Value of Rain Gardens in Winnipeg

The Ecole St Avila Rain Garden Case Study

by

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Abstract

With rising concern about flooding and water pollution in the Red River and particularly in Lakes Manitoba and Winnipeg in recent years, building rain gardens in cities may become one solution with considerable potential for improving water quality. The literature illustrated the many benefits that can be provided by a rain garden system, not only aesthetically pleasing gardens with educational and biodiversity values, but they also can reduce storm water pollution and flooding in downstream water bodies.

In order to address questions of public understanding and perceptions of their usefulness so as to better promote future implementation, the study examined social feedback about rain gardens through a survey at Ecole St Avila, an elementary school in Winnipeg. The findings from the survey indicated that the largest obstacles for rain garden development are funding and the lack of knowledge by the public.

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List of abbreviations

EPA – Environmental Protection Agency
USEPA- United States Environmental Protection Agency
SARG – Ecole St Avila Rain Garden
REB – Research Ethic Board
JFREB - Joint-Faculty Research Ethic Board
BMP - Best Management Practices
LID - Low Impact Development
SUDS - Sustainable Urban Drainage System
WSUD - Water Sensitive Urban Design
LIUDD = LID + CSD + ICM (+ SB)
ICM - Integrated Catchment Management
CSD - Conservation Sub-Divisions
SB - Sustainable Building
NPDES - National Pollutant Discharge Elimination System
CSO - Combined Sewer Overflow
SSO - Sanitary Sewer Overflow
UNHSC - University of New Hampshire Stormwater Center
MDE - Maryland Department of the Environment
DNREC - Delaware Natural Resources and Environmental Control
MPCA - Minnesota Pollution Control Agency
ASLA - American Society of Landscape Architects
SMM - Scatliff + Millar + Murray Landscape Architects
RKCC - Richmond Kings Community Centre
SUSTAIN - Urban Stormwater Treatment and Analysis INtegration

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Chapter 1.0 Introduction

1.1 Background and Motivation

Urban areas contain large amounts of impervious ground that can range from 20% in residential areas to as much as 85% in commercial areas (Nebraska Department of Environmental Quality, 2009). A large volume of rainwater with excess nutrients and other chemicals directly runs into river systems from urban areas. Urban runoff often contains a wide variety of other pollutants including nutrients, oxygen-demanding substances, pathogens, road salts, petroleum hydrocarbons, metals, and excess thermal energy (USEPA, 2005). Historical patterns of urban development can result in flooding, drainage problems, non- point source pollution that alters the ecological environment, and many other concerns. Therefore, studies to develop effective, economical, easy to maintain, aesthetically pleasing and acceptable runoff treatment measures are especially necessary and have been occurring in a number of cities, including Winnipeg.

This study aims to consider the development and operation of rain gardens and the benefits that can be derived using this system as one method of urban storm water management. The concept is considered useful because every choice made about an environment, whether it is small or large, can ultimately have a large impact in complex direct and indirect ways. In the case of rain gardens there are potentially significant social values as well as indirect and direct environmental values, and this thesis will explore them from both perspectives.

1.2 Conceptual Context

A rain garden is a landscape feature designed to capture local runoff from precipitation falling on roofs, driveways, parking lots and lawns. The garden includes hydrophytic woody and herbaceous species planted in naturally or established low lying areas in a small watershed or runoff area. It is designed to slow runoff after a rain or snow melt event and catch and cleanse storm water runoff by using plants to break down chemical pollutants and by infiltrating water into the soil rather than directly running overland and into storm drains. Rain gardens have the potential to: (1) reduce runoff volume and peak flows, (2) facilitate groundwater recharge, (3) increase evapotranspiration, and (4) reduce the amount of runoff pollutants through a variety of processes that include sedimentation, adsorption, infiltration, biological transformation (decomposition), and precipitation (USEPA, 2000). Several studies indicated that rain gardens are effective in removing up to 90% of excess nutrients and chemicals, and up to 80% of sediments from rainwater runoff (Davis et al., 2006). Field-scale rain gardens were highly effective in removing nitrate-N (~91%), phosphate-P (~99%), atrazine (~90%), dicamba (~92%), glyphosate (~99%), and 2,4-D (~90%) under high levels of pollution loading conditions simulated in urban runoff events (Yang, 2010). In addition, compared to a conventional lawn, rain gardens could infiltrate 30% more water into the ground (Nebraska Department of Environmental Quality, 2009).

A growing number of homeowners are building small rain gardens in their yards. There are many successful rain garden applications in North America. Some cities have initiated plans to develop a rain garden network. For example, the City of Madison, Wisconsin has adopted a goal to develop 1,000 rain gardens for individual homeowners in the metro area that will have a cumulative benefit. Another example is the Kansas City 10,000 Rain Gardens program, which emerged as part of a response to aging storm water and wastewater infrastructure. Local government approved a $500 million fund to improve water infrastructure for Kansas City. The most significant case is the rain garden pilot project in Burnsville, Minnesota. Since 2002, the project was studied by the local organization and USGS to measure the effectiveness of rain gardens in reducing pollution and volume of storm water runoff into nearby Crystal Lake from surrounding suburban areas. In Canada, so far, there is no plan to develop a rain garden network in any Canadian cities. However, in North Delta, BC, since installing the first demonstration rain garden at Cougar Canyon Elementary School in 2006, Delta's Engineering Department has been installing rain gardens at several elementary schools (Delta, 2012). Delta staffs have also helped to develop a rain garden curriculum for Grade 4 and 5 students in North Delta. These rain gardens help local residents to understand their local watershed and raise awareness as to how their efforts may impact nearby water quality. Students could get experience of caring for nature by maintaining the garden (Delta, 2012). These case studies provide examples of different but effective methods of municipal storm water management through the use of rain garden systems, which provide valuable insight and information.

The research elaborated upon details of this storm water management technique, including the origin, evolution, function, application, and maintenance of rain gardens. The research also investigated a specific local case in Winnipeg, a rain garden that was recently constructed at Ecole St. Avila School. It is a K – 6 French immersion school in the Pembina Trails School Division directly adjacent to Richmond King's Community Centre.

Rain gardens could be a significant contributor to public education on environmental awareness and storm water management in Winnipeg and surrounding communities, and could help to encourage long-term sustainable development of the region. Achieving sustainability is dependent on the ability of urban management to refine or redesign land use in ways that generate environmental benefits while also providing economic and social benefits to individuals, organizations and businesses in the area, now and in the future. The imperative to accomplish this will likely increase as public concerns about management of water quality and quantity grow. The situation is likely to be enhanced, with the development of high profile pilot projects such as the rain garden at Ecole St Avila. With a clearer understanding of the social feedback from Ecole St Avila and other school rain garden projects, society could be inspired to encourage the wider adoption and development of rain gardens in Winnipeg and surrounding communities.

1.3 Rationale

The rationale for this study stems from the poor understanding of social feedback in relation to rain garden development in Winnipeg. Enhancing the use of rain gardens in storm water management is a relatively recent field of study. Cities and towns, nationally and internationally, are increasingly implementing these systems to treat and manage storm water (Dietz, 2007). While local governments and communities are building some of the rain gardens in use, relatively few studies have documented the multiple effects of rain gardens. The installation of rain gardens, a small-scale bio-retention system planted with native species, has been increasing in popularity in urban areas such as Winnipeg.

Since the initial development of rain gardens during the 1990s, most research has focused on their hydrologic and contaminant removal properties (Dietz, 2007). However, social research regarding the impacts of rain gardens in communities, has not generally been performed and little information is known about existing rain garden projects and potential projects, the specific reasons why rain gardens are installed, or the resources invested in their installation. Nonetheless in Manitoba, the Manitoba Water Stewardship Division of the provincial government in 2011 allocated $24,000 to develop a Sustainable Storm Water Management Guide. The completed guide was distributed to over 900 schools in Manitoba on World Water Day in 2012. The Storm Water Management Guide for Schools will contribute to a wider understanding of the concept of storm water management, will explain how to implement a storm water management system, and will show how to use the system as an educational tool (Rivers West, 2012). This guide could promote the wider development of rain gardens in Manitoba schools, and ultimately contribute to the development of a rain garden network throughout the Province (Rivers West, 2012).

In Winnipeg, no study has been performed regarding the social feedback of rain gardens in order to address questions of public understanding and perceptions of their usefulness so as to better promote future implementation options in school settings. Before undertaking future storm water management programs, local research is needed to better inform this.

1.4 Research Objectives

The overall purpose of the thesis is to provide valuable insight and information on storm water management using rain gardens in the Winnipeg area. The specific objectives of the study are to:

1. Provide a brief historical account of the development and studies of storm water management practices specific to rain gardens to better understand the key influences and experience behind past developments. Studying and understanding what has been tried in the past will help to define what 'best practices' should be considered for Winnipeg.
2. Investigate the benefits that could be achieved through the application of rain gardens at Ecole St Avila School. Several events will be discussed so as to better understand the benefits from this project that can also be extended for wider application.
3. Collect and evaluate the social feedback from the Ecole St Avila Case. Survey the local community (school teachers and parents) to determine the interests and obstacles, as well as possible solutions. The process of garnering public support is

a key part of any government program, and storm water management is no exception.

4. Finally, increase public exposure regarding the benefits of rain gardens so as to diffuse knowledge about storm water management in Winnipeg. Results will be communicated to the government to inform policy decision-making, to educate the public through outreach endeavors, and to engage Winnipeg Schools to participate in storm water practices and education. Complementing the existing efforts from the Ecole St Avila, innovative approaches for storm water management will be shown as a catalyst for wider positive change within the urban landscape.

1.5 Thesis Structure

In Chapter 1, I have introduced the background, rational and purpose of the research on storm water management and rain gardens.

In Chapter 2, I provide the research design and methods used to explore the effects of rain garden development in Winnipeg. One case study (Ecole St Avila, Winnipeg) was selected for this study. A discussion of the methods that were used to gather information is presented. Finally, this chapter outlines why the questionnaire survey was selected to form a component of the research. The process used, including the rationale for the design of the questionnaire, the implementation technique, method of the data obtained from the responses and subsequent techniques used to analyse the acquired information, are also discussed.

In Chapter 3, the history of storm water management is described. Basic principles and design applications of several different advanced and more mature storm water management systems are discussed, primarily focusing on a characteristic comparison. Past and current rain garden studies in North America are also introduced, regarding technical design characteristics and system performance.

In Chapter 4, a number of communities addressing the problem of runoff are examined. This chapter looks at a few examples from across North America having well-developed rain garden programs. Each case study has its unique features that will be described and this will add context to the situation in Winnipeg.

In Chapter 5, the background of the Ecole St Avila rain garden project was provided, including the location, stakeholders, timeline and purpose of the project. The detailed design of the project is also described in this chapter, including the planting zone that was designed by Native Plant Solutions of Ducks Unlimited Canada. Supporters and partners of the project are introduced to display and explain their efforts. Each of these partners may be able to play an important role to enhance the future development of rain gardens in Winnipeg and other communities. At the end of the chapter, several events catalyzed by the Ecole St Avila project are discussed to explore the efforts of this rain garden project.

In Chapter 6, results of the survey on rain gardens are provided. The aim of this survey was to determine the perspective of various stakeholders including school teachers and the public, about rain gardens and their potential future value and short comings.

Chapter 7 highlights the overall findings of this investigation. The results of the survey and findings are discussed in order to inform future decision making on storm water management in Winnipeg and the role that rain gardens might play.

In Chapter 8, a summary and the conclusions from the thesis research are presented. Implications for future investigation are included and several recommendations are provided.

Chapter 2.0 Research Design

2.1 Information Gathering

Information on rain gardens as a concept and their operating practices, exploring their history, present uses, and future possibilities, were all analyzed as part of this research.

Since an initial EPA literature review was published in 2001, many studies have focused on rain garden practices (USEPA, 2000). Most of the work done has shown the promising results, and new successes have been documented, but other unexpected issues have also arisen. Information gathered was from scientific and popular literature and internet sources, so that I could assess the current status of and future research needs for rain gardens.

Information for this research was gathered from a wide range of sources and analyzed using a variety of quantitative and qualitative methods. This helped me to assess what additional strategies are needed to provide a better way to implement rain garden development in Winnipeg and surrounding areas of Manitoba. Together this analysis provided a means to identify any gaps in understanding and the social expectations likely required to implement a broad rain garden project in this jurisdiction.

Documents (including local and national government material, academic research, journals, magazines, newspaper reports, as well as internet sources) were reviewed to aid in undertaking a literature review and research design for this study. This approach helped to establish the background and context for my study and clarified research gaps. Furthermore, this documentary analysis allowed a comparison of rain gardens as a means of urban storm water management with other possible approaches that could be used in Winnipeg.

2.2 Case Study Selection

The Ecole St Avila Rain Garden (SARG) in south Winnipeg was used as a case study to illustrate the concepts and ideas discussed in this study. This school, in partnership with its neighbors, Agassiz Child Care Centre and the Richmond Kings Community Centre, sought an innovative and ecologically beneficial approach to the drainage issues they were experiencing. The solution was developed focusing on water conservation and stewardship using a rain garden system.

Ecole St. Avila and the adjacent Richmond Kings Community Centre received more than $500,000 in federal, provincial and city funding to help manage storm water and curb nutrient runoff. The rain garden acts as a public education area, and inspiration for other schools and communities (Pembina Trails School Division, 2012). The system is the city's only public demonstration site for Winnipeggers who want to find out how a rain garden system works. The rehabilitated site will include interpretive signage for visitors.

The SARG project focused on the public regarding environmental sustainability and engaging them in bio-retention solutions, while making an impact on storm water management issues. The SARG constituted the central core of this study.

2.3 Survey

A survey was conducted to investigate the understanding and interest of teachers and parents with respect to the SARG rain garden development. In Fall/Winter 2011-2012, a sample of teachers and parents in the Ecole St Avila Elementary School area were asked to participate in a survey. Each participant received two consent forms and a survey question sheet that provided background information about the project, with more information available on a rain garden website. The link to the website was provided in the letter. Each participant took about 15 -20 minutes to complete the survey.

2.3.1 Survey Instruments

The instruments used in this research included a consent letter and two different survey questionnaires for the different participant groups. In order to better provide information, a rain garden website was previously developed to provide the appropriate background and knowledge for the survey respondents. The structure of the surveys included a variety of close-ended questions, offering multiple-choice ranking answers. Space was also provided at the end of the surveys for additional comments, so respondents could offer any additional information, comment about the survey, or clarify their responses. All survey answers were collected through Ecole St Avila. The raw data was transcribed and stored in Microsoft Excel. Descriptive statistics were used to characterize perceptions about and attitudes toward the rain garden concept. The research instruments do not have potential risk for participants, and were approved by the University of Manitoba Human Ethics Committee.

Website (Pembina Trails School Division, 2012):

http://www.pembinatrails.ca/stavila/schoolgroundgreeningproject/index.html

http://web.me.com/hchen628/Rain_Garden/Home.html

2.3.2 Participants

Participants were chosen from teachers and parents in the Ecole St. Avila Elementary School. All participants were adults, and each was assured of confidentiality of their responses. The reported research is from a sample pool of 15 teachers and 30 parents of students at the school. Each participant was given the brochure and related website information to allow them to better understand the research topic. Participants had a choice of whether to be involved in the research or not. After they agreed to participate in the research, a consent form was provided for their signature. Parents were randomly selected by the School's Parent Committee Chairperson. Teachers were directly contacted at the school. The investigator held a meeting for teachers to explain the research information. A consent form was obtained at the end of the meeting from those choosing to participate. The investigator contacted the School's Parent Committee Chairperson to deliver the survey to parents, and to obtain the responses and consent forms. All participants answered the questions on the survey sheet.

2.3.3 Informed Consent

A consent form was attached with each survey sheet. The consent form explained the research purpose, how participants would engage in the research, and the risks to which they might be exposed. If participants had any additional questions with regard to the research, contact information was also available for them to reach the investigator. The investigator collected and securely stored signed consent forms received back from participants.

2.3.4 Feedback

After all analyses were completed, the results of the social survey and a summary report were provided to participants and related partners. The analysis included a summary of respondents' barriers and incentives, relative to the use of rain gardens, their comments, discussion and future research recommendations. The investigator directly sent the summary report to participants through their email address if provided.

2.3.5 Risks and Benefits

One purpose of the survey was to enable officials, scholars and the public to be more aware of storm water runoff issues and concerns, and to enhance their knowledge of storm-water management. The results of the survey are expected to assist provincial and local governments concerning the effective implementation of various policies, and ultimately to develop a better functioning storm water management system for Manitoba. There was no potential risk for participants other than those encountered in everyday life.

2.3.6 Anonymity

In order to ensure respondents remain anonymous and to keep their responses confidential, there was no place on the survey for the respondents to indicate their name. The results of the research did not contain personal identifiers. Participants could provide their email contact information, so that research results could be provided to them. All raw data were analyzed and stored in the investigator's personal computer. The results of the data analysis were contained in the thesis report.

2.4 Attitudes and Ideal Practices

Respondents were asked to indicate their preferences using a Likert scale question. They were distinguished as having five relative orders of rating, including strongly disagree, disagree, neither agree nor disagree, agree and strongly agree. Five-order Likert questions were used because there was no need in this research to use greater than five, and using less than five does no always provide an adequate degree of separation for interpreting the meaning from the responses (Wuensch, 2005). Using this scale, respondents have a greater idea as to what each point in the scale represents, and are not forced to answer with an extreme response.

Along with strengths and weaknesses of other types of closed questions, those based on the Likert scale carry the additional advantage of providing consistent and uniform responses, but also the additional disadvantage of repetition that may lead to boredom by respondents (Wuensch, 2005). The main aim of the survey was to define public thinking and obstacles for rain garden development. The questions were divided into several parts, so that it was easier for participants to understand the process of the survey. Overall the questionnaire was designed to be relatively easy to answer to encourage a high response rate.

2.5 Questionnaire Response Analysis

After qualitative data are collected, they needed to be interpreted through the use of appropriate qualitative data analysis. In this study, the aim was to understand the social, economic and environmental processes at play in this initiative by exploring meanings, understandings, knowledge, experiences, feelings or opinions of the respondents. Therefore, qualitative analysis is inter-subjective knowledge that is constructed through the procedure of research and the interactions between the researcher and participants.

Results are presented primarily as bar graphs. In this study, qualitative data analysis was used in the form of data summary with some analytic ideas. Based on an interpretative philosophy, an analytical method is used to examine the meaningful and symbolic content of the qualitative data. If the questions do not have mean responses to be analyzed statistically, discourse analysis becomes a method to categorize the collected data. Discourse analysis provides meanings, practices and the extent to which individuals take up the forms of subjectivity offered by the particular discourses. This can explore various views held by the different respondents, and also address the unique obstacles and relevant characteristics mentioned in the responses.

2.6 Ethical Considerations

No special ethical considerations were identified in the study. This research was approved by the University of Manitoba Joint-Faculty Research Ethic Board (JFREB). As required by JFREB, participants were also provided a letter with information about the research and signed before the survey was conducted. (Appendix 1.1). The Project was evaluated and judged to be low risk. Confirmation of this is included in Appendix 1.2.

Chapter 3.0 Overview of Rain Garden Development and Research

3.1 Storm Water Management in the World

In many developed countries, point-source pollution has been controlled in a number of ways. However, non-point source pollution caused by storm water runoff has become a growing issue. In the United States, about 60% of lakes and 50% of rivers were significantly affected by non-point source pollution. U.S. Environmental Protection Agency (EPA) recent data also show that in some states, such as Minnesota and Wisconsin, urban runoff and other non-agricultural non-point source pollution are listed as leading sources of the pollution to local watersheds (Marshall, 2001).

Scientists and managers of many countries have undertaken a lot of research and practices to improve urban storm water runoff management. Some of these initiatives include the United State's BMP (Best Management Practices) (CSIRO, 2006) and LID (Low Impact Development) (USEPA, 2000), United Kingdom's SUDS (Sustainable Urban Drainage System) (Chatfield, 2005), Australia's WSUD (Water Sensitive Urban Design) (Lloyd, 2003) and New Zealand's LIUDD (Low Impact Urban Design and Development) (Van Roon, 2004). To promote the development of these measures, the relevant government departments have drawn up specific guidelines and set up specific research institutions; for example the United States established the Low Impact Development Center in 1998. Many cities have developed storm water management systems, which are based on sustainable management principles to control urban storm runoff negative impact (USEPA, 2000).

The traditional solution to storm water runoff mitigation has been a centralized end-of-pipe approach. In the past, decentralized wastewater treatment systems were commonly viewed as a temporary approach to storm water management and were intended for use only until centralized treatment systems could be installed. However, centralized systems are neither the most cost effective nor the most sustainable treatment option for a variety of reasons. There are several disadvantages to this approach including (USEPA, 2000):

- Disturbance to communities during construction.
- Ongoing maintenance costs
- Limited and unpredictable effectiveness
- Inability to address a wider range of water protection issues.

Urbanized areas have a broad mix of land uses, distinctive community characteristics, complex environmental and design regulations, and a wide range of community and economic goals. Hence, development of a customized implementation strategy for retrofitting decentralized controls in an urban area has to be fully understood by both the government and community stakeholders as a good practice in order to best manage the storm water issue.

3.1.1 Urban Storm Water Runoff Control Measure in USA

The United States was one of the first countries to study urban storm runoff control.

For example the USEPA spent $11.5 billion U.S. on the National Urban Runoff Project Research between 1981 and 1983 (CSIRO, 2006). Many large cities were included in this study to analyze local water pollution levels and its control. The United States Environmental Protection Agency (USEPA), through extensive research concluded, after nearly 20 years, developed a Best Management Practice (BMP) protocol to guide non-point source pollution management and urban storm water runoff pollution control (CSIRO, 2006). Since 1987, USEPA amended the Water Pollution Control Act to control urban runoff pollution in accordance with the law. The National Pollutant Discharge Elimination System (NPDES) expanded to include urban runoff pollution control and non-point source pollution control, officially promulgated in 1990, mainly for cities with populations over 10 million and with more than 11 types of industrial activities, including construction site areas greater than 5 acres (CSIRO, 2006). On March 2003, the second generation of the BMP system, urban water pollution control laws are more severe and technology to meet these guidelines is improved. The core objective of the BMP protocols is to ensure effective control of surface runoff pollution through a variety of cost-effective technologies and to meet the requirements of eco-environment measures before pollution of water bodies occurs. BMP includes engineering and non-engineering measures (Puget Sound Action Team, 2005). The engineering measures focus on runoff control, which includes the use of vegetation, retention ponds and filtration systems. Non-engineering measures included laws, regulations, and education methods. BMP's are widely used by USEPA to control urban non-point source pollution and pollution related to urban drainage systems, such as Combined Sewer Overflow (CSO) and the Sanitary Sewer Overflow (SSO) (EPA, 2004). Experience has shown that BMP's are an effective runoff control management option (CSIRO, 2006).

With the accumulation of experience and research results, it is clear that traditional control measures, such as retention ponds, are too expensive and difficult to achieve water quality goals (CMHC, 2012). Since the 1990s, storm water management experts in Maryland's Prince George's County began to study and establish a multi-point source runoff control strategy called Low Impact Development (LID) (Prince George's County Department of Environmental Resources, 2001). LID is an alternative strategy to replace BMP storm control, which was first used in building construction (USEPA, 2000). LID is mainly used in managing small watershed hydrology or conservation using natural control measures, including infiltration, filtration, storage, volatile and retention, so as to control runoff at the source (USEPA, 2000). As such, LID is different from the traditional approach of using large, expensive runoff management basins. LID measures can be easily integrated into the urban infrastructure, which has lower costs and better landscape results. Thus, the LID model provides a wide range of storm water management applications and is used in many developed countries, including the United States, Canada and Japan.

3.1.2 Other Innovative Storm Water Management

Drawing on the experience gained from both BMP and LID protocols, many countries have formed their own storm water management control system, such as

Australia's WSUD, United Kingdom's SUDS and New Zealand's LIUDD.

WUSD emphasized use of natural river systems as a gradual storm water runoff resource rather than rapid storm water discharge which provided the following benefits (Lloyd, 2003):

1. Natural protection of the city water system;
2. Consideration of landscape effect
3. Protection of the water quality of receiving water;
4. Use of natural retention ponds reducing the proportion of impervious surfaces so as to reduce the downstream peak flow;
5. Minimized efficiency of drainage infrastructure

Originating in Britain, SUDS incorporated a multi-disciplinary approach, coordinating development of urban storm water systems with input from developers, planning departments, construction groups, architects, landscape designers, ecologists and hydrological experts (Chatfield, 2005). Compared with BMP, SUDS is more comprehensive, not only for urban storm water management, but also for meeting some requirements of city sewage management. SUDS can also apply to rural areas, known as SDS (Sustainable Drainage System). SUDS was widely used in European countries, such as England, Scotland and Sweden. Since 1993, Scotland has implemented 767 sets of SUDS measures (Chatfield, 2005).

Since the 1990s, LIUDD was initiated to promote storm water runoff control systems in New Zealand. LIUDD used LID design and is similar to the WSUD techniques, which emphasize Integrated Three Waters Management (Van Roon, 2004). Integrated Three Waters Management is a key urban water management measure in New Zealand, which integrates measures associated with water supply, wastewater and storm water management. The core idea of LIUDD is to use an Integrated Catchment Management (ICM) method, integrating a number of households to the catchment area for land use and water design, to avoid the adverse effects brought about by the traditional urbanization process (Van Roon, 2004). In summary,

LIUDD = LID + CSD(Conservation Sub-Divisions) + ICM(Integrated Catchment Management) + SB(Sustainable Building)

Compared to BMP, LIUDD emphasizes the localization of the urban water cycle (Van Roon, 2004), to control storm water runoff at the source, thereby reducing the downstream water quantity and erosion effects. In implementation, LIUDD enhanced natural hydrological processes through the encouraging the penetration of runoff into soil groundwater

Compared with traditional urban treatment, innovative storm water management fully considers the characteristics of the natural water cycle to reduce the pressure on city sewer systems.

Table 3.1 Comparison of Different Storm Water Runoff Management

Strategy	Characteristics	Country
BMP	Control before runoff into the water body	USA
LID	Control at the source, Natural protection	USA, Canada, Japan
WSUD	Use runoff as a resource	Australia
SUDS	Reduce runoff & pollution to improve residential area	England, Scotland
LIUDD	Same as LID, Collect and recycle storm water	New Zealand

3.2 Past and Current Studies of Rain Garden Development

Since an initial EPA literature review was published in 2000, many studies have focused on rain garden practices (USEPA, 2000). Most of the research has shown promising results and documented new successes, but other unexpected issues have also arisen. These issues include the suitability of rain gardens for a particular site, water improvement, and winter performance. Despite the relatively rapid development of the rain garden concept throughout North America, detailed design guidance and related performance information are not currently available for many regions, including Winnipeg. In the United States, several local governments have adopted rain garden guidelines published by agencies of other states, often without modifying the guidelines for local weather, vegetation, soil conditions, or other local conditions. However, variations of the original design concept were only developed to solve the local problem, such as promote infiltration or specific nutrient reduction. Therefore, before developing any rain garden project, it is necessary to have a local guideline, including site criteria, design specifications, construction guidance, and maintenance recommendations

The following section summarizes the state of current knowledge of rain garden in addressing hydrologic, water quality issues and design consideration. It includes both field demonstration and laboratory mechanistic results.

3.2.1 Design Objectives

The design objectives are based on the local storm water management requirements. A wide range of storm-water management objectives need to be investigated to achieve the best local rain garden design.

Groundwater Recharge

In some areas, one of the design objectives of the rain garden approach to storm water management is to maintain pre-development groundwater recharge functions. Unfortunately, only a few governments have established regulations and design criteria for maintaining groundwater recharge. Maintaining groundwater recharge should not be excluded from rain garden design, but it is a serious issue in storm water management. The rain garden has the ability to recharge or restore groundwater in a given location.

Current Canadian policies do not have strict regulations on groundwater recharge in residential areas and there is limited research information here on groundwater recharge. Infiltration rates should be monitored to test the idea that rain gardens can enhance this hydrological factor. The result of such analysis may encourage the development of groundwater recharge policies in Canadian urban areas.

Infiltration and evapotranspiration processes are important functions of rain garden systems. Until now, however, only limited results have been published relating to how these processes function within a rain garden system, or how they benefit hydrology and contribute to removal of pollutants. A field study by Sharkey (2006) showed evapotranspiration accounting for the fate of 15–20% of all inflow water on an annual basis. Infiltration and evapotranspiration together can account for the fate of 50–90% of inflow, depending on local weather, soil type, media type and depth, and drainage configuration (Hunt et al., 2006 ; Heasom et al., 2006).

Water Quality Improvement

One of the most common goals of rain gardens is to reduce and remove pollutants from storm water runoff. Information on the pollutant removal performance of rain garden systems is limited but growing. Overall performance results indicated that rain garden systems have the potential to be one of the most effective storm water management systems in pollutant removal (Dietz, 2007).

However, because of the variability of conditions during runoff events, the water quality efficiency for rain gardens is not easily assessed. For example, when water quality input is relatively good, and pollutant concentrations are low, the output quality may not have significant difference from the input. The percentage removal may be low, but the output water quality is still good (Davis et al., 2001). Rain garden performance should not be indicated as unsatisfactory in this case. The runoff volume captured has a large influence on quality performance, and small storm capture is extremely effective.

Phosphorus and Nitrogen

Laboratory studies were used to provide some guidance on pollutant removal in rain gardens (Davis et al., 2001). Removal of total phosphorus (approximately 80% from an input concentration of 0.5 mg/L as phosphorus [P]), total Kjeldahl nitrogen (TKN) (50 to 75% from an input of approximately 3.5 mg/L), and ammonium (60 to 80%, 1.2 to 2.4 mg/L as nitrogen [N] input) were found, though nitrate removal was poor (Davis et al., 2001). Overall, these studies supported rain garden as an efficient treatment practice.

Nonetheless, because of the complexity of the chemistry, nutrient results have been variable. Some results documented a very high level of removal, but in others, the treatment efficiency was very low (Dietz, 2007). Due to various soil and vegetation condition, nutrient pollution removal of rain gardens is very complicated. Laboratory studies have shown 70–85% phosphorus removal (Davis et al., 2006). Field results in Maryland have also shown 77–79% phosphorus mass removal (Davis, 2007). The Davis study showed that the phosphorus content of the soil used in the original rain garden media was critical to phosphorus removal performance, which indicated that the variation was dependent upon initial levels of soil phosphorus (Davis, 2007).

Studies showed that organic nitrogen is captured well by the organic material in the media and total Kjeldahl nitrogen removal is also at 55–65% (Davis et al., 2006). However, nitrate is generally quite mobile in soil systems. Because the biogeochemical process of the nitrogen species is very complex, nutrient pollution deserves more investigation.

Metals

Several studies showed that metals appear to be very efficiently removed by rain gardens (Davis et al. 2003). Most removal appears to occur in the upper surface layers (Li & Davis, 2008). Copper, lead, and zinc, and some cadmium have been tested (Davis et al., 2003; Davis, 2007), and results showed the low concentrations in the output of the rain garden. Dietz and Clausen (2005) also found that metal concentrations in their rain garden output were very low, but the input concentrations were also not too high. At the UNH and the Villanova study, zinc removal was reported at 99% (UNHSC, 2006), and 74% (USEPA, 2006).

Oil and Grease

Rain gardens with several mixes of media seem to be very efficient in removal of motor oil (Hsieh & Davis, 2005). Laboratory studies have indicated that motor oil can be completely absorbed from incoming simulated storm-water runoff (Hong et al., 2006). Native bacteria in mulch can biodegrade the hydrocarbon pollutant in a few days, so the mulch layer may be one of the best means of removing oil and grease in rain gardens. The New Hampshire field data indicated that 99% removal of total petroleum hydrocarbons-diesel was removed by mulch (UNHSC, 2006).

Chlorides

Road deicing operations in winter may lead to rain gardens being exposed to a very high episodic chloride load condition (CEPA, 1999). Studies on chloride removal need to be conducted in the early spring or after snowfall, especially in Canada, as the presence of chlorides may dominate. No chloride study was found during my literature review.

<u>Flood Control</u>

Current storm water management perceive rain gardens to be a primary water quality management tool, but few recognize its ability to affect on peak discharge control and management for flooding control. Some examples clearly indicated that rain garden can be effective in controlling peak discharge rates (UNHSC, 2006). Field studies from the UNH Center reported that an average peak reduction of 85% was achieved from a rain garden site treating a large parking area (UNHSC, 2006).

3.2.2 Design Considerations

<u>Location Guidelines</u>

The rain garden concept was originally developed as a small storm water control measure. The fundamental concept includes integration of rain gardens into a site's landscape elements, which provides storm water control ability and reduces the cost of traditional storm water treatment.

However, the definition and drainage area criteria associated with rain garden technology have been changed due to the variation in local conditions and requirements. A rain garden can be not only installed in the front or back of a residential yard, but it can also be added into the overall plan of community development. However, due to safety issue and design feature, a school rain garden should be designed to ensure that the water it receives empties from it within 48 hours for the design rainfall (Murray, 2010).

The width, length, and depth of drainage area have minimum design criteria. However, with more than 10 years of design experience, field monitoring and research on rain gardens, more design criteria are required, including storage volume, ponding, media storage, and drainage area/bio-retention area ratios (Dietz, 2007). So the existing design procedures and criteria should be reevaluated and updated to consider the local characteristics, such as flood mitigation and pollutant removal needs.

Ponding Depth

Since the initial design of rain gardens was for very small applications, they were designed to provide very shallow ponding of 0.15 m (Clar & Green, 1993) and the infiltration rates of the surface and subsurface soil media was only 1.3–5.1 cm/h and 0.5 cm/h, respectively. The goal of the entire storm storage volume was to infiltrate to a depth of 60 cm in 48 hours (Clar & Green, 1993).

The initial Maryland 2000 Storm Water Management Design Manual (MDE 2000) modified the allowable ponding depth to 30 cm. In the design manual of an infiltration device, the subsoil infiltration rate must be at least 1.3 cm/h to meet the requirement for rain gardens. If the subsoil provides for less than 1.3 cm/h, the site is considered to be a filter rain garden and is required to use an under drain system to drain the water to meet specifications.

After many years of experience and study, the following ponding depth criteria should be considered for rain gardens (Davis, 2009):

1. The flow rate, storm duration, and the total volume;

2. The long-term runoff variation.

3. The surface storage ponding volume

4. The storage space in the soil and media

5. The infiltration rate of the subsoil and filter media

6. The anticipated maintenance schedule.

Deeper pond depths may increase the need for rain garden maintenance. Some rain gardens have been found to clog up and require cleaning. A study at a site in Minnesota found 4 of 12 rain gardens examined to have become substantially clogged after four years of the construction (Gulliver et al. 2008). The clogged pond resulting in deeper, longer standing water may pose a danger for people and promote mosquito breeding.

Soil Media Composition and Depth

The original rain garden design saw the application of natural soils with high permeability (Clar & Green, 1993). It included three soil textural classifications which included loamy sand (f =5.1 cm/h), sandy loam (f =2.5 cm/h), and loam (f =1.3 cm/h). These three are still being used on many rain gardens. However, the problem is the loam can have a clay content that may lead to failure of the system. In order to fix this problem, the soil and media mixes with high infiltration rates have become an alternative to the former design. A mix consisting of 50% sand, 30% topsoil, and 20% well-aged organic material such as composted leaf mulch, has been used by Prince George's County (Maryland) (PGCo, 2001). It can support the rain garden system, but this mix can result in increased cost for the media. Another example developed by the state of Delaware recommends a mix consisting of 1/3 peat moss, 1/3 sand, and 1/3 double-shredded mulch (DNREC, 2005), which supports the adequate infiltration, but further raises the cost of the mix. The soil and media mix need more study with the goal of reducing costs.

Hsieh and Davis (2005) confirmed that rain garden media characteristics do not have a large influence on the removal of metals and oil/grease. No matter what the soil media is, the system can remove all of these pollutants. However, media characteristics appear to play a significant role on the treatment of nitrogen and dissolved phosphorus species. Field studies by Sharkey (2006) have shown proper media selection is much more effective in phosphorus removal. Because the soil and media provide water quality benefits, in order to reduce the cost, soil and media specifications need to be more specific (Sharkey, 2006).

The original media depth was recommended be 1.2 m so as to provide proper amount of growth medium for selected plants (Clar & Green, 1993). However, some studies have shown that pollutant removal appears to be sensitive to soil depth. As mentioned before, Davis (2003) has shown high metal removal with media depths of 20 cm. Sharkey (2006) also showed over 60 % of N and P removal with 0.75 m media depths. So the media depth selection has to be adapted to local pollutant types.

In order to meet the design objectives, the advantages and disadvantages of different mixes, media materials, and depth need further research. Depending on the different objectives and parameters, a suitable soil mix and depth should be able to support the selected vegetation while emptying the ponded water in 48 h, and reducing the runoff and pollutant load. The life cycle and the cost of the system also need to be considered in the design of soil mix and depth.

Vegetation

Plants can promote short- and long-term benefits within a rain garden system in a number of ways. Vegetation can help to promote media permeability while diverting and slowing surface flow. Pollutants can be degraded by roots through microbiological processes. It seems that any native emergent aquatic vegetation with long roots could be effective in the rain garden system.

Maintenance

As many rain garden practices have been developed, the inspection and maintenance requirements for rain gardens continue to be investigated. Early on most rain garden developments focused on the maintenance of aesthetics, such as removing trash, adding mulch, mowing and pruning. Subsequently other maintenance activities concerning hydrologic performance were also considered, which include debris removal from the overflow inlet and improving the mulch layer and the top of soil media to maintain required infiltration rates. In order to ensure the inlets are not blocked by the deposited sediment, the area at and near the inlets needs periodic sediment removal. Laboratory and field studies indicate that sediment and metals accumulate only in the top 5–10 cm of rain garden media (Li & Davis, 2008), so that surface layers may also needs periodic removal and replacement to revitalize water quality performance. In the future, more issues of rain garden performance will arise. On-going research will allow greater refinement of rain garden design criteria and provide more solutions for their efficient maintenance.

Chapter 4.0 Urban Rain Garden Development Precedents

In the USA, many municipalities have begun to use rain gardens in new developments as part of an innovative storm water management strategy in order to solve local water quality issues, as well as to encourage groundwater recharge and control flooding. However, few government sponsored programs have been developed to promote the use of rain gardens in existing developments.

Because of the expanding knowledge base and increased public awareness of environmental responsibility, the number of projects addressing urban storm water management has been steadily growing in recent years. This chapter examines four significant examples of rain garden programs across North America.

4.1 Burnsville, Minnesota – Rain Gardens

Since the 1990s, storm water management experts in Maryland Prince George's County began to establish and study a multi-point source runoff control strategy --- Low Impact Development (LID), with rain gardens as one of the practices (Prince George's County Department of Environmental Resources, 2001). While the original rain garden may have been established in Maryland, a pilot rain garden project developed in Burnsville, MN followed soon after. The City of Burnsville is a suburb of Minneapolis - St. Paul. This project included the first study to measure the performance of rain gardens on pollution removal and runoff control (Barr, 2006).

Figure 4.1 Treatment Watershed Rain Garden Layout in Burnsville (Barr, 2006)

In order to deal with the increasing levels of pollutants found in local bodies of water, and specifically in Crystal Lake, Burnsville was chosen by the Minnesota Pollution Control Agency (MPCA) in 2002 to participate in a storm water management program for the urban area. The program required Burnsville to minimize the impact of storm water discharges. The program also required an in-depth storm water management study of pollution removal and volume control of the urban runoff. Co-funded by Metro Council and the City of Burnsville, BARR Engineering, a local firm with experience in innovative storm water management techniques, was hired to perform the rain garden study (Barr, 2006).

Burnsville's General Fund and Metropolitan Council offered $30,000 and $117,000 grants, respectively to start the rain garden project. The total budget of $147,000 underwrote the cost of the project and study. Initial technical research on rain garden practices was conducted by BARR Engineering to help ensure the project was within the scope of funding maximising the reduction of runoff. BARR Engineering designed the rain gardens, selected landscape plantings, worked with the City of Burnsville in educating the homeowners and oversaw the construction process.

The City of Burnsville was responsible for community meetings and informational brochures discussing the project and its pollution removal goals, so as to raise the knowledge and awareness of neighborhood residents. BARR Engineering conducted soil testing and analyses to select the suitable neighborhoods. Through the analysis, one street was selected as most suitable to participate in this study as 85% of residents confirmed their participation. After several months of construction, 17 gardens were built in 14 lots, four of which were in back yards. Another street nearby the study street was chosen as the control site for the research (Barr 2006).

In order to obtain accurate performance results, gauges were installed to measure runoff volume for both the project site and the control site. After several discussions between the landscape architect and the home owners, they decided upon the final design of rain gardens. All home owners agreed to take the responsibility of long-term maintenance of the gardens. The actual construction work was completed by a local landscape business, Mike's Lawn and Landscape, with less than a $50,000 budget (Barr 2006). The planting work started in September 2003 by the participating home-owners, city employees and community volunteers.

This project is a textbook example of successful rain garden implementation. Many parties, such as local government, private consultants and residents, were intimately involved in the design and implementation of this pilot project and study. This case study was used by other cities looking for methods to effectively reduce their own storm water volume and pollution through more natural and cost-effective methods.

4.2 Portland, Mount Tabor Middle School Rain Garden

The Mount Tabor Middle School Rain Garden was designed and built in the summer of 2006 by Kevin Robert Perry Landscape Architects, as approved by the Portland City Council in Oregon, USA. It is one of the most significant cases of innovative storm water management in Portland. The Mount Tabor Middle School Rain Garden received the

ASLA General Design Honor Award in 2007(Kevin, 2007).

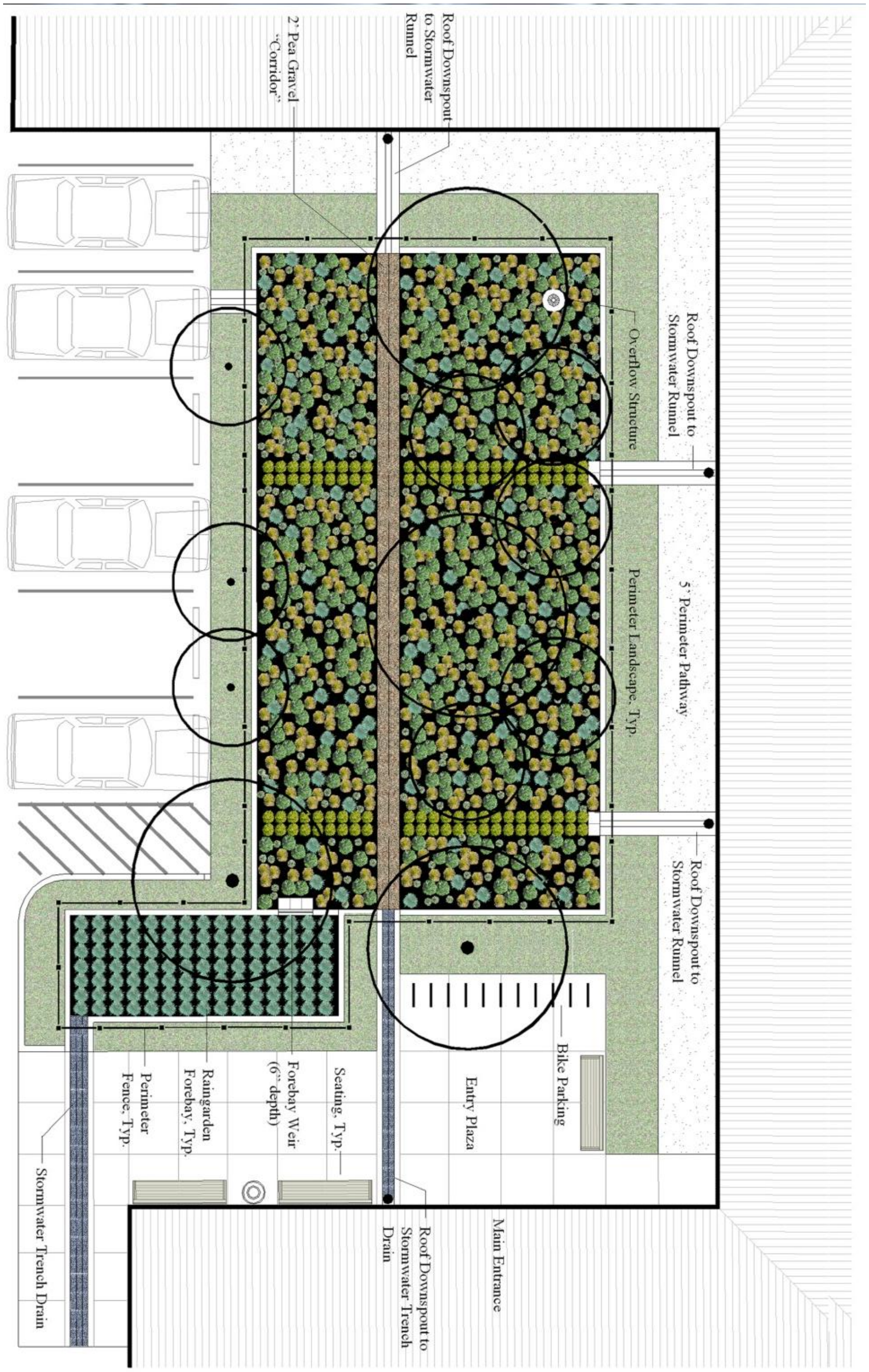
The original site was an underutilized asphalt parking area. Before installing the rain garden, and with no vegetation cover in the parking area, the adjacent school building and playground were very hot in the summer. The designer did not only plan to turn the entire gray parking into ‘green ground’, but also planned for aesthetic improvements, shade and cooling for the classrooms, educational benefits for the students, and storm water management improvement. The rain garden and other catchment areas manage runoff from the school building roof, playground, parking lot, and street surface (Kevin, 2007).

The Mount Tabor Middle School Rain Garden is the first such demonstration site in a school ground, which allows the City of Portland to promote the rain garden as an alternative storm water management program for other schools. The cost of construction was $523,000. The estimated cost for an alternative, replacing six sections of combined sewer pipe, was more than $1,300,000. The cost for construction was lower than the alternative of replacing the local combined sewer system (Kevin 2007). In a long term perspective, the value of these savings and benefits also results in a net savings over the life of the project, including maintenance activities for the systems. Although this is a small-scale storm water practice, it shows many features of imaginative and innovative landscape architect designs.

This award winning project has been a part of the recognition of Mount Tabor Middle School as the most comprehensive sustainable school in the United States (Kevin, 2007). This school has many elements of ‘green thinking’ in its design and construction.

Its rain garden system provides the natural treatment for the entire school storm water runoff, making nature and sustainability a key aspect of the experience of being in school (Kevin, 2007).

Figure 4.2 General plan of rain garden in Mount Tabor Middle school (Kevin, 2007)



ASLA Award Recipient, Mount Tabor School Rain Garden by Kevin Robert Perry, ASLA (photo by Kevin Robert Perry) Used with permission from ASLA, June 12th 2012

4.3 Kansas City, Missouri – 10,000 Rain Gardens

The Kansas City 10,000 Rain Gardens program was proposed as an alternative solution to replacing the aging storm water and wastewater system for that city (Buranen, 2008).

In April 2005, Kansas City approved a $500 million budget to improve storm water management. The local authorities decided to find an alternative solution to replace the ancient underground pipes. The idea for 10,000 Rain Gardens was first put forward at a Storm Water Coordination Meeting in May 2005, and was proposed as an alternative method of storm water management improvement during the lengthy process of infrastructure changes.

Kansas 10,000 Rain Gardens is a regional effort that puts the city at the forefront of public awareness about sustainable water management. The project website (www.rainkc.com) was developed as a resource for educating citizens about storm water issues and what individuals can do to reduce non-point source pollution in storm water runoff. It also provided detailed information about the design and installation of residential rain gardens in the region. The website received more than 100,000 'hits' in the summer of 2007. Through the media campaigns alone, it was estimated that the program reached more than 1 million people in 2006 and more than 3 million in 2007 (Kansas City, 2009). As a result of these efforts, by July 2008, 303 rain gardens had been registered on the website. The program's goal was 10,000 rain gardens in five years, by 2010. Unfortunately, progress has stalled since the economic down turn in 2008, and efforts to register additional rain gardens have ceased. While the budget was $500 million as part of an aggressive rain garden strategy, the money has yet to flow, leaving the program without financial capacity (Kansas City, 2009).

Although there were not enough funds to support future programs, the rain garden development is now heavily supported by the citizens of the entire city. The 10,000 Rain Gardens program could be considered as an excellent example of a successful aggressive education and public support campaign for on-site storm water retrofitting (Buranen, 2008). All types of properties are encouraged to participate, from public parks managed by the city to private business lots and especially private residential lots, where individual owners can elect to support the program (Buranen, 2008). The initial success and continued growth of the program shows how a well-defined educational initiative combined with a strong support web can change the way an entire region thinks about storm water management.

4.4 Rain Garden Program in North Delta, BC

In 2006, Cougar Creek Streamkeepers, in cooperation with the Corporation of Delta, the Delta School District, and Stream of Dreams, applied for and received a $12,300 grant from the Pacific Salmon Foundation to install a demonstration rain garden at Cougar Canyon Elementary School, 11664 Lyon Road, North Delta, BC (Delta, 2012). In late summer of 2006, Delta Engineering installed drain rock, soils and boulders, and planted a dozen larger trees. Under the supervision of the Streamkeepers, the rain garden native plants were planted by students themselves.

Since 2006, within the Delta School District, there are six elementary schools had a rain garden installed. The goal is for all elementary schools in North Delta to have a rain garden installed and 1-2 new rain gardens will be added each year until this has been accomplished (Delta, 2012).

As mentioned before, the Cougar Creek Streamkeeprs initiated the first Delta school rain garden at Cougar Canyon Elementary. Building on the success of the Cougar Creek Elementary School Rain Garden Project and other ongoing school projects in North Delta, the Office of Climate Action & Environment (CAE) was developing the Rain Gardener program to ensure the long term viability of rain gardens at other schools through the delivery of in-classroom education modules that raise participants' awareness of their connection to the watershed (Corporation of Delta, 2010).

With the installation of a rain garden, CAE has provided a set of curriculum based learning modules to a designated classroom (Gr. 4 or Gr. 5) that educated and engaged students as well as ensure the long term maintenance of the rain garden (Corporation of Delta, 2010) (Appendix 6). Every year the maintenance of the rain garden has been assigned to one classroom.

So far, this is the most significant school rain garden case in Canada. Local naturalist groups and Local First Nations have been also asked to speak on environmental issues as part of the program. It believes that the continued education of youth on environmental issues through school rain garden will build a long-term awareness of people connection to their local environment.

4.5 Observations

These four examples provided different but effective methods of storm water management through the use of a rain garden system. While every local area is different and warrants individual research and in-depth study before the undertaking of any storm water management program, these four examples provided valuable insight and information. The third and fourth examples are especially pertinent to this thesis. The Kansas 10,000 Rain Garden program and North Delta Rain Garden Program provide two excellent examples for establishing a grass roots rain garden development in Winnipeg.

Chapter 5.0 Overview of Ecole St Avila Rain Garden

5.1 Project Background

Ecole St. Avila is a K – 6 French immersion school in the Pembina Trails School Division directly adjacent to Richmond King's Community Centre, and is located about 0.5 kilometers south of the University of Manitoba. Ecole St. Avila is at capacity with 400 students due to the increasing popularity of its French Immersion program. The Agassiz Child Care Centre is also located in a separate building on the school property.

The entire 14 acres of land is owned and shared by each organization, and historically it has experienced repeated drainage problems falling significant rain events. After rain events, the uneven ground always resulted in large areas of standing water and soggy muddy spots. The school and playground area are surrounded by 9,000 residents. There is a large Regional Park (Kings Park) nearby, but there is no other significant public park in the surrounding area. In response to this gap and the hydrological problems, the school's Parent Advisory Committee began investigating an alternative form of drainage and developing an area for play, recreation and outdoor education (Pembina Trails School Division, 2012).

In 2008, the Parent Advisory Committee identified many parents who were willing to help and offer their expertise to improve their community, including a landscape architect, lawyer, accountant, professional photo journalist, and several parent groups. The School

Ground Greening Committee, a subcommittee of the Parent Advisory Committee was formed to look further into improving the grounds, which includes Richmond Kings Community Centre, Agassiz Child Care Centre, and École St. Avila School (Pembina Trails School Division, 2012).

After several discussions, an innovative project was devised by the School Ground Greening Committee which was to transform the existing grounds into a unique environmental friendly natural play area that would be landscaped with education in mind, not only aesthetically pleasing gardens with biodiversity values, but also provide educational materials to facilitate and enrich the learning opportunities. The Parent Advisory Committee accepted the concept and engaged the expertise of Scatliff + Miller + Murray Landscape Architects (SMM). Mr. Derek Murray, a parent of a child attending the school was a partner in the architectural firm and he joined the Parent Advisory Committee

SMM is a landscape architectural firm that was involved in developing Winnipeg's first community scale natural drainage systems in the residential community of Royalwood. This development was followed by using the same 'natural wetlands approach' at other Winnipeg housing developments, including Bridgewater Forest, Sage Creek, and South Point (Pembina Trails School Division, 2012). The landowners, City of Winnipeg and Pembina Trails School Division each provided extensive support towards the project along with 25 community partners who provided financial and technical backing. Native Plant Solutions, (NPS) a subsidiary of Ducks Unlimited Canada, later became a significant contract partner in the project. NPS also had been instrumental in developing naturalized wetland and upland systems throughout Winnipeg and in other parts of Manitoba. The Ecole St Avila Project is now nearing the end of a 5 year planning and construction period, which started in the 2008 – 09 school year. The project will be completed and fully operational in the 2012 – 2013 school year.

5.2 Project Steps

In October 2008, the rain garden concept was developed by the School Ground Greening Committee (Murray, 2010). At the same time, a funding strategy and stakeholder consultation were also initiated by the committee. The committee hired Scatliff + Miller + Murray Landscape Architects as the designer to create the master plan for the Ecole St Avila Project. Together with other stakeholders, SMM discussed and developed many features of the project. In April 2009, SMM collected all feedback from stakeholders, and finished the master plan. Concurrently, public open houses were held to raise public awareness about the rain garden concept (Murray, 2010).

In fall 2010, fences were installed on the site and the heavy construction equipment moved in. The first steps in developing the rain garden system were to transform the entire site into swales (ditches), berms (hills) and rain gardens (lower area to catch water). The total land area draining to the rain garden is approx. 23,000 sq m. (5.7 acres). The total area of grading work was approx. 8700 sq m (2.1 acres) and the total size of the rain garden is approx. 2340 sq m (0.6 acres) (Pembina Trails School Division, 2012). After the re-grading work was finished, boardwalks, an amphitheater and play structures were constructed at the end of October, 2010. Several photos were taken in the phase one period, between August 1 to November 15th 2010 (Appendix 3).

In the 2010 – 2011 school year, trees were planted and Native Plant Solutions, began planting the swales and rain garden with native species. Students, teachers, parents and the community provided much support. Additional tree and native plantings will occur in 2012 along with the installation of seating areas and interpretive signage (Native Plant Solutions, 2010).

5.3 Detail Design

An important aspect of the design is the development of the children's play area. The landscape architect divided the project area into several children's play zones. Each zone uses an animal as its feature (Murray 2010). As seen in Figure 5.1, a snake play area and a bird play area are consolidated at the south and southwest end of the site. The mouse play area is in the middle of the site, and the north and northeast of the site make up the frog play area and squirrel play area, respectively. The interior rain garden area separates each of the play areas, and provides the opportunity for each area to drain into it. These areas are located on the north of the school building. The play areas contain imaginative and natural elements and have a rubberized, colorful surface material.

Figure 5.1: Master plan of Ecole St Avila Rain Garden (Murray, 2010)

Used with permission from SMM, June 12th 2012

5.4 Planting for Ecole St Avila

The Ecole St. Avila Rain Garden was designed with three main planting zones by Native Plant Solutions (Figure 5.2), based on various site specific conditions as well as public use of the area by the school and local community (Native Plant Solutions, 2010). In June 2010, the upper- and backslope areas of the site were planted with a tall/mid-grow grass mix. This mix is composed mainly of mid-grow grass species with a sprinkling of tall grass species mixed in (Table 5.1). This design will help maintain good sight lines on site for smaller children while still providing for visual diversity in the plantings and interpretive opportunities for the school (Native Plant Solutions, 2010). The lower footslope areas at St. Avila were planted to a wet meadow mix of species better adapted to wet soil conditions. The wettest toeslope locations on site are dominated by a mix of wet meadow and shallow marsh species best adapted to ongoing wet conditions (Native Plant Solutions, 2010). Table 5.1 provides a list of the various plant species being considered for each zone. It is important to note that species composition within each zone will change over time and even on an annual basis based on site specific conditions (i.e. upper versus lower slopes), local hydrology, annual climatic variation, and ongoing management activities (Native Plant Solutions, 2010).

Wet Meadow and Shallow Marsh (Native Plant Solutions, 2010)

This mix is comprised of native grass and forb species that naturally grow to a height range of 45-150cm when in full seed head. Wet meadow and shallow march plantings consist of 12-17 species best suited to wet, low drained range sites. The wet meadow and shallow marsh mix requires irrigation but no fertilizers. Weed control is important during the first few years of establishment. Accumulated duff should be removed every 4–5 years to maintain plant vigor using cutting/raking, burning or grazing techniques (Native Plant Solutions, 2010).

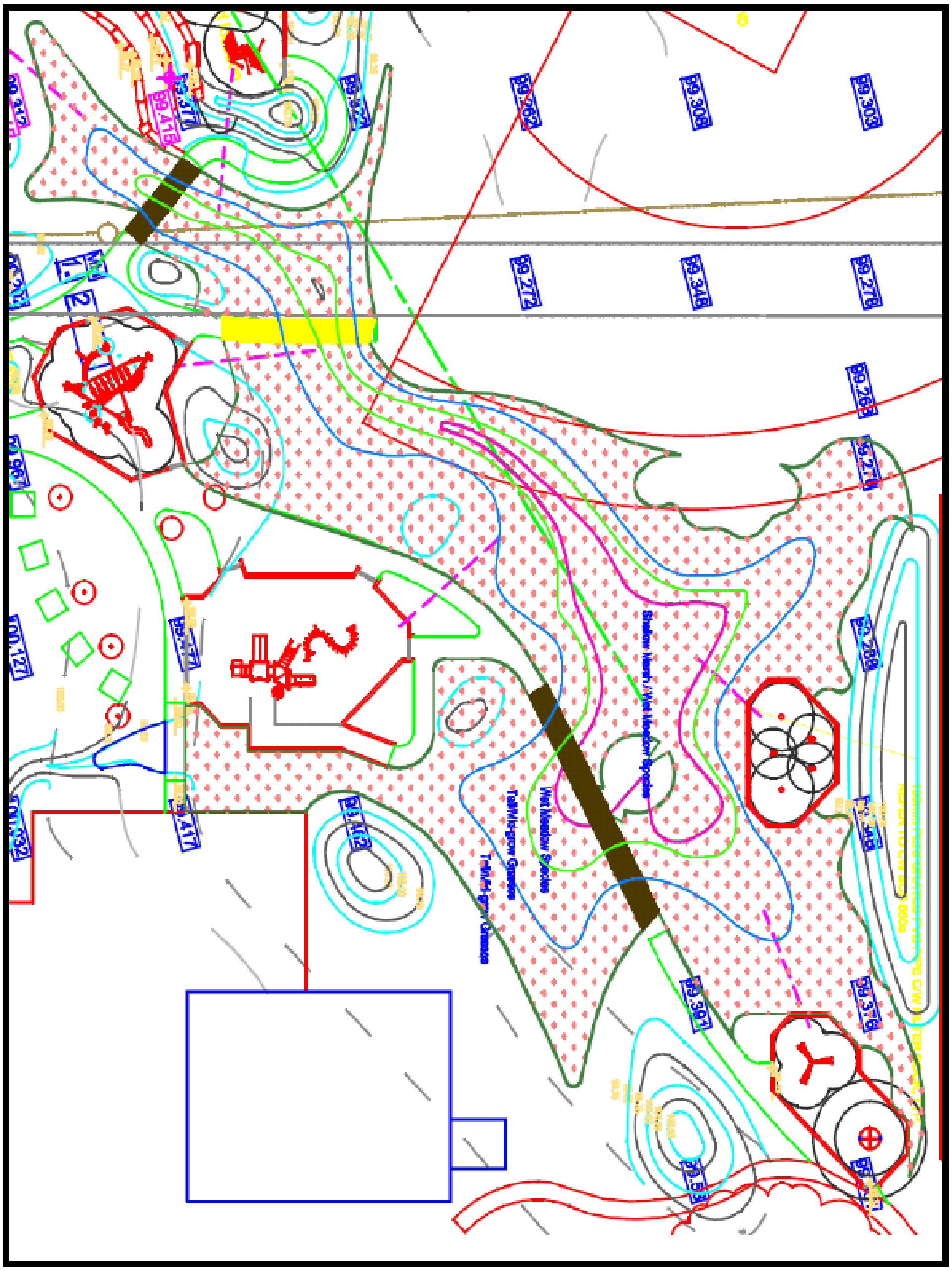
Mid-Grow Grass Plantings (Native Plant Solutions, 2010)

This mix is comprised of native grass and forb species that naturally grow to a height range of 50-80 cm when in full seed head. Mid-grow plantings consist of 10-15 species best suited to dry, well drained range sites with full sunlight. Fall colors are evident in this mix owing to several species of warm season grasses that produce purple-red foliage from mid-August to mid-September. Similar to other native grass blends, the mid-grow mix requires no irrigation or fertilizers. Weed control is important during the first few years of establishment. Accumulated duff should be removed every 4–5 years to maintain plant vigor using cutting/raking, burning or grazing techniques (Native Plant Solutions, 2010).

Tall Grass Plantings (Native Plant Solutions, 2010)

This mix is comprised of native grass and forb species that can naturally grow to a height of 100–150 cm in full seed-head. The tall grass plantings generally consist of 9-15 species, several of which are very drought tolerant. Many of the taller species tend to be better suited to upper-mesic range conditions on tops of slope. Starting around mid-August, the dominant tall grasses turn red, giving the entire planting this color and providing a striking contrast to surrounding ground cover. Like the mid-grow blend, the tall grass mix requires no irrigation or fertilizers but does require weed control during the establishment period. Accumulated duff removal is also recommended every 4–5 years (Native Plant Solutions, 2010).

Figure 5.2 : Location of the planting zones for École St. Avila: 1) Tall/mid-grow grass blend; 2) Wet meadow planting mix; and 3) Wet meadow/shallow marsh zone. (Native Plant Solutions, 2010)



Used with permission from SMM, June 12th 2012

Table 5.1 Proposed plant species lists for the vegetative zones at École St. Avila. (Native Plant Solutions, 2010)

Tall-Grass Species	Growth Height (cm)	Mid-Grow Species	Growth Height (cm)	Wet Meadow Species	Growth Height (cm)	Wet Meadow/Shallow Marsh Species	Growth Height (cm)
Green Needlegrass	50-100	Western Wheatgrass	30-90	Northern Wheatgrass	20-80	Prairie Cord Grass	90-240
Northern Wheatgrass	20-80	June Grass	15-40	Western Wheatgrass	30-90	Sedge species	20-60
Western Wheatgrass	30-90	Tufted Hairgrass	60-90	Canada Wildrye	100-150	American sloughgrass	50-70
Canada Wildrye	100-150	Nuttals Alkaligrass	30-60	Slender Wheatgrass	60-75	Blue-joint reed grass	90-200
Slender Wheatgrass	60-75	Fowl Bluegrass	25-90	Awned Wheatgrass	50-100	Needle spikerush	20-30
Awned Wheatgrass	50-100	Little Bluestem	30-70	Tickle Grass	15-100	Common spikerush	20-30
Big Bluestem	100-175	Side-Oats Gramma	30-60	Tufted Hairgrass	60-90	Fowl bluegrass	25-90
Indiangrass	100-175	Blue Gramma	25-50	Switchgrass	80-120	Arctic rush	30-45
Switchgrass	80-120	Buffalograss	10-20	Prairie Cord Grass	90-240	Seasice rush	30-45
		Purple Prairie Clover	30-60	American sloughgrass	50-70	Alpine rush	30-45
				Tall Mana Grass	60-90	Switch grass	80-120
				Fowl Bluegrass	25-90	Wild mint	15-80
						Softstem bulrush	120-150
						Hardstem bulrush	120-150
						Tickle grass	15-100
						Broadleaf cattail	70-150
						Aster species	30-90
Height Range (cm)	**20-175**		**10-90**		**15-240**		**15-240**
Average (cm)	**90**		**50**		**60**		**60**

Used with permission from SMM, June 12^{th} 2012

5.5 Support and Partners

The School Ground Greening Committee was looking for partners and technical supporters since 2008. Because this project is unique and because it is on school property, extensive expertise was required to ensure safe and effective results. The following partners were involved with the project.

Table 5.2 Support and Partners for Ecole St Avila Rain Garden (Lukes, 2011)

City of Winnipeg:	Public Works, Property Planning and Development, Parks and Naturalist Services Branch worked closely with the project. The City owns part of the site property and assisted in the planning, design and implementation of the project on the City property. The City sees this as an opportunity to assist in a mid-size public water stewardship project.
Richmond Kings Community Centre (RKCC):	RKCC supported this project in partnership with the City to offer services to help with maintenance of the project.
Scatliff + Millar + Murray Landscape Architects (SMM):	SMM provided technical advice, guidance and project management on the project from conception to conclusion. SMM works closely with Native Plant Solutions and Ducks Unlimited. SMM are the architects incorporating wetland projects into two large scale urban residential developments in Winnipeg, Royalwood and Waverly West South.
Native Plant Solutions / Ducks Unlimited:	Native Plant Solutions has been working closely with the project since 2009. Extensive insight and expertise on native plants, grasses and wetland development was offered to the project.
Ecole St. Avila Home and School Association (Representing 400+ children & families in the community):	The project Lead is the Ecole St. Avila Home & School Association. The Association has proven to be very effective over the years in fundraising for projects to enhance the children's educational opportunities. As a parent with children attending the school, Mrs. Janice Lukes contributed significant effort with her experience in fundraising development for the project (Lukes 2012).
Ecole St. Avila School Age Child Care Association:	This association provided programming for 60 participants before and after school hours. They have limited access to the school's gymnasium, kindergarten and computer rooms. They will have many occasions to use the improved outdoor site.
Agassiz Child Care Centre:	Also located on site, the Child Care Centre was undergoing a re-roofing of their facility and was working closely with the SMM design team to ensure proper channeling of roof runoff related to the rain garden. The Child Care Centre, with 70 children in their care, sees improved drainage, recreational and educational opportunities as a huge bonus.

Pembina Trails School Division:	The school division is a key partner and funder of the project. RKCC worked with Pembina Trails School Division in 2007 when they installed the underground drainage system on both properties. They initiated a series of monthly update meetings to work through the many unique development challenges and opportunities that arose during the project. The Division is very interested in the project and will be closely monitoring the results.
Evergreen Foundation:	Evergreen is a registered national charity founded in 1991and motivates people to create and sustain healthy, natural outdoor spaces, giving them the practical tools to be successful through its three core programs. Evergreen Canada is monitoring this project closely as it sees it to be a model for future projects.
Province of Manitoba, Department of Education:	The Department of Education's Sustainable Development initiative staffs were working with the project to assist in maximizing outdoor classroom features related to curriculum.
Department of Conservation and Water Stewardship:	Manitoba Conversation provides funding for the project from its Sustainable Development Innovations Fund and the Special Conservation Fund. The project is also supported by the Manitoba Water Stewardship Division and its Minister. Who provided funds for development of curriculum linked educational resources.
Science, Technology Energy and Mines:	The project has incorporated ideas relating to Manitoba mineral mining and it may incorporate this theme as part of the schools outdoor classroom components.
Seine Rat River Conservation District & LaSalle Redboine Conservation District:	Both rural conservation districts border the south part of the city of Winnipeg and see extensive benefits in supporting this project. Seine Rat River has developed a rain garden brochure which they have offered to the project to use in community outreach for the water stewardship project.
Rivers West:	Rivers West is educational consulting consortium who have offered technical and educational advice to the project. Rivers West has managed the development of curriculum guides to help teachers use the Red River watershed as an example when teaching the Manitoba curriculum. All three guides provide local information, encourage hands-on site-based learning and contain hundreds of activities and fieldtrip ideas that match curriculum outcomes (Rivers West, 2012).
Winnipeg Trails Association:	With improved drainage on site, The Winnipeg Trails Association provided technical advice on trial development throughout the proposed site.

Table 5.3 Funder and Funding amount for Ecole St Avila Rain Garden (Lukes, 2010)

No.	Funder	Amount	
1	Pembina Trails School Division	$	10,000.00
2	Ecole St. Avila	$	11,000.00
3	Agassiz Child Care Centre	$	7,500.00
4	ESA Home and School Association	$	6,500.00
5	ESA School Age Child Care	$	1,000.00
6	Manitoba Hydro	$	14,700.00
7	Winnipeg Foundation	$	10,000.00
8	Lake Winnipeg Foundation	$	5,000.00
9	City of Winnipeg	$	145,000.00
10	Assiniboine Credit Union	$	3,000.00
11	Evergreen	$	2,000.00
12	World Wildlife Federation	$	5,000.00
13	Province of Manitoba	$	97,500.00
14	LaSalle Redboine Conservation District	$	2,100.00
15	TD Friends of the Environment	$	10,000.00
16	Wal-Mart Evergreen	$	10,000.00
17	Royal Bank Blue Water	$	5,000.00
18	Environment Canada – Federal Gov't	$	46,014.00
19	Playstructures (RInC - Federal Gov't)	$	23,666.00
20	Playstructures (RInC - Federal Gov't)	$	76,500.00
	Project Total	$	491,480.00

5.6 A Catalyst for Engagement

There is both an increasing awareness of and participation in rain garden development, resulting from the effects of the rain garden project at Ecole St Avila. Led by Mrs. Janice Lukes, the Ecole St. Avila rain garden became a catalyst for the following engagement (Lukes, 2011):

- Upwards of 18 schools have toured the site and are developing similar projects
- Twelve community organizations including the St. Norbert Farmer's Market are working together to develop a similar project in St. Norbert
- Eight partners including the Province of Manitoba, Dept. of Education and Water Stewardship are developing a Manitoba guide for storm water management for use by schools and the public
- World Water Day 2011 was celebrated with plans underway to make it an annual event
- The Minister of Water Stewardship has made multiple visits and is engaging the school with Israeli schools on a collaborative water quality testing project
- The teachers are taking focused educational watershed courses supported by Pembina Trails School Division, Green Manitoba, the Oak Hammock Marsh Interpretive Centre and Ducks Unlimited Canada.
- Several University of Manitoba students are monitoring the project and doing thesis work it.
- The Fort Richmond Collegiate Wetland Centre of Excellence high school students worked with Ducks Unlimited and other partners to deliver wetland and watershed training to the students of Ecole St Avila.
- The SARG will be featured at the 'Sustainability: Educating for ACTion' conference in 2012

5.7 Summary

The Ecole St Avila Rain Garden was a ground breaking project in Manitoba. There was no other school or community centre addressing outdoor drainage in a sustainable manor in Manitoba. This project was unique to Manitoba and was one of only a few schools in Canada addressing water stewardship on school grounds. Because it was the first school rain garden project in Manitoba, many other positive experiences may arise from it. For example a better understand by the public about local water management issues is one such outcome. The next chapter presents findings from the social feedback of rain gardens through a survey at Ecole St Avila.

Chapter 6.0 Social Surveys

School teachers and parents at Ecole St Avila were surveyed about rain gardens to investigate social characteristics through an examination of their attitudes and opinions. While previous surveys were performed to gauge the student's attitudes towards this rain garden (Lukes, 2010), no data existed about the attitudes of teachers and parents towards it. Also unknown was the likelihood that local residents would build a rain garden in their own yards. Although the project is not fully operational, this survey was also intended to help understand how teachers and parents gained knowledge from this project to date, in order to better communicate and promote future rain garden implementation. It will also act as a baseline for future studies of a similar nature, once the project has been operational for a number of years. Research questions and results are reported below, and survey questions are in Appendix 2. Due to a small sample size (Teachers=15, Parents=16), descriptive statistics only were performed on all questions.

The results indicated that teachers and parents were not very familiar with the idea of rain gardens before they learned about the rain garden project at Ecole St Avila (Figure 6.0.1). Thereafter, however, the knowledge of participants about rain gardens was found to be much improved (Figure 6.0.2). It seems that the Ecole St Avila project and related information has enhanced the understanding of teachers and parents about rain gardens and local water management issues.

Figure 6.0.1 Teachers' knowledge on rain garden before seeing the website

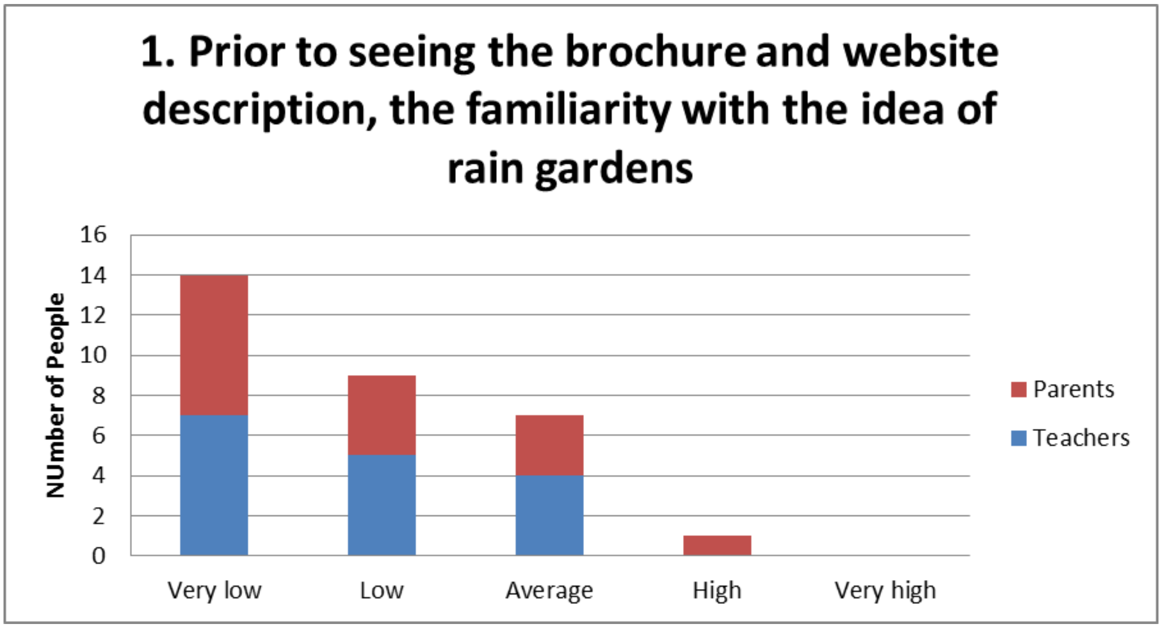
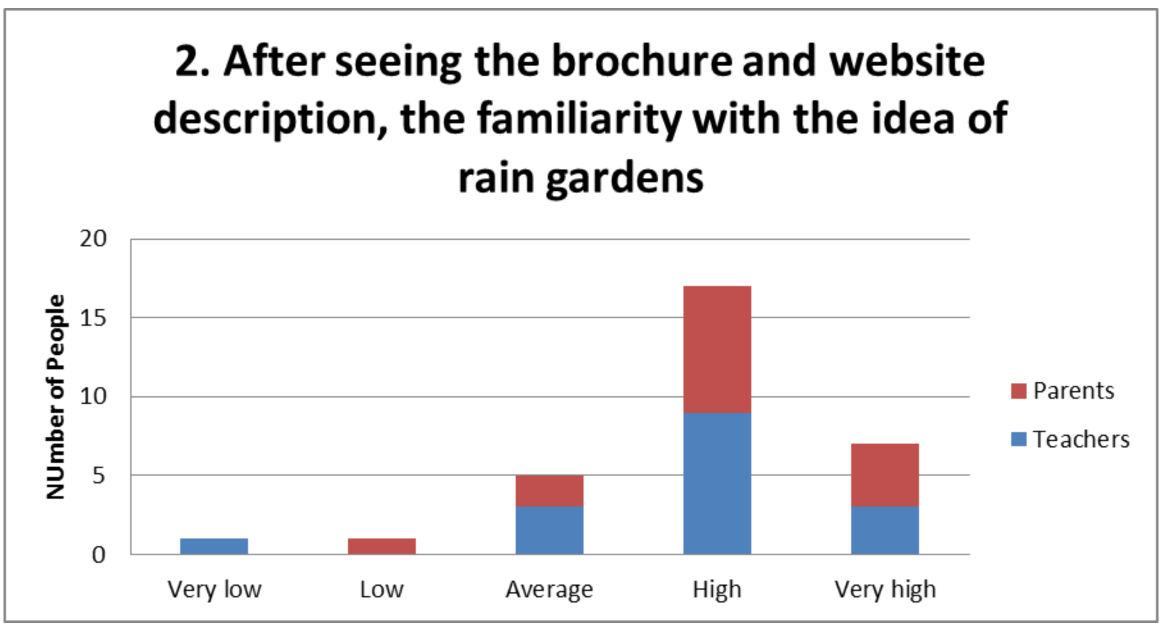


Figure 6.0.2 Teachers' knowledge on rain garden after seeing the website



6.1 How the school would be affected by building a rain garden

The teachers at Ecole St Avila thought that building a rain garden on their school ground was not very difficult (Figure 6.1.1). Also, 7 of 16 teachers thought building a rain garden at the school was enjoyable (Figure 6.1.2). Most of the school teachers indicated that building a rain garden was not very affordable (Figure 6.1.3). In addition to financial investment, time was also a major consideration. Compared to building a grassy lawn, over half of the teachers thought that installing rain gardens was very time-consuming (50%). Only two teachers thought it was not time-consuming (Figure 6.1.4).

Figure 6.1.1 Teachers' perception about the difficulty in building a rain garden

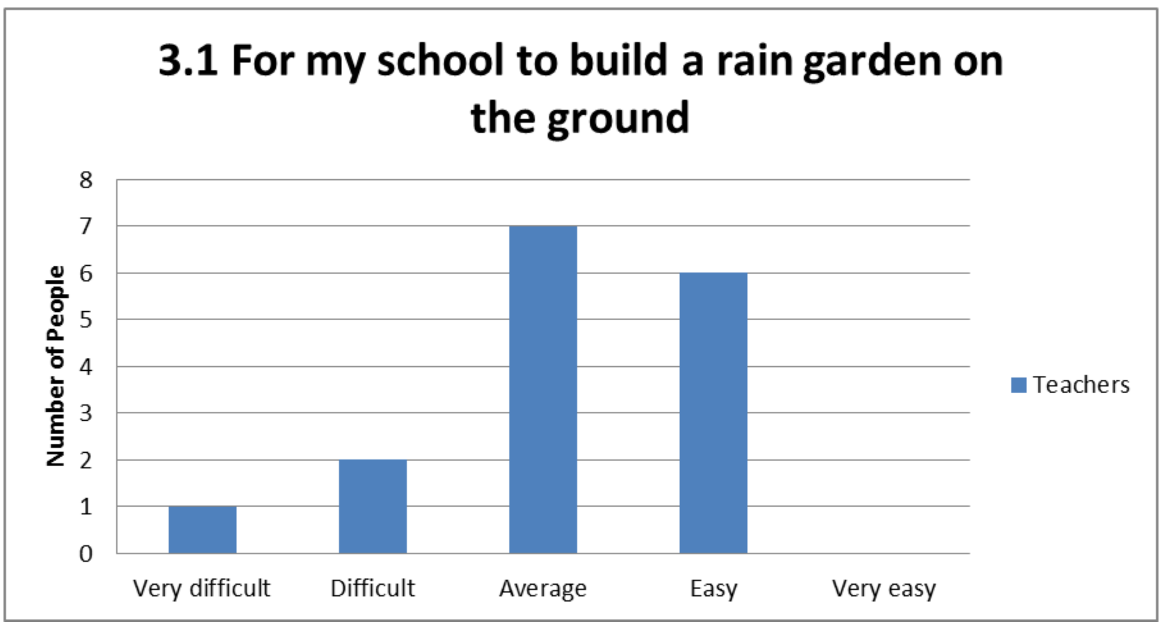


Figure 6.1.2 Teachers' perception about the pleasure of building a rain garden

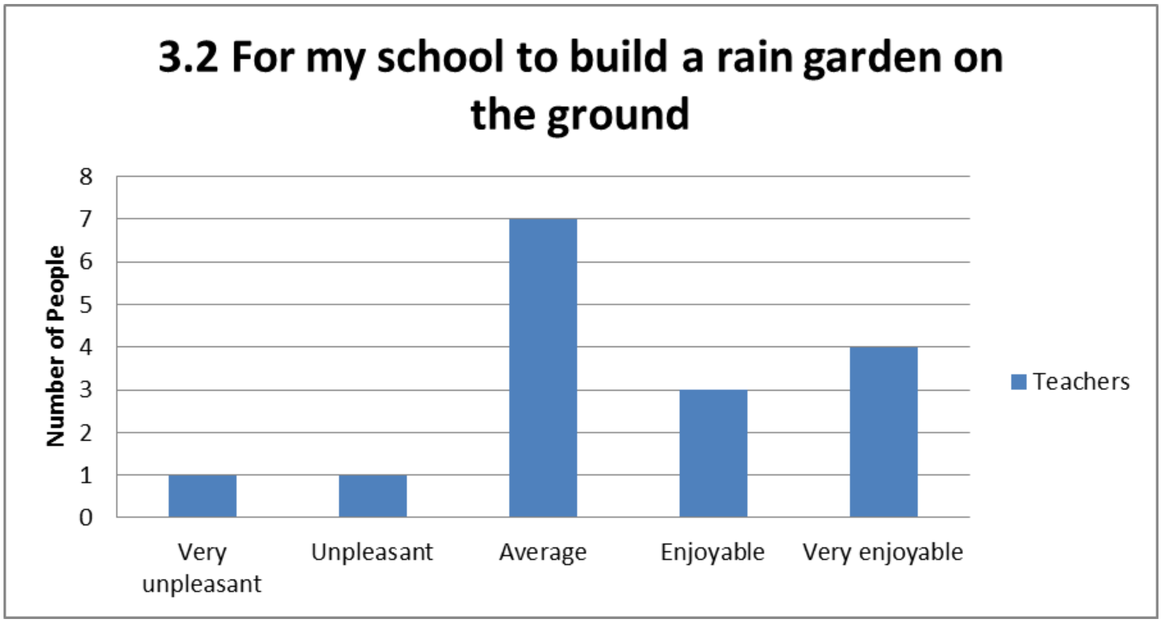


Figure 6.1.3 Teachers' perception of cost of building a rain garden

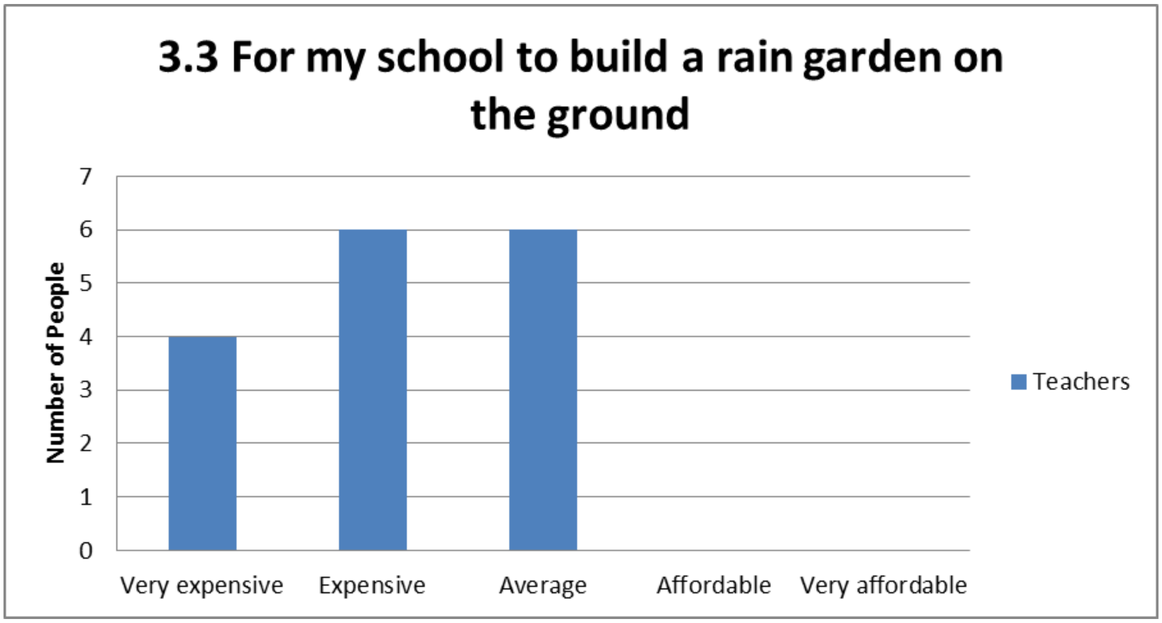
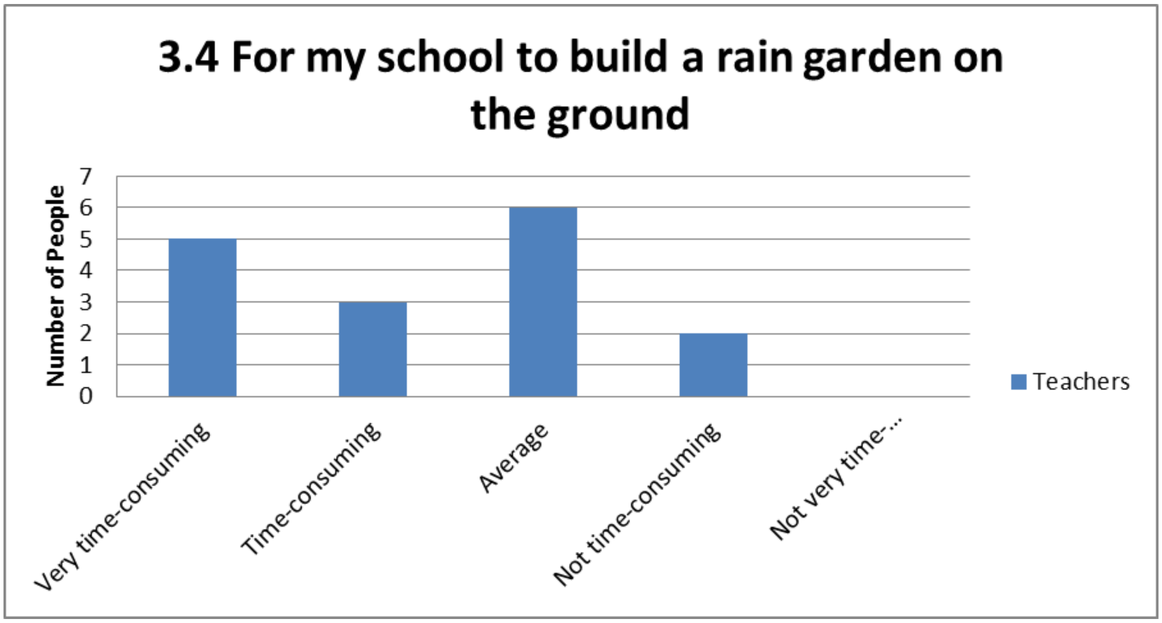


Figure 6.1.4 Teachers' perception of time to build a rain garden



The majority of school teachers (56%) indicated that it was necessary for their school to hire someone to undertake the installation of their rain garden (Figure 6.1.5). Most of the school teachers (93%) thought it was not difficult to hire someone to help the school with this undertaking (Figure 6.1.6), but 44% of teachers indicated that it would still be expensive for their school to complete the project (Figure 6.1.7).

Figure 6.1.5 Teachers' perception on the necessity of hiring someone to build rain garden

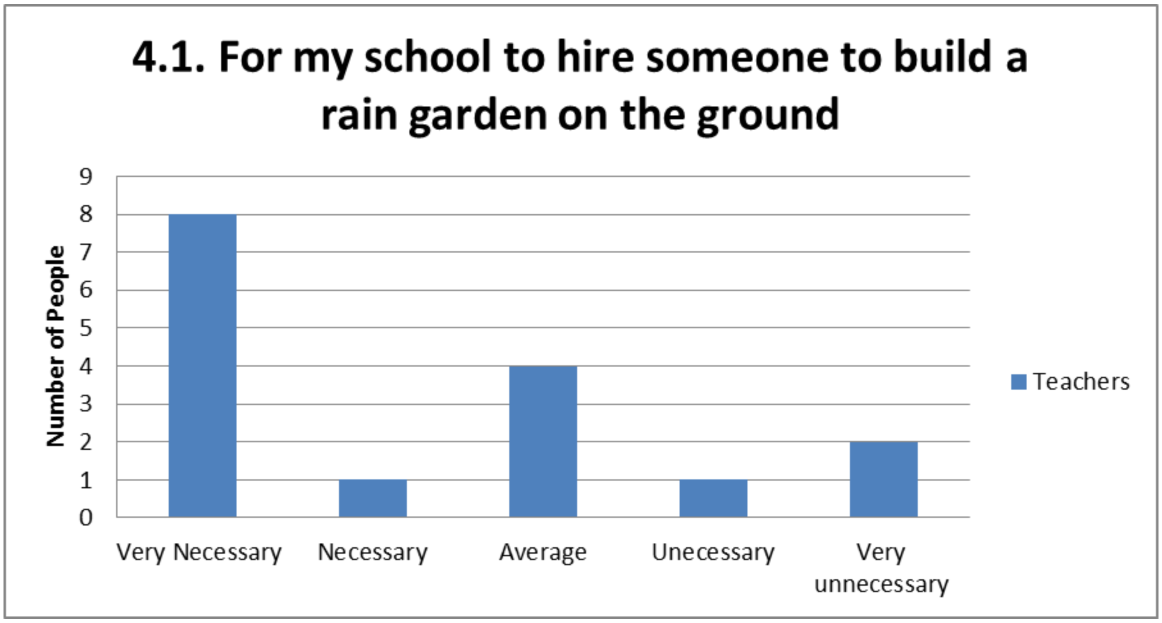


Figure 6.1.6 Teachers' perception of the difficulty of hiring someone to build rain garden

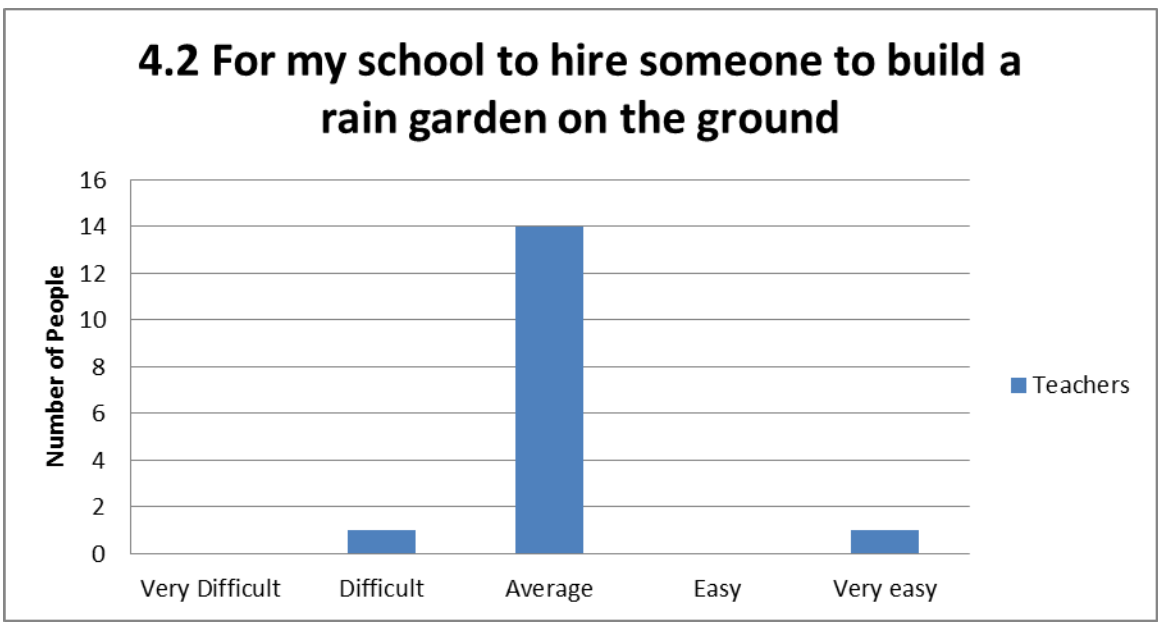
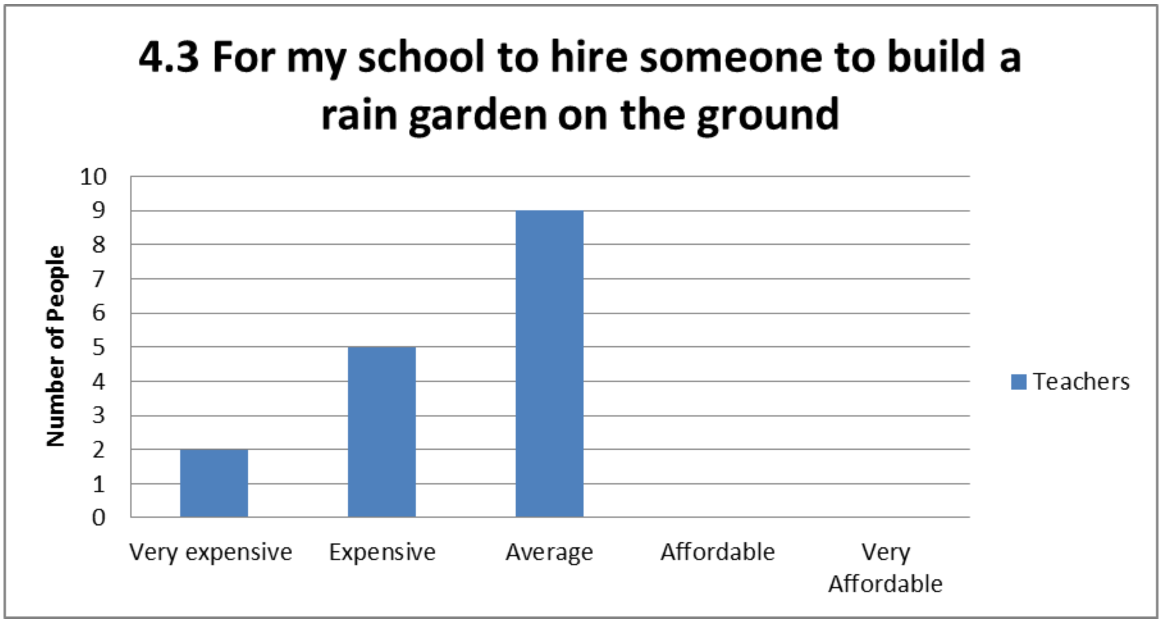


Figure 6.1.7 Teachers' perception of the cost of hiring someone to build rain garden



Maintenance is also a major part of the operation of a rain garden. 5 of 16 teachers thought more time would be spent on gardening or lawn care than before completion of a rain garden (Figure 6.1.8). Some of the teachers (4 of 16) also indicated that spending more time on maintaining a rain garden was undesirable for school staff (Figure 6.1.9). In addition, the key consideration in the school was the safety of students. Several teachers and parents felt that the building of a rain garden might bring significant safety issues to students, but 42% of total participants were not sure about the safety issue (Figure 6.1.10).

Figure 6.1.8 Teachers' perception of time required to maintain a rain garden

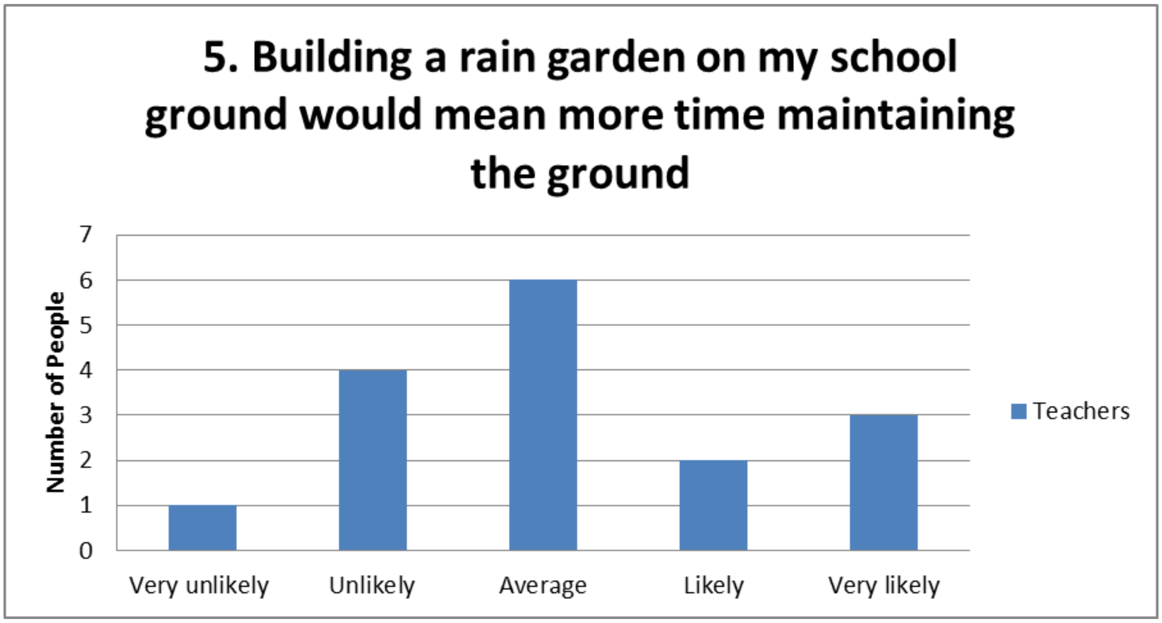


Figure 6.1.9 Teachers' perception of pleasure of maintaining a rain garden

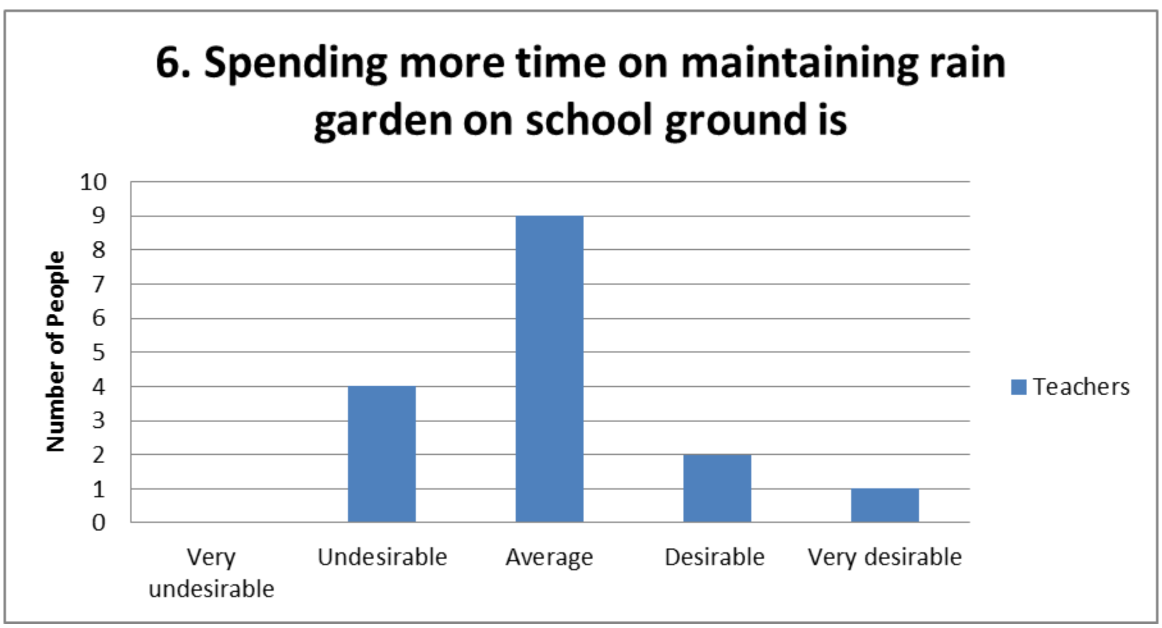
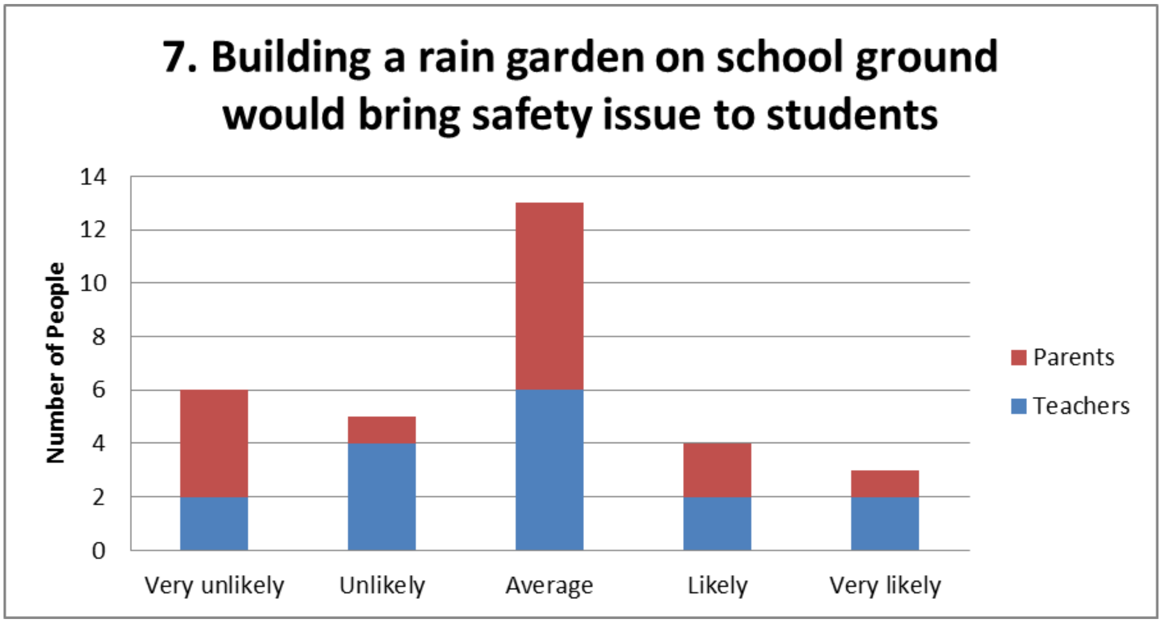


Figure 6.1.10 Teachers' and parents' perception of safety to students by building a rain garden



6. 2 The school capacity to build a rain garden

When asked about the four demands for installing their rain garden, the majority of the teachers (69%) cited the knowledge needed as their most influential demand (Figure 6.2.2). However, most of the parents thought they had the knowledge needed to help the school build a rain garden. A majority of teachers (Figure 6.2.3), 82%, indicated that they did not have free time to help the school to build the rain garden, and 60% of parents were not sure if they had time to help the school in its maintenance, such as removing trash, adding mulch, mowing or pruning. Without funding received from organizations and government, most of the teachers thought that the school did not have the financial means to install a rain garden (Figure 6.2.4). Compared to the teachers, most of the parents felt that they had the physical ability for the installation of a school rain garden

(Figure 6.2.1).

Figure 6.2.1 Teachers' and parents' perception of physical ability to help school to build a rain garden

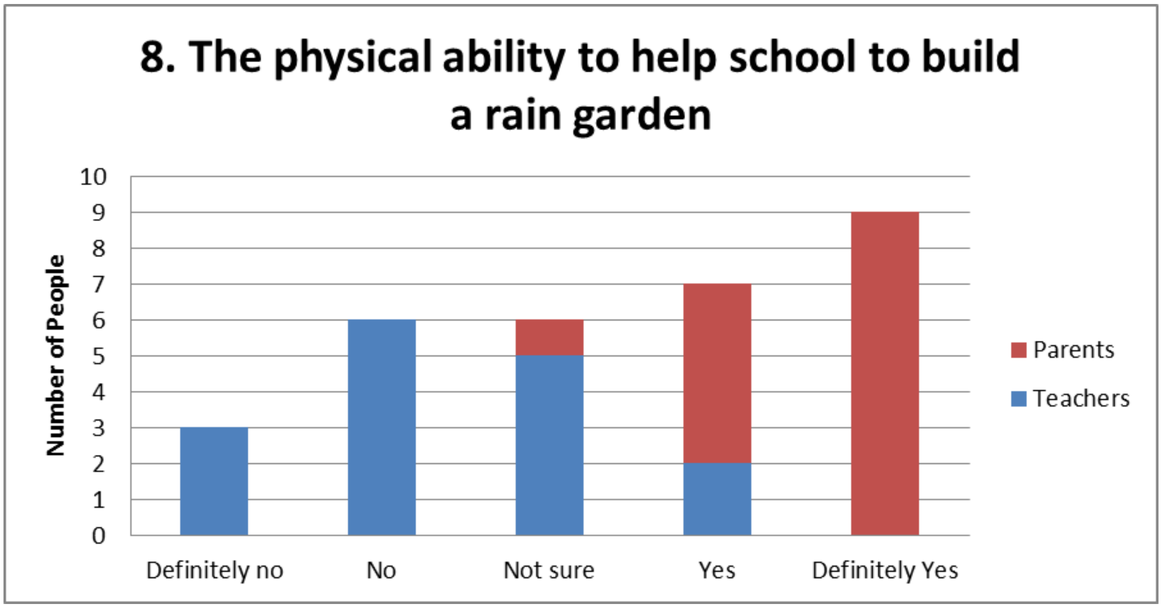


Figure 6.2.2 Teachers' and parents' perception of knowledge needed to help school to build a rain garden

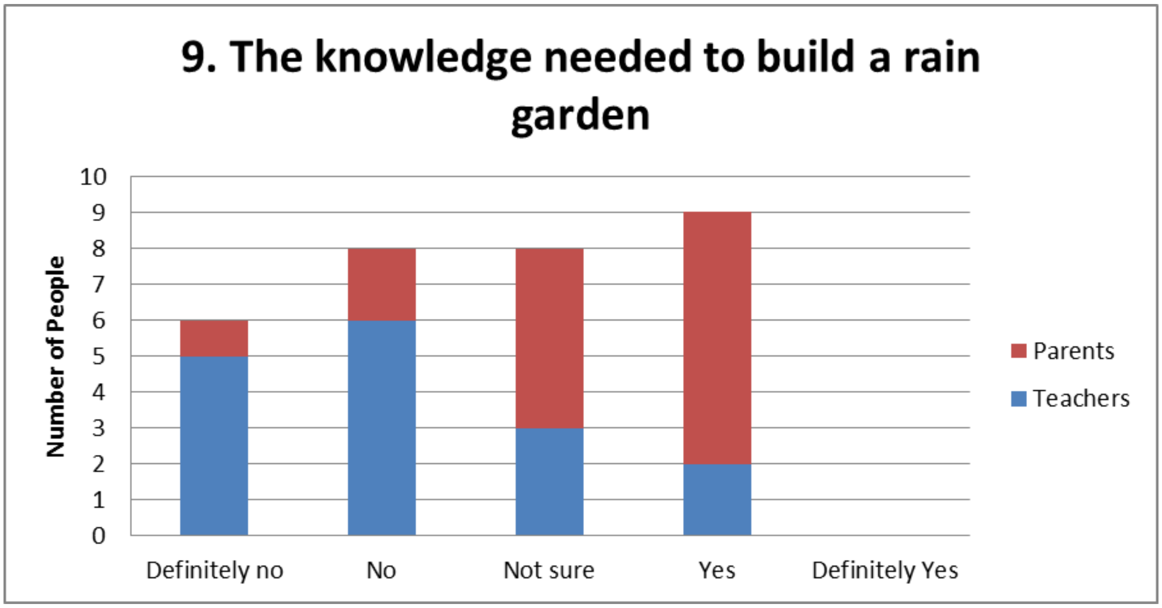


Figure 6.2.3 Teachers' perception of school financial means to build a rain garden

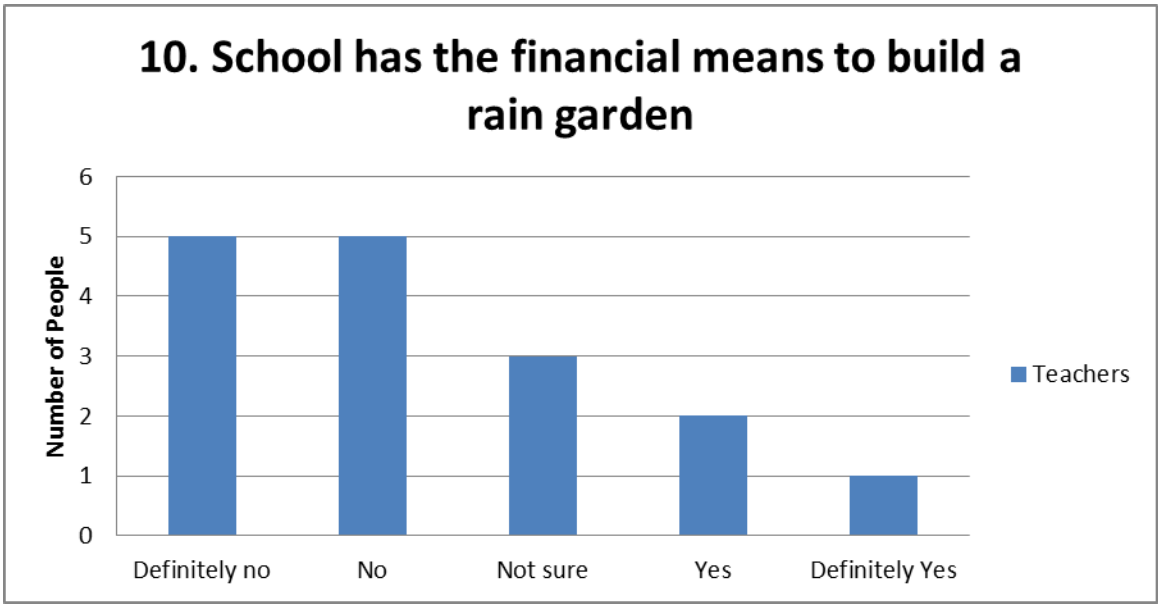
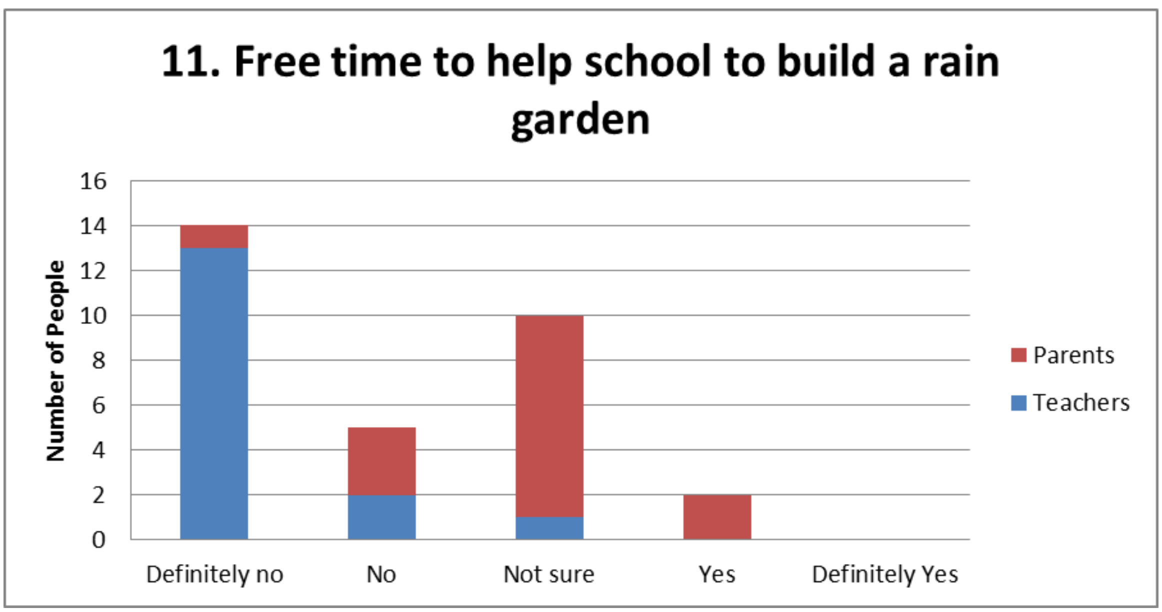


Figure 6.2.4 Teachers' and parents' perception of free time to help school to build a rain garden



6. 3 How the school would be affected by a rain garden

With regard to the value of school property after the building of a rain garden, most of the teachers and parents (68%) (Figure 6.3.1) felt that their rain garden would definitely increase the value of the school, and would very likely improve the appearance of the school ground (Figure 6.3.2). In addition, the majority of the teachers and parents also felt that their rain garden would very likely increase the amount of wildlife attracted to the school ground (Figure 6.3.3), and would be a benefit for students by increasing the wildlife habitat on the school ground (Figure 6.3.4).

Figure 6.3.1 Teachers' and parents' perception of the value of school property by building a rain garden

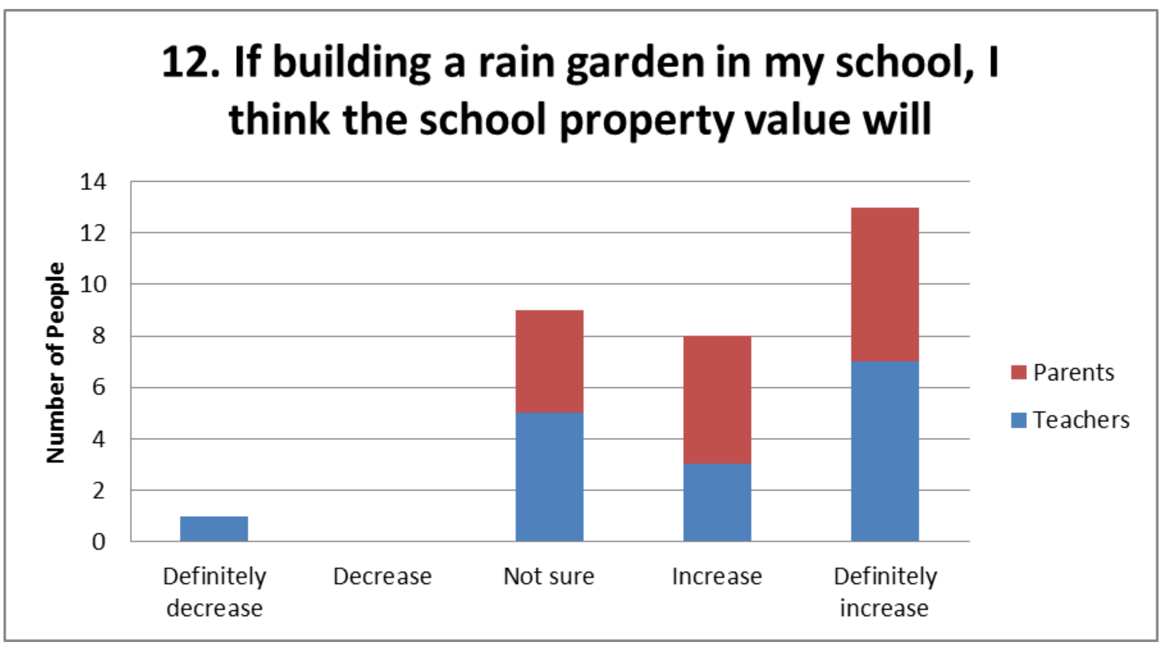


Figure 6.3.2 Teachers' and parents' perception of improving the appearance of the school by building a rain garden

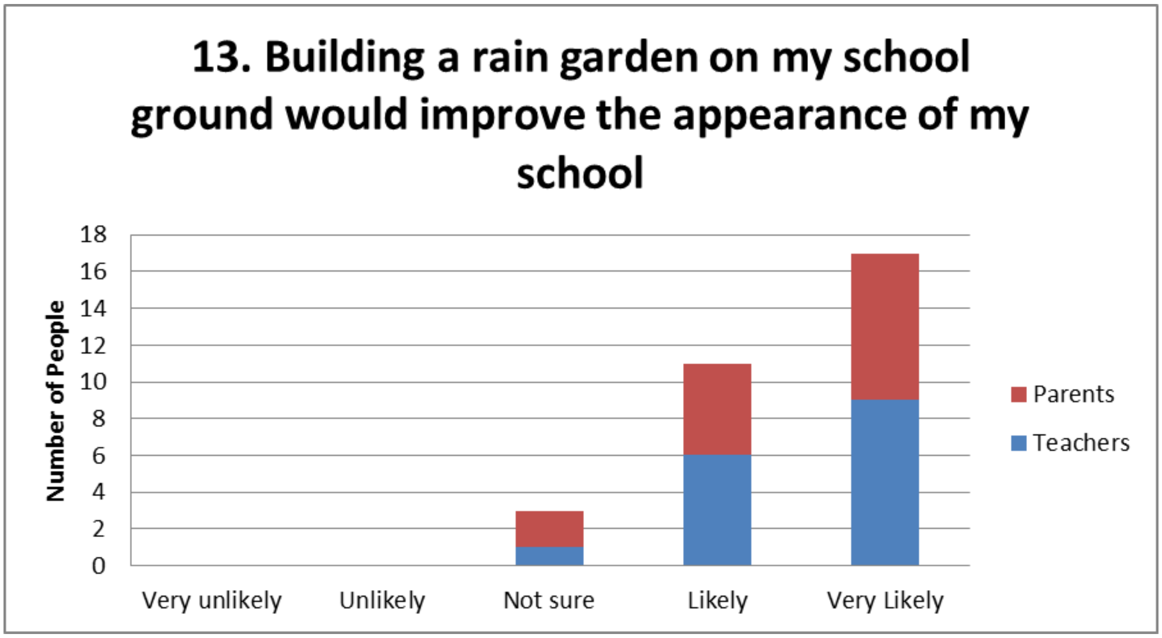


Figure 6.3.3 Teachers' and parents' perception on attracting wildlife by building a rain garden

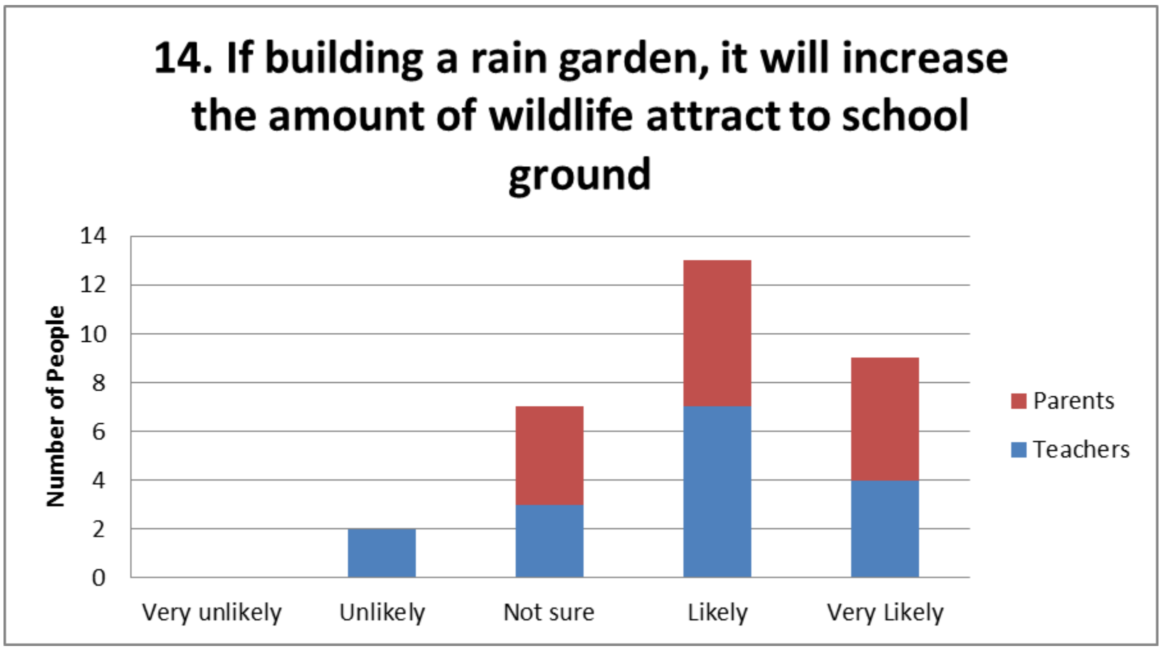
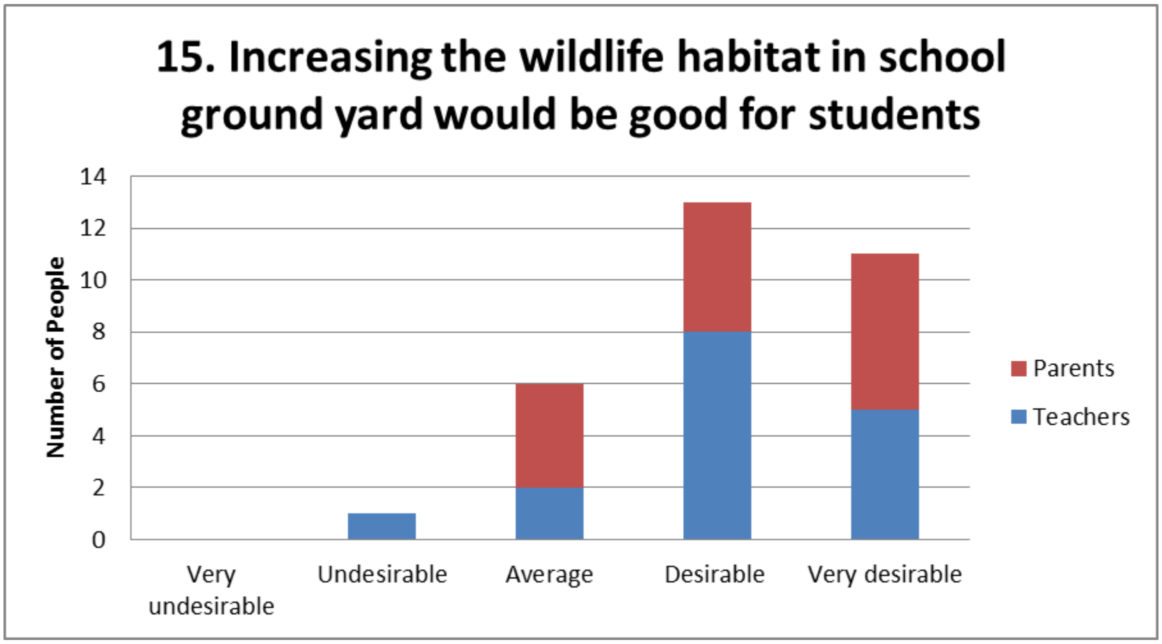


Figure 6.3.4 Teachers' and parents' perception on increasing the wildlife habitat by building a rain garden



When asked about the mosquito issue, several teachers and parents (35%) thought that rain garden would create standing water that could attract mosquitoes (Figure 6.3.5), and almost all of them indicated that it was very important to prevent standing water on the school ground (Figure 6.3.6). Having a yard that is mostly lawn is not very important for over half of the teachers and parents (Figure 6.3.7). Over half of them were very excited to have a rain garden at their school (Figure 6.3.8), but there was still a large number of the teachers and parents who were not sure whether the rain garden was good for the school or not.

Figure 6.3.5 Teachers' and parents' perception on the mosquito issue

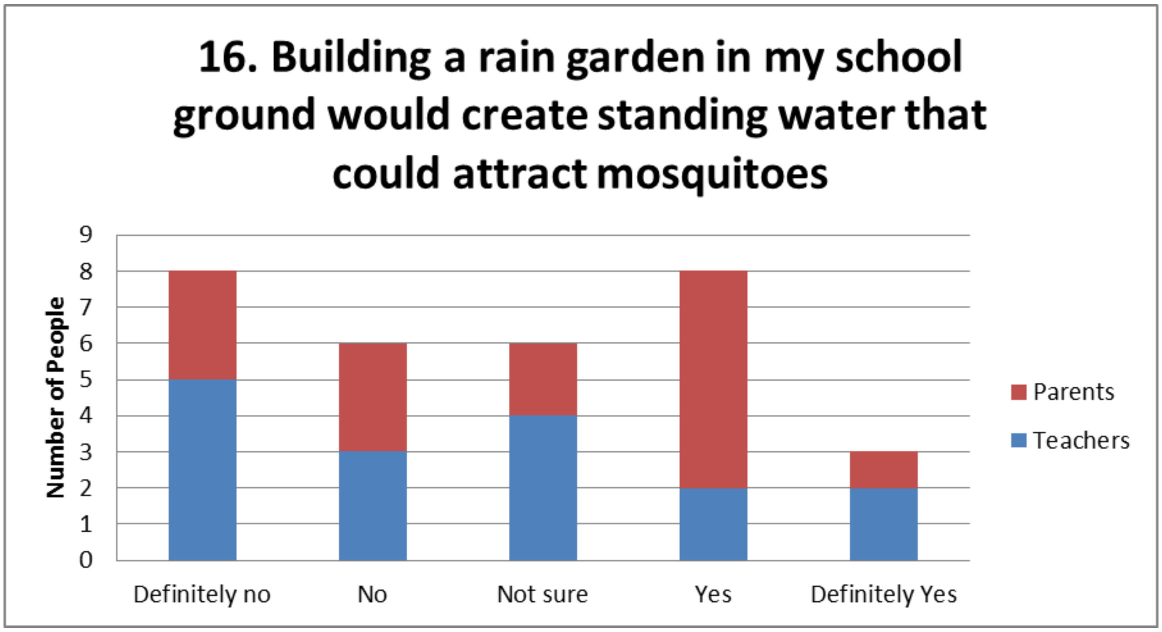


Figure 6.3.6 Teachers' and parents' perception of standing water and mosquitoes

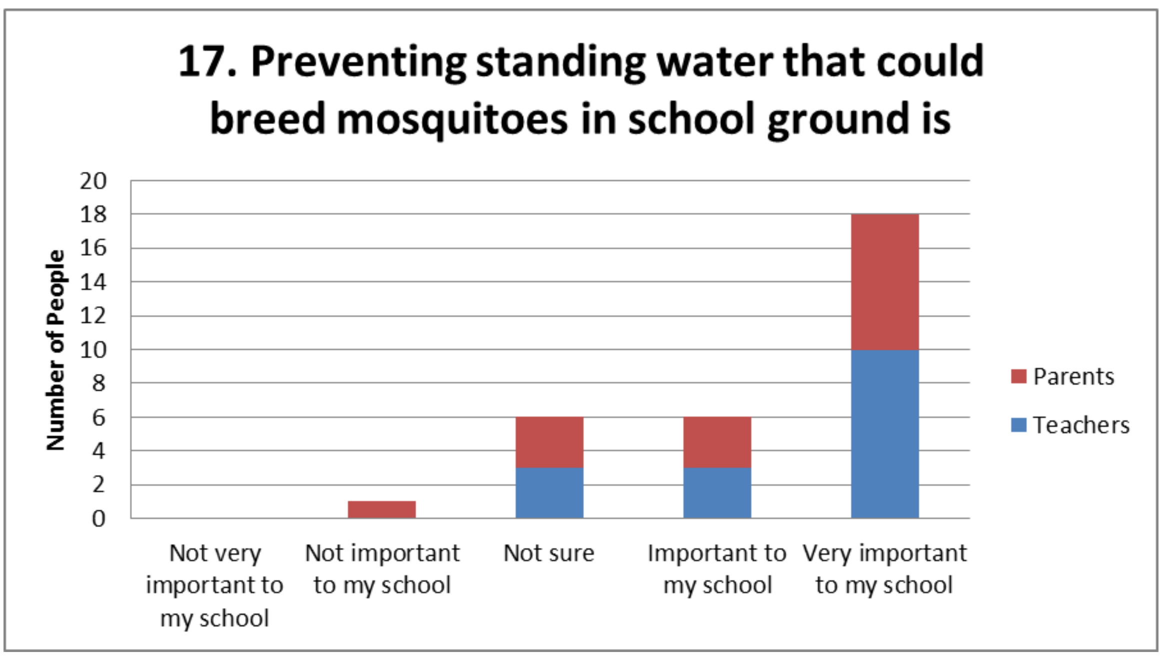


Figure 6.3.7 Teachers' and parents' perception of the importance of grassy lawns

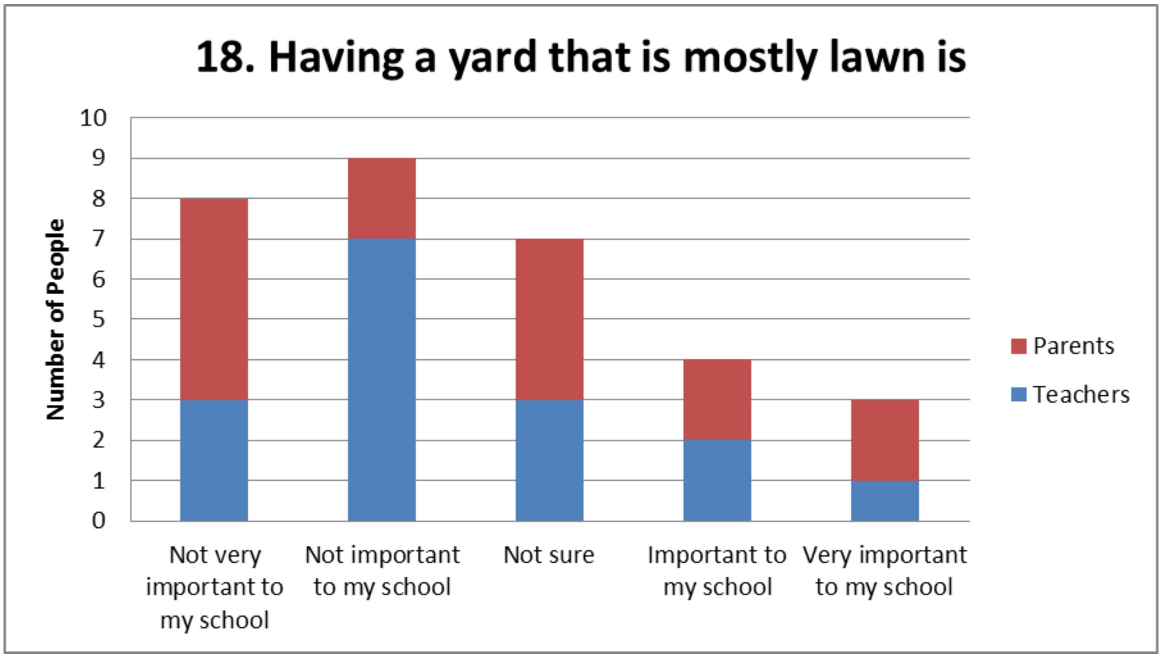
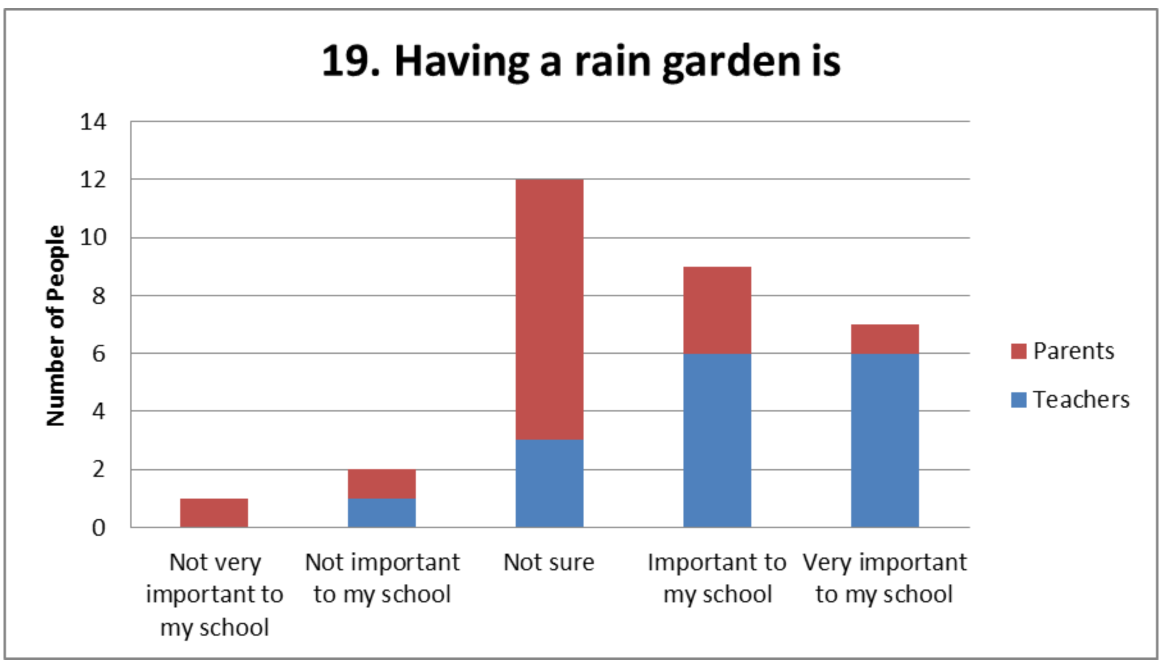


Figure 6.3.8 Teachers' and parents' perception of the importance of a rain garden



6. 4 How Lake Winnipeg would be affected

This survey found that 68% of total participants thought that the rain garden could play a useful in improving the water quality of Lake Winnipeg (Figure 6.4.1). Of course, one small project at the school on its own would have limited effect on water quality in Lake Winnipeg, but the spinoff of having a network of such projects is something that could have a greater effect. When asked about their feeling about the water quality of Lake Winnipeg, 90% of the respondents shared that improving the water quality of Lake Winnipeg was very important to them (Figure 6.4.2). When asked to compare to other actions they can take to impact the water quality in Lake Winnipeg (Figure 6.4.3), 61% of the participants felt that building a rain garden in the school would have a very large impact, but 30% of them were not sure.

Figure 6.4.1 Teachers' and parents' perception of improving water quality of Lake Winnipeg by building a rain garden

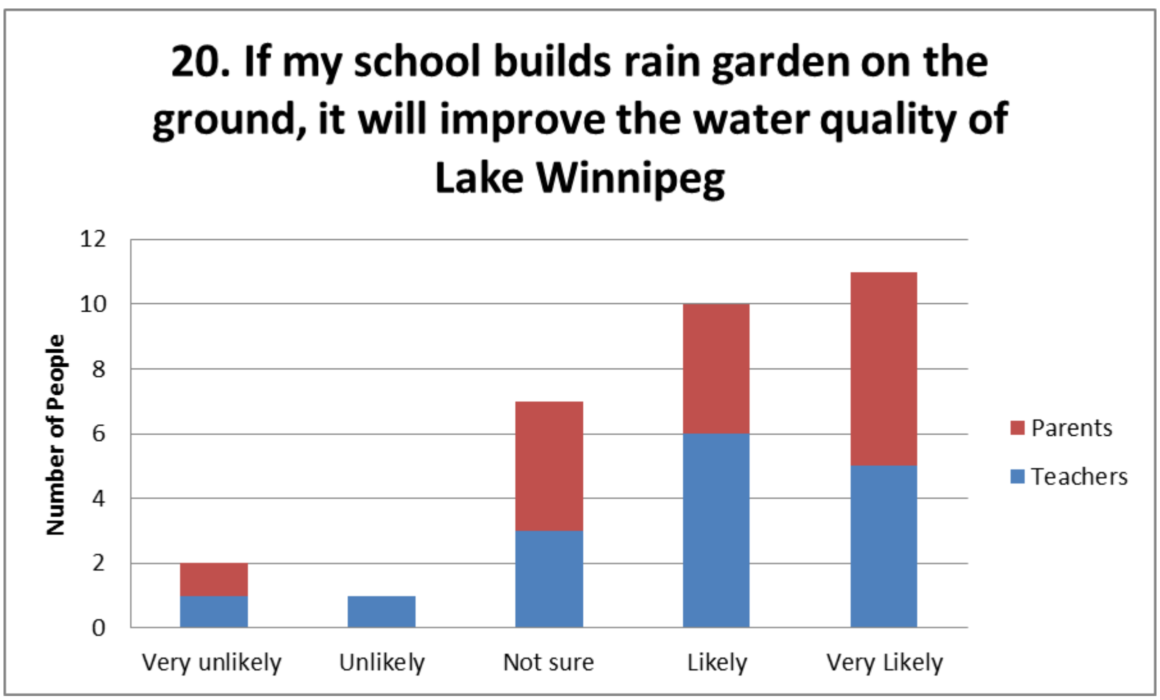


Figure 6.4.2 Teachers' and parents' perception of the importance of improving water quality of Lake Winnipeg

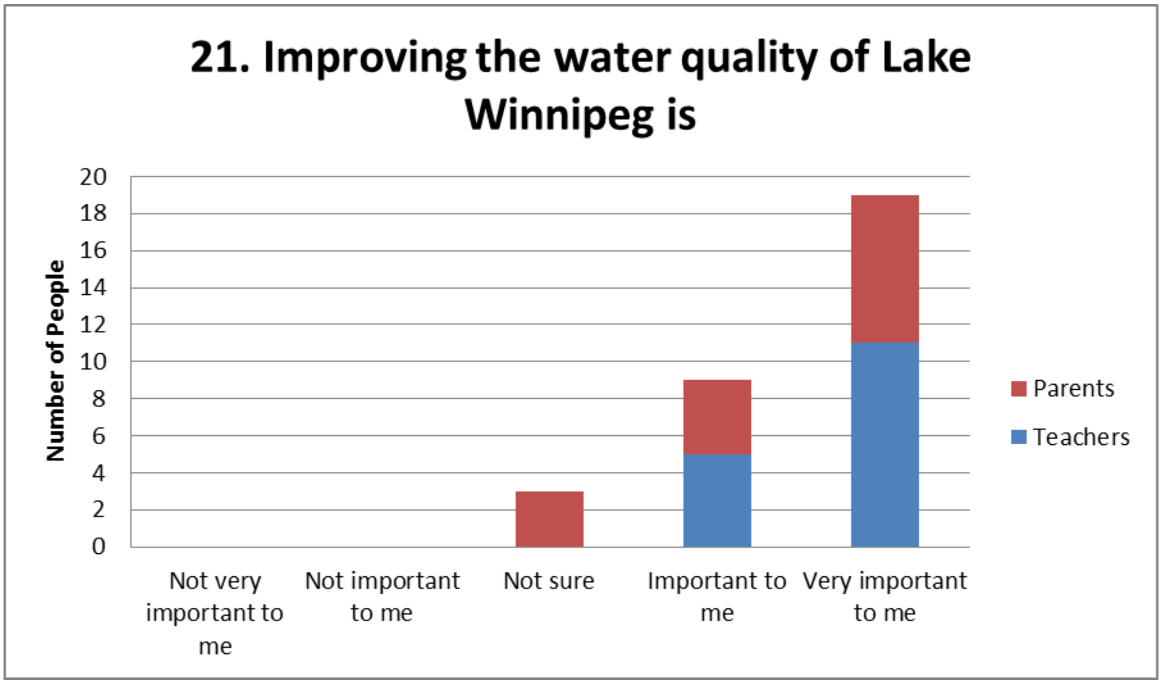
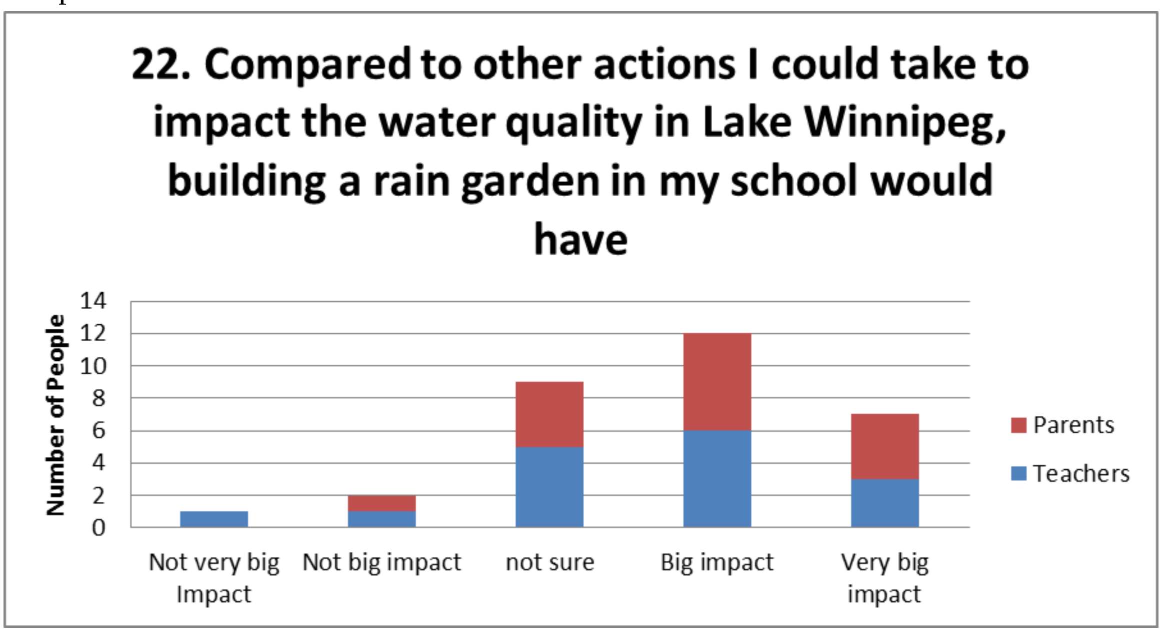


Figure 6.4.3 Teachers' and parents' perception of impact of building a rain garden compared to other actions



6. 5 Anticipated opinions of others

The Ecole St. Avila Rain Garden project involved many different groups of people, including community neighbors, students, and parents of the students. The opinion of each group is an important factor to consider in project design and completion. When asked to specify which group was most important to the school, community neighbors, students and their parents were all mentioned as important groups by teachers (Figure 6.5.2, Figure 6.5.3, Figure 6.5.4). And from the teachers' understanding, all of these people from the local community would strongly approve of building a rain garden at the school. (Figure 6.5.1, Figure 6.5.3 Figure 6.5.5)

Figure 6.5.1 Teachers' perception on community neighbors' opinions

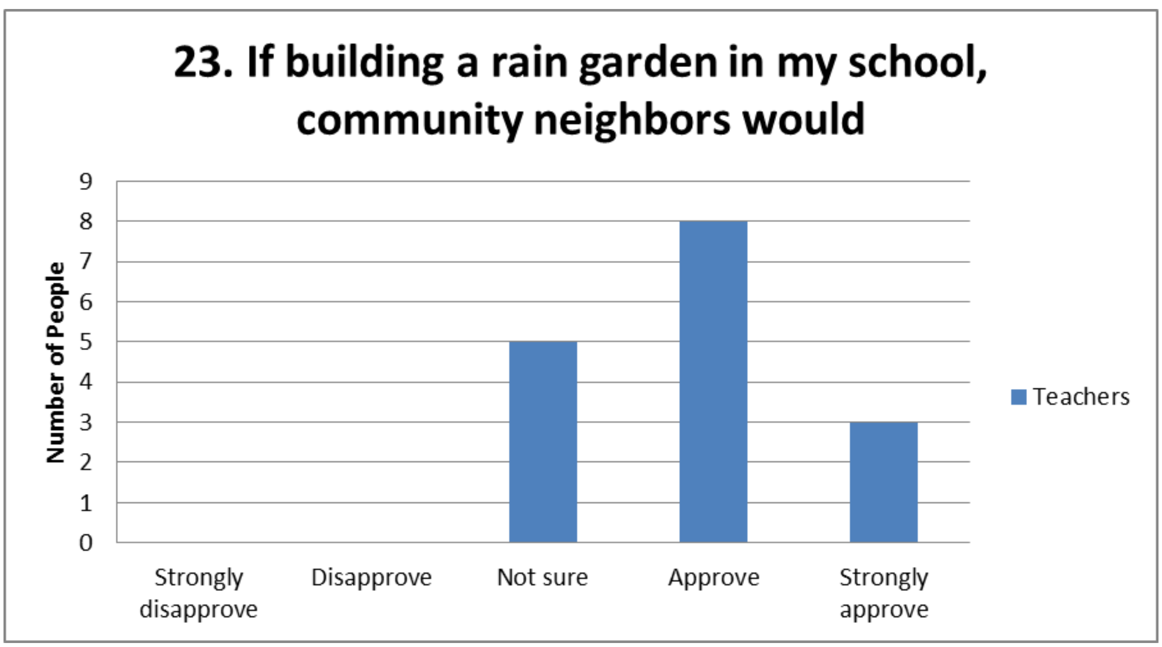


Figure 6.5.2 Teachers' perception on student's parents' opinions

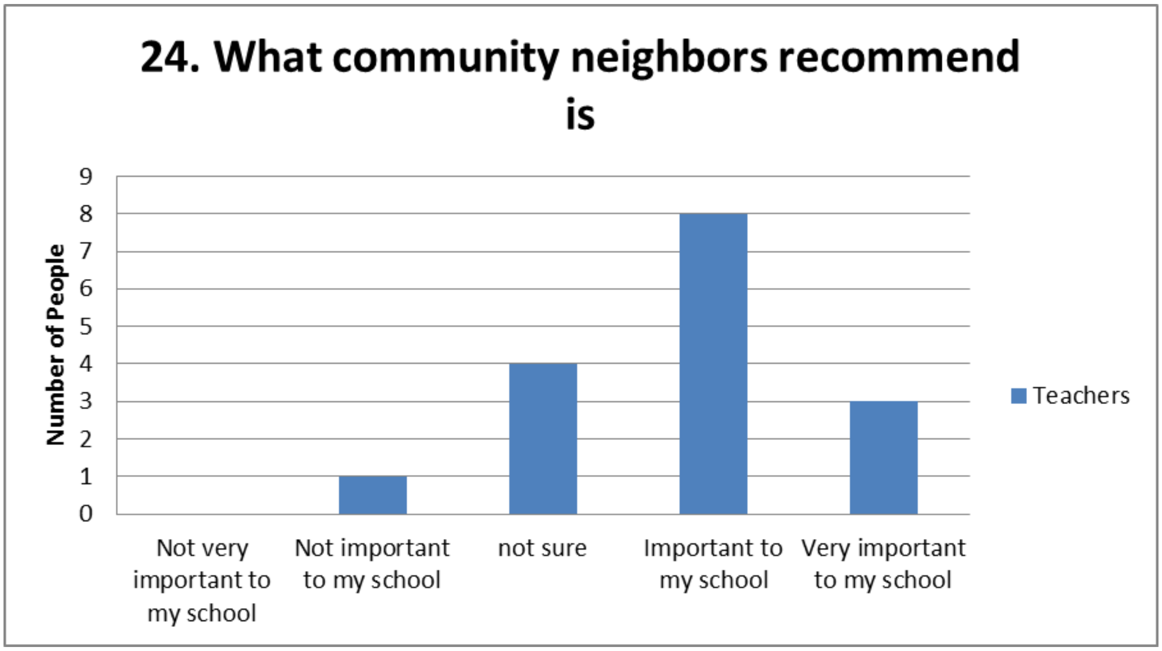


Figure 6.5.3 Teachers' knowledge on student's parents' opinions

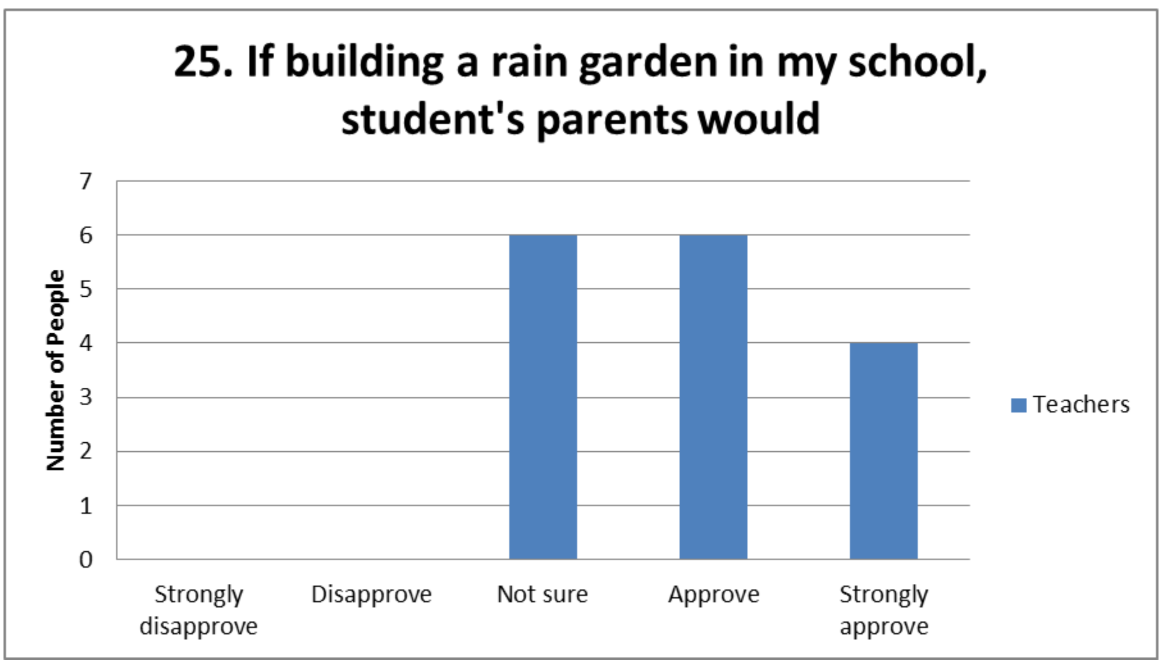


Figure 6.5.4 Teachers' perception on student's parents' recommendations

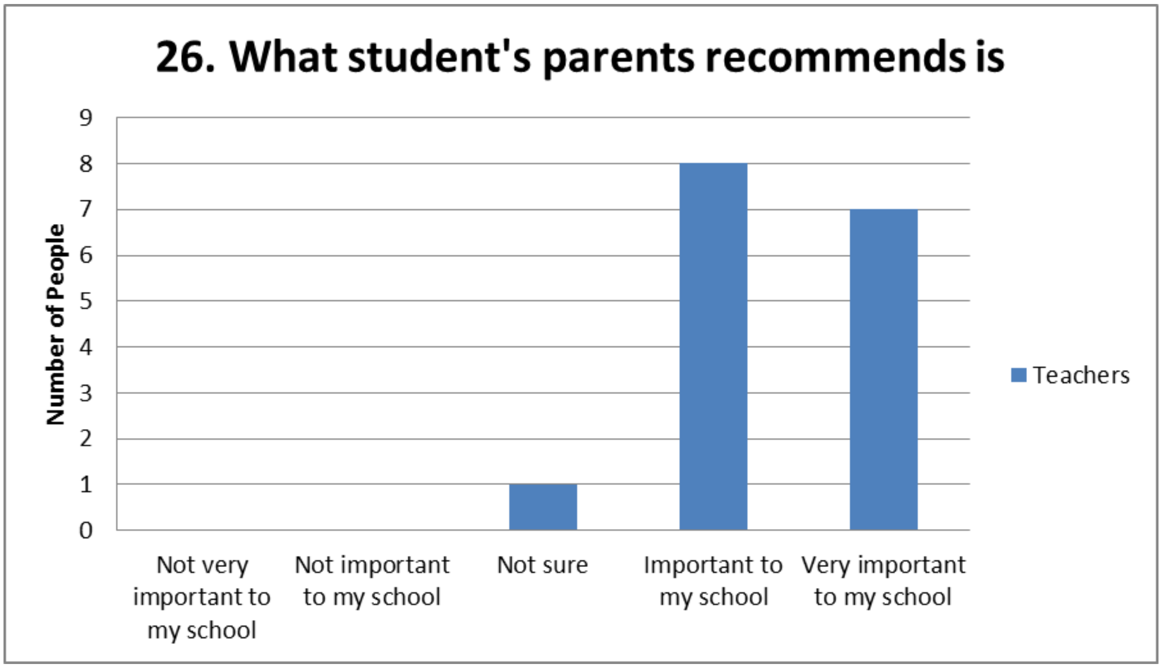


Figure 6.5.5 Teachers' perception on students' opinions

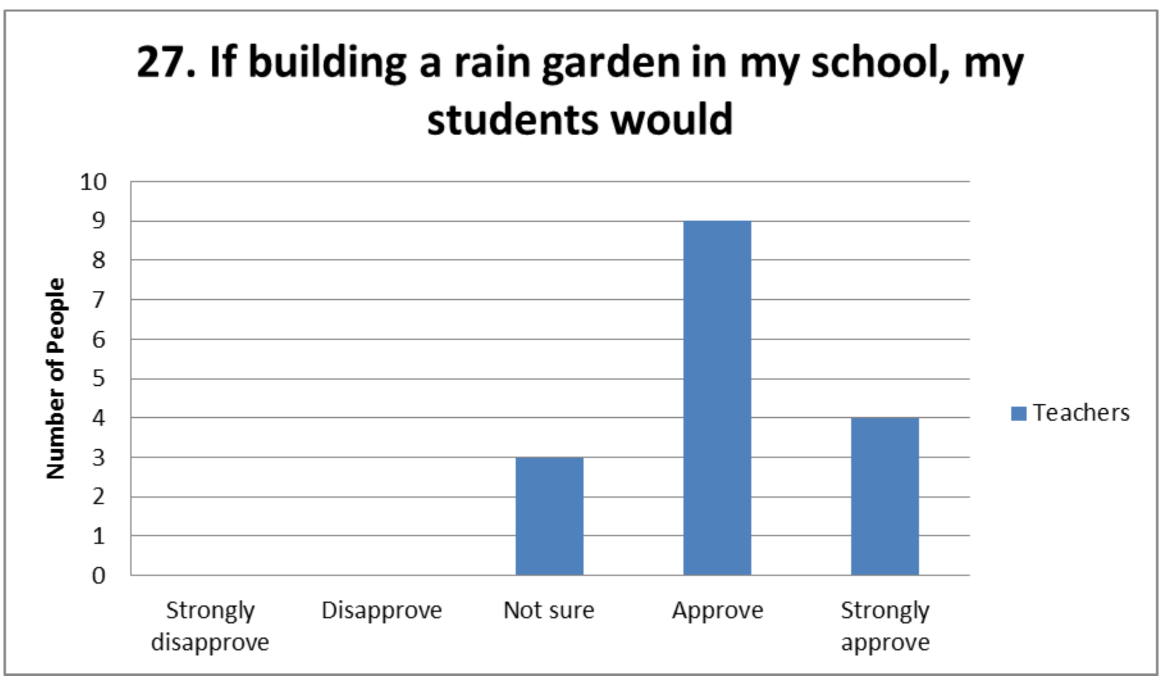
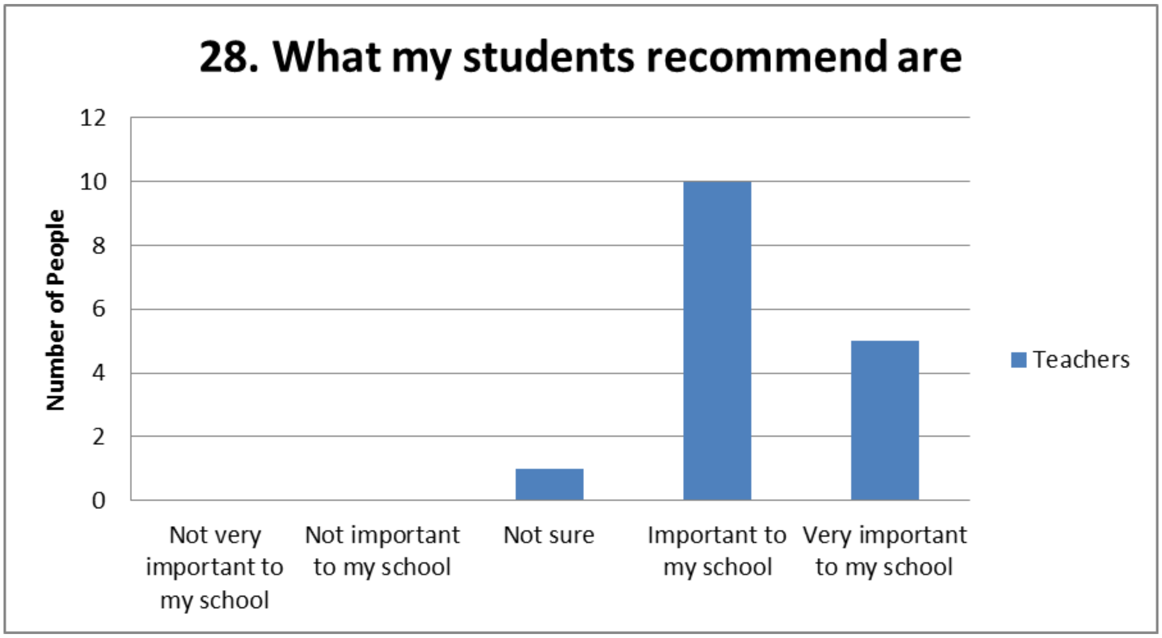


Figure 6.5.6 Teachers' perception on students' recommendations



6. 6 Likelihood of Building a Rain Garden in Own Yard

When presented with separate situations, respondents rated the likelihood of building a rain garden in their own yard with more varied scores. Without any given information or assistance, only a few participants (25%) would likely build their own rain garden (Figure 6.6.1). A large number of the participants (74%) thought they would not likely hire someone to build a rain garden on their yard in the next few years (Figure 6.6.2). Some of the respondents wanted to have more detailed information materials or assistance when considering the installation of rain gardens, with. 30% indicating they would build a rain garden if given detailed instructions on how to do so (Figure 6.6.3). And over 50% of them would likely build a rain garden if they received cost sharing assistance (Figure 6.6.4). If other people in their community built a rain garden, nearly 36% of the participants (Figure 6.6.5) would also likely build a rain garden. In addition, if other people helped to build the rain garden, it would increase their possibility of constructing their own (Figure 6.6.6). Half of the respondents would also like to share their physical assistance with other people who are like to build a rain garden in the next few years (Figure 6.6.7).

Figure 6.6.1 Teachers' and parents' perception on building a rain garden in own yard

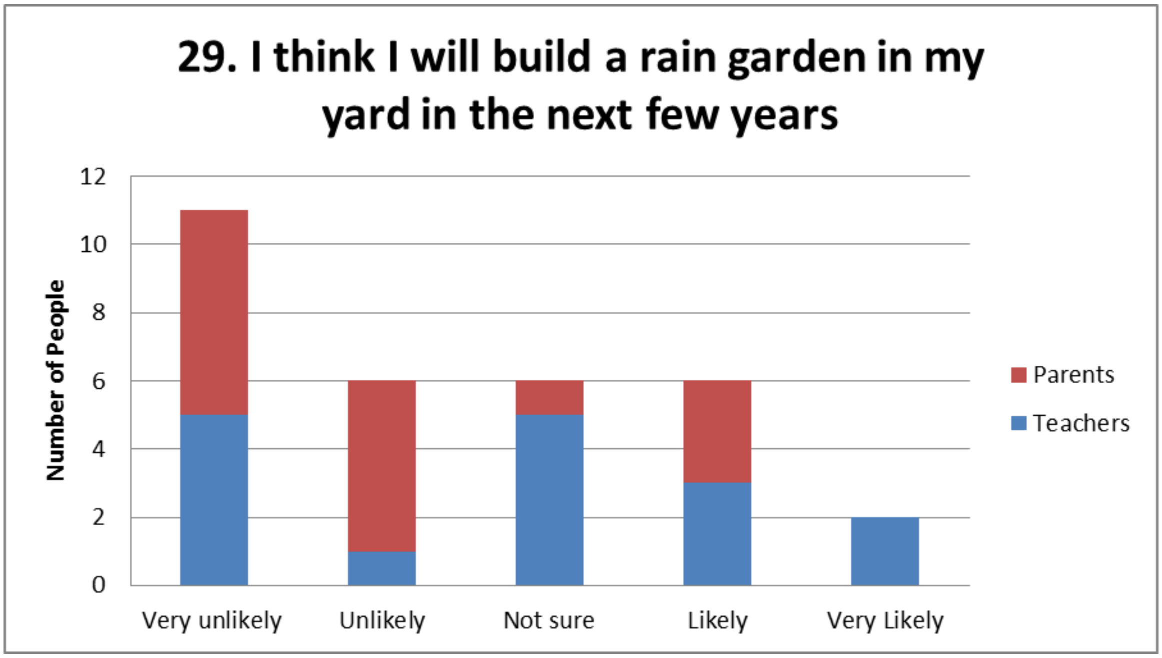


Figure 6.6.2 Teachers' and parents' perception on hiring someone to build a rain garden in own yard

Figure 6.6.3 Teachers' and parents' perception on building a rain garden in own yard if they are given detailed instructions

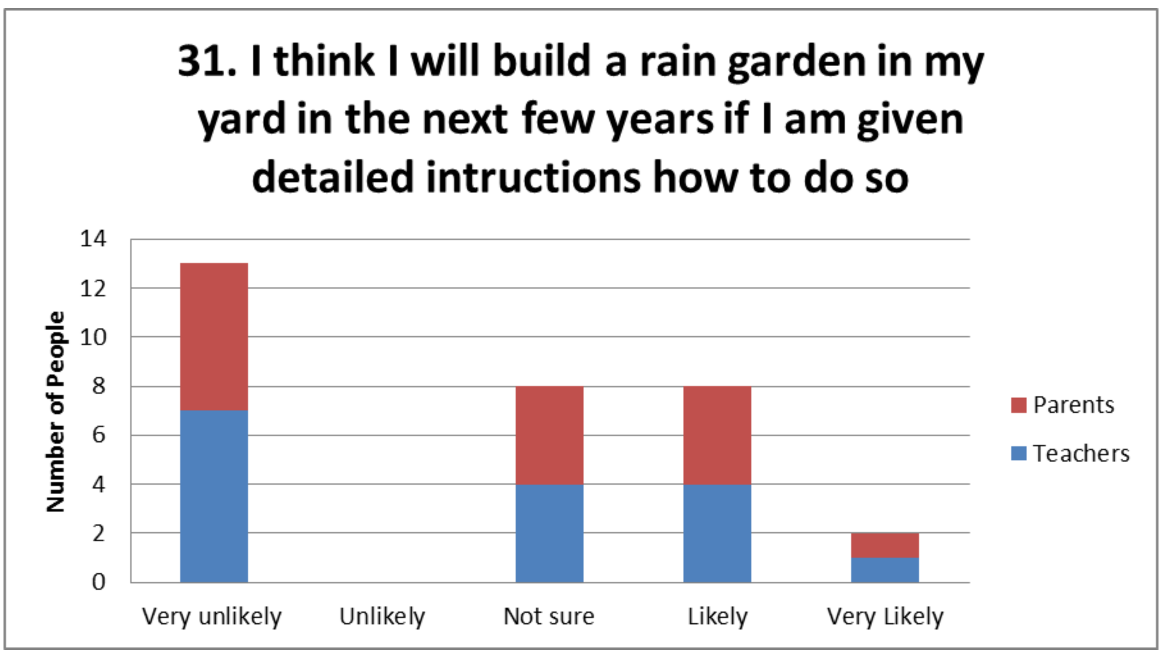


Figure 6.6.4 Teachers' and parents' perception on building a rain garden in own yard if they received cost-sharing assistance

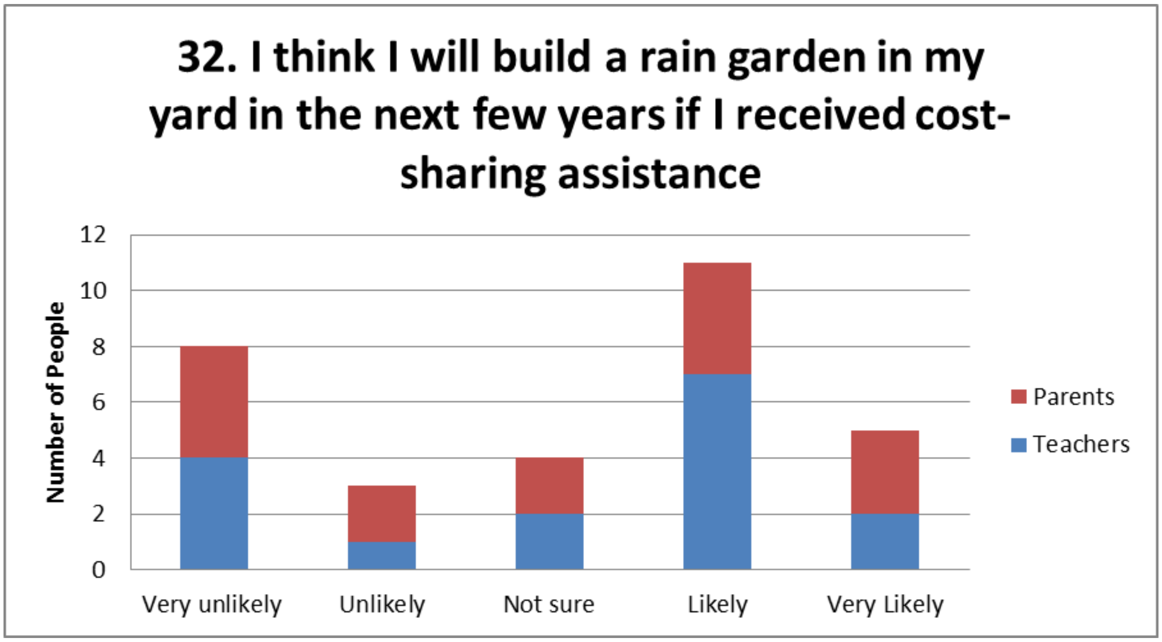


Figure 6.6.5 Teachers' and parents' perception on building a rain garden in own yard if other people in their community also build one

Figure 6.6.6 Teachers' and parents' perception on building a rain garden in own yard if help was available

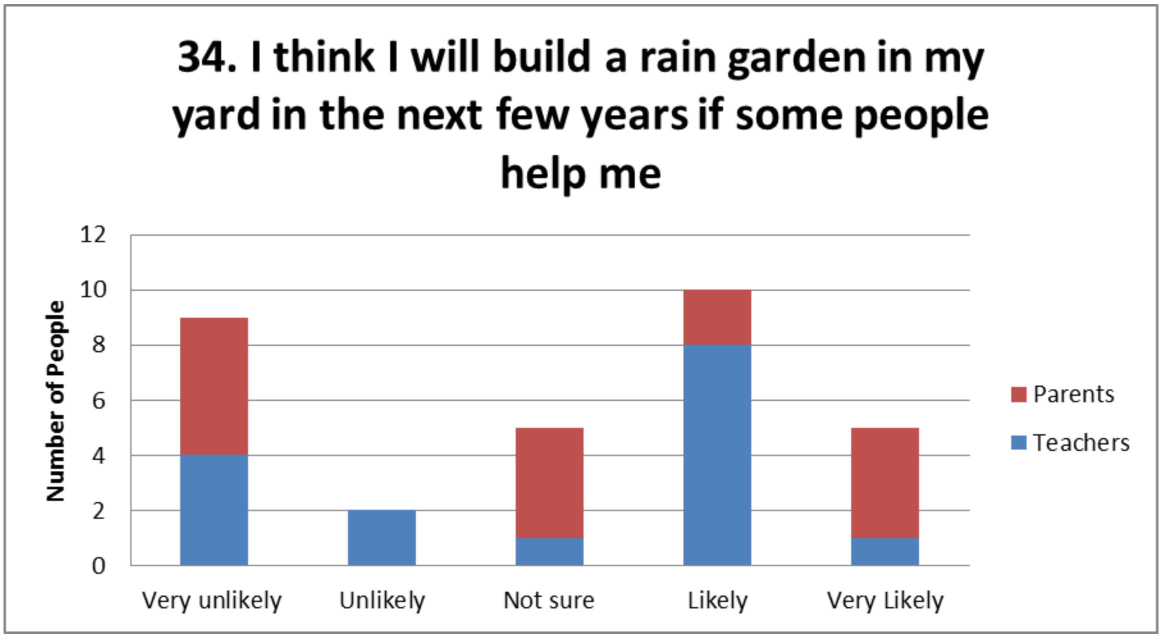
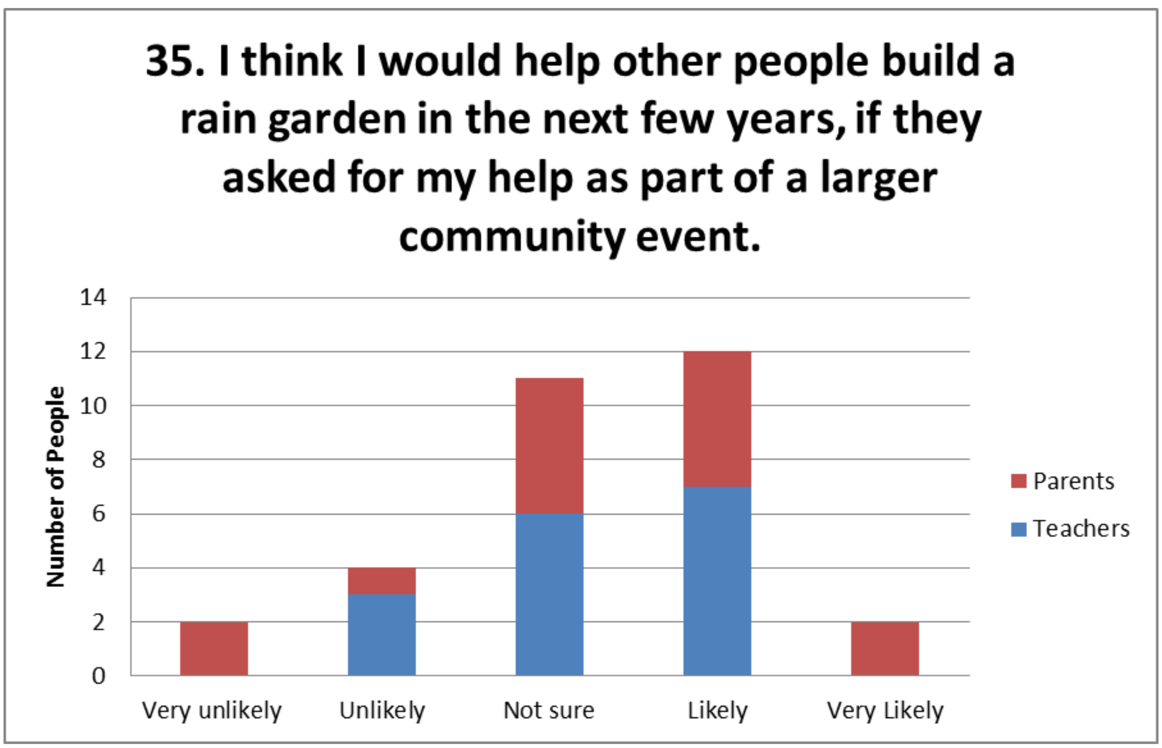


Figure 6.6.7 Teachers' and parents' perception on helping other people build a rain garden



6. 7 Summary of Major Obstacles

When questioned more specifically about the top obstacles that may be preventing them from building a rain garden in their own yards, most participants indicated the cost as their largest obstacle (Figure 6.7.1). The second most influential obstacle preventing them was the need for too much work on a rain garden; nearly 26% chose this answer.

In accordance with these responses, when asked about any other reasons preventing them from constructing rain gardens on their own property, insufficient time was the most frequently cited reason (23% of all responses given) (Figure 6.7.1). Lack of knowledge was also cited as a reason. Few respondents felt that their yard was too small (6% of all responses) or too steep (3% of all responses) for installation.

Figure 6.7.1 Teachers' and parents' perception of the largest obstacle preventing them from building rain garden in own yard

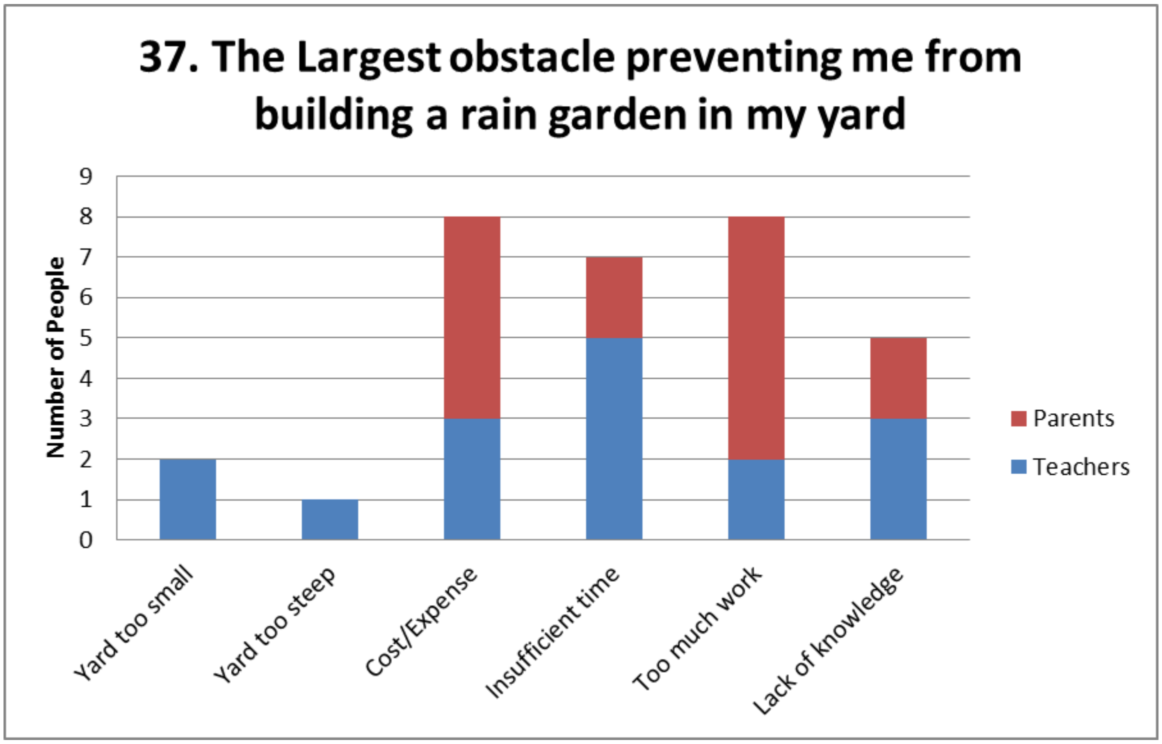


Figure 6.7.2 Teachers' and parents' perception of yard size obstacle

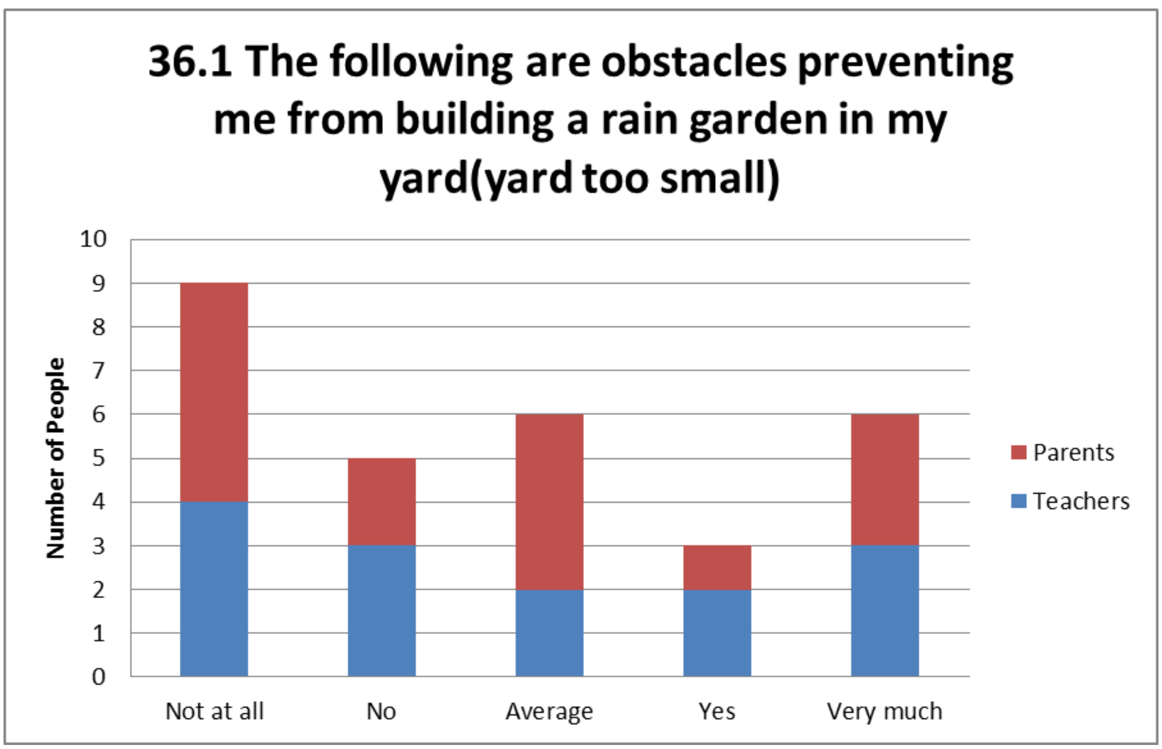


Figure 6.7.3 Teachers' and parents' perception of steepness obstacle

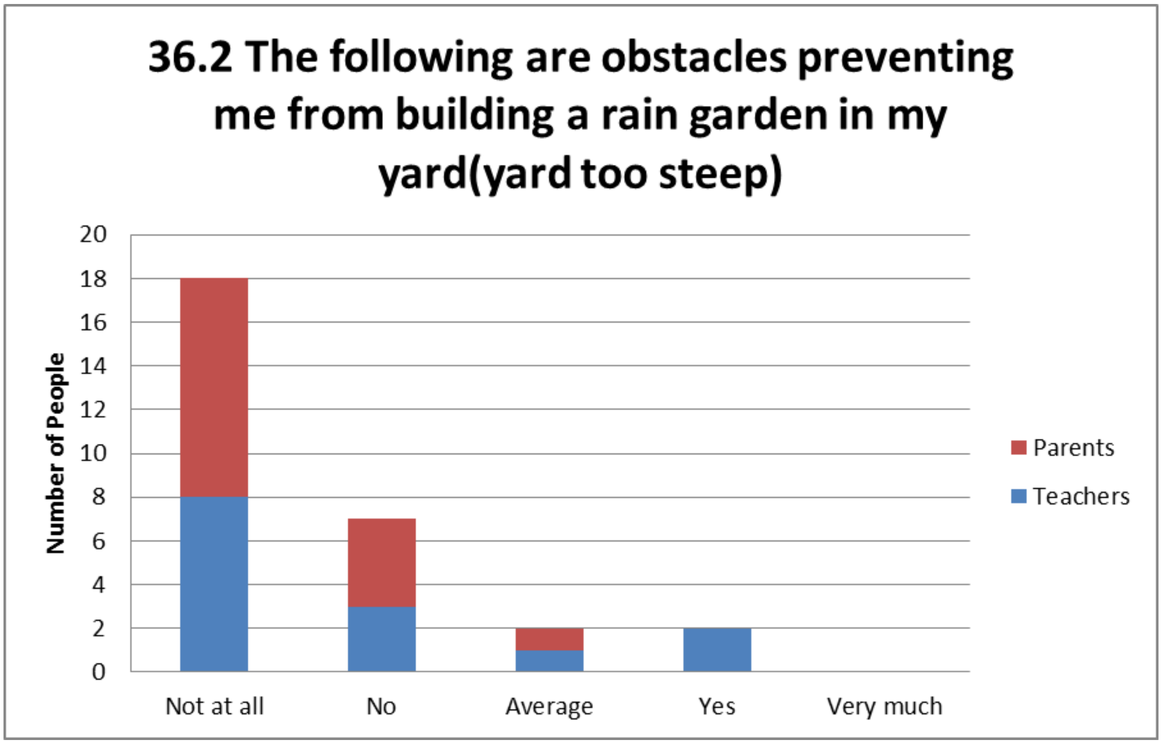


Figure 6.7.4 Teachers' and parents' perception of the cost obstacle

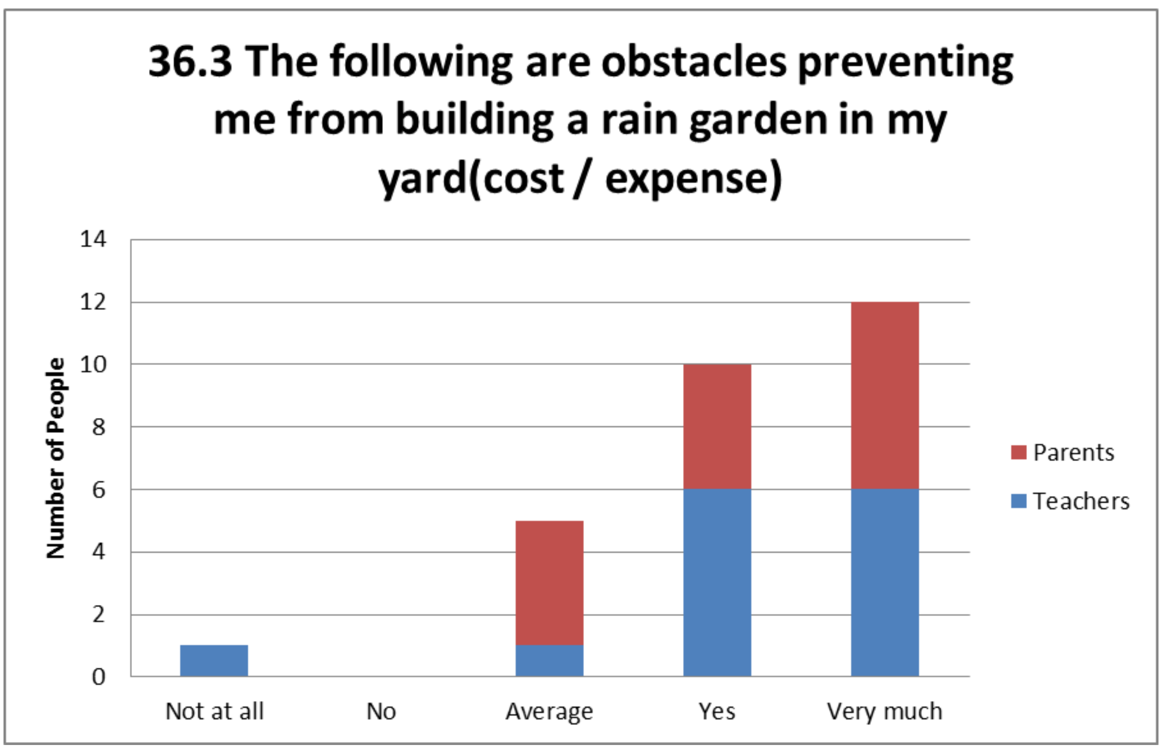


Figure 6.7.5 Teachers' and parents' perception of the time obstacle

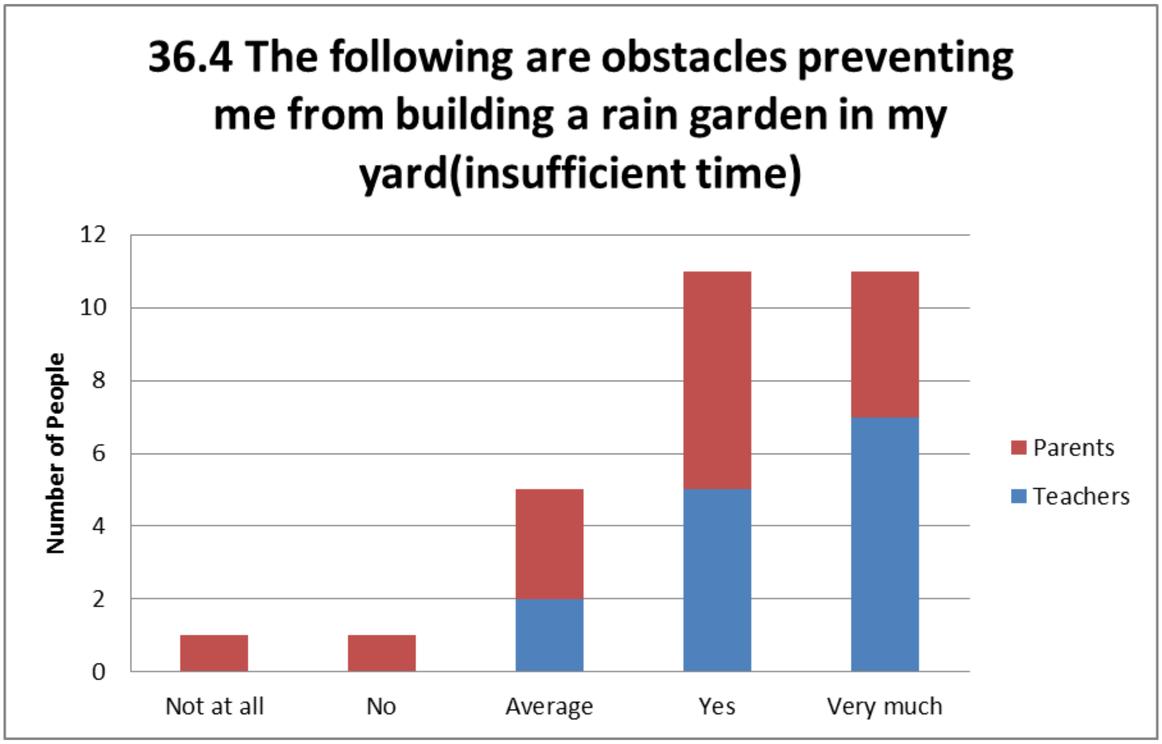


Figure 6.7.6 Teachers' and parents' perception of the effort obstacle

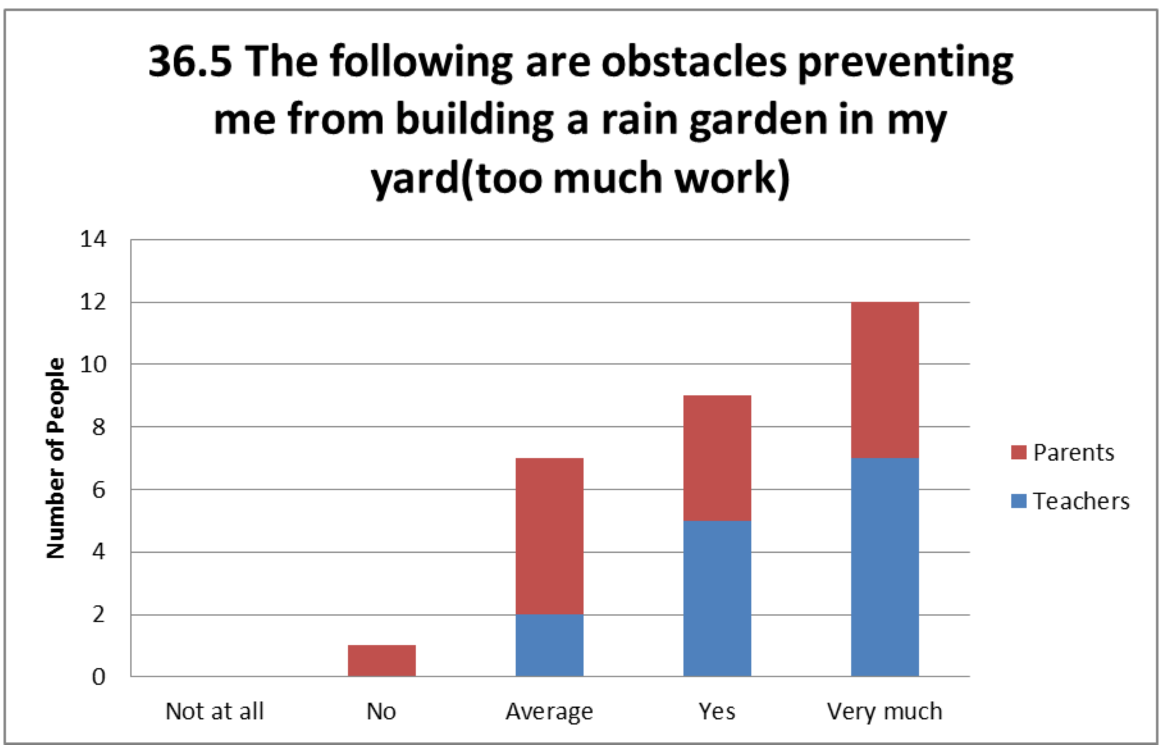
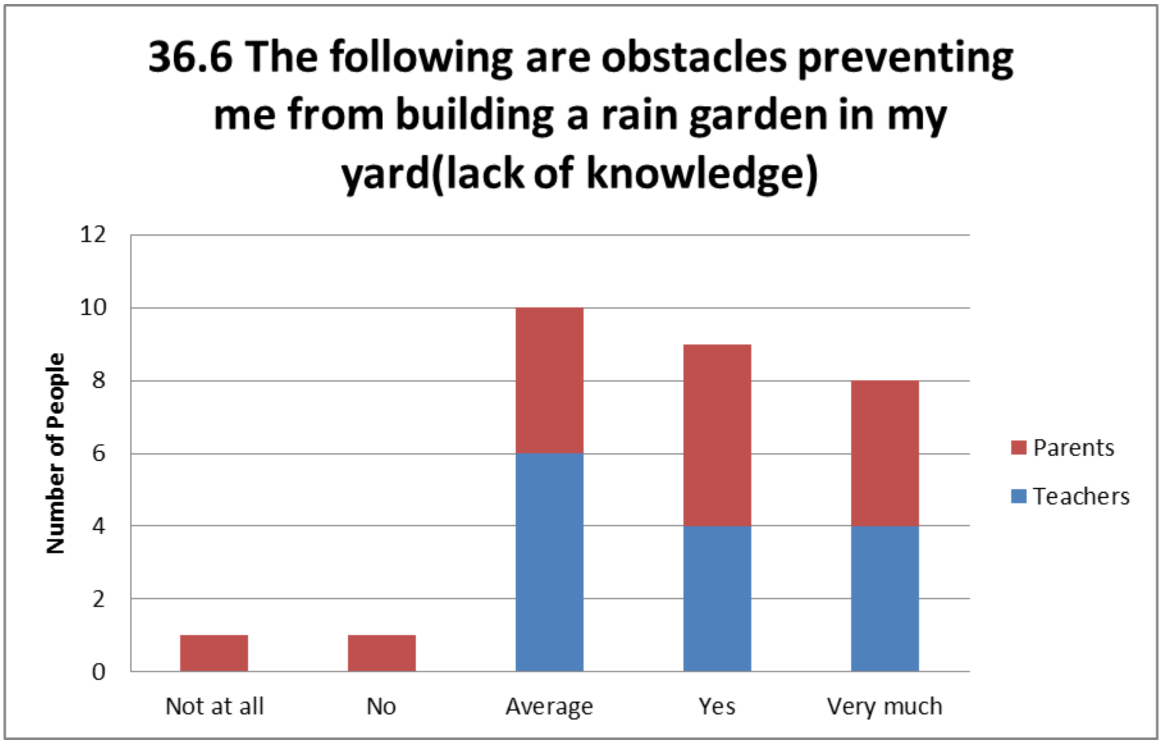


Figure 6.7.7 Teachers' and parents' perception of the knowledge obstacle



6. 8 Summary of Survey Results

The results showed positive feedback from the public about the Ecole St Avila Rain Garden. Although the teacher sample pool was about 5% of the total parents associated with Ecole St Avila, these results have offered their attitudes toward the Ecole St Avila rain garden. The results indicated that the Ecole St Avila Project helped teachers and parents gain the knowledge needed about the rain garden concept. However, the results also indicated that some knowledge gaps still need to be filled by further efforts. Most of their concerns will need serious consideration by the Provincial Government, in order to better communicate and promote future rain garden implementation.

Chapter 7.0 Discussion

7.1 Overall highlights from the findings

The various sources of information I evaluated as well as the results from my parent/teacher surveys for this project provided me with valuable insights for future community water management projects and research. The historical accounts of storm water management in various countries provided the context for the evolution of thought and practice leading to devising the rain garden concept. Those studies also indicated that rain gardens might be one of the most suitable strategies for developing a broad based, grass roots system of storm water management in Canada.

The literature I reviewed illustrated the many benefits that can be provided by a rain garden system, and also indicated that design objectives and siting considerations of undertaking a broad scale rain garden project in relation to local environmental and site conditions. In addition, the four urban rain garden case studies as well as the Ecole St Avila project illustrated the potential macro-benefits of rain garden projects in an urban area, and the gaps to consider in undertaking a program of rain garden promotion and development in Winnipeg.

The social feedback received about the Ecole St Avila case provided much valuable information, which could help to address questions of public understanding so as to better promote future implementation. In order to address those questions of public perception, the following discussion attempts to explain the benefits of rain gardens and suggest means of overcoming public concerns about them.

7. 2 Economic benefits of rain gardens

One of the most interesting results from this study is the perception of cost and time spent on rain garden installation and maintenance. Most participants felt that it would be hard for them to involve themselves personally in the installation, and also felt that the cost for a rain garden may be higher than they expected. However, in comparison to the cost of lawn maintenance, rain gardens can be economically viable (USEPA, 2006). A rain garden manual provided by the University of Wisconsin indicated that the cost of a rain garden will vary depending on who does the work and where the plants come from (UWEX, 2003). If people grow their own plants there can be very little or no cost at all. If people do all the work but use purchased prairie plants, a rain garden will cost approximately $3 to $5 per square foot (UWEX, 2003). If a landscape architect does everything, it will cost approximately $10 to $12 per square foot (UWEX, 2003). Native Plant Solutions also provided a local price list of different size rain gardens. It suggests costs are lower than the UWEX manual, at approximately $2 to $3 per square foot (Appendix 5).

Although the initial spending on building a rain garden is relatively high, compared to the price of sod at approximately $0.50 to $1.00 per square foot (LawnCare, 2012), the future maintenance cost is quite low (USEPA, 2006). Within the first several years, plants in rain gardens may need weeding and may require some maintenance to become established. However, the USEPA (2006) indicated that the cost of construction and maintenance for a rain garden can be less than one-fifth of the costs for conventional lawn care over a 10-year period, because native plants do not need any labor, irrigation, fertilizers, herbicides, insecticides, fungicides, replanting annual flowers, fossil fuels, or mowing to thrive. In addition to their savings in labor and maintenance costs, rain gardens can increase the resale value of property. It is estimated that properties that incorporate LID (low impact design) practices such as rain gardens sell for $10,000 more than conventionally-designed lots (USEPA, 2006).

The study in the City of Madison, Wisconsin showed that although there might be a number of hours invested in the design and installation process for a rain garden, once the rain garden is installed, within its first year, the majority of owners only spent a few hours per month on rain garden maintenance (UWEX, 2003). The study also suggested that the amount of time devoted to rain garden maintenance should be even lower in subsequent years, due to the ability of native plant species to thrive.

7.3 Social benefits of rain gardens

Another interesting result from this study was that students, parents, teachers and other residents in the community were very supportive of this project. In 2010, a survey conducted by Mrs. Janice Lukes indicated that all the students at Ecole St Avila were very interested in the rain garden project at their school (Lukes, 2010). Students showed their perception and imagination about rain gardens through artwork (Appendix 4). Place-based environmental learning related to storm water management, could be incorporated in several ways into the K to Grade 12 school curriculums to enrich learning by students through hands-on and engaging initiatives. Learning about the ecosystem and environmental issues by using a familiar place like a rain garden outdoor classroom may help redefine the roles of schools, teachers and students in better meeting government prescribed learning outcomes.

This is especially important as indicated by Louv (2008) who cited numerous studies documenting the benefits to students from school grounds that are ecologically diverse and include free-play areas, habitat for wildlife, walking trails, and gardens. Two major studies, “Gaining Ground” and “Grounds for Action,” were conducted in Canada, one in the Toronto school district, the other in the provinces of British Columbia, Alberta, Manitoba, Ontario, Quebec, and Nova Scotia. Researches there found that children who experience school grounds with diverse natural settings are more physically active, more aware of nutrition, more civil to one another, and more creative (Anne & Janet, 2006; Janet, 2005). The greening of school grounds resulted in increased involvement by adults and members of the nearby community (Janet, 2005). In the “Grounds for Action” study, green school grounds were found to enhance learning, compared with conventional turf and asphalt based school grounds; that the more varied green play spaces suited a wider array of students and promoted social inclusion, regardless of gender, race, class, or intellectual ability; and they were safer (Anne & Janet, 2006; Janet, 2005). Compared to other typical educational equipment, such as books or computers, students could have a more direct connection to the learning place. As such places like rain gardens and other features like vegetable gardens, grasslands, wetlands and forested areas in school yards ought to be considered essential equipment for place-based education.

In the Ecole St Avila case, students and their parents had opportunities to design and plant the rain garden on-site. The goal was to explore students' imagination about their 'school greening program'. This long-term approach could stimulate the holistic understanding of the importance of storm water management for school students, parents, school staff and others in the community. School rain garden workshops can be held in the future, and educational materials about rain gardens should also be provided to facilitate and enrich the learning opportunities. Initiatives similar to this case can be replicated in other schools, so schools generally can be redefined to include an educational mission on environment in the Manitoba School Curriculum Guide (Rivers West, 2012).

The Provincial Department of Education should help and encourage schools to form their own unique ecological education programs. For example, through rain gardens, students can better see the connection between the local neighborhood and the rivers and lakes, uplands and ground water that connect all of these through the process of gravity, infiltration and runoff as components in the hydrological cycle. Through recreation and visitation, residents of the local community could learn and participate in local efforts. Projects like the Ecole St Avila rain garden could serve as a demonstration example in the city, and as an educational center for the local community. The school rain garden could be expanded further to become an outdoor environmental classroom with enhanced place-based learning opportunities. At this site, students, parent and other local residents can learn about a small functioning natural treatment system as well as regional environmental knowledge. Moreover, in addition to the opportunities to learn at the rain garden site, school staff can also offer a coordinated mix of indoor laboratory and exhibition site projects, such as teaching the complex hydrological system through indoor laboratory can be easier and more fun to understand.

Rivers West River Corridor Inc., a non- profit organization has developed a Sustainable Storm Water Management Guide with the Province of Manitoba and other project partners to stimulate Manitoba schools to design and use their own school green and ecological features (Rivers West, 2012). The Sustainable Storm Water Management Guide will help people better understand the concept of storm water management, learn how to implement a storm water management system, maintain it, use the system as an educational tool, and help improve the quality of water that eventually moves through the Red River and Lake Winnipeg watershed (Rivers West, 2012). Rivers West also has future plans including the development of lesson plans with general and specific learning outcomes, as well as technical tools for use by schools and the general public (Rivers West 2012). As these features and others are made available to students by like-minded groups (eg Oak Hammock Marsh Interpretive Centre, Fort Whyte Alive, Evergreen, Manitoba Forestry Association, etc), they will become as important to the learning process as the usual textbooks, blackboards, and classroom.

7.4 Environmental benefits of rain gardens

Another most interesting result of this study was the public's environmental perspectives about local water issues, such as the water quality of Lake Winnipeg. Participants were very interested in the environmental benefits of rain gardens in this context. Specifically respondents were most interested in ameliorating storm water quantity and quality issues affecting Lake Winnipeg.

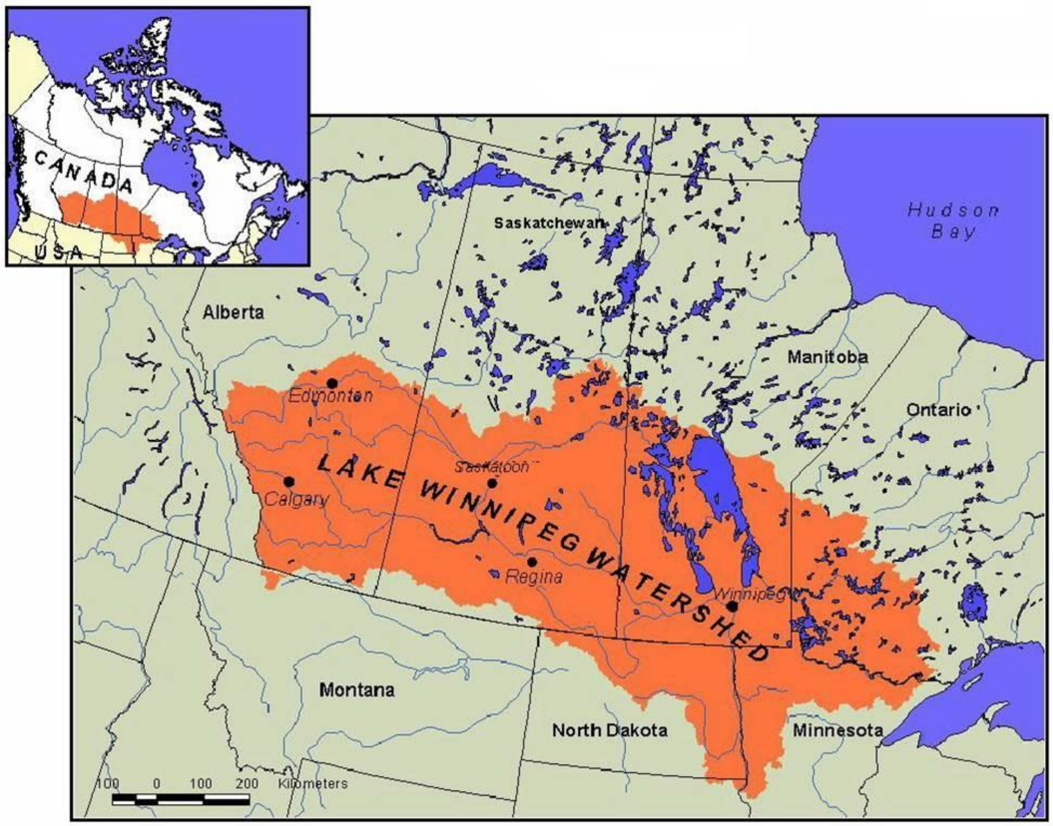
Although most of the respondents perceived that rain gardens are extremely effective in addressing local storm water quantity issues and increasing plant diversity and animal habitat, most people were still unsure about the effectiveness of rain gardens in enhancing the water quality of Lake Winnipeg.

Chapter 3 has illustrated that rain gardens in urban settings can provide many environmental benefits. As mentioned previously, overall performance indicated that rain garden systems have the potential to be one of the most effective storm water management tools in removing pollutants from the watershed (Dietz, 2007). Laboratory studies indicated that removal of total phosphorus (approximately 80%), total Kjeldahl nitrogen (TKN) (50 to 75%), and ammonium (60 to 80%) were found (Davis et al., 2001). And metals also appear to be very efficiently removed by rain garden (Davis et al., 2003). In addition, some examples clearly indicated that rain gardens can be effective in controlling peak discharge rates and providing flooding control (UNHSC, 2006).

Respondents felt that a single rain garden may play a role in water quality enhancement, but were unsure about their effectiveness in the large-scale. This is an important point to note, as people were touting the likely remediation values of rain gardens although they were unsure how to verify the potential benefits these would have on Lake Winnipeg. Currently, there is no simple way to monitor a rain garden's effectiveness in watershed quality improvement. People are only able to visually assess their rain garden's performance in areas such as increasing plant and animal biodiversity and reducing surface runoff, but it is not possible for them to easily distinguish their rain garden's ability to remediate storm water pollution. Therefore, it is important for the government and organizations involved in local rain garden performance to research the possible effects they would have on local water quality improvement. Such studies could help people to increase their knowledge and confidence about the value of their own rain gardens and encourage others to develop them as well.

The watershed drainage basin of Lake Winnipeg is about 1 million square kilometers and is home to 5 million people, which spans parts of four Canadian provinces and four American states (Figure 7.1) (Water Stewardship Division, 2012). Urban runoff pollution might account for just a small amount of the total flow and pollution running into Lake Winnipeg references. Although controlling urban runoff may not have significant impacts on water quality and quantity issues in the watershed, there are both environmental and socio-political benefits to be gained through developing a successful urban storm water and rain garden program.

Figure 7.1 Map of Lake Winnipeg Watershed (Water Stewardship Division, 2012)



Natural and constructed wetlands are an important source of Natural Capital providing hydrological, geochemical, and biological functions within a watershed. This capital is responsible for a wealth of Ecological Goods and Services (EG&S), which result in flood and drought mitigation, groundwater recharge, water quality improvement, carbon sequestration and provision of wildlife habitat and recreational opportunities for people (National Research Council, 1995). Unfortunately, Canada has lost more than 70% of its original wetlands in prairie regions and the other settled parts of southern Canada (DUC, 2007). This is due in some measure to unsustainable land use practices and policies that have contributed to the impacts we are now witnessing in the Lake

Winnipeg watershed. It is important to know that in order to solve the water issues of Lake Winnipeg, there should be a number of approaches taken in both urban and rural jurisdictions including enactment of provincial and municipal policies to protect, restore and create wetlands, and foster land use changes by farmers and landowners that will enhance water quality. In response to the alarming wetland losses, there are numbers of studies to evaluate the environmental benefits of prairie wetlands at a watershed scale. The Broughton's Creek study was one of the studies to evaluate water quantity and quality benefits from wetland conservation and restoration in the Broughton's Creek watershed. Broughton's Creek is a 25,139-ha prairie watershed located in southwestern Manitoba (Yang, 2008). This study estimated reductions of total phosphorous (TP) and total nitrogen (TN) at the Broughton's Creek watershed outlet as a result of wetland restoration (Yang, 2008). Hence, restoring wetlands in the watersheds drained by the major tributaries of the Red River of the North is likely to alleviate the eutrophication stresses being suffered by the Lake Winnipeg (Yang, 2008).

Rain gardens also have a role to play as one of the positive approaches, providing both environmental, social benefits. These systems when used as educational sites can help to educate people and raise public awareness about the need for broad scale programs and policies to improve water quality and sustain our environment, human health and economy.

7.5 Role of local government and organizations

As evidenced by the results, local government and other organizations have been effective in informing Winnipeg residents about rain gardens. First developed in 1990 in Maryland, rain gardens have since become part of a growing international movement embraced by homeowners, schools, and municipalities (Prince George's County Department of Environmental Resources, 2001). In 2008, rain gardens were introduced to Winnipeg when the first rain garden in Ecole St Avila School was installed by SMM Landscape Architects, who had experience with urban wetlands through previous work on the Royal-wood Wetland project. In February 2011, Rivers West approached the Province of Manitoba's Department of Education and the Water Stewardship Division to develop a Sustainable Storm Water Management Guide for schools in Manitoba. The official launch was held on World Water Day on March 22nd, 2012 (Rivers West, 2012). An online version of the guide is also available at www.riverswest.ca and www.routesonthered.ca. Therefore, rain gardens can also be used to encourage Manitoba schools to develop these systems on their grounds as an educational tool to teach students and the public about storm water management, the connectivity of watersheds and the role people can play in conserving a healthy environment.

In August 2011, the St. Norbert Community Center, the St. Norbert Farmers Market and other St. Norbert organizations, in conjunction with SMM Landscape Architects announced their intention to jointly plan the development of a rain garden community park in South Winnipeg (Lukes, 2011). The first open house was held in December 2011, which put rain gardens and other natural landscaping on display to the general public. At the same time, other schools in Winnipeg also began designing rain gardens for their school grounds, as a response to the Sustainable Storm Water Management Guild (Lukes, 2011). Native Plant Solutions of Ducks Unlimited Canada, and other local environmental organizations, also have provided people with a source of rain garden plants. Landscaping contractors and landscape architecture firms such as SMM have also begun to provide rain garden plants, design, and installation services.

Local residents have been instrumental in promoting rain gardens. Mrs. Janice Lukes, coordinator of the Ecole St Avila School Ground Greening Committee, made a major effort to promote the Ecole St Avila project and the expansion to the St Norbert Rain Garden Community Park Project. Rivers West has also made an effort to develop school rain gardens as part of their Storm Water Management Guide activities. Aside from rain garden promotion, rain garden research work has also been performed in Winnipeg. To inform the general public about rain gardens, open houses and workshops have been offered by a variety of organizations, such as Ducks Unlimited Canada, Ecole St Avila School, Rivers West, and the St Norbert Community. These local organizations will be instrumental in promoting rain gardens more generally to residents of Winnipeg (Rivers West, 2012).

7.6 Obstacles and incentives

Another important finding of this study is that although most respondents had a positive perception about building a rain garden, they still listed several reasons that would prevent them from installing one in their private yards. One of the most frequently cited reasons was the lack of knowledge of rain gardens, including their performance and how to build them. Before receiving any information in regard to rain gardens, almost all participants did not have any knowledge about this concept. After they better understood the basic concept they still did not believe they had enough knowledge to build a rain garden on their own.

In Kansas City, the municipal government offered a rain garden website to help their residents to learn more about rain gardens. A group of rain garden experts in the city provided both physical and educational assistance if residents needed any additional help (Kansas City, 2009). Plant Dane Rain Garden Cost-Sharing Program also provided a website to help their residents to learn the rain garden concept and design, and provided native plants at the greatly reduced price of $1.80 each – less than half the normal price (Plant Dane, 2012).

Another frequently cited barrier preventing the building of a rain garden was insufficient time. Some respondents felt that they would spend more time on building and maintaining a rain garden compared to their current yard made up mostly of lawn. This showed that most people do not have sufficient knowledge about the relative cost/benefits of rain garden systems. Most of the plants in a rain garden are native species that do not need much maintenance time or cost in the performance of the garden (UWEX 2003). Over an extended period, rain gardens should save time for residents in lawn maintenance (UWEX, 2003).

The cost of installation and maintenance was also perceived as an obstacle by concerned respondents. Cost-sharing and rebate programs for rain gardens should be started in Winnipeg to aid in promoting their development by private citizens. The Madison Area Municipal Storm Water Partnership, along with Dane County, began a native plant and seed grant program in 2005, called Plant Dane, to provide matching grants to individuals interested in installing a rain garden (Plant Dane, 2012). The City of Kansas (2009) also gave a credit on storm water bills for implementation of on-site storm water practices, such as rain gardens, rain barrels, and pervious pavement. The City of Winnipeg could also develop a rain garden cost-sharing program for our residents based on these experiences.

The evidence showed that cost-sharing programs, such as in Kansas City, could help the city to successfully achieve the goal of increased rain garden development. However, the experience in Kansas City also showed that there is a need for another program in addition to the 10,000 Rain Garden Program, which would provide installation and maintenance assistance rather than just financial assistance (Kansas City 2009). By providing financial incentives and developing such programs to include additional incentives to residents and schools, widespread development of Rain Gardens throughout Winnipeg and surrounding areas might occur.

Chapter 8.0 Summary, Conclusions, and Recommendations

8.1 Summary and Conclusions

This research has provided valuable information about Winnipeg residents' perceptions and environmental concerns, and the following conclusions have been made as a result of the findings.

Firstly, the literature illustrated the many benefits that can be provided by a rain garden system, and also indicated that design objectives and siting considerations of undertaking a broad scale rain garden project should be developed in relation to local environmental and site conditions.

Secondly, people do believe that rain gardens may benefit local water quality to some extent, but they still have doubts about whether their own small rain garden could affect the water quality of Lake Winnipeg. This indicates that local studies are necessary to increase the confidence of people and put individual efforts into the larger context. It means that more public education and information is needed to change public perception in this regard.

Thirdly, the finding from the survey results indicated that people are concerned about the environment; however this does not solely influence their decision to build a rain garden, even if some seem to be aware of its positive impact on pollution removal and flood control. Awareness of rain gardens was found to be low among the respondents at the beginning of the project. However, the rain garden at Ecole St Avila led to increasing awareness and engagement in rain garden development. These, efforts by local government and organizations should be continued to overcome perceived barriers developing a rain garden.

Lastly, the provincial government needs to rethink the direction of their education system – especially regarding innovative opportunities for development of curricula. Learning about the ecosystem and environmental issues by using a familiar place like a rain garden outdoor classroom may help redefine the roles of schools, teachers and students in better meeting government prescribed learning outcomes. The educational value of the school rain garden, project was high and it had a positive impact on school students' understanding and perceptions about water management.

This study has demonstrated that local organizations can be remarkably effective in promoting rain gardens in Winnipeg. Even in the short time frame, work being performed by these organizations has inspired more schools to construct their own rain gardens. If this becomes a widespread movement this program could significantly change the urban hydrologic cycle and benefit water quality and runoff management. Our city and province would benefit from such an outcome socially, environmentally and economically. It is my hope that rain gardens will continue to increase in popularity throughout Winnipeg and Manitoba generally so that these benefits can be fully realized.

8.2 Recommendations

The overall goal of rain garden development is to help people to understand the importance of stormwater management, as well as the importance of the urban ecosystem. This study has examined the rain garden at Ecole St Avila and has uncovered previously unknown information about the social behavior of area residents and teachers. These included perceived obstacles and barriers to building rain gardens, how the school would be affected by building a rain garden, what would be the likelihood of building a rain garden in a residence yard, and major obstacles preventing people from building a rain garden in their own yards. Through this project, it has also found that Ecole St Avila project plays an instrumental role in rain garden knowledge diffusion in Winnipeg.

In order to better promote and teach Winnipeg residents about rain gardens, Ecole St Avila rain garden should be used as a demonstration site to investigate and display challenges and needs to be addressed in order to better implement the rain garden concept in Winnipeg. Therefore, based upon this thesis, the following recommendations are provided.

8.2.1 Recommendation 1 –Education for students

Education should be considered initially as the most significant benefit of rain garden development in Winnipeg. Information about rain gardens should be incorporated into both formal and informal education systems to reach a broad audience. The Provincial Department of Education should enhance their curriculum guides for schools by emphasizing the use of rain gardens and similar ecosystems in the local community.

Likewise, it should provide teachers with support to enhance their capability to use rain gardens and other systems in a process of outdoor, hands on place-based teaching.

The Provincial Government should develop an educational model that uses a collaborative process for participatory research, community discovery, and action in rain garden development. This approach to learning about and taking actions to improve local environments provides a promising educational tool. Such an approach will enhance teaching about watershed management through practice, and empowering students to use science to understand, organize and improve their community, and contribute to the development of systems thinking. In addition, ecological field trip costs for schools could be reduced by bringing biodiversity to the schoolyard.

8.2.2 Recommendation 2 – School as multi-functional sites

There is no reason why schools cannot be fundamentally conceptualized to be the very centers of neighborhoods and communities, multi-use places where generations come together, not simply large single-use facilities occupied for only a portion of the day. Schools should be redefined as community and intergenerational centers. Any new project in a school should be increasingly viewed as an opportunity to do something positively to benefit the community as a whole. The future school should be an inviting place both inside and outside the building, rather than a foreboding institution. These sites should aim to expand knowledge about sustainable living by acting as Centres of Excellence in this regard.

The example at Ecole St Avila points to ways that schools can better serve as the center of local communities, either by playing a more integral role in sustainability education or by integrating a project, such as a rain garden, further into the community. This new model of collaboration and integrated learning can have a meaningful and significant impact on both the local and the broader community.

This new vision of the school could include partnerships among governments as well as citizens and non-profit organizations for wider effect and benefit. These schools could be viewed as a full service centers and provide a variety of educational and extracurricular community programs of broad benefit to all citizens. The vision of multifunctional, neighborhood and community-based school envisioned here is a compelling one, and Ecole St Avila School is moving in this direction as an example for others. However, it should be also noted that when schoolyards are used more often, how to alleviate risk and liability issues if increased multifunctional use of schoolyards occurs must be considered. This should be a major focus of a future study.

8.2.3 Recommendation 3 – A call for rain gardens on private and public sites.

Provincial government and other local organizations in Winnipeg should embrace the rain garden concept recognizing the ecological goods and services such systems can provide to society. The Provincial Government should play a leadership role in the promotion of rain gardens and should continue to incorporate rain gardens into the City storm water management plan. The Provincial Government could offer assistance in removing perceived barriers to this program by providing installation and maintenance assistance and other incentives. Organizations could organize work days to help install rain gardens, or help residents with planning their rain garden and choosing native plants. Local environment groups, especially those involved with native plants, such as Ducks Unlimited Canada, have extensive knowledge about plants and rain garden development which would greatly benefit future rain garden owners. Organizations could also construct demonstration rain gardens in suburban apartment, institutions, commercial properties and parks of each community using their knowledge and resources to convince others to utilize rain gardens on their property. Using signs, such as those available through the Ecole St Avila Rain Garden and Ducks Unlimited, could help to promote rain gardens by educating people about these demonstration projects. Lastly, continuing and expanding cost-sharing programs will help to make rain gardens more affordable. This study found that many participants would be willing to install rain gardens if the government offered a cost-sharing program. However, even with some financial assistance as occurred in Kansas City, rain gardens can still be prohibitively expensive (Kansas, 2009). Plant-sharing programs using plants harvested from existing rain gardens could reduce costs, and organizations could begin projects to grow native plants from seed and sell plugs at low cost to interested rain gardeners.

This study found most of the survey respondents felt that rain gardens could have a positive environmental impact on Lake Winnipeg when compared to other possible environmental actions they could take. However, because of lack of knowledge, many respondents did not know of the efficacy of rain gardens on pollution removal and flooding control. Therefore, it is necessary for researchers and local organizations to continue to disseminate information about rain gardens in order to reinforce the public understanding about beneficial rain garden functions. There is a need for additional research to evaluate the small scale and large-scale environmental impact of rain gardens on the quality of large watersheds such as the Red River/Lake Winnipeg system in Manitoba.

Research would also be beneficial in identifying needs for future rain garden locations. Rain gardens have started to develop in some Winnipeg school yards, primarily scattered in south Winnipeg. A targeted approach to rain garden implementation using models and identifying neighborhoods and sub watersheds with water quantity or quality issues and appropriate soil types would show the greatest needs and opportunities for future rain garden developments. The government should lead a study to implement a rain garden process and placement tool, such as the system developed by the USEPA in 2003(USEPA, 2003). This tool would help to develop, evaluate, select, and place rain gardens in priority areas.

8.3 Implications for Future Research

The findings from this study and from literature reviewed suggest that further research is needed in order to better understand how to best go about enhancing watershed management using a rain garden concept. This study took a qualitative approach to better understand the gaps affecting broad deployment of this management and education tool but additional study is needed.

In order to better undertake further research, the suitable procedures and method need to be set out.

Table 8.1 Suggested procedures and methods for future research

Future Research	**Where**	**Who**	**Suggested Procedures and Methods**
Water quality test	Ecole St. Avila	School teachers and students	Department of Education could allocate fund to make the water test curriculum for school students in Manitoba
Social learning	Ecole St. Avila	U of M students	U of M students could help Ecole St. Avila to offer rain garden workshop and to collect social feedback from future activities.
Modeling of the region	Different scales	Manitoba water stewardship division	A modeling process using such systems as ***SUSTAIN*** could explore the direct and indirect benefits of a broad scale rain garden program on the Red River and Lake Winnipeg system as a whole.
Other project (St. Norbert Rain Garden)	St. Norbert Community	U of M students and residents in St. Norbert	U of M students could track the new project at initial stage in order to get better data. They could also work with local residents on volunteer hours, donation and other activities, which help to collect good experiences for other same project.

The data set from this study was limited and a broader survey is needed to fully understand the reservations and concerns that people expressed. For example more information is needed to understand how best to encourage people to take action to develop a rain garden on their own property. To be able to overcome the knowledge gap people expressed about their understanding of the rain garden concept, ways to better illustrate the benefits rain gardens can provide must be found.

Local research on the performance of rain gardens will likely provide a better understanding for educating people about benefits of rain garden on local environmental issues. As has been discovered in this study, there are many promising results that were documented by researchers in the United States. More research is needed to determine the performance of the rain garden at Ecole St Avila or other rain gardens in Winnipeg. This will help change attitudes and also overcome the knowledge gap. However, the benefits of a single rain garden will be of limited value in promoting the concept when compared to the evaluation of a larger scale sub watershed project. The priority should be on exploring the direct and indirect benefits of a broad scale rain garden program on the Red River and Lake Winnipeg system as a whole. A modeling process using such systems such as ***SUSTAIN***, is a priority for further investigation.

The growing severity of recent flood events in Manitoba and the declining water quality in Lake Winnipeg implies that major societal changes are needed in both rural and urban parts of the watershed. This has repercussions for both provincial and national policies affecting wetlands and land use. Knowledge about potential new initiatives and their possible outcomes is needed to aid governments in planning sustainable water management programs over the long term.

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Appendix 1.1 Consent Form

UNIVERSITY OF MANITOBA | Department of Environment and Geography

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70A Dysart Road
Winnipeg, Manitoba
Canada, R3T 2M6
Telephone (204) 474-9451
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environment_geography@umanitoba.ca

Research Project Title:
Effect of Rain Gardens in Winnipeg - Application and Development
Principal Investigator and contact information:
Hao Chen Email: umche224@cc.umanitoba.ca
Research Supervisor and contact information:
Dr. Rick Baydack Email: baydack@cc.umanitoba.ca

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Manitoba would like to know what you think about rain gardens. Rain gardens are shallow depressions planted with native, deep-rooting grasses and wildflowers. They are landscape features designed to capture and soak up excess rainwater. Water that washes off roofs, driveways, and other hard surfaces gets directed to the garden where it is absorbed by plants and soil. Because everyone who lives in the Lake Winnipeg Watershed has a stake in the future of the Lake, it is important that we hear from you. I thank you again for your participation in this research study and would like to ask for your assistance in this research. The research is in the partial fulfillment of my Master's degree.

The research project contains a short social survey. I am using this survey because I am interested in learning more about what people think about rain gardens. I am very interested in your feedback and want to assure you that all of your answers will remain anonymous. Compiled statistical results from this survey will be shared with organizations currently promoting rain gardens, and will shape the way that information about rain gardens is communicated to interested communities.

I am hoping that you are able to review the research and background information from the brochure and rain garden website. I have provided a website link at the end of the consent form. The survey questions are posted on the Survey Monkey website. The link is also available at the end of this consent form. After you better understand the research and background information. I hope that you can take the time to complete the survey questions. It should only take about 15-20 minutes of your time to complete, and given the small pool of individuals who were selected to fill out this survey, your participation will be very important to this study.

umanitoba.ca

Results of this research study will improve understanding about the effectiveness of rain gardens in Manitoba and will be used by local governments to better understand their social impacts. The social feedback that you provide will help the Provincial government to improve stormwater management and enhanced protection for surface and ground water. Compiled statistical results from this survey will be shared with organizations currently promoting rain gardens, and will shape the way that information about rain gardens is communicated to interested communities.

After all analyses have been completed, the results of the social survey will be posted in December 2011 on Rain Garden website. A summary report will also be posted on the website in April 2012. You will also receive the summary report in April 2012 through email.

Thank you in advance for taking the time to complete the survey, and I look forward to receiving your survey input. Please feel free to contact me with any questions you might have. Thank you again for making this research study possible!

Website: http://www.pembinatrails.ca/stavila/schoolgroundgreeningproject/index.html

http://web.me.com/hchen628/Rain_Garden/Home.html

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba Research Ethics Board(s) and a representative(s) of the University of Manitoba Research Quality Management / Assurance office may also require access to your research records for safety and quality assurance purposes.

This research has been approved by the Joint-Faculty Research Ethics Board (JFREB). If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator (HEC) at 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Participant's Signature ________________________ Date ____________

Researcher and/or Delegate's Signature ___________________ Date _______

Sincerely,

Hao Chen
M.Env. Candidate

Appendix 1.2 Approval Certificate

UNIVERSITY OF MANITOBA | OFFICE OF RESEARCH SERVICES
Office of the Vice-President (Research)

CTC Building
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Winnipeg, MB R3T 2N2
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www.umanitoba.ca/research

APPROVAL CERTIFICATE

November 21, 2011

TO: **Hao Chen** (Advisor R. Baydack)
Principal Investigator

FROM: **Wayne Taylor, Chair**
Joint-Faculty Research Ethics Board (JFREB)

Re: **Protocol #J2011:097**
"Effects of Rain Gardens in Winnipeg ---- Application and Development"

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 (2). 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.

Please note:

- **If you have funds pending human ethics approval, the auditor requires that you submit a copy of this Approval Certificate to the Office of Research Services, fax 261-0325 - please include the name of the funding agency and your UM Project number. This must be faxed before your account can be accessed.**

- **if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.**

The Research Quality Management Office may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba Ethics of Research Involving Humans.

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/ors/ethics/ors_ethics_human_REB_forms_guidelines.html) **in order to be in compliance with Tri-Council Guidelines.**

Bringing Research to Life

Appendix 2 Survey Question

Please circle one number from the choice area. 1: Definitely no 2: Probably no 3: Not sure 4: Probably yes 5: Definitely yes

Rain Garden Survey (Teacher)

1. **Prior to seeing the brochure and website description, my familiarity with the idea of rain gardens was:**

   Very low 1 2 3 4 5 Very high

2. **After seeing the brochure and website description, my familiarity with the idea of rain gardens is improved:**

   Very low 1 2 3 4 5 Very high

FOR ME, HOW MY SCHOOL WOULD BE AFFECTED BY BUILDING A RAIN GARDEN…

3. **For my school to build a rain garden on the grounds is:**

   Very difficult 1 2 3 4 5 Very easy

   Very unpleasant 1 2 3 4 5 Very enjoyable

   Very expensive 1 2 3 4 5 Very affordable

   Very time-consuming 1 2 3 4 5 Not very time-consuming

4. **For my school to hire someone to build a rain garden on the grounds is:**

   Very necessary 1 2 3 4 5 Very unnecessary

   Very difficult 1 2 3 4 5 Very easy

   Very expensive 1 2 3 4 5 Very affordable

5. **Building a rain garden on my school ground would mean more time maintaining the grounds.**

   Very unlikely 1 2 3 4 5 Very likely

6. **Spending more time on maintaining rain garden on school grounds is:**

   Very undesirable 1 2 3 4 5 Very desirable

7. **Building a rain garden on school grounds would bring safety issue to students**

   Very unlikely 1 2 3 4 5 Very likely

MY SCHOOL CAPACITY TO BUILD A RAIN GARDEN…

8. **School staff has the physical ability to build a rain garden.**

   Definitely no 1 2 3 4 5 Definitely yes

9. **School staff has the knowledge needed to build a rain garden.**

   Definitely no 1 2 3 4 5 Definitely yes

Please circle one number from the choice area. 1: Definitely no 2: Probably no 3: Not sure 4: Probably yes 5: Definitely yes

---

10. School has the financial means to build a rain garden.

Definitely no 1 2 3 4 5 Definitely yes

11. School staff has free time to build a rain garden

Definitely no 1 2 3 4 5 Definitely yes

HOW MY SCHOOL WILL BE AFFECTED BY A RAIN GARDEN…

12. By building a rain garden in my school, I think the school property value will:

Definitely decrease 1 2 3 4 5 Definitely increase

13. Building a rain garden on my school ground would improve the appearance of my school.

Very unlikely 1 2 3 4 5 Very likely

14. Building a rain garden will increase the amount of wildlife attracted to the school grounds.

Very unlikely 1 2 3 4 5 Very likely

15. Increasing the wildlife habitat in school ground yard would be good for students:

Very undesirable 1 2 3 4 5 Very desirable

16. Building a rain garden in my school ground would create standing water that could attract mosquitoes.

Definitely no 1 2 3 4 5 Definitely yes

17. Preventing standing water that could breed mosquitoes in school ground is:

Not very important to me 1 2 3 4 5 Very important to me

18. Having a yard that is mostly lawn is:

Not very important to my school 1 2 3 4 5 Very important to my school

19. Having a rain garden is:

Not very important to my school 1 2 3 4 5 Very important to my school

HOW LAKE WINNIPEG WOULD BE AFFECTED…

20. If my school builds a rain garden on the ground, it will improve the water quality of Lake Winnipeg.

Very unlikely 1 2 3 4 5 Very likely

21. **Improving the water quality of Lake Winnipeg is:**

    Not important to me 1 2 3 4 5 Very important to me

22. **Compared to other actions I could take to impact water quality in Lake Winnipeg, building a rain garden in my school would have:**

    No impact 1 2 3 4 5 Very big impact

ANTICIPATED OPINIONS OF OTHERS…

23. **By building a rain garden in my school, community neighbors would:**

    Strongly disapprove 1 2 3 4 5 Strongly approve

24. **What community neighbors recommend is:**

    Not important to my school 1 2 3 4 5 Very important to my school

25. **If building a rain garden in my school, student parents would:**

    Strongly disapprove 1 2 3 4 5 Strongly approve

26. **What student parents recommends is:**

    Not important to my school 1 2 3 4 5 Very important to my school

27. **If building a rain garden in my school, my students would:**

    Strongly disapprove 1 2 3 4 5 Strongly approve

28. **What my students recommend is:**

    Not important to my school 1 2 3 4 5 Very important to my school

LIKELIHOOD OF BUILDING A RAIN GARDEN…

29. **I think I will build a rain garden on my yard in the next few years.**

    Very unlikely 1 2 3 4 5 Very likely

30. **I think I will hire someone to build a rain garden on my yard in the next few years.**

    Very unlikely 1 2 3 4 5 Very likely

31. **I think I will build a rain garden on my yard in the next few years**
    if I am given detailed instructions how to do so.

    Very unlikely 1 2 3 4 5 Very likely

32. **I think I will build a rain garden on my yard in the next few years if I received cost-sharing assistance.**
Very unlikely 1 2 3 4 5 Very likely

33. **I think I will build a rain garden on my yard in the next few years if other people in my community also build one.**
Very unlikely 1 2 3 4 5 Very likely

34. **I think I will build a rain garden on my yard in the next few years if some people help me.**
Very unlikely 1 2 3 4 5 Very likely

35. **I think I would help other people build a rain garden in the next few years if they asked for my help as part of a larger community event.**
Very unlikely 1 2 3 4 5 Very likely

SUMMARY OF MAJOR OBSTACLES…

36. **The following are obstacles preventing me from building a rain garden on my yard:**

A) Yard too small: Not at all 1 2 3 4 5 Very much

B) Yard too steep: Not at all 1 2 3 4 5 Very much

C) Cost/Expense: Not at all 1 2 3 4 5 Very much

D) Insufficient time: Not at all 1 2 3 4 5 Very much

E) Too much work: Not at all 1 2 3 4 5 Very much

F) Lack of knowledge: Not at all 1 2 3 4 5 Very much

37. **Largest obstacle** (please enter one letter from above): ____

38. What additional comments would you like to add?

Please return your survey as soon as you are able, and once again thank you for your time and effort.
If you would like to receive the study result and report, please leave your email address:

____

Rain Garden Survey (Parent)

1. **Prior to seeing the brochure and website description, my familiarity with the idea of rain gardens was:**

   Very low 1 2 3 4 5 Very high

2. **After seeing the brochure and website description, my familiarity with the idea of rain gardens is improved:**

   Very low 1 2 3 4 5 Very high

3. **Building a rain garden on school ground would bring safety issue to students**

   Very unlikely 1 2 3 4 5 Very likely

4. **I have the physical ability to help school to build a rain garden.**

   Definitely no 1 2 3 4 5 Definitely yes

5. **I have the knowledge needed to help school to build a rain garden.**

   Definitely no 1 2 3 4 5 Definitely yes

6. **I have free time to help school to build a rain garden**

   Definitely no 1 2 3 4 5 Definitely yes

7. **By building a rain garden in my child's school, I think the school property value will:**

   Definitely decrease 1 2 3 4 5 Definitely increase

8. **Building a rain garden on my child's school grounds would improve the appearance of the school.**

   Very unlikely 1 2 3 4 5 Very likely

9. **Building a rain garden will increase the amount of wildlife attracted to the school grounds.**

   Very unlikely 1 2 3 4 5 Very likely

10. **Increasing the wildlife habitat in school ground yard would be good for my child:**

    Very undesirable 1 2 3 4 5 Very desirable

11. **Building a rain garden in my child's school grounds would create standing water that could attract mosquitoes.**

    Definitely no 1 2 3 4 5 Definitely yes

12. **Preventing standing water that could breed mosquitoes in school ground is:**

    Not important to my child 1 2 3 4 5 Very important to my child

13. **Having a yard that is mostly lawn is:**

    Not important to my child 1 2 3 4 5 Very important to my child

14. **Having a rain garden is:**

    Not important to my child 1 2 3 4 5 Very important to my child

15. **If the school builds a rain garden on the ground, it will improve the water quality of Lake Winnipeg.**

    Very unlikely 1 2 3 4 5 Very likely

16. **Improving the water quality of Lake Winnipeg is:**

    Not important to me 1 2 3 4 5 Very important to me

17. **Compared to other actions I could take to impact water quality in Lake Winnipeg, building a rain garden in my child's school would have:**

    No impact 1 2 3 4 5 Very big impact

18. **The following are obstacles preventing my child's school from building a rain garden on the ground:**

    A) <u>Yard too small</u>: Not at all 1 2 3 4 5 Very much

    B) <u>Yard too steep</u>: Not at all 1 2 3 4 5 Very much

    C) <u>Cost/Expense</u>: Not at all 1 2 3 4 5 Very much

    D) <u>Insufficient time</u>: Not at all 1 2 3 4 5 Very much

    E) <u>Too much work</u>: Not at all 1 2 3 4 5 Very much

    F) <u>Lack of knowledge</u>: Not at all 1 2 3 4 5 Very much

19. **Largest obstacle** (please enter one letter from above): ____

20. **I think I will build a rain garden on my yard in the next few years.**

    Very unlikely 1 2 3 4 5 Very likely

21. **I think I will hire someone to build a rain garden on my yard in the next few years.**

    Very unlikely 1 2 3 4 5 Very likely

22. **I think I will build a rain garden on my yard in the next few years if I am given detailed instructions how to do so.**

    Very unlikely 1 2 3 4 5 Very likely

23. **I think I will build a rain garden on my yard in the next few years if I received cost-sharing assistance.**

    Very unlikely 1 2 3 4 5 Very likely

24. **I think I will build a rain garden on my yard in the next few years if other people in my community also build one.**

    Very unlikely 1 2 3 4 5 Very likely

25. **I think I will build a rain garden on my yard in the next few years if some people help me.**

    Very unlikely 1 2 3 4 5 Very likely

26. **I think I would help other people build a rain garden in the next few years if they asked for my help as part of a larger community event.**

    Very unlikely 1 2 3 4 5 Very likely

27. **The following are obstacles preventing me from building a rain garden on my yard:**

    A) <u>Yard too small</u>: Not at all 1 2 3 4 5 Very much

    B) <u>Yard too steep</u>: Not at all 1 2 3 4 5 Very much

    C) <u>Cost/Expense</u>: Not at all 1 2 3 4 5 Very much

    D) <u>Insufficient time</u>: Not at all 1 2 3 4 5 Very much

    E) <u>Too much work</u>: Not at all 1 2 3 4 5 Very much

    F) <u>Lack of knowledge</u>: Not at all 1 2 3 4 5 Very much

Please circle one number from the choice area. 1: Definitely no 2: Probably no 3: Not sure 4: Probably yes 5: Definitely yes

---

28. **Largest obstacle** (please enter one letter from above): ____

29. **What additional comments would you like to add?**

Please return your survey as soon as you are able, and once again thank you for your time and effort.
If you would like to receive the study result and report, please leave your email address:

____

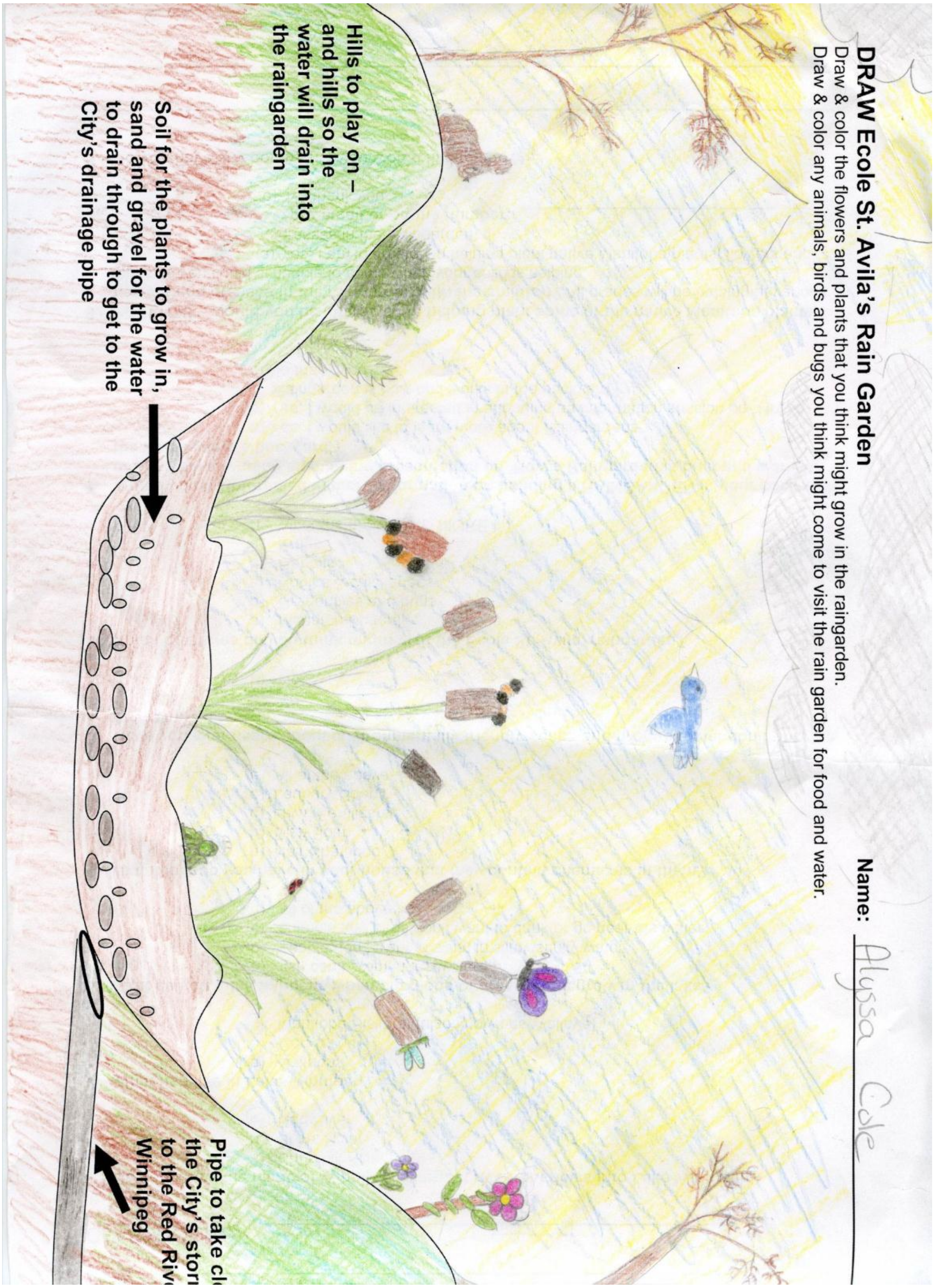
Appendix 3 Photos

World Water Day in Ecole St Avila School –
Student explained the function of rain garden (Photo by Hao Chen)

Mr. Derek Murray showed the Master Plan of Ecole St Avila Rain Garden (Photo by Hao Chen)

2011, after snow melting (Photo by Hao Chen)

Appendix 4 Students' drawing



Appendix 5: Native Plant Solutions: Plants List and Price

Pre-Designed Gardens

Rain Gardens

Rain Gardens for other soil types are available online! www.prairienursery.com

Rain gardens for medium soil in full sun

Plant a Rain Garden to "retain the rain" with native plants and create habitat at the same time. Instead of running off into storm sewers and drains that can lead to flooding, your rainwater will soak into the soil to recharge the water table. The plants in our Rain Garden are excellent for attracting birds and butterflies, too!

The size of the garden should be based upon the rooftop area, each garden has rooftop size listed. Choose the correct rooftop size for proper water infiltration. The garden should be between 10'-30' from the building or downspout.

32 Plant Rain Garden
(infiltrates 200 sq. ft. of rooftop)

Comes with Complete Planting and Layout Instructions.

Wildflowers
2 Red Milkweed
3 Crooked Stem Aster
2 Mistflower
1 Maple Leaved Alum Root
2 Bergamot
2 Marsh Phlox
4 Downy Phlox
1 Cupplant
1 Ohio Goldenrod
2 Culver's Root

Sedges
6 Palm Sedge
6 Fox Sedge

$139.00 Item #50068
Covers 72 sq. ft. (approx. 12' x 6')

We design large custom Rain Gardens!

64 Plant Rain Garden
(infiltrates 350 sq. ft. of rooftop)

Comes with Complete Planting Layout and Instructions.

Wildflowers
4 Red Milkweed
7 Crooked Stem Aster
1 White False Indigo
3 Mistflower
4 Prairie Smoke
2 Maple Leaved Alum Root
2 Great Blue Lobelia
2 Bergamot
3 Marsh Phlox
4 Downy Phlox
1 Sweet Black Eyed Susan
1 Cupplant
2 Ohio Goldenrod
2 Ironweed
2 Culver's Root

Sedges
12 Palm Sedge
12 Fox Sedge

$239.00 Item #50069
Covers 112 sq. ft. (approx. 16' x 7')

96 Plant Rain Garden
(infiltrates 500 sq. ft. of rooftop)

Comes with Complete Planting Layout and Instructions.

Wildflowers
5 Red Milkweed
3 New England Aster
8 Crooked Stem Aster
2 White False Indigo
2 Wild Senna
3 Mistflower
6 Prairie Smoke
2 Maple Leaved Alum Root
3 Great Blue Lobelia
3 Bergamot
5 Marsh Phlox
6 Downy Phlox
2 Sweet Black Eyed Susan
1 Cupplant
3 Ohio Goldenrod
3 Ironweed
3 Culver's Root

Grasses & Sedges
14 Palm Sedge
14 Fox Sedge
8 Indiangrass

$349.00 Item #50070
Covers 171 sq. ft. (approx. 19' x 9')

Appendix 6: Delta’s Rain Gardeners Classroom Program

Delta’s Rain Gardeners Classroom Program

Teacher Resource Manual

Intermediate Grades 4 - 7

Curriculum Developed and Designed by Jennifer Stonehouse (BA, BEd, MSc)

For the Corporation of Delta

Photo Credits: Cougar Creek Streamkeepers

c 2010