you mainly judge the success of a greywater recycling intervention?

The first interview took one hour to conduct (originally scheduled for 20 minutes), since a number of questions needed to be clarified. The original questions in the questionnaire did not cover what I intended to know, so Q5 was added and the original question was changed to Q6.

After the first interview, notes and examples were written along the questions on the questionnaire to guide the interviewee as to the intent of the questions. Furthermore, for the second interviewee, a copy of the questionnaire was provided in the beginning of the interview, to facilitate responding to the questions. Following this second interview, in order to let the interviewees understand the questions thoroughly, a copy of the questionnaire was sent to each interviewee so the participants could think about these questions prior to the next interview. After the revision of interview questions, Q6 was not used, since the responses were similar to that of Q5. The interview with the third interviewee took a relatively short period of time. Upon the completion of this interview, this third interviewee informed me that he was not willing to participate in the second round of interviews, since he felt that he would not have any more information or opinions to relate.

The interviews are examined and summarized in Chapter Four. The exact or similar words used by the interviewees were also maintained in Chapter Four to reflect their opinion and attitude in the practicum. Furthermore, the interviewees were not interrupted unless the participants needed clarification of the questions.

The following is a copy of interview questionnaires faxed to the interviewees before the interviews. Notes are included to clarify the questions.

In this interview you will be asked to comment on six open-ended questions regarding the opportunities/constraints of the use of greywater reuse facilities in shopping centre. The interviewees are key informants based on their expertise, who are also in a position to promote and implement such proposals. Interviewees for my practicum will also include a mall manager, a designer and a developer and a site manager of a greywater facility. The goal is to obtain different viewpoints about the practicality and complexity of realizing this idea.

(2 short conceptual questions -- no detail necessary)
1. How familiar are you with the concept of greywater recycling? *(have you heard of it? how much do you know about the concept and what it is like?)*

2. Do you support the use of a greywater facility, in a mall context, such as the Grant Park Mall? Why or why not? *(as a designer/or educator, do you think it's appropriate in a mall would you attempt to do it given opportunities?)*

(Main question)
*3. What do you perceive as the environmental, economic and social benefits and/or drawbacks of incorporating, greywater reuse facilities in a mall such as the Grant Park Mall? *(Please be as specific and detailed as possible) (3 separate perspectives- 2 sides, you can talk more about what you concern the most)*

(Related to the conceptual design)
*4. *(as a designer/or educator)* What would be the most important considerations/criteria you would reference as regards the design of a greywater facility in a mall? *(e.g. Economic: initial cost- potential saving/benefits...potential funding, Aesthetics and efficiency of facilities, Environmental: technical -zero discharge/biodiversity, social-the educational value)*

5. How do yon think those criteria can be realized/demonstrated in a conceptual design exercise? *(e.g. economic- as cheap as possible - conceptual design (math) wants to estimate how much I can save in this particular mall) (aesthetic - want to see how it may look like - attractive to people to come) (biological system - what are the components) (educational centre - design, educational program)*

*6. How would you mainly judge the success of a greywater recycling intervention? (initial cost is repaid after 5 years - demonstrate a sound investment, demonstrate an attractive design, demonstrate its potential to relieve the present wastewater plant, technically sound... concrete- conceptual)

Original Questions in the Second Round of Interviews

1. What is your considered opinion of the conceptual design(s) in terms of demonstrating the potential environmental, economic and social benefits, while minimizing the drawbacks, of the proposed/illustrated on-site solar aquatic facility?
2. What are the main deficiencies of the design(s) in terms of environmental, economic and social issues? How would you suggest that they be remedied?
3. As a conclusion, with the demonstrated conceptual design, do you think it is feasible to realize a solar aquatic facility in the Grant Park Shopping Centre?

Since most of the first round of interview sessions took longer than intended, more attention was paid on the duration of the second round interviews. As a result, 7 to 10 minutes were spent on presenting and explaining my conceptual design, then allowed 15 to 20 minutes for feedback in the interviews. In the first interview session, the interviewee was asked to comment with all my design criteria, but after that session I realized that it would take longer than 20 minutes for interviewees to comment on the conceptual design. Furthermore, there was a tendency that the interviewees either did not have specific comments on certain parts of the conceptual design, or simply could not recall most of the design criteria was mentioned to them before, except the ones that they specifically emphasized before. Therefore, I concluded that the overall interviews would be more effective if the interviewees focused their critique on the areas related to their expertise. Consequently, after the first interview session, the interviewees were no longer guided to discuss specific issues. Instead, they were reminded most of the issues/criteria they raised during the first interviews, and they were asked to comment on those issues directly.

The conceptual design was presented to each interviewee, so that they were able to gain new information and knowledge from the interview sessions. Each interviewee spent a considerable amount of time suggesting how to improve the quality of the conceptual design, rather than focusing solely on the discussion of the strength of conceptual design. Although they focused on examining specifically to a few issues, their comments appeared to complement one another.

Appendix A 4.1: Modification of Conceptual Design After Second Round of Interviews

Input from the first interview – Grant Park Mall Site Manager:

The GPM site manager mentioned that some estimated figures on the cost-benefit analysis should be subjected to further research. He claimed that the cost of wastewater collection line on my original cost-benefit analysis needed to be seriously re-considered. His recommendation related to the diameter (sewer line: 7"-10", water line: 3 ½ ") and materials (water line: copper) of the wastewater collection line were taken. Other costs such as excavation cost needed to be considered. He supported the selected location of the proposed solar aquatic facility.

On the other hand, the developer (in the first round of interview) claimed that the tenants should be responsible to pay for the maintenance cost. I initially thought that the tenants would pay the maintenance cost directly. The Mall site manager clarified that the GPM owner, not the tenants, should not be directly responsible for the maintenance cost. Tenants should only pay for the rental increase agreed upon at the invitation of the mall renovation, but the mall owner would collect the extra money to pay for the maintenance and pay back the loan for the investment through the increase of rent. Therefore, the item "maintenance cost" on the Saving/Revenue column was omitted in the cost-benefit analysis.

The Mall site manager also emphasized that the loan must be paid back in 5 years, while 10 years payback period would not be appreciated by most investors. In conclusion, if the cost-benefit analysis showed that the payback period is 5 years or less, the proposal would be perceived favourably, otherwise the proposal is economically unfavourable.

Input from the second interview - Designer

The designer modified my original formula related to the calculation of gradients, in which the slope of 1 degree had been used. He recommended the formula, H=V/G, and 1% gradient to determine the depth of the wastewater collection line buried underground. He also mentioned that to enhance the accuracy of the estimated figures on the cost-benefit analysis, further telephone interviews with experts would be essential. Therefore, the price estimation of proposed greenhouse structure, maintenance of greenhouse, land excavation and governmental funding were obtained through informal telephone interviews.

The recommendations of the designer was taken as to create two options of intervention. An option is to design the facility as a service depot, and another option is to design the facility to be fully integrated with the mall. The option that could generate the more revenue would be recommended. The designer also felt that the physical design of the facility needs to be elaborated with design considerations such as access, public space, relationship between the facility and the existing fabric, degree of exposure to the public.

Input from the third interview – Retail Developer

The developer attempted to assist me to calculate the initial capital cost, loans and annual payment. He also provided new information (such as interest) required in the cost-benefit analysis. He also suggested ways to further modify the cost-benefit analysis, by creating two sets of charts, comparing the costs prior to and after the intervention. Furthermore, he provided some estimated figures related to the cost-benefit analysis, such as the typical cost of rental space and mortgage interest rate, and the projected increase of tenant rent.

The recommendation of developer was taken as to create two options for the cost-benefit study. An option is the cost and revenue with no intervention, and another option with an intervention. After rethinking of the designer's recommendation, three options were developed in the cost-benefit analysis. The first option is no intervention (quo status), the second option is an intervention as a service depot. The third option is an intervention with an elaborated design to integrate the solar aquatic facility in GPM.

The developer's optimistic view about the long payback period (10 or even 20 years) provided a different opinion than that of the Grant Park Site Manager. As a result, the proposal of the use of solar aquatic facility may be appealing to investors even if it does not meet the 5 years payback period.

Appendix A 4.2: Modification of Conceptual Design After Further Study

After the feedback and further study following Design Concept II, there were two choices of improving the conceptual design. The first choice is that the Design Concept II would not need to be changed but specifications would have to be provided to emphasize some certain features in the design. The second choice is that a more elaborate plan would be developed with additional design criteria. The second option was chosen. The purpose of the Final Design Concept was to examine how the new development (Option C in the cost-benefit analysis) was designed based on the response of the interviewees and further thought and exploration on the topic. New design criteria included in the Final Design Concept were:

- Establishment of stronger connection between the mall and the surrounding neighbourhood – develops a stronger social relationship between the two
- Addition of a free market – allows the community members buy and sell their home-made food and goods
- Addition of a mini-golf course – further expands retail space to increase revenue, enhance bio-diversity and increase shoppers
- Interruption of direct access to the solar aquatic facility from the mall – ensures the safety of the shoppers and minimizes vandalism
- Installation of skylights – allows the growth of vegetation in the reactors and flower beds, which are placed at a distance from the greenhouse
- Addition of planters and small sitting space in the main interceptions of pathways in the mall – further links all the anchors and tenants together
- Add planters in all main entrances and throughout the malls – maximize the use of treated water in the mall, and further reinforce the ecological theme developed in the mall

Appendix A 5.1: Interview Records: First Round of Interviews

Participant #1: A Designer/Educator

1. Yes, I have seen some examples as well, I am similar with some literature on this subject, some Danish examples. I know design such as John Lyle who designs it.

2. Yes, I think we should think about the opportunities to use it in every situation, whether it is residential, commercial, and recreational. There are great opportunities for shopping malls to use it

i) people should take every opportunities to implement it
ii) get a large crowd of people everyday – good for educational purpose
iii) teach and encourage people to recycle greywater,
iv) if it is done well, it can do a lot of positive things for the community
v) all the recycling-related idea would become popular: conservation, reuse and reclamation e.g. saving water → go green
vi) helps to create a more sustainable community in a long run

I have never had any opportunities to be involved in a project that allows this kind of experimentation, but if I do, yes for sure.

***3.** *Environmental:*

(+) It provide more physical diversity in the urban area of Winnipeg, increase bio-diversity and allowing wild life to live. It would be visually pleasing with potential cooling of the temperature in the surrounding environment. Hence it can create a healthier physical environment.

One is doing an ecological service to an urban environment – encourage wildlife habitat in urban area

(-) Technical: concern about the sanitary system

-the existing sanitary system is designed to connect to the local sewer system. the sanitary system is designed in such a way to use water to flush the toilet and carry the solid waste all the way to the sewage line on the street, by natural gravitation with 1-1.5% slope (Figure A1). If the greywater (water from urinal, sinks) are now separated from blackwater, taken away from the system, there are less flow as less liquid carrying the sludge, and the sludge might not reach the sewage line on the street, but build up along the sewage line instead. It is a prototype, and that's the problem that is needed to be thought about. There's a possibility that the solid waste may get backed up the sewage line. But this mechanical problem could be addressed technically by engineers.

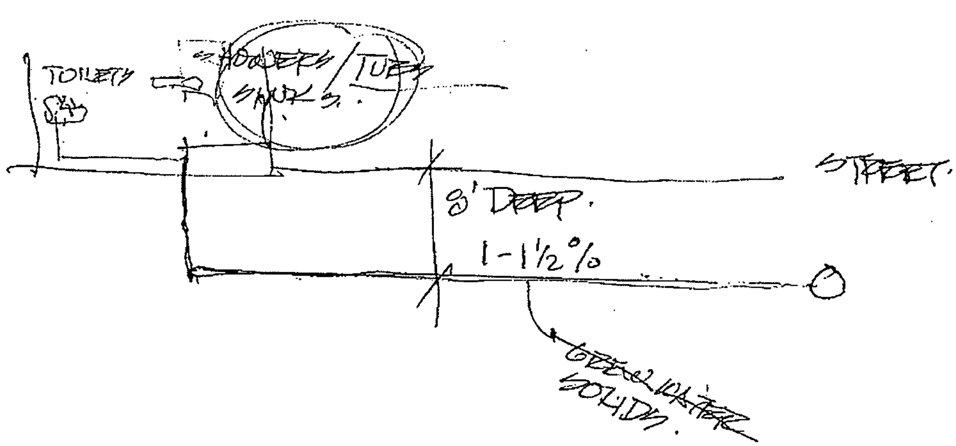


Figure A1: Designers' Explanation of Gradient

Do you have adequate space to treat the greywater? for sunlight to filter in the greywater system. A well-designed greywater system is necessary.

Also precautionary measures, that any sludge/solid is removed, greywater treated to a satisfactory level, and any chemical is removed if the water is used in agriculture.

As far as I know the mall is in a urban area, and there is public health restriction that may prohibit the greywater system. I think the changes in public health restriction and zoning regulation are required if the greywater system are put in place.

There are potential physical problem in wintertime as the greywater freeze up. (Kent State University) use spray irrigation to irrigate the forest in winter time (greywater will freeze but the sunlight may break it down and land on the vegetation, or the frozen greywater will sit on top of the soil and wait for spring time to melt and be absolved into the soil.

If it's a internal system there is little problem with winter.

Economic

(+) There is definitely longer term economic benefit. It reduces the fresh water required. The mall becomes environmental friendly-probably much more popular than now.

(-) The whole existing water system is needed to be changed because greywater is separated from the blackwater. So two sets of pipes in the building are necessary, rather than one. It will be more expensive, epically in a prototype situation.

If used in a small scale would due expensive, don't have space for it.

Social

(+) A mall is a great place because it makes a lot of people realize the value of greywater recycling.

New form of public space will be created in the community, helping to foster more social interaction, and generate potentially social capital. It creates a real amenity to the community, a major plus to the community and the city.

(-) I think the public is not ready for it. General people do not understand, and do not see the value of recycling greywater.

All do not prevent a commercial development like malls to experiment with it.

Location – where do you locate these features, next to building, rooftop, and parking lot? where are you going to treat this greywater. Is there enough space? How are you going to treat it? What does it look like? Is it going to be surface water or underwater. If it is a surface water then you have to have safety issues to deal with, will children felt into the water, also public health issues as well, is it going to have any smell, negative sight, or is the greywater harmful to be contacted. Is there other negative things that are needed to be get rid of?

e.g. Germany, residential block... 4-5 story greenhouse-treat greywater terrace.

Orientation – presence of sunlight. Ventilations, depth, how depth the new sewer line is, the greywater system(whole or parts) if it's hidden underground (below frost line?)

Safety-kids
Public Health-smell, overthrown of sludge
How it is a positive addition to the sight(mall)?

Volume – is there adequate volume of greywater available? Is it just office, restaurants, or what is connected to the common sewer lines? Other water resource may be added to it, surface runoff like rainwater can be added to it. Parking lot has 100% runoff since there are no planted areas.

5. Now what you have is a massive structure (shopping centre) and a parking lot

Design: there are many features that you can add to it – like ponds, fountains, pools, add visual delight to it. Design wildlife habitats and social meeting place

- -visually what it may look like
- -an urban design project
    - -it demonstrate how successful those criteria work out
    - -give someone an idea what the idea can turn out to be like

Performance Specification: -What is this landscape suppose to do – irrigation…
-indicate benefits
-Some Sustainable Criteria can be met (um website)
-indicators of a sustainable community
-water become an important element

Public acceptance
Economic facility – not too expensive to operate
-Not a huge maintenance cost/liability
Normal sewage system still work
-The new system has little impact to the existing sewage system (not affecting other people)
Physical – don't have smell, physical mechanical problem

6. Public acceptance
Economic feasibility – not too expensive to operate
-not a huge maintenance cost/liability
Normal sewage system still work
-the new system has little impact to the existing sewage system (not affecting other people)
Physical – don't have smell, physical mechanical problem
Another step –inquire the public, post it in mall, let the community comment, participate, get feedback…

Participants #2 – A Retail Developer

1. A low level of consciousness
See headlines about greywater reuse
However, when it brought to my attention
-I think of it in a more positive way
-there would be marketing advantage, political agenda, feel-good reason
-maybe a little more capital cost worth of it.

2. It will allow people going to the mall
-to see it used in a commercial setting
-put a little more effort to recycle in their residential environment

3. Environmental – conservation aspect
Economic – can be the potential to attract environmentally-sensitive shoppers and tenants
-less consumption within mall
Social – the thinking outside the box to benefit the citizens
-including those that are neither tenants nor shoppers
Negative aspects
Environmental – no negative effect
Economic – a fear of the unknown
-will there be more maintenance cost
-there is a sufficient amount of technician available
-worth of hiring, funding availability
→ maintaining the equipments

4. If there are any visual, physical constraints by using the conventional systems
-that (innovation) will be minimized
-will be used in consumption
-the "goodwill" of a developer
the layout of tenants and public space is something that evolves and changes through tour the life of mall
-will the facility create inflexibility of this change in the future?
e.g. Future Store want to expand 175 Sq. m.→ sewer line anywhere to accommodate?
Look at the system if it is flexible and compatible with location, change of tenants

5. Cost-benefit analysis can show the tenants

-Capital cost paid by developer (who has to know all the capital cost in order to set up rents)
-Maintenance cost paid by tenants
Calculation with examples
-explanation of calculation
-to share with future tenants, investors, lenders
6. The capital cost is reasonable
If there are government program initiative
-Tax credit
Publicity from project
-promote the project
-by articles, business publication
If it is going to add to the project
-quite a risk
-a few % to the total cost of a project
-need a more serious consideration
Retrofit situation
-yes, it must be different
-all capital is additional, not complicated
- weight against Energy – Consumption saving
- whether tenants give you credit to help them in the future

Participant #3: Wastewater Facilities Site Manager

1. No very little, have all the brochures.
2. I don't really know the mall context, so I can't comment
-think that every study should be site specific
3. Education – education to the public should be the theme (goal)
-experiment any environmental-sound systems
-kids need to learn
– change perception that waste can be reused
– be environmentalists in future
Environmental – protecting the wild nature – biodiversity
-bring some wildlife – more diversity, variety back to urban centre
Could be very low maintenance cost
-little training for on-site managers
rely on expertise's knowledge
-engineers, biologists to study
-might have difficulties to find technicians to fix the problem if it happens
-no prior experience hurts
if no sewer/water line –economically-sound

4. -presumably self-sustaining
-little training is necessary
-almost no need for maintenance
-no cost
have a backup plan – if things do not work –what to do?
Easy enough to let me
-present it in a way that the visitors know the systems
Where is it
-Easy to maintenance
-wildlife – components like marsh is valuable
5. Report of current situation
-visitors (number)
-water (amount spent)
-change in future

technically-sound conceptual design
-make sense to me
conceptual diagram
-a back up system
consideration on maintenance need

Participant #4: Grant Park Mall Site Manager

1. Basic

Make use of uncontaminated water
-reuse that water
-for all purpose – urinal, drinking water

2. Under certain circumstance → yes

Reality – in new construction situation – yes
Retrofit situation – cost → hard to recover
Yes –under a lot of circumstances
Not cost-benefit
Now combined greywater + blackwater
-new- system – 2 pipes
-dig in concrete – add pipes
-lot of noise, work
Unless water price increases dramatically
-don't see it happen now

3. Social barrier

-people don't understand greywater
-biggest problem in Canada
- (if facility is used) people on street start to recognize
-"Everybody wants to save, but not for me"
-the idea hard to sell
-City is bad with recycling
Typically in a mall
-a different sewer
-not one central sewer location → hard to collect
-run to different drainage
-some freshwater demand can be replaced by rainwater easily
If you want to
-rainwater – piping
-reuse, minor filtration
-nutrient, cleaner, a lot of rainwater
-piping gallery → buried on the ground

Environmental – nothing better than recycling
Only problem is economic
Now combined sewer
-rainwater- blackwater –greywater combined
-large volume
-separate – a lot more effective
-same for most malls
-can't recover easily
-half a million feet roof, runoff, 400,000
-catch base – separate from sanitary
-1 million square feet

4. Not necessary to save money

→ no deficit
"environmentally-friendly"-big

-ongoing –close to break-even
(+) public relation value
-owner of property – look at dollars
-cost – save
-has to be close –money wise
(design) aesthetic pleasing – fit in
-can't change existing tenants
Mall- problem-don't have room for storage
-space – premium
- has to be compact
- narrow – resizing, relocating
- not bigger the McDonald's
- land – expensive
-have certain amount of footage
-don't take up a lot of space – floor space
Efficiency – part of design
Greater Social educational values
– environmental –concern
– 1950s – tremendous waste of resources
Yes. It has to be present
-dollars and cents that add up
-give a good idea
conceptual drawing
-actually see how it fit in
Full mechanical layout
-conceptual
-block diagram form
5. Not real dollars
Increase in water cost
-5-10 years payback period
-life expectancy
-20 years
-30 years
-e.g. pumps
Benefits of systems more than just payback → continue
-life expanse
-people want to see economic gain
Payback – not necessary equal
-Has to look at increase of customers
-Most people -advertise – a project – more than 5 years
-most people don't like longer
Very difficult to do retrofit
-sometimes never recover capital cost
code: sanitary, catch basin, rainwater
New facilities – need more storage system
-under the ground → environment
-don't lose space
sewage charge decrease
look at Wal-Mart and Safeway as well

Appendix A 5.2: Interview Records: Second Round of Interviews

Participant #1: Grant Park Mall Site Manager
(No comments on biological process of the designated solar aquatic facility)
Addition of new sewer line

-not accurate estimation ($ 4,000)

-a new water line was installed around the part of the perimeter of the mall two months ago, and its cost is $ 500,000. Since the length of that water line is half of the length of the proposed sewer line in my proposal, he estimates that the cost of installing the proposed main sewer line would cost at least $ 100,000

-the sewer line would be 7"-10" in diameter, starting from 7" from either end to appropriately 10" when the sewage reaches the point where the sewage plant is.

Estimation of new water line

-estimates the length and material of water line (Copper) that is necessary to connect the facility to the main washrooms. He estimates that it would cost $5,000 – $6,000.

Proposed location of solar aquatic facility

-difficult for loading tracks, semi-trailers to drop off products and pass the facility in the parking lot

-agrees that this is the only under-utilized place available, with relatively short additional sewer lines to collect all the sewers.

-he disagrees the idea of the solar aquatic facility building on the 2nd floor, claiming that such investment would be astronomical.

-claims that the interest is an important part of the whole investment,

-considers that the interest of such investment is very high.

One has to put up a monitor, or meter to evaluate the amount of wastewater not going to the public sewer system, in order to obtain reduction of sewer discharge fee.

When the facility occupies the original mall space, the rents of the occupied space should be added to the total cost of the facility.

-about $ 20-30 per Sq. Ft.

Tenants should not pay for the maintenance cost, the maintenance cost should be paid by the mall management together with the reduced fresh water and sewer discharge cost.

Tenants in the mall are likely to oppose the increase of rents. Getting the existing tenants to agree on the rental increase would be very difficult.

In conclusion, although there is inadequate information in the cost-benefit analysis, the number seems to suggest that the initial capital cost would not be recovered in 10 years.

-5 years pay-back period would be attractive

-10 years pay-back period is discouraging

-such a proposal is difficult to be implemented

-since the sewer and potable water gathering and distributing systems were never designed to accommodate such facility

Participant #2: Designer
States that the gradient of main sewer line should use the following equation

-1% gradient

$H = V/G$ H = horizontal distance, G = Gradient

phone the City – water and sewage department

-excavation cost per linear feet – wider of sewer pipes: 8 in

All figures on the cost-benefit analysis must be legitimate estimation

-with some source

-Greenhouse – nursery should call Plant Science Greenhouse, Dept. of Agriculture on Campus

-talk to expertises

-cost associated with greenhouse has to include heating, lighting and cooling cost per annum

Two approach of installing a solar aquatic facility in the Grant Park Mall

1. as a service depot - hide the facility, while weight the cost of the facility against the saving it brings
2. integrate the facility with the existing retail fabric in the mall (Figure A5), promote educational value of recycling. So the cost of the facility will be weighted against the water savings, and the environmental and social benefits the facility bring

-right now the design looks as if it is excluded from the rest of the mall

-the physical design needs further elaboration

-with design issues such as access, public space,

-establish more relationship between the facility and the existing fabric

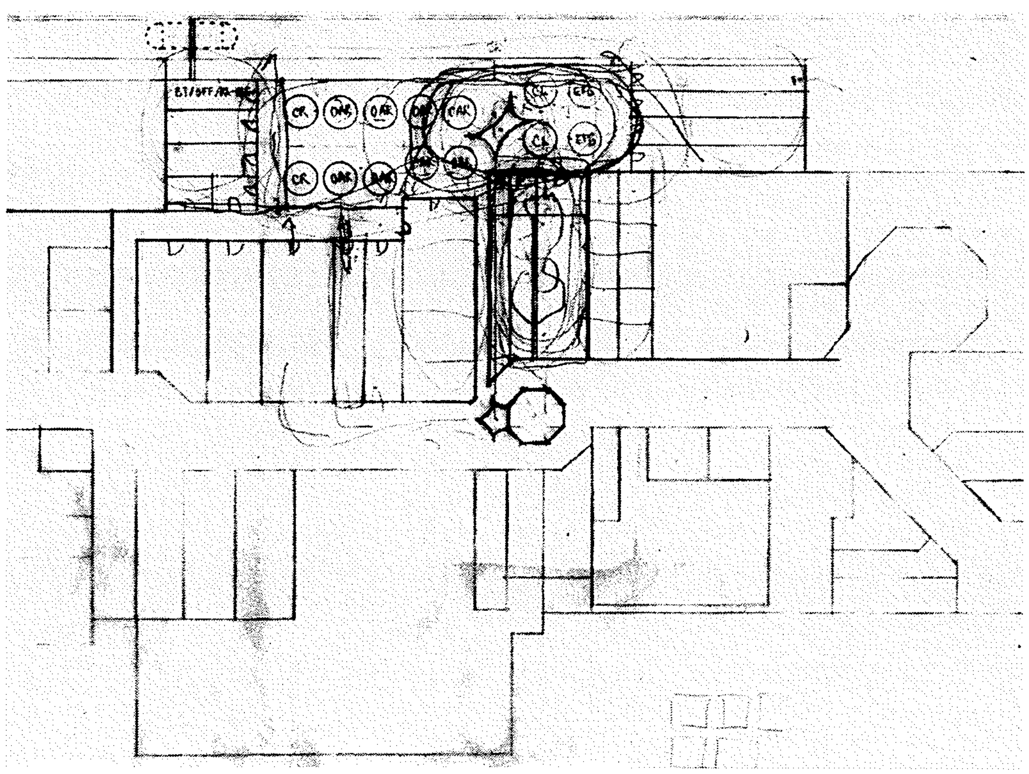
-maybe 2-3 levels are used

-design questions: is all the solar aquatic system components exposed to public

-potential odour, safety issues

-what's the design of all the solar aquatic system components

There is possibility of implementing the intervention, because economic cost is weighed against a lot of things besides the saving, such as environmental, social benefits. One needs to further research some of the figures in the cost-benefit analysis and further elaborate the design.



Designer's Suggestion on Design Integrated with Mall

Participant #3: Developer

Should separate one-time cost and the annual fees (maintenance)

The rents of a mall such as the Grant Park Mall

-appropriately $ 50 per Sq. Ft.

The cost-benefit analysis should include inflation

-1.5% every year

The cost-benefit analysis should include two sets of chart

1. if you install a solar aquatic facility
2. if you do not install a solar aquatic facility

The tenants should be willing to pay $ 1.00 to $ 1.50 per Sq. Ft. to install the facility

If the lifespan of the facility is 20 years, maybe the developer should get a 20 years mortgage

- 8%

Facility provides enormous Social benefit

Impact on communities

-not only 2 miles

-include 3 miles from the mall

Vegetation & fertilizer

-more detail is needed

-quantity, who to sell it to (Wal-Mart)

Payback time

-10 years – good deal: saving, being "environmentally-friendly

-even 20years payback time is a good deal

-because this is a local, national and global trend to be environmentally-friendly

-very significant to a mall

Table 6.5 Short-term Cost-Benefit Analysis (1 Year period)

	Cost	Saving / Revenue	
Capital Cost *- Solar Aquatic Facility* *- Design Service* *- Greenhouse structure* *- New Piping Systems* *- Project administration*[94]	$ 1,029,197 -$ 726,750 -$ 109,012 -$ 60,960 -$ 131,475 -$ 1,000	$ 12,397	***Reduced Water Consumption***
Total Maintenance Cost	$ 76,500	$ 54,237	***Reduced Sewer Charge***
Occupied existing retail space	$20,000	$ 69,888	***Horticulture*** net profit
~~***Interest (3% Capital Cost)***~~	$ 30,876	$ 16,350	***Fertilizer Sale***
		$ 76,500	***Payment by tenants for Maintenance cost***
		$ 50,000	***Potential Governmental Funding (Waste Reduction & Pollution Prevention Fund)***
Total	**$ 1,129,573**	**$ 279,372**	

Simple Interest
1029,197
@ 8% over
20 YEARS
Monthly compounding
pmt 8608.62
x 12
103,303.39
per annum
76,500
subtotal
179,803.39

psf -

+ water costs

Figure A6: Developer's Explanation to Calculate Capital Cost

Note: the illustration above is reduced for keeping record in the document

Appendix A 6: Presentation Materials associated with Second Round of Interview

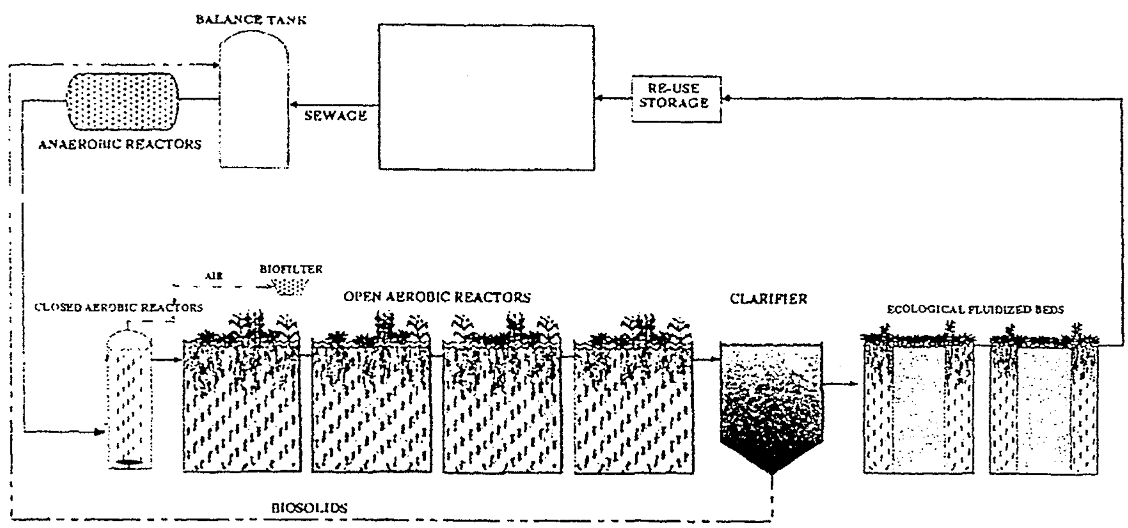
The purpose of this design concept development is presented to the interviewees and solicits their response.

Design for Ecological Benefits

1. Evaluation of Wastewater Design Flowrates

Month	Water Consumption according to Meter One & Two (/Cubic Foot)	Total Estimated Water Consumption (*1.8) (/Cubic Foot)	Total Estimated Water Consumption after Renovation (*1.2) (/Cubic Foot)	**Total Estimated Amount of Wastewater** (*0.85) (/Cubic Foot)
Nov. - Feb.	251,830	453,294	543,952.8	
Feb. - May	225,002	405,003.6	486,006.3	
May - Aug.	271,881	489,385.8	587,263	
Aug. - Nov.	334,255	601,659	721,990.8	
Total Per Year	1,082,968	1,949,342.4	2,339,212.9	1,988,331
Monthly Average	90,347.3	162,445.3	194,934.4	165,694.2
Daily Average	3,015.6	5,414.8	6,497.8	**5523.1 per day (156,462 Litres/day, 41,338 US gpd)**

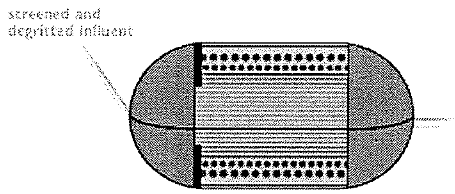
2. Development of Treatment Process Flow Diagram

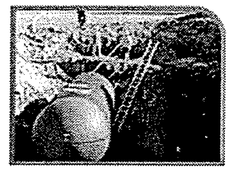


Basic principles and system components of the solar aquatic facilities

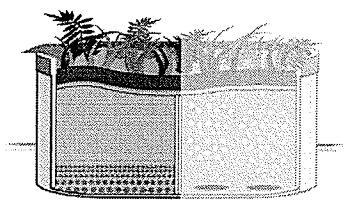
1. Microbial Communities - bacteria, foundation of facility, as catalysts for biological reactions, as food for higher-order organisms
2. Photosynthesis - main source of energy
3. The concept of natural ecosystem - nature being capable of adapting to a changing environment
4. Sufficient supply of mineral nutrients must be maintained by controlling wastewater flow.
5. Species diversity - all biological tasks have a role in the overall functioning of the facility

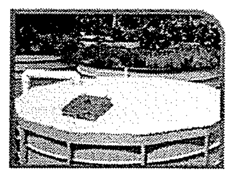
Step One: Anaerobic Reactor



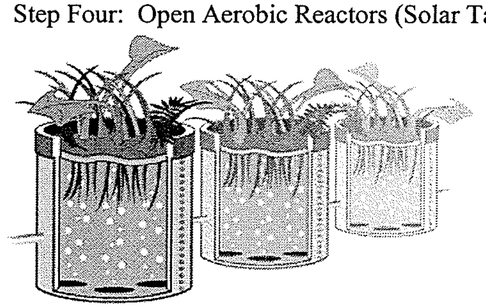


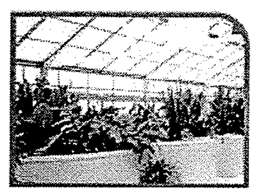
Step Two: Closed Aerobic Reactor



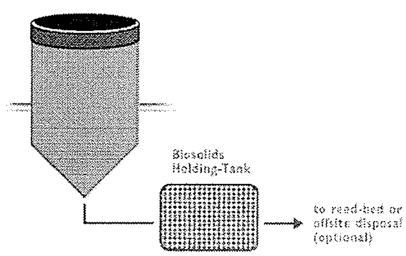


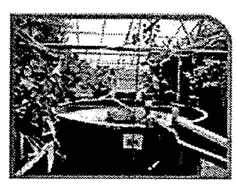
Step Four: Open Aerobic Reactors (Solar Tanks)



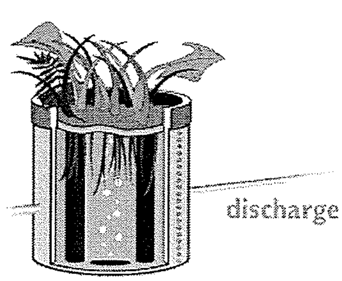


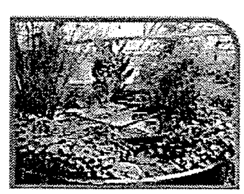
Step Five: Clarifier





Step Six: Ecological Fluidized Beds (EFBs)





3. Preliminary Sizing of Treatment Components

Process Summary: Components	*Number*	*Total cubic meters*	*Retention Hour*
Closed	1	48.5	9
Open	4	194	34
Clarifiers	1	48.5	6
EFB's	2	97	11
Total	8	388	60 (both Trains)

4. Development of a Facility's Physical Layout

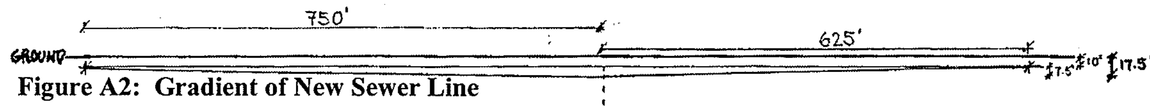
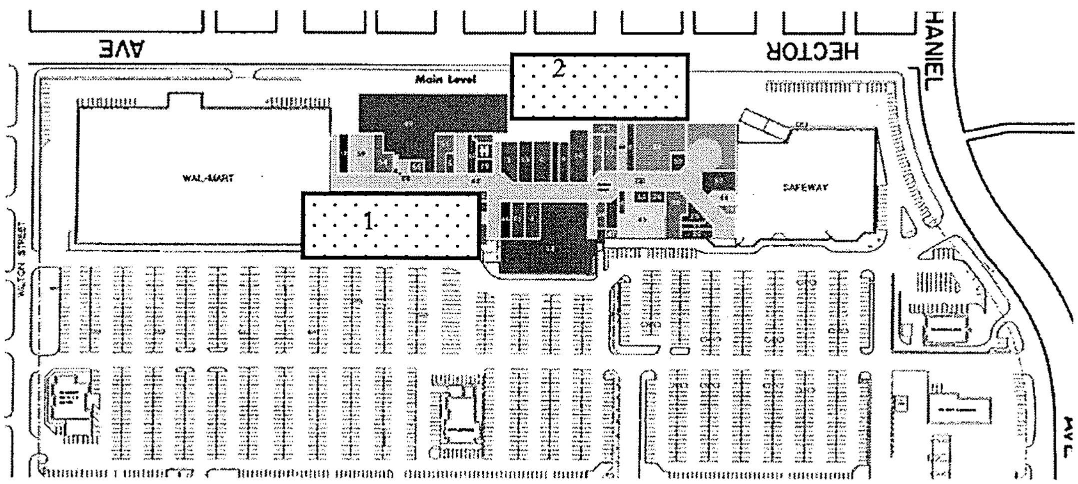


Figure A2: Gradient of New Sewer Line

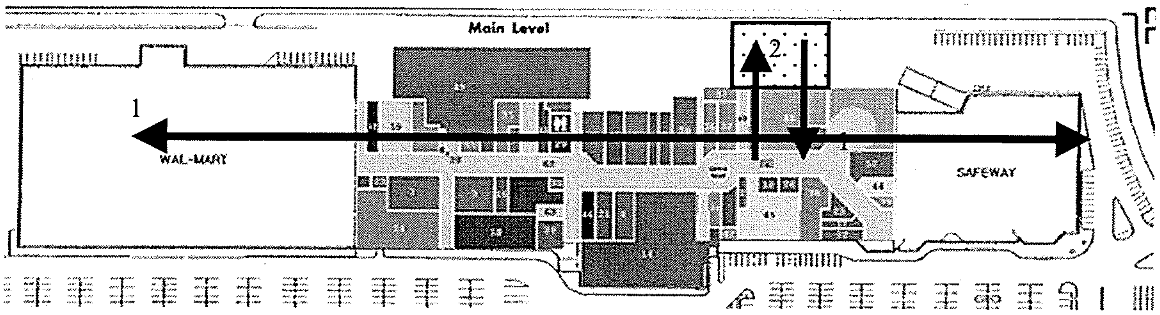
Location of a solar aquatic facility



1 Front:
- Higher visibility
- More attention from the visitors
- More shoppers using the organic gardening
- Physically more appealing
- Tremendous energy loss – resource inefficiency

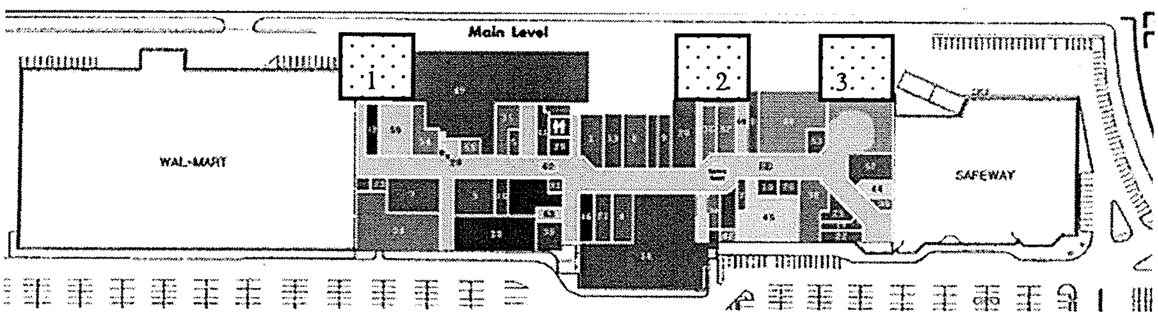
2 Back (Adopted)
- South facing with more sunlight. More efficient for wastewater purification
- More economical
- Closer to main sewer lines
- Un-utilized space available for the building of new facility

Designated Circulation Path



1. Existing Layout
- I - shaped
- Linear circulation path
- Perceived far distances between anchors

2. Proposed Layout (Adopted)
- L – shaped or T– shaped
- Circular circulation path
- Shortened perceived mall distance between anchors
- Encourage longer visit

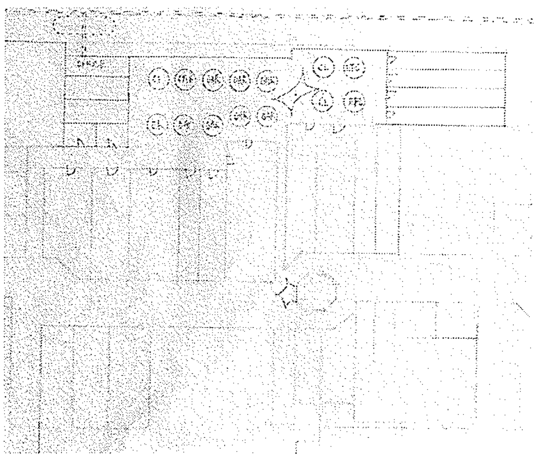


1. Close to Cinema/Zellers
- Attract many visitors because the space is popular now
- Lowest cost for main sewage collection line
- Close to major bathroom, the educational value is higher
- Limited amount of space for the facility and new retails
- Difficult to attract shoppers from the opposite ends to

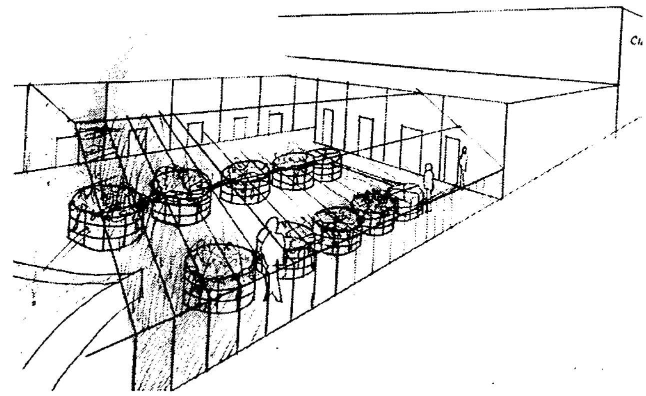
2. Close to Central Courtyard (Adopted)
- Existing skylight in the central courtyard provide lighting for the proposed vegetation
- Middle point of the mall would attract shoppers from left or right wing of the mall
- Shortened perceived distance for the mall
- Opportunities for watering the plants in the courtyard
- Close to all three anchor stores and food court
- Relatively low cost for the sewage collection pipes

3. Close to Food Court/ Safeway
- Attract many visitors because the space is popular now
- Cannot attract shoppers from the opposite ends to come
- extremely high cost for main sewage collection line
- Difficult to attract shoppers from the opposite ends to come

Design Concept I - Grant Park Mall Solar Aquatic Facility



Design Concept I - Grant Park Mall Solar Aquatic Facility



Sketch of Grant Park Mall Solar Aquatic Facility

Design for Economic Benefits

Short-term Cost-Benefit Analysis (1 Year period)

	Cost	Saving / Revenue	
Solar Aquatic Facility	$ 726,750	$ 12,397.35	Reduced Water Consumption
Design Service	$ 109,012	$ 54236.63	Reduced Sewer Charge
Greenhouse structure	$ 15,000	$ 69,888	Horticulture***
New Piping Systems	$ 4,000	$ 16,350	Fertilizer Sale
Total Maintenance Cost	$ 76,500	$ 76,500	Payment by tenants for maintenance cost
Total	$ 929,262	$ 229,371.98	
preliminary analytical work			Increase in rental price
project administration (application for rezoning, approval from Manitoba Public Health, etc)			Funding/government leverage Sustainable Development Innovations Fund (SDIF) and Waste Reduction & Pollution Prevention (WRAPP) Fund
Occupied existing retail space			
interest			

Long-term Cost-Benefit Analysis (5 Year period)

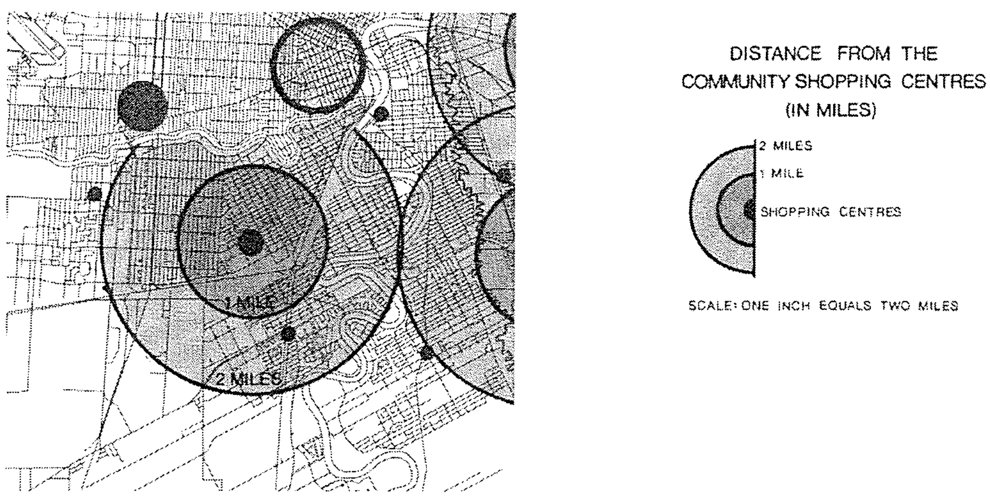
	Cost	Saving / Revenue	
Solar Aquatic Facility	$ 726,750	$ 61986.75	Reduced Water Consumption
Design Service	$ 109,012	$ 271,183.15	Reduced Sewer Charge
Greenhouse structure	$ 15,000	$ 349,440	Horticulture
New Piping Systems	$ 4,000	$ 81,750	Fertilizer Sale
Total Maintenance Cost	$ 382,500	$ 382,500	Payment by tenants for maintenance cost
Total	$ 1,236,262	$ 1,146,860.15	
preliminary analytical work			Increase in rental price
project administration (application for rezoning, approval from			Funding/government leverage Sustainable Development

Manitoba Public Health, etc)			Innovations Fund (SDIF) and Waste Reduction & Pollution Prevention (WRAPP) Fund
Occupied existing retail space			
interest			

Long-term Cost-Benefit Analysis (10 Year period)

	Cost	Saving / Revenue	
Solar Aquatic Facility	$ 726,750	$ 123,973.5	Reduced Water Consumption
Design Service	$ 109,012	$ 542,366.3	Reduced Sewer Charge
Greenhouse structure	$ 15,000	$ 698,800	Horticulture
New Piping Systems	$ 4,000	$ 163,500	Fertilizer Sale
Total Maintenance Cost	$ 765,000	$ 765,000	Payment by tenants for maintenance cost
Total	$ 1,619,722	$ 2,293,639.8	
preliminary analytical work			Increase in rental price
project administration (application for rezoning, approval from Manitoba Public Health, etc)			Funding/government leverage Sustainable Development Innovations Fund (SDIF) and Waste Reduction & Pollution Prevention (WRAPP) Fund
Occupied existing retail space			
interest			

Design for Social Benefits



Neighbourhoods within Primary Trade Area (within 1 mile)
See Appendix C 3

Neighbourhoods within Secondary Trade Area (within 2 mile)
See Appendix C 3

Appendix B: Site Data

Appendix B 1: Traffic Counts – GPM 1999 and 2000

Appendix B 2: Site Map of Grant Park Shopping Centre

Appendix B 3: Existing Sewer Lines

Appendix B 4: Site Photos

B 4.1: South Elevation of Proposed Site

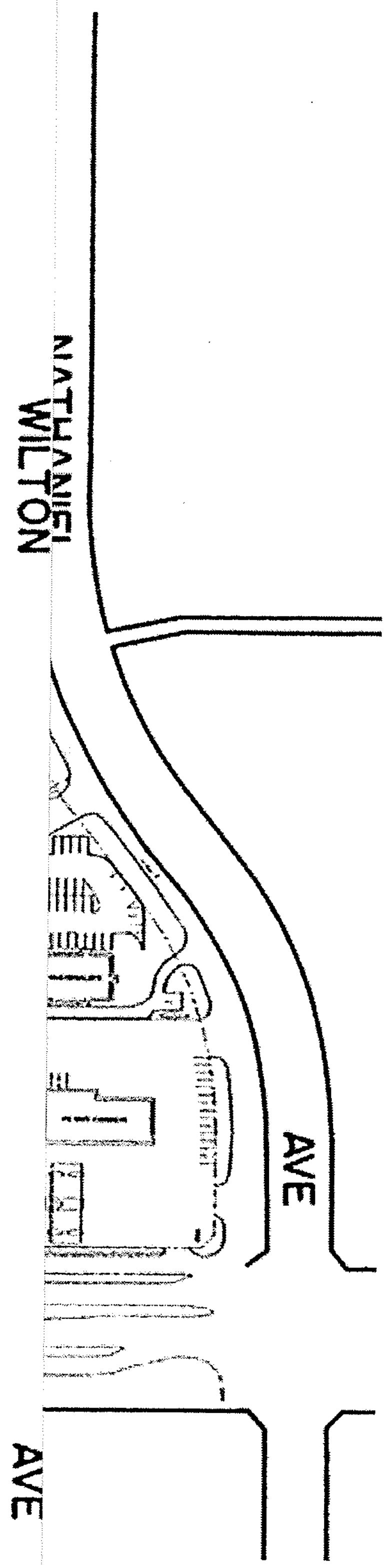
B 4.2: North Elevation of Proposed Site

B 4.3: South Elevation of Adjacent neighbourhood

Appendix B 5: Tenants List - Grant Park Mall, 2000

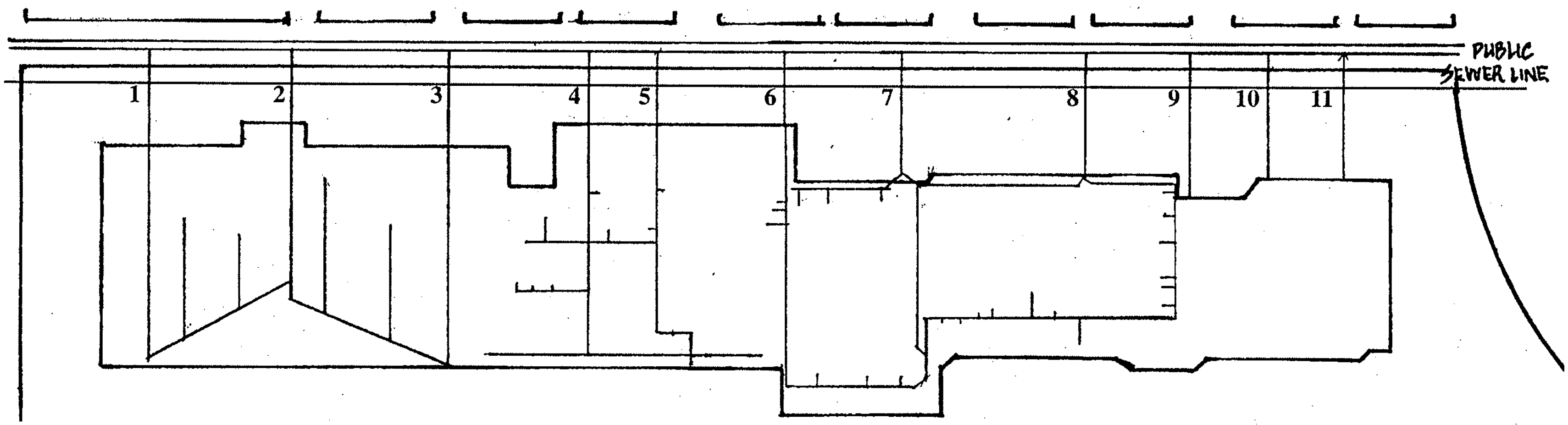
Appendix B 1: Traffic Count - Grant Park Mall (GPM) 1999 and 2000 (Grant Park Shopping Centre Traffic Count 2001)

Month	Number of Shoppers (1999)	Number of Shoppers (2000)
January	700,255	682,087
February	557,018	544,278
March	555,126	542,690
April	734,335	706,270
May	601,551	551,726
June	636,864	565,818
July	797,328	700,594
August	635,628	560,584
September	714,322	646,040
October	608,304	356,388
November	603,086	361,670
December	670,613	388,213
Total number of shoppers per year	7,814,430	6,606,358
Average number of shoppers per month	651,203	550,530
Average decrease of shoppers from 1999 to 2000	-15.4%	



S
Scale
1 in. = 200 ft.
N

Appendix B 2: Site Ma



Appendix B 3: Existing Sewer Lines

Appendix B 4.1: Site Ph

Appendix B 4.2: Site Ph

Appendix B 4.3: Site Ph

Appendix B 5: Tenant Lists - Grant Park Shopping Centre (Adapted from Grant Park Mall a)

Tenant no	MAIN FLOOR	Tenant no	MAIN FLOOR	Tenant no	MAIN FLOOR
20	A Buck Or Two	2	Diva Lingerie	1	Cotton Ginny/Cotton Ginny Plus
21	A Child's Place	41	Elite Communications /MTS Mobility	40	Liquor Mart
22	A-1 Nutrition	25	Enviro Trends	61	Little Bo Peep Boutique
52	A&W	34	Flair Travel	49	Cineplex Odeon Theatres
17	Among Friends	26	Framing & Art Centre	28	Lottery Ticket Centre
9	Athletes World	35	Grant Park Dental Centre Dr. Ahluwalia	3	Mariposa
44	Black's Photography	36	Grant Park Medical Centre Dr. Fitz-Simon	14	McNally Robinson Booksellers
45	Blockbuster Video	13	Hallmark Cards	24	Mister Minit Shoe Repair
23	Bubbles & Bangles	38	Jerry's Hair Design & Day Spa	41	MTS Phone Centre
18	C. I. B. C.	27	Key Man Engravables	29	Noiseworks
62	Century 21-Bachman & Associates	39	Leipsic Insurance	15	Peoples Jewellers
42	Perth's Cleaners	30	Pet Valu	54	Pizza Place Restaurant
10	Quark Shoes	46	Radio Shack	4	Ricki's
19	Vaccant	47	Safeway	16	San Francisco Gifts
31	Shefield & Sons	32	Shopper's Optical	48	Shoppers Drug Mart
60	Something Beautiful	6	Suzy Shier	8	T. H. E. Warehouse
11	The Calico Clothing Company	53	Tim Hortons	7	Tip Top Tailors
43	Vacant (new Zellers)	59	Warehouse One: The Jean Store		
SECOND LEVEL					
201A	Achilles Foot Clinic	200A	Cineplex District Office	225	Dr. Chalaturnyk (Chiropractor)
201B	Dr. Portnoy (Dentist)	211	Dr. Waller (Physician/Surgeon)	204	Edmond-Muir (Legal)
233	Grant Park Administration	203	Grant Park Hearing Centre	220	Lawson, Tollefson (Accountants)
221	Lepic Insurance	235	Maureen Scurfield Counselling	200	Radio Shack District Office
213	Simon Imports Limited	231	Sinclair & Associates (Legal)	205	Taubers Kawai Music
206	W. R. Van Walleghem & P. H. Bromley	239	Winnipeg Orthodontic Group		
Parking Lots					
Applebee's Neighborhood Grill & Bar		McDonald's Restaurant		Pony Corral Restaurant & Bar	
Petro Canada					

Appendix C: Conceptual Design Calculations

Appendix C 1: Process Engineering

Section 6.2.1 Evaluation of Design Wastewater Flowrates

Step One: calculate the water consumption according to Meter One and Two

Information is provided from Grant Park Shopping Centre, water bills 2000.

Month	*Water Consumption according to Meter One and Two (/Cubic metre)*
Nov. – Feb.	7,100
Feb. - May	6,400
May – Aug.	7,700
Aug. – Nov.	9,500
Total Per Annum	30,700
Monthly Average	2,600
Daily Average	87

Step Two: calculate total water consumption of the whole mall

Safeway, Cineplex Odeon Theatres and the recently built Zellers have their own separate water meters. Grant Park Mall site manager states that the total water/wastewater consumption may be estimated by multiplying the total amount of wastewater of the Mall's meters one and two by 1.8.

Month	*Total Estimated Water Consumption (/Cubic metre)*
Total Per Annum	55,200
Monthly Average	4,700
Daily Average	156

Step Three: calculate wastewater production after renovation

The design flowrate would allow 20% increase of shoppers

Month	*Total Estimated Wastewater Production after Renovation (/Cubic Metre)*
Total Per Annum	66,000
Monthly Average	5500
Daily Average	184

Step Four: calculate percentage water withdrawn from the water supply system but does not reach the sewer system

1. Number of retailers using water in the manufacturing process - 10%
2. Water for plants irrigations - 3%
3. Potential leakage given the age of the mall (28 years) - 2%

Step Five: calculate the wastewater design flowrate

85% of the water recorded by the water meter is estimated to become wastewater.

Month	*Total Estimated Amount of Wastewater (per Cubic Metre)*
Total Per Annum	56,300
Monthly Average	4700
Daily Average	156 per day (156,462 Lit./day, 41,338 US gpd)

Overall Summary

Month	*Water Consumption according to Meter One and Two (/Cubic Metre)*	*Total Estimated Water Consumption (*1.8) (/Cubic Metre)*	*Total Estimated Water Consumption after Renovation (*1.2) (/Cubic Metre)*	***Total Estimated Amount of Wastewater (*0.85) (/Cubic Metre)***
Nov. - Feb.	7,100	-	-	-
Feb. – May	6,400	-	-	-
May - Aug.	7,700	-	-	-
Aug. - Nov.	9,500	-	-	-
Total Per Annum	30,700	55,200	66,000	56,300
Monthly Average	2,600	4,700	5,500	4700
Daily Average	87	156	184	156 per day (41,300 US gpd)

Section 6.2.3 Preliminary Sizing of Treatment Components

A total of 8 reactors are used. The total retention (residence) time is approximately 2.5 days. To find out a rough capacity, multiply the wastewater flow by 2.5 and figure out the dimensions of 8 cylindrical reactors, approximately 12 feet high, to accommodate such capacity.

Step 1: find out the overall capacity of all reactors

Design flow: 156 cubic metres

Design flow with retention period:

Quantity of wastewater x Retention time = Overall Capacity of all reactors

156 cubic metres x 2.5 = 390 cubic metres

Overall Capacity of all reactors = 390 cubic metres

Step 2: find out the dimension of each circular reactor

8 circular cylinder (reactors) are used

Capacity/Volume of each cylinder = Area of a reactor x Height

Capacity of each cylinder = (3.14 x Radius of a reactor^2) x Height

Capacity of total amount of reactors = (3.14 x Radius of a cylinder^2) x 3.75m x 8 reactors

390 cubic metres = 3.14 x R^2 x 3.75 x 8

Radius of a circulator reactor = 2 m

Dimensions of each reactor: Diameter: 4.m (13 ft.), Height: 3.8m (12 ft.)

Step 3: find out the dimension of a reactor with the height of 8 feet

Capacity of each reactor = 3.14 x $(2.03)^2$ x 3.75

= 48.5 cubic metres

Capacity of each reactor = (3.14 x Radius of a reactor^2) x Height

$48.5 = (3.14 \times R^2) \times 1.9 \times 2$

R = 2m or 6.4 ft

Some reactors have a height of 8 ft and a diameter of 12.8 ft

Table 6.1: Grant Park Mall Solar Aquatic Facility Flow Summary

a) Solar Aquatic Facility Suggested by Alm (2001)

Process Summary:Components	***Number***	***Total Volume (m^3)***	***Retention Hours***
Closed	1	48.5	9
Open	4	194	34
Clarifiers	1	48.5	6
EFB's	2	97	11
Total	8	388	60

b) Solar Aquatic Facility modified by the Design

Process Summary: Components	*Number*	*Total Volume (m^3)*	*Height* (ft)	*Diameter* (ft)
Closed	1	48.5	12	12.9
Open	8	194	6	12.8
Clarifiers	2	48.5	6	12.8
EFB's	2	97	12	12.9
Total	**13**	**388**		

Section 6.2.4 Wastewater Collection Line and Reused Water Distribution Line

Wastewater collection line A and B are both ends of the same main wastewater Collection (Figure 6.8).

Step 1: find out the depth of wastewater collection line A

According to the designer (modification made after the Second Round of interviews), the length of wastewater collection line is equal to the vertical distance /gradient (H = V/G).

Vertical distance / Gradient = Length (Horizontal distance) of wastewater collection line (V/G = H)

Vertical distance of wastewater collection line A / 1% = 920 ft.

Vertical distance of wastewater collection line A = 920 ft. x 1%

Vertical distance of wastewater collection line A = 9.2 ft.

The existing sewage lines = 10 ft

The new depth of wastewater collection line A = 10 ft. + 9.2 ft = 19.2 ft.

Step 2: find out the depth of wastewater collection line B

Vertical distance / Gradient = Length (Horizontal distance) of wastewater collection line (V/G = H)

Vertical distance of wastewater collection line A / 1% = 455 ft.

Vertical Distance of Wastewater collection line B = 455 ft x 1%

Vertical Distance of Wastewater collection line B = 4.55 ft.

The existing sewage lines = 10 ft.

The new depth of wastewater collection line B = 14.6 ft.

Section 6.2.5 Selection of Plants and Animals

Flora Type	**Species used in the systems (Common Name)**
Flowers	water hyacinth, Carnations, daffodils, alstromeria, orchids, streptocarpus, clivia, iris
Ferns	Maiden hair, bears foot, Japanese holly, hay scented ferns
Foliage Plants	Philodendron, flowering ginger, creeping cress, papyrus
Shrubs/Trees	Pussy willow, black willow, Pacific willow, red twig dogwood, viburnum, mock orange, bald cypress, high bush cranberry, Japanese maples, sugar maples, sweet gum, mountain laurel, winter berry
Vascular Plants	Water lilies, calla lilies, elephant ears, banana, Chinese water chestnut, water poppy
Other Plants	Bullrush, fire flag, Egyptian paper reed, papyrus, hybrid Canna , giant papyrus , white butterfly ginger , green taro
Animal Type	
Mollusk	Snail, mussels, crayfish
Fish	Tilapia, grass carp, golden shriner, flathead minnows, escargot

Appendix C 2: Cost-Benefit Analysis

Section 7.1.1.2 Operation and Maintenance Cost

O/M Cost for Bear River SAS, 1997/98

Cost Items	**Cost**
Advisory Services (process designer)	$ 8,500
Electricity and Heat	$ 9,000
O/M	$ 7,400
Operator Salary/Benefits	$13,000
Total Cost Per Annum	**$37,900**
Tourist promotion costs	$5,000
Grand Total	**$42,900**

Section 7.1.1.3 Wastewater Collection Line and Reused Water Distribution Line

Step 1: find the cost of wastewater collection line

Required length for wastewater collection line: 1375 ft.

Cost of material and labour (RS Means, 2000):

8 in per linear ft. costs $ 231 Can ($ 154 US)

Total: $ 231 * 1375 = $ 318,000

Total Cost of wastewater collection line is $ 318,000

Step 2: find the cost of reused water distribution line

Required length for reused water distribution line: 493 ft.

Cost of material and labour (RS Means, 2000):

3 ½ in. per linear foot = $ 42.8 Can ($ 28.5 US)

Total: $ 42.75 * 493 = $ 21,100

Total Cost of reused water distribution line is $ 21,100

Section 7.1.1.5 Net Amount of Retail Space

Step 1: find out the net increase of retail space in summer time (6 months)

Addition of new enclosed retail space: 55 ft. x 30 ft. (interior space adjacent to the solar aquatic facility) + 60ft. x 75ft. (open space for mini-golf course)

Subtraction of existing enclosed retail space (all seasons): 45 ft. x 90 ft.

Net increase of retail space in Summer time

Addition of new enclosed retail space (interior space adjacent to the solar aquatic facility and open space for mini-golf course) - Subtraction of existing enclosed retail space

(55 ft. x 30 ft.) + (60ft. x 75ft.) - (45 ft. x 90 ft.) = 2100 sq. ft.

Net increase in retail space in summer time (6 months) is 2100 sq. ft.

Step 2: find out the net decrease of retail space in winter time (6 months)

Subtraction of existing enclosed retail space - Addition of new enclosed retail space (interior space adjacent to the solar aquatic facility)

(60ft. * 75ft.) - (55 ft. * 30 ft.) = -2400 sq. ft.

Net decrease in retail space in winter time (6 months) is 2400 sq. ft.

Step 3: find out the net deficit in rent per annum

Net Deficit in rent x 6 months

(-2400 sq. ft. = 2100 sq, ft.) x $51.50 Sq. Ft. /2 = $ 7,725 per annum

Net deficit in rent per annum is $ 7,725

Section 7.1.2.1 Reduced Water Consumption

Reduced Freshwater Consumption

Step 1: find out the projected water consumption per three month

Projected annual water consumption: 66,200 cu. m.(23392.12 cu. Ft) (this figure is obtained from calculation in Section 6.2.1)

In order to obtain the accurate water charge, the water consumption has to convert to a three-month period, since City of Winnipeg bills consumers once every three months.

Water consumption per three months: 23392.12 cu. ft / 4 = 584,830 cu. ft[1].

Step 2: find out the current water supply charge

Water rate is different with increasing water consumption volume (City of Winnipeg d).

0 - 9600 cu. ft. = $2.75

9601 - 96,000 cu. ft. = $2.27

More than 96000 cu. ft = $1.74

Step 3: find out the water charge based on 2001 water rate

9,600 cu. ft. x 2.75 = $264

96,000 cu. ft. x 2.22 = $2,131.2

4792.3 cu. ft. x 1.74 = $8338.6

[($264 + $2,131.2 + $8,338.6) x 4] = $ 42,935

Water charge per annual = $ 42,935

Step 4: find out the increase in water rate from 2000 – 2001

Increase in water rate from 2000 - 2001:

Water Rate 2000 = 2.70 (0 - 9600 cu. ft.)

Water Rate 2001 = 2.75 (0 - 9600 cu. ft.)

(WaterRate2001 – WaterRate2000) / Rate 2000 x 100%

(2.75 - 2.70) / 2.70 x 100% = 1.85% (estimated annual water rate increase every year)

Step 5: find out the reduced freshwater consumption

Fifty-four percent of the total commercial water consumption[2] can be replaced with recycled wastewater. Consequently, freshwater consumption would be reduced by 54%.

Step 6: find out the % of total number of bathrooms/planters fed by treated water

The Reused Water Distribution Line is designed to direct treated wastewater to only 65% of the total number of bathrooms and planters in GPM (Illustration in Appendix D 2).

Step 7: find out the reduced freshwater consumption per annum

Total Reduced Freshwater Consumption per 3 months:

Water charge based on 2001 water rate (Step 3) x Increase in water rate from 2000–2001 (Step 4) x Reduced freshwater consumption (Step 5) x total number of bathrooms/planters fed by treated water(Step 6)

(42,935) x 101.85% x 54% x 65% = $15,400

Total reduced freshwater consumption per annum = $15,400

Section 7.1.2.2 Reduced Sewer Charge

Step 1: find out the current sewer charge (from Grant Park Shopping Centre Water Bill 2000)

Month	*Sewer Charge (Meter One)*	*Sewer Charge (Meter Two)*
November - February	$ 5444.16	$ 1581.64
February - May	$ 4940.07	$ 1315.00
May – August	$ 5937.11	$ 1621.17
August - November	$ 7704.50	$ 1587.81

---

[1] The City of Winnipeg uses cu. ft as the unit.

[2] Commercial water consumed percentage: WC flushing: 35%, Washing/bathing: 26%, Urinal flushing 15%, Food preparation/drinking: 9%, Laundry: 8%, Washing-up: 2%, Car washing/garden use: 4%, Others 1% (Butler & Davies, 2000). WC flushing (35%), Urinal flushing (15%) and Car washing/garden use (4%) can be replaced by treated water.

Step 1: find out the total sewer charge of GPM

Safeway, Cineplex Odeon Theatres and the recently built Zellers have their own separate water meters. Grant Park Mall site manager states that the total water/wastewater consumption may be estimated by multiplying the total amount of wastewater of GPM's meters one and two by 1.8.

Month	*Sewer Charge (Meter One)*	*Sewer Charge (Meter Two)*	*Total Estimated Sewer Charge (*1.8)*
November - February	$ 5444.16	$ 1581.64	$ 12,646
February - May	$ 4940.07	$ 1315.00	$ 11,259
May – August	$ 5937.11	$ 1621.17	$ 13,605
August - November	$ 7704.50	$ 1587.81	$ 16,726

Step 2: find out the discount of sewer charge

It is assumed that The City of Winnipeg is willing to provide a 90% discount from its usual sewer charge.

Month	*Total Estimated Sewer Charge (*1.8)*
Total Amount of Sewer Charge per Annum	$ 54,237
TOTAL AMOUNT OF SEWER CHARGE PER ANNUM AFTER A 90% DISCOUNT	$ 48,813

Appendix C 3: Communities Benefiting from Social Programs

Neighbourhoods within Primary Trade Area (within 1 mile)

Neighbourhood	*Population*	*Neighbourhood*	*Population*	*Neighbourhood*	*Population*
Grant Park	2,920	South River Height	2,850	Rockwood	4,045
Central River Height	3,225	Crescentwood	2,795	North River Height	5,720
Earl Grey	4,540	Ebby Wentworth	715	Lord Roberts	5,200
Point Road	1,855	Brockville	140	Beaumont	2,410
Lindenwold	6,470				
Total	**40,185**				

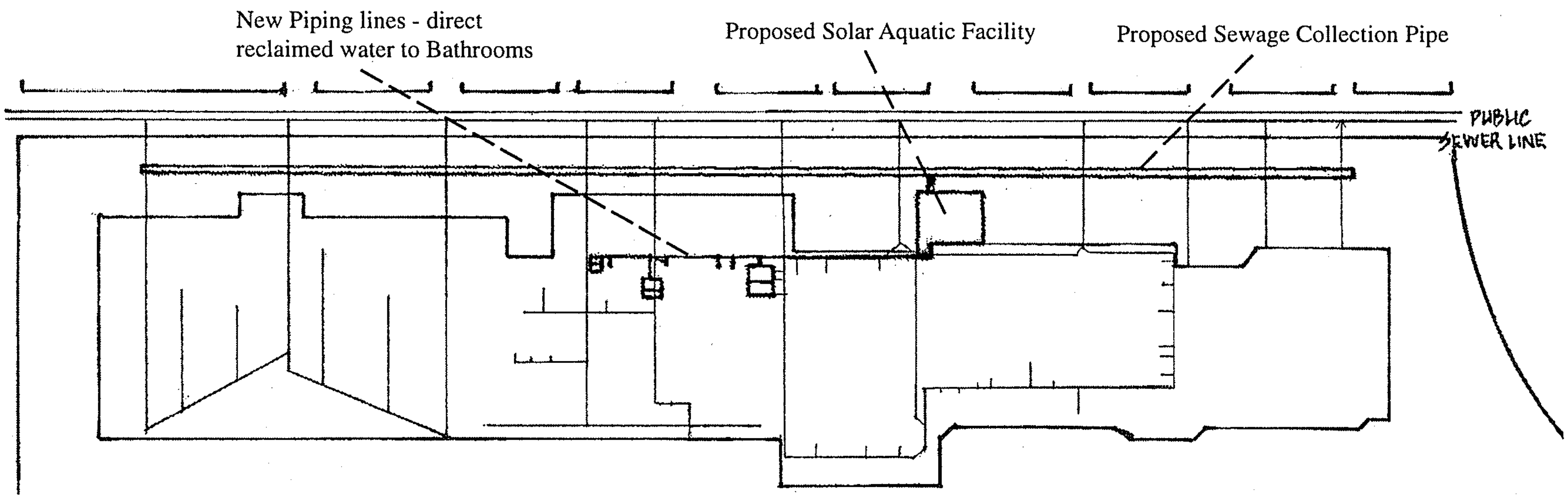
Neighbourhoods within Secondary Trade Area (within 2 miles)

Neighbourhood	*Population*	*Neighbourhood*	*Population*	*Neighbourhood*	*Population*
Wellington Crescent	1,615	Mathers	2,485	Sir John Frankin	2,525
J. B. Mitchell	1,950	McMillan	3,760	Roslyn	4,255
Riverview	4,470	Kingston Crescent	715	Elm Park	1,610
Vareenes	1,095	Victoria Crescent	585	Norbery	1,340
Wildwood	1,120	Crescent Park	2,245	Maybank	2,395
Chever	65	Tuxedo	3,170	Tuxedo Industrial	145
Old Tuxedo	930	River Osborne	4,615	South Tuxedo	3,545
Edgeland	1,430				
Total	**46,065**		**Total Population**	**within 2 Miles of Trade Area**	**86,250**

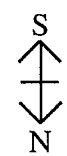
Appendix D: Design Concept Development

Appendix D 1: Treatment Process Diagram of Solar Aquatic Facilities

Precedents of Living Machines Treatment Process	Fredensgade Block Kolding, Demark	South Burlington Sewage Treatment Facility, Vermont	Corkscrew Swamp Living Machine, Naples, Florida	Industrial Wastewater Treatment at Ethel M. Chocolates, Henderson, Nevada	Sonoma Mountain Brewery Facility	Industrial Wastewater Treatment at Master Foods, New South Wales, Australia	Body Shop, Toronto
Anaerobic Reactor	√		√				√ Septic Tank
Anoxic Zone		√		√ Biofilter (Odor)	√ Biofilter (Odour)	√ Earth-based Biofilter	
Closed Aerobic Reactor				√	√	√	√
Open Aerobic Reactors	√	√		√	√	√	
Clarifier		√	√ Reed Bed	√ Reed Bed	√ Reed Bed	√	√
Ecological Fluidized Beds		√		√	√	√	
Constructed Wetland	√ Marsh		√	√	√		√
Pond	√ Creating Food-chain			√	√		√ Creating Food Chain
Disinfections	√ UV-rays & Ozone						√ Ultraviolet
Greenhouse	√						√
Other Systems		Sedimentation (Solids Holding Tank)		Grease Trap	Balanced Tank, Sedimentation (Bio-solid Holding tank)	Balanced Tank, DAF, Blanket Reactor (UASB)	

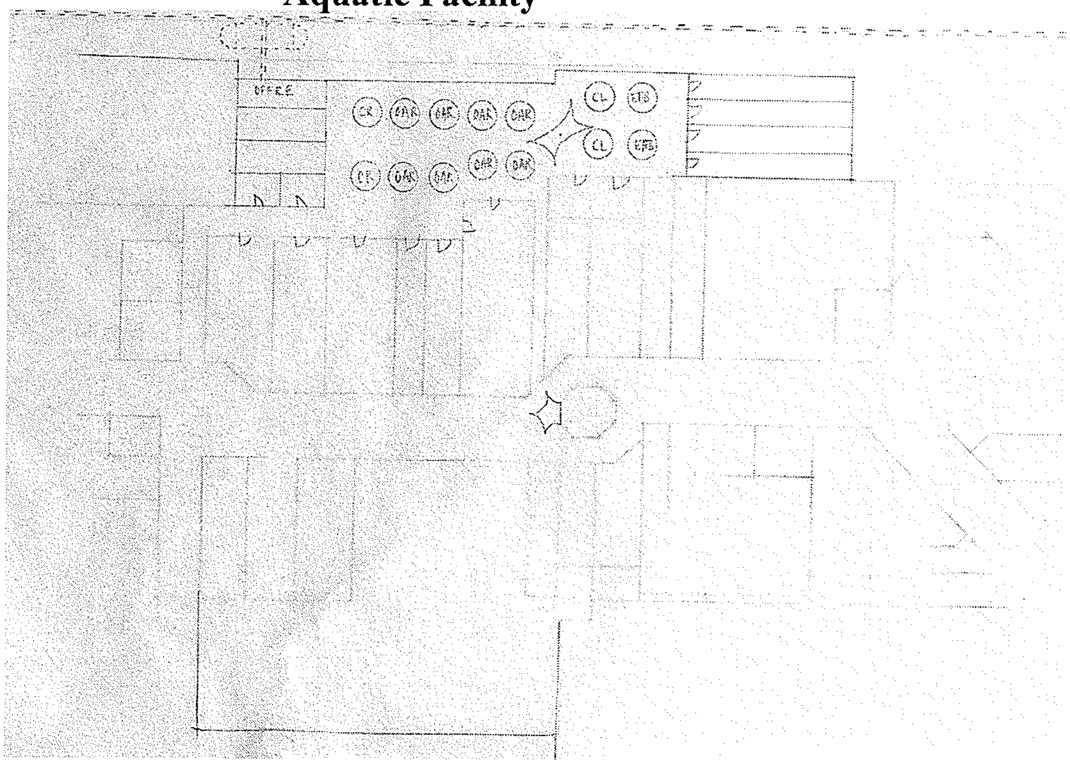


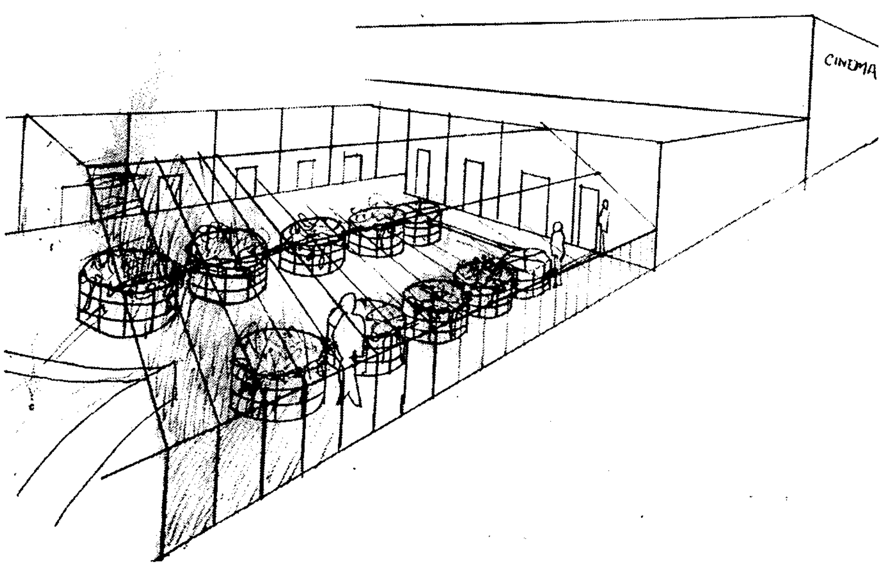
Appendix D 2: Proposed Wastewater Collection Line and Recycled Water Distribution Line



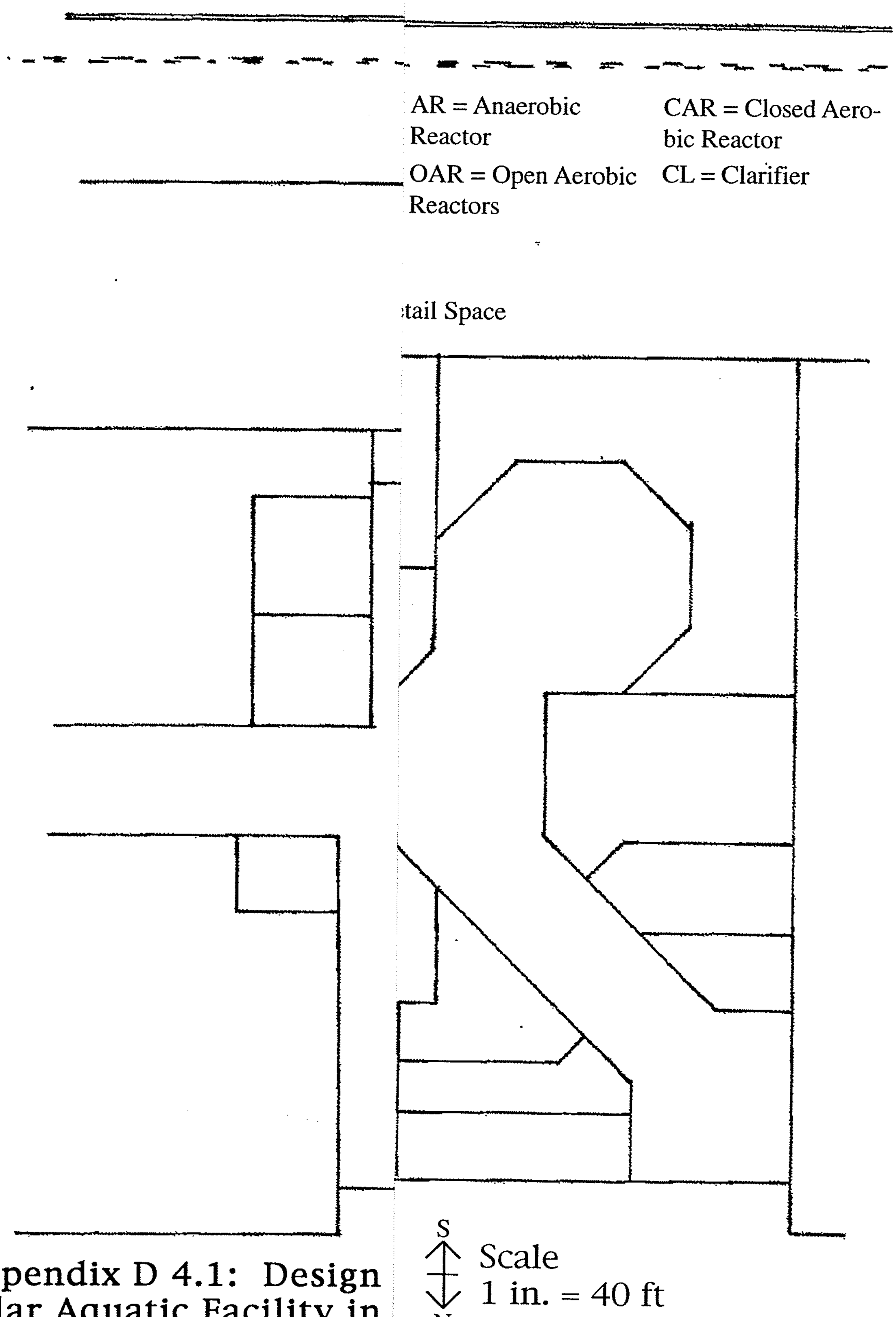
Scale
1 in. = 200 ft.

Appendix D 3.1: Design Concept I – Plan - Grant Park Mall Solar Aquatic Facility

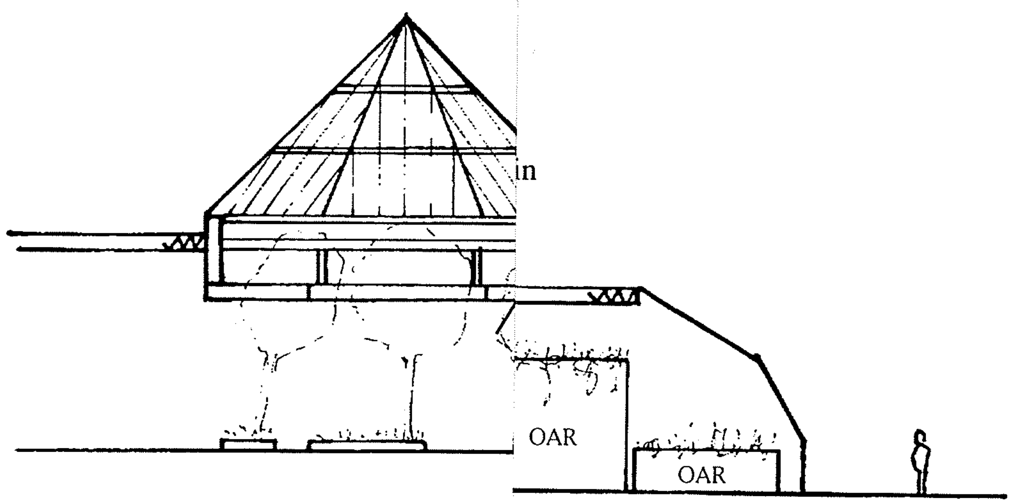




Appendix D 3.2: Design Concept I – Sketch of Grant Park Mall Solar Aquatic Facility

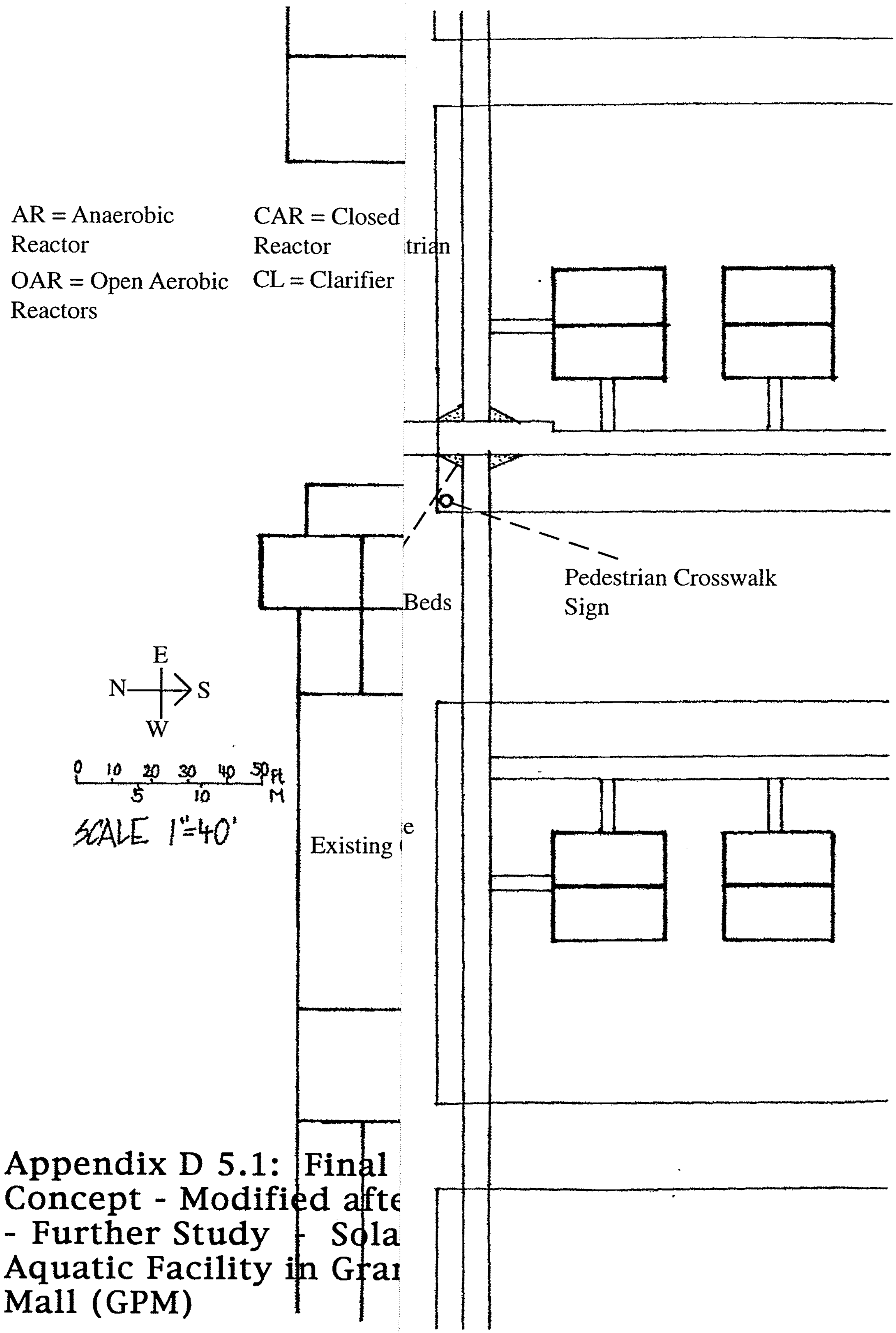


Appendix D 4.1: Design
Solar Aquatic Facility in

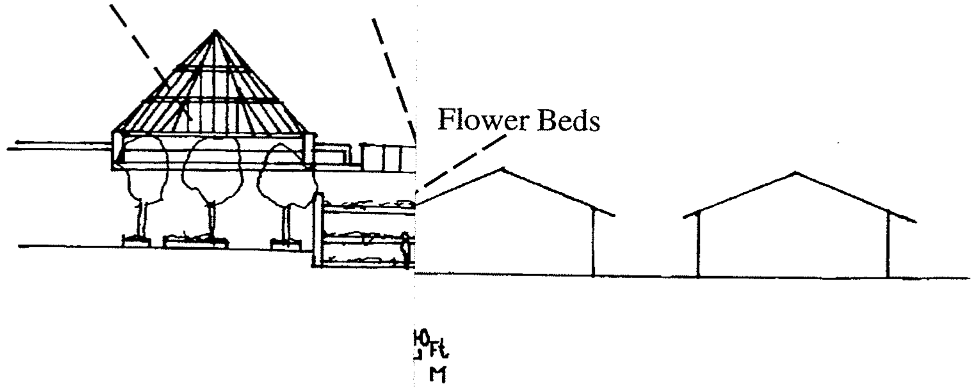


Appendix D 4.2: Design
Section AA - Solar Aquat

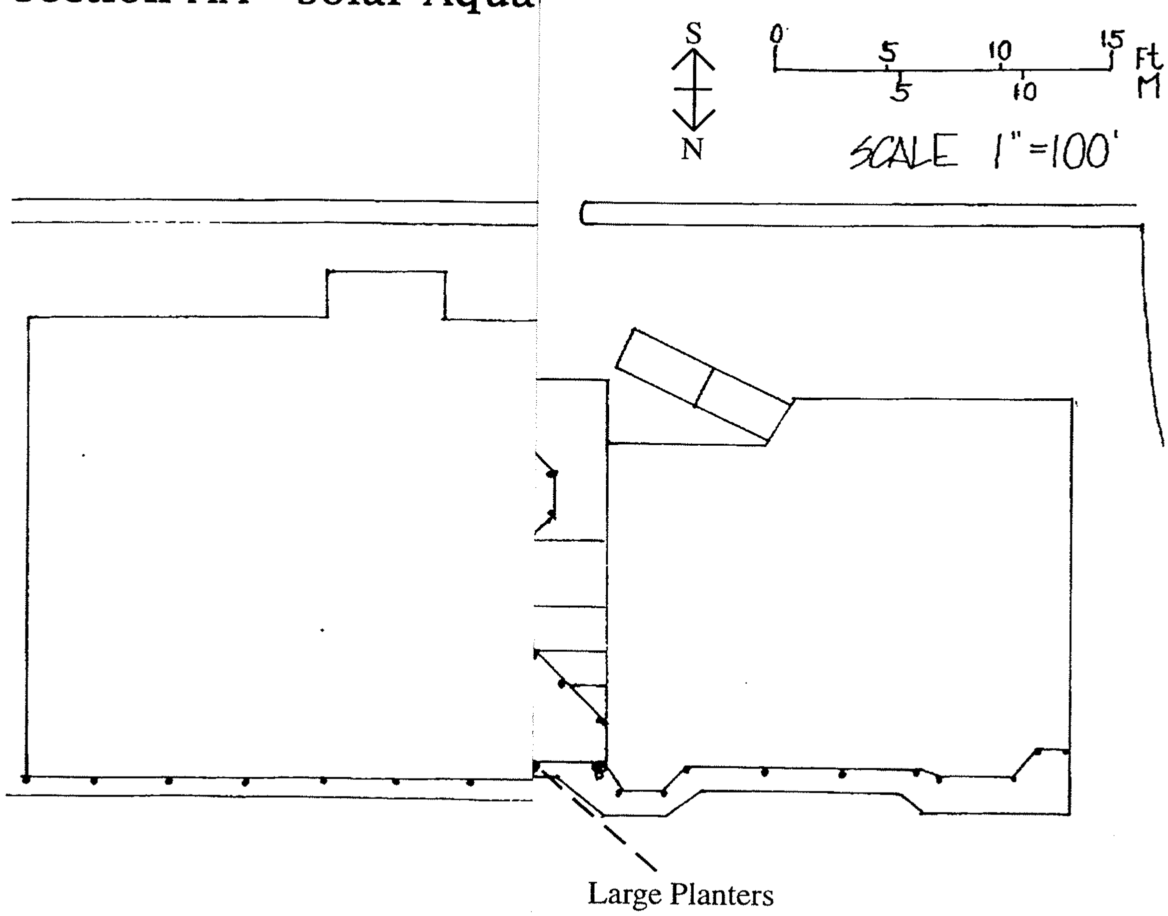
S
N
Scale
1 in. = 40 ft.



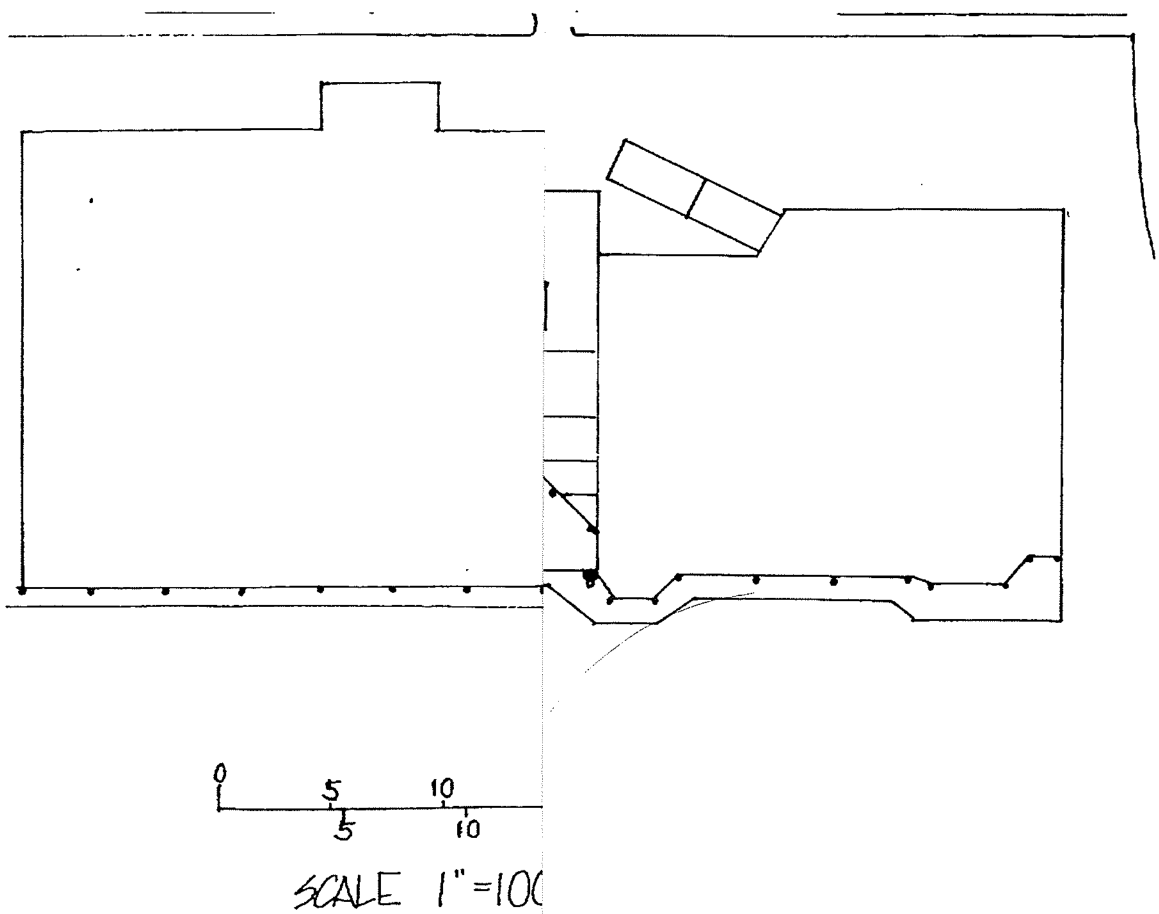
Appendix D 5.1: Final Concept - Modified afte - Further Study - Sola Aquatic Facility in Grai Mall (GPM)



Appendix D 5.2: Final
Section AA - Solar Aqua



Appendix D 5.3: Final
- Landscape Features in



Appendix D 6: Proposed

Appendix G: Glossary

Appendix G 1: Public Health (Tottem Sims Hubicki Associates, 1997)

Alkalinity
Alkalinity is a measure of the presence of anions (negatively charged ions) in the water. The term is often used in conjunction with pH. The predominate anions are carbonates, bicarbonates and hydroxide.

Bacteria
Bacteria counts are often expressed in plate counts where bacterial colonies are incubated in a volume of the sample and the colonies are counted. The count is usually reported as most probable number of (MPN) colonies per 100 mL of sample volume.

Dissolved Minerals
Measurement of dissolved minerals electronically can be expressed as specific conductance or resistance. These parameters are usually measured as ohms per centimetre (resistance) or micromhos per centimetre (conductance). As the resistance increases, the conductivity and dissolved mineral level decreases.

Dissolved Solids
Total dissolved solids represents the total minerals dissolved in the water sample. The majority of dissolved solids comprise cations: Calcium, Magnesium and Sodium, and Anions: Chlorides, Sulfates and Carbonate.

Iron
Iron in water can cause rust staining and an iron sludge which can clog pipes and valves. The sludge is the end product of bacteria which consume iron. Iron in the water can result in staining at levels greater than 0.2 mg/L (parts per million) and can impart a metallic taste to the water.

Manganese
Manganese in the water when oxidized can result in a black stain in levels as low as 0.05 PPM.

N: Nitrogen
This nutrient is present in various forms in wastewater.

P: Phosphorus
This nutrient, which is present in wastewater, acts as a fertilizer in surface waters.

Sulfates
Sulfate compounds can have a laxative effect, form a scale at high concentrations and cause a "totten egg" odour (hydrogen sulfide).

Turbidity
Turbidity represents a measure of the transmission of light through a volume of water. The higher the turbidity value the more particles there are in the water. Particles can include fine sand, silt or clay.

pH (acidic or basic)
The term pH represents the reciprocal of the hydrogen ion concentration measured on a log scale. The measurement is expressed between 14.0 (basic) and 0.0 (acidic) with 7.0 representing a neutral or mid point. The acidity of a solution increased by a factor of 10 between log scale units (i.e. 6 to 7).

Water Hardness
Water hardness is a measure of the presence of calcium, magnesium, related chlorides and sulfates in the water, often expressed as equivalent calcium carbonate levels. One indication of water hardness is the amount of soap added to water required to precipitate hardness, indicated when soap foam suds form. Water hardness combined with alkalinity represents a primary source of scale formation. Water hardness compounds can form a hardness scale or when combined with detergents an insoluble soap compound.

Appendix G 2: Wastewater Reuse Facilities (Todd, 2001)

Aerobic
Wastewater treatment depending on oxygen for bacterial breakdown of waste.

Anaerobic
Wastewater treatment in which bacteria breakdown waste without using oxygen.

BOD
Biochemical Oxygen Demand. Decomposing organics require oxygen. The BOD_5 test measures the oxygen consumed by organisms as they decompose organics over a five-day period. BOD is thus an indicator of the concentration of organics in water.

COD
Chemical Oxygen Demand. The COD test measures the chemical oxidant required to break down organics. COD is an indicator of the concentration of organics in water. The COD test can be completed in a few hours and is frequently substituted for BOD. COD levels are usually greater than BOD for a given wastewater.

Cold Climate Limitations
Cold temperatures, ice cover, plant dormancy, equipment performance, ice buildup and reduced microbial action create design challenges for cold weather wastewater treatment.

Combined Sewers
Sewer systems in which the storm water and sanitary waste are combined. A benefit is that non-point pollution flushed from the watershed during moderate rain is treated, but the system can be overwhelmed during severe storms, resulting in untreated waste being flushed into the receiving waters as a combined sewer overflow (CSO).

Detention Time
The average period of time wastewater stays in a treatment system. Detention times vary for different types of wastewater treatment systems and can range from hours to weeks.

EFB
Ecological Fluidized Bed, which is a patented tertiary wastewater treatment process for final polishing after clarification.

Living Machines
Ecologically designed aquatic systems that utilize a diverse community of biological organisms, from bacteria to plants and fish, to treat water to advanced levels. This is a trademark used by Todd (2001).

Natural Systems
Ecologically based biological wastewater treatment systems such as constructed wetlands having minimal dependence on mechanical elements.

Onsite
Local wastewater treatment for a single house or small community.

Primary Wastewater Treatment
Removal of sand, grit, and larger solids from wastewater by screens, settling tanks and/or skimming devices.

Domestic Sanitary Wastewater
Wastewater, including toilet, sink, shower and kitchen flows, originating from human domestic activities.

Secondary Wastewater Treatment
Biological removal or organics and solids from wastewater. Secondary wastewater effluent limits are generally 30 mg/l BOD5 and 30 mg/l of TSS.

Sludge
Biosolids removed after secondary or tertiary treatment. Sludge may be applied to agricultural fields as a soil amendment, composted or palletized. The 92 municipal wastewater facilities in Vermont generate 35 dry tons of sludge a day.

Tertiary Wastewater Treatment (Advanced)
Biological or chemical polishing of wastewater to remove organics, solids and nutrients. Tertiary wastewater effluent limits are generally 10 mg/l BOD5 and 10 mg/l TSS.

TSS
Total suspended solids in wastewater.

Ultraviolet Disinfection (UV)
A disinfection method in which final wastewater effluent is exposed to ultraviolet light to kill pathogens and microorganisms.

Appendix G 3: Shopping Centres (City of Winnipeg a, 1973)

Annual Rental Value
The basis for the business tax in the City of Winnipeg. It represents a fair evaluation of the amount each business premise should be rented for, and can therefore be used as an indication of the relative market value of a business expressed in dollars.

Gross Floor Area
The area equal to the gross leasable floor area plus another floor area. It is the total floor space of all the buildings. It includes the ground floor, the upper floors, mezzanines and basements. It includes malls, general storage space, ramps, etc.

Gross Leasable Floor Area
The total floor space that is designed for and used exclusively by individual tenants and upon which rent can be obtained. It is the true generator of trade and parking requirements. It can be divided into the actual sales area and storage space.

Parking Area
The paved space devoted to parking and includes aisles, islands and other features incidental to parking.

Parking Area Ratio
The Parking area/Gross Floor Area. The relationship between the sites is devoted to parking and the gross floor area.

Parking Index
The number of car parking spaces per 1000 square feet of gross leasable area.

Site Area
The gross land area of the property within the property lines. It is broken down into the building area, the parking area and any other land use.