

Best Practices Guide for Community Gardens - Prepared for the London Community Resource Centre

Cirrus Consulting Group

Ms. Linda Davies

ENVRUS 9200

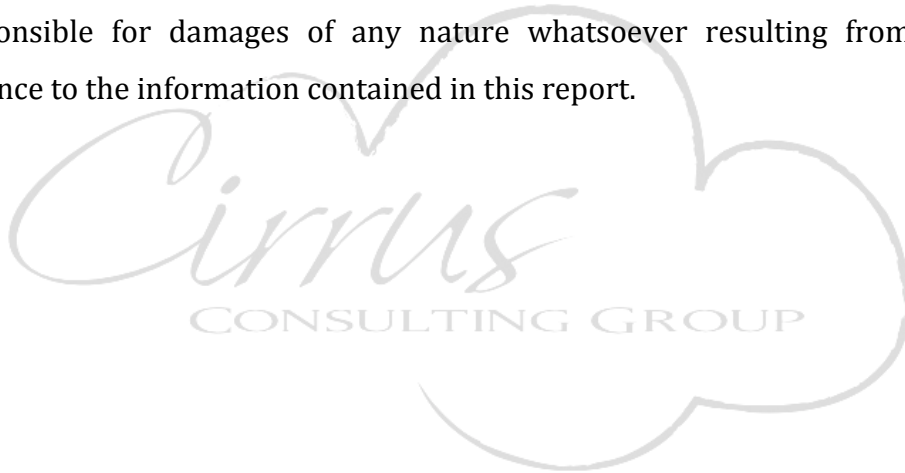
April 23, 2010



Report Disclaimer

The information contained within this report has been collected from a variety of sources and by a variety of organizations and individuals, all considered reliable. All information is offered on a "best intentions" basis.

Cirrus Consulting Group has prepared this report for academic purposes only and in no way represents this information for implementation by the client. In no event shall the authors of information provided herein, be liable for special, direct, indirect or consequential damages, losses, costs, charges, demands, or claims for lost profits or expenses of any nature or kind. In particular, Cirrus Consulting will in no event be responsible for damages of any nature whatsoever resulting from the use or reliance to the information contained in this report.



CIRRUS CONSULTING GROUP
“REACH FOR THE SKY”

Introductory Letter

London Community Resource Centre
652 Elizabeth Street
London, Ontario
N5Y 6L3

ATTN: Ms. Linda Davies,

Cirrus Consulting Group has developed this report for the London Community Resource Centre.

This report is the final deliverable for the London Community Resource Centre and to you, our client, Ms. Linda Davies.

Sincerely,

Jeremiah Brenner, Dane Labonte, Martha Fallis and Joshua Wise
Cirrus Consulting Group



Executive Summary

The following report contains detailed information and recommendations resulting from an objective review of the current watering practices, maintenance techniques and environmental sustainability of the London Community Resource Centre's (LCRC) community gardens.

To provide background and context to this project, a comprehensive literature review on the history and importance of community gardens was completed. Community gardens are quickly gaining popularity in urban centres as their benefits are being realized. Socially, community gardens have been found to detract youth from crime, improving personal health and help to educate individuals on growing their own produce. Environmentally, community gardens help to reduce air pollution, filter rainwater and provide pesticide free food to the local population. Finally, from an economic standpoint, community gardens can produce economic means for lower income families, to raise property values in neighbourhoods and provide community savings, as maintaining community gardens is cheaper than maintaining parklands.

It is vitally important to consider the biophysical conditions in London, ON when developing recommendations related to water use and soil manipulation. As such, data related to climate, rainfall, soil type and watering techniques for Southwestern Ontario were collected for reference in this report. With projected increases in temperature for Southwestern Ontario due to climate change, it is likely that evapotranspiration will continue to increase during the garden-growing season, thereby requiring more frequent uses of water. As such, research regarding a number of irrigation techniques, such as hand watering, drip and clay pot irrigation, have been reviewed. Also, a number of tilling and organic fertilization techniques are discussed for their ability to reduce the environmental impact of garden sites.

Secondary literature has been explored by Cirrus Consultants regarding environmental auditing in order to develop environmental audit checklists and performance measures for the LCRC. Few secondary sources exist regarding environmental audits for community gardens. As a result, research has focused on the process itself and the best techniques for developing environmental audit checklists.

In order to collect comprehensive data, a number of research techniques were implemented. Information was collected to further develop recommendations for the LCRC, through face-to-face interviews, consultation with key stakeholders, extensive document reviews of statistical information, researching for best practices in the municipal sector, personal observations and information gathered from the LCRC and City of London staff.

Utilizing the collected data, a number of results were produced that highlighted key considerations for the creation of best practice recommendations. These key results included the identification of best practice techniques for watering, fertilizer use and tilling. As well, a summary analysis and comparison on the strengths and weaknesses of water supply methods was produced. Also, an examination of summarized quantitative data provided the basis for the creation of environmental audit checklists and key performance measures. Finally, an evaluation of the LCRC's website resulted in areas for suggested improvement.

Through the quantitative and qualitative research conducted for this report, a number of recommendations have been developed. The current practices of the LCRC community gardens were used as a baseline to be analysed for possible improvement. These recommendations are expected to contribute and enhance the current environmental performance of the LCRC community gardens, as well as, improve their operations' sustainability in the future.

Best Maintenance Practices Recommendations:

Regarding water irrigation, the installation of drip-irrigation or a clay pot irrigation system would result in the lowest loss of water and improve water conservation. Enthusiastic gardeners may test these systems in the early stages of development. As well, where hand watering continues, increased education on water conservation and awareness to gardeners will help to ensure the most responsible water use.

To retain soil productivity, the implementation of a no-till method for use in community gardens through mulch cover or cover crops would be ideal. If not feasible for widespread use the implementation of shallow-till method, using hand-tools for use in the gardens would increase soil resilience. If tilling by the LCRC is necessary for gardeners with physical limitations, it is important to properly time roto-tilling, including bi-annual soil inspections.

Regarding fertilization practices, the promotion of the use of homemade compost should be investigated. This would need to include added education as well as infrastructure on the part of the LCRC. This would insure positive environmental effects both on-site in the gardens as well as for the greater environment.

Water Supply Recommendations:

In terms of the water supply, the needs of the LCRC are best addressed by onsite taps, which have less environmental risk than installation of water wells. Rainwater harvesting can also help to reduce the environmental impact of the LCRC garden sites and reduce water bills. As well, expanding communication systems may allow for fewer LCRC student and City of London worker trips to refill rain barrels and water tanks. It was found that neighbour-sourced water is an effective short-term solution to water supply issues but should be considered to be temporary and will need to be addressed in the future to insure the sustainability of water supply.

Environmental Audit Recommendation:

To minimize the environmental impact of the community gardens and their operations, a pre-construction and seasonal environmental audit checklist should be utilized by the LCRC. As well, key performance measures of the LCRC should be captured with currently available data in the short-term, and long-term, as data capture strategies become available.

Website Review Recommendation:

Finally, in order to improve the current LCRC website by making it more user friendly and effective, the LCRC should consider re-organizing their home page. This includes the overall navigation, organization and appearance of the website.



Table of Contents

Introductory Letter	ii
Executive Summary	iii
Table of Contents	vii
List of Figures, Images and Tables	ix
Glossary.....	x
1.0 Introduction and Problem Statement.....	1
2.0 Literature Review.....	2
2.1 What is a Community Garden?	2
2.2 Benefits of Community Gardens	3
2.2.1 Social Importance	3
2.2.2 Environmental Importance	6
2.2.3 Economic Importance	6
2.3 Environmental Background: Climate	7
2.4 Evapotranspiration.....	9
2.5 Effects of Climate Change	10
2.6 Soils	13
2.7 Water Conservation	15
2.8 Irrigation Techniques	17
2.9 Watering Efficiency Improvements.....	23
2.10 Tilling Practices	25
2.11 Fertilizer Techniques	29
2.12 Environmental Audits	33
3.0 Methodology.....	37
3.1 Benchmarking Questionnaire	37
3.2 Observational Research	37
3.3 Staff Consultation	38
3.4 Best Maintenance Practices Methodology	38
3.4.1 Irrigation Considerations	38
3.4.2 Tilling Considerations.....	39
3.4.3 Fertilizer Considerations.....	41
3.5 Multi-Criteria Evaluation	43
3.6 Water Supply Pros and Cons Analysis	44
3.7 Environmental Audit Checklist.....	45
3.8 Website Review Methodology	46
4.0 Results	47
4.1 Best Practice Results	47
4.1.1 Watering Best Practice	47
4.1.2 Tilling Best Practice	49
4.1.3 Fertilizer Best Practice	52
4.2 Water Supply Pro and Con Analysis	54
4.3 Environmental Audit Checklists.....	59
4.4 Key Environmental Performance Measures.....	60

4.5 Community Garden Comparison Questionnaire.....	63
4.6 Fertilizer and Pesticide Use:	64
4.7 Tilling:	64
4.8 Water Management:	65
4.9 Website Review:.....	66
5.0 Recommendations & Conclusions.....	70
5.1) Best Maintenance Practices: Irrigation, Tilling & Fertilization	70
5.1.1) Irrigation Recommendation:.....	70
5.1.2) Irrigation Recommendation (Alternative):	71
5.1.3) Tilling Recommendation:	72
5.1.4) Tilling Recommendation (Alternative):	73
5.1.5) Tilling Recommendation (Alternative 2):	73
5.1.6) Fertilization Recommendation:	74
5.2 Best Maintenance Practices: Water Supply	74
5.2.1) Water Supply Recommendation:	74
5.2.2) Water Supply Recommendation (Alternative):	75
5.2.3) Water Supply Recommendation (Alternative 2):.....	75
5.2.4) Water Supply Recommendation (Alternative 3):.....	76
5.3) Best Practice Recommendation: Environmental Audit	76
5.3.1) Environmental Audit Recommendation	76
5.4) Best Practice Recommendation: Website Review	78
6.0 Conclusion.....	79
References.....	80
Appendices.....	86
Appendix 1: Thornthwaite Equation.....	86
Appendix 2: MCE Tables	86
Appendix 3: Pre-Construction Environmental Audit Checklist	89
Appendix 4: Pre - Season Environmental Audit Checklist	91
Appendix 5: Community Garden Questionnaire Responses	94
5.1 Hamilton:.....	95
5.2 Kingston:.....	95
5.3 Kinsbridge:	96
5.4 Windsor:	96
5.5 University of Waterloo- School of Architecture:.....	98
5.6 Sarnia:	98
5.7 York Region:.....	99
5.8 University of Western Ontario:.....	100

List of Figures, Images and Tables

FIGURES:

1.0 Figure 1. MNR Summer Temperature forecast	11
2.0 Figure 2. MNR Summer Precipitation forecast	12
3.0 Figure 3. Soil Types and Soil Particles	13
4.0 Figure 4. Soil Types in London, Ont.	14
5.0 Figure 5: Standard Drip Irrigation System	21
6.0 Figure 6: Community Gardens Tilling Practices	65
7.0 Figure 7: Community Garden Irrigation Methods.....	66
8.0 Figure 8: Website Design Example	69

IMAGES

1.0 Image 1: Hand Watering Method.....	17
2.0 Image 2: Sprinkler Irrigation System.....	19
3.0 Image 3: No Till Farming Method.....	27
4.0 Image 4: Roto-tilling Farming Method	28
5.0 Image 5: Sample Compost Site	32

TABLES

1.0 Table 1: Average Climatic information for City of London	8
2.0 Table 2: Potential Evapotranspiration for City of London	9
3.0 Table 3: Varieties of Organic Fertilizers.....	30
4.0 Table 4: Environmental Systems & Subsystems	36
5.0 Table 5: Irrigation Methods and Environmental Criteria.....	39
6.0 Table 6: Tilling Methods and Environmental Criteria.....	41
7.0 Table 7: Fertilizer Methods and Environmental Criteria	43
8.0 Table 8: Irrigation Methods Final Scores and Environmental Rank	48
9.0 Table 9: Water Conservation Rankings.....	48
10.0 Table 10: Environmental Scores for Tilling Methods.....	49
11.0 Table 11: Environmental Factors for Tilling Consideration	50
12.0 Table 12: Environmental Considerations for Deeper Tilling.....	52
13.0 Table 13: Fertilization Methods: Final Environmental Score	53
14.0 Table 14: Environmental Considerations for Fertilization Application	53
15.0 Table 15: Water Sourcing Considerations	55
16.0 Table 16: Community Gardens Questionnaire Responses	64

Glossary

Audit Framework – A compilation of key criteria used to assess and evaluate operational performance

Audit Checklist – Tool used which a party can use to measure and establish baseline data on performance

Community Garden – A green space managed and developed by a neighborhood community in which urban agricultural activities take place

Deep Percolation – A form of water loss where water seeps past the root zone of plants and into deeper soils where it cannot be used by the plant

Environmental Audit – An assessment of an organization's potential environmental impacts through an evaluation of their inputs, outputs and operational practices

Evapotranspiration - The transfer of water to the atmosphere through water evaporation from the soil and water transpiration from vegetation

Furrow - A trench dug into the soil creating a ridge and valley

Garden Site – refers to a location which contains a grouping of a number of garden plots

Garden Plot – Garden area designated for an individual gardener

Hand Watering – A crop watering method that is preformed through manual application of water by individual gardeners using either a watering can or a hand held hose

Irrigation Efficiency – A comparison of the amount of water collected in the plant root zone with the amount of water applied during irrigation

LCRC – London Community Resource Centre

MCE – Multi-Criteria Evaluation

Micro Irrigation – A form of irrigation, which is characterized by the frequent application of small volumes of water to the plant base or to the root system using low pressure and low flow

Mulch – A protective layer of organic or inorganic material placed over soil, which allows for water infiltration

Soil Horizon – The distinct levels of soil separated by organic composition and consistency or size of grains (horizons range from topsoil to bedrock)

Root Zone – The area of penetrated by plant roots

Transpiration – Water released to the atmosphere through the stomata of plants as vapour (Burt et al. 1997)



1.0 Introduction and Problem Statement

Cirrus Consulting was retained by the London Community Resource Centre to increase their capacity to implement environment and sustainability practices in their 22 community gardens. The role of Cirrus was to determine the most environmentally friendly route possible for the development and maintenance of these gardens. The practices involved in maintenance and cultivation at gardens sites can have environmental implications both on-site and in the greater ecosystem. On-site concerns are primarily based on soil health and vitality, as healthy topsoil helps to ensure the long-term success of the gardens. Concerns over water sourcing and use are also of significant importance. Impacts from the gardens to the surrounding environment can range from water contamination to increases in atmospheric carbon dioxide emissions.

To date, the quick growth and small workforce of the LCRC has allowed these gardens to evolve naturally. It is the objective of this report to ensure that these gardens provide social and economic benefits to the community and progress in an environmentally sustainable manner. True sustainability of the community gardens means a balance between environmental, social and economic factors. The popularity of the gardens has grown based on the social rewards they create within the community and they continue to evolve based on their economic viability. It is vital that environmental considerations receive the attention needed to ensure the prolonged health of this noble operation.

Cirrus accomplished this mission through:

- A comprehensive literature review of community gardens, London's environmental conditions, gardening watering, tilling, and fertilization practices, and Environmental Auditing for community gardens;
- A Best Practices Guide to irrigation, tilling and fertilization techniques;
- A pro and con analysis of various water supply methods;

- A custom-made environmental audit for benchmarking and measuring performance;
- A comparative guide of other community garden operations in Ontario; and
- A review of the LCRC's current website layout and design

The information provided by Cirrus Consultants will allow the LCRC to move forward in their operations in a more environmentally responsible manner. This report will act as a guide to recommend immediate improvements, identify areas for future improvements and provide valuable background information to serve as a guide for future decision-making.

2.0 Literature Review

In order to provide context and quantitative data for the development of this report, a comprehensive literature review was completed. Literature concerning the importance of community gardens, water sourcing, soil types, tilling, organic pesticides, environmental auditing and website design was researched and evaluated for relevance. This literature provided a foundation for developing recommendations that would allow the LCRC to pursue environmentally sustainable practices in their current and future operations.

2.1 WHAT IS A COMMUNITY GARDEN?

A community garden can be described as a green space managed and developed by a neighborhood community in which urban agricultural activities take place (Holland, 2004). Community Gardens require hard work and organization because gardens are rarely planned for in development processes and usually result from community organization or group interest and leadership. When planning for community gardens, there are many factors to consider in order to ensure its initial success and for its ongoing operational functioning and long-term success (Williamson, 2002). Environmental factors, such as sunlight and soil type need to be included in the plans. Safety and theft concerns should also be addressed. Once

operational, regulations need to be agreed upon by participating gardeners. These include, but are not limited to; the hours of operation, dues, and allowed gardening techniques (Williamson, 2002). The benefits of today's community gardens then pertain to social and physical aspects of the environment. These benefits include; aesthetic improvements, increased soil health, a reduction in transportation costs, public health, cultural connections, and interactions with humans, other life forms and biological processes. There are many social, environmental and economic benefits to having and implementing community gardens. Below is a breakdown of these benefits.

2.2 BENEFITS OF COMMUNITY GARDENS

Community gardens provide many benefits to different age groups, neighborhoods and demographics. The benefits of community gardens can be divided into three major categories: social, environmental and economic. Each of these categories will be discussed in detail below.

2.2.1 Social Importance

There are many social benefits to community gardens including youth, reduction of crime, health, therapy, community development and education.

Youth and Crime:

Community gardens are being used to develop alternatives for young people exposed to drugs and the crime economy (Ferris, Norman, & Semik, 2001). Organizations have implemented gardens in their communities to keep at risk youth from getting into trouble. An example of one of these projects is the Youth Garden Project, which was created to help juvenile youths stay out of trouble (Heffron, 2009). The project is intended to help children with personal growth, self-responsibility and community awareness through organic gardening, experiential education programs and community service (Heffron, 2009). Community gardens are an effective way to rehabilitate run-down or vacant land where troubled youth

would generally reside. Residents have often taken over neglected urban sites that were occupied by teenage gangs and drug dealers and converted it. Once the land is converted into a community garden, crime rates have proven to be reduced. For example, in New York residents built gardens in vacant lots that were left empty by the City (Ferris, Norman, & Semik, 2001). It has been shown that many gardens are strategically placed and used to create a “defensible space.” These spaces are usually neighborhood areas in which escape routes from criminal perpetrators are limited and public range of vision is maximized to prevent illicit conduct (Schukoske, 2000). When these areas are converted into gardens they are then unable to be used as escape routes and meeting areas for criminals.

Therapy:

Healing or therapy gardens are becoming an important element in community care provision. Following the closure of mental hospitals, community gardens have been an effective form of therapy for people with disabilities (Ferris, Norman, & Semik, 2001). These types of gardens also offer rehabilitation programs to people who have suffered barriers to full social inclusion (Ferris, Norman, & Semik, 2001). Community gardens offer an outlet for people to gain rehabilitation through nature and feel selfworth towards completing and participating in a community project.

Health:

There are many health benefits to community gardens, including strengthened immunity, reduced rates of asthma, decreased stress, increased overall sense of well being and reduced risk of childhood lead poisoning (Lorincz, 2009). Community gardens are also a good form of low impact exercise for all ages, especially the elderly who cannot always do higher impact physical activities. It is a good low paced outdoor form of exercise that has been proven to be beneficial to one’s overall health.

Community Development:

Community gardens create a sense of public ownership and democratic control (Ferris, Norman, & Semik, 2001). The community garden movement promotes interaction between diverse residents of urban neighborhoods along common

interests, such as beautification, local food production, personal safety, health and group projects (Schukoske, 2000). The community garden movement draws upon individual talents, knowledge and efforts without creating barriers to participation such as high cost, language, or educational achievement, which may otherwise divide residents. Community gardens promote self-respect in residents of all income neighborhoods because it fosters the spirit of community cooperation (Schukoske, 2000).

Community gardens also help new immigrants adapt to a new country, improve access to traditional cultural foods, and teach them about sustainability and personal and family health (Twiss, Dickinson, Dumas, Kleinman, Paulsen, & Rilveria, 2003). Many community gardens also lead to further neighborhood organization by providing a physical location for individuals to meet, socialize, and learn about other organizations and activities/services in their local community (Armstrong, 2000).

Education:

Outdoor education is a rare commodity in the urban 21st century lifestyle. Most children are raised in urban settings and only experience the rural outdoors a few times in their early life. Community gardens allow people of all ages to learn about flora and fauna in an urban environment. According to a study in South Africa, there are many educational benefits of community gardens (Liddicoat & Krasny, 2005). A community garden can be both a classroom and a textbook for formal and non-formal education programs and institutions. Learning to grow plants is mentally stimulating and adds to an individual's wealth of knowledge and expertise. Growing a garden teaches people to think sustainably and use long-term problem-solving skills rather than relying on quick fix, short-term solutions. Gardens can educate the public on issues such as waste minimization and recycling through composting and mulching. The educational value behind community gardens varies across demographics and age, which is why they are such beneficial organizations to have in a community.

Overall, the social benefits to community gardens are immense and cross-cultural. They can break social barriers in communities and create a sense of community in areas that may not have it. They allow for people to exercise outdoors in a cheap and educational manner. Community gardens are an informal way for families to bond. It is evident that community gardens have many social benefits to a neighborhood.

2.2.2 Environmental Importance

Community gardens have many positive benefits on the natural environment. They create green space in urban environments. They allow for a social meeting place that is outdoors and reconnects communities with nature. Community gardens are a huge benefit towards the overall sustainability of a neighborhood. Rainwater is filtered through gardens, helping to keep lakes, rivers and groundwater clean. Community gardens restore oxygen into the air and help reduce air pollution. Large quantities of organic waste can be used to fertilize gardens, thus helping to minimize a community's overall waste output. Most community gardens are organic and pesticide free which allows for healthier food and ground water (Williamson, 2002).

2.2.3 Economic Importance

When implementing a community garden organization in a neighborhood, the economical benefits will always be an area of discussion. Community gardens can improve a community's economic output through building and saving capital, occupying vacant land, and increasing food production. These benefits will be discussed in further detail below.

Build/ Save Capital:

Implementing community gardens in neighborhoods builds and saves capital. This can be done through many mechanisms, for example by reclaiming and preserving urban spaces (Schukoske, 2000). When an area is reclaimed and preserved it can have positive outcomes on the surrounding neighbourhoods. The implementation

of community gardens leads to property improvements in neighborhoods, which can also cause the value of properties in the area to increase. In New York, a garden can raise neighborhood property values by as much as 9.4% within five years of the gardens opening (Voicu & Been, 2008). In terms of saving capital, developing and maintaining garden space is less expensive than parkland area, in part because gardens require little land and 80% of their costs is labor (Bremmer, Lenkins, & Kanter, 2003).

Vacant Land:

Community gardens are a good solution to city owned vacant land. In the last three decades, community gardens have proliferated in cities across the US as a means of citizens addressing many problems with vacant lands (Schukoske, 2000). As mentioned above in the social benefits section, the minimization of vacant lands also decreases crime in communities.

Food Production:

Community gardens can be a significant source of food and/or income for community members. This is especially helpful for families and individuals without much land who would not otherwise be able to produce their own food (Lorincz, 2009). Urban agriculture is three to five times more productive per acre than traditional large-scale farming (Lorincz, 2009). Many organizations have allocated specific plots where the produce is donated to the local foodbanks and shelters.

2.3 ENVIRONMENTAL BACKGROUND: CLIMATE

Biological regions are broadly defined by the seasonal precipitation and climate, and soils and topography (Cunningham et al. 2005). Regions with similar characteristics tend to support similar vegetation and biological communities. These regions are called biomes.

London, Ontario sits in a temperate forest biome. This biome is characterized by high seasonal variation in temperature and plentiful precipitation with little to

moderate seasonal variation (Cunningham et al., 2005). The temperate forest biome tends to support deciduous forest with broad-leaved trees, which are shed over winter (Cunningham et al., 2005). Southern Ontario's climate is also regionally affected by the Great Lakes. The Great Lakes increase autumn and winter precipitation due to increased available moisture (Environment Canada, 1997). The lakes moderate seasonal extremes in temperature, by acting as a heat source in the winter and as a cooling source in the summer (Environment Canada, 1997). Traditionally, London has been within a transitional ecological zone between the Mixed Deciduous forest region to the south and the Great Lakes- St. Lawrence forest region to the north. (UTRCA, 2003).

When considering the environment and sustainability of the LCRC community gardens, it is important to consider the local climate and what type of vegetation the region naturally supports. Below in table 1, is the average climatic information for the City of London based on data collected from the London International Airport between 1971-2000 (Environment Canada, 2009). The table is limited to the months most related to the community gardens operation.

	March	April	May	June	July	August	September
Daily Average Temp °C	-0.3	6.3	13	18	20.5	19.5	15.3
Average Daily High	4.2	11.6	19	23.8	26.3	25.2	20.9
Average Daily Low	-4.7	1	7	12.1	14.6	13.7	9.6
Average Rainfall	53.8	73.8	82.6	86.8	82.2	85.3	97.7
Average number of days with rainfall >0.2mm	8.6	11.5	12.1	11.6	11	10.9	12.1
Rainfall >5mm	3.5	4.7	5.4	4.9	4.6	4.8	5.1

TABLE 1: Average Climatic information for City of London

(Environment Canada, 2009)

2.4 EVAPOTRANSPIRATION

In addition to climatic information, the amount of evapotranspiration is an important consideration, especially in terms of water use and conservation. Evapotranspiration is the transfer of water to the atmosphere through water evaporation from the soil and water transpiration from vegetation (Burba, 2006). The true evapotranspiration rate is affected by water availability, heat, humidity, wind, vegetation community and soil composition. However, there are several ways of estimating evapotranspiration (Burba, 2006).

The thornthwaite method, (Appendix 1), was used to estimate the potential evapotranspiration for the London area. This method was selected because the information necessary for the calculations is readily available. Using the climatic information available from Environment Canada and average monthly day length data (based on 43° 0' N latitude and 81° 0' W longitude), the potential evapotranspiration was calculated for months during London's growing season (Table 2).

	March	April	May	June	July	August	September
Potential Evapotranspiration (mm.month ⁻¹)	N/A	33.76	80.74	114.15	132.97	118.25	79.78
(mm.day ⁻¹)	N/A	1.13	2.61	3.81	4.29	3.81	2.66

TABLE 2: Potential Evapotranspiration for City of London

By comparing the rainfall data and potential evapotranspiration data, the three warmest months (June, July, and August) have greater potential evapotranspiration than rainfall. This is important when considering water efficiency and use for the community gardens.

2.5 EFFECTS OF CLIMATE CHANGE

Climate change as a result of human activities is expected to have varying effects on different global regions. As the LCRC program moves forward, it will be important to consider the potential effects of climate change.

The figures below were created using the climate forecasting models available through the Ontario Ministry of Natural Resources website. The projections were modeled on high greenhouse gas emissions.

The region will potentially become 4-5°C warmer by the end of the century and 1-2°C warmer in the next few decades (Figure 1). April to September precipitation levels are expected to drop by less than 10% by the end of the century (Figure 2). However, with the higher temperatures it can be expected that greater evapotranspiration will occur during the summer months leading to drier growing conditions.

It is expected that the growing season will increase as climate change progresses, due to warming in the region. However, the drying conditions induced from increased temperatures and slightly reduced rainfall may strain water availability (Hayhoe & Shuter, 2003). This could create a situation where there is greater evapotranspiration than rainfall throughout the entire growing season. This suggests that water conservation concerns will be of growing importance as the climate change progresses. The following figures highlight the projected temperature and precipitation rates for Southwestern Ontario.

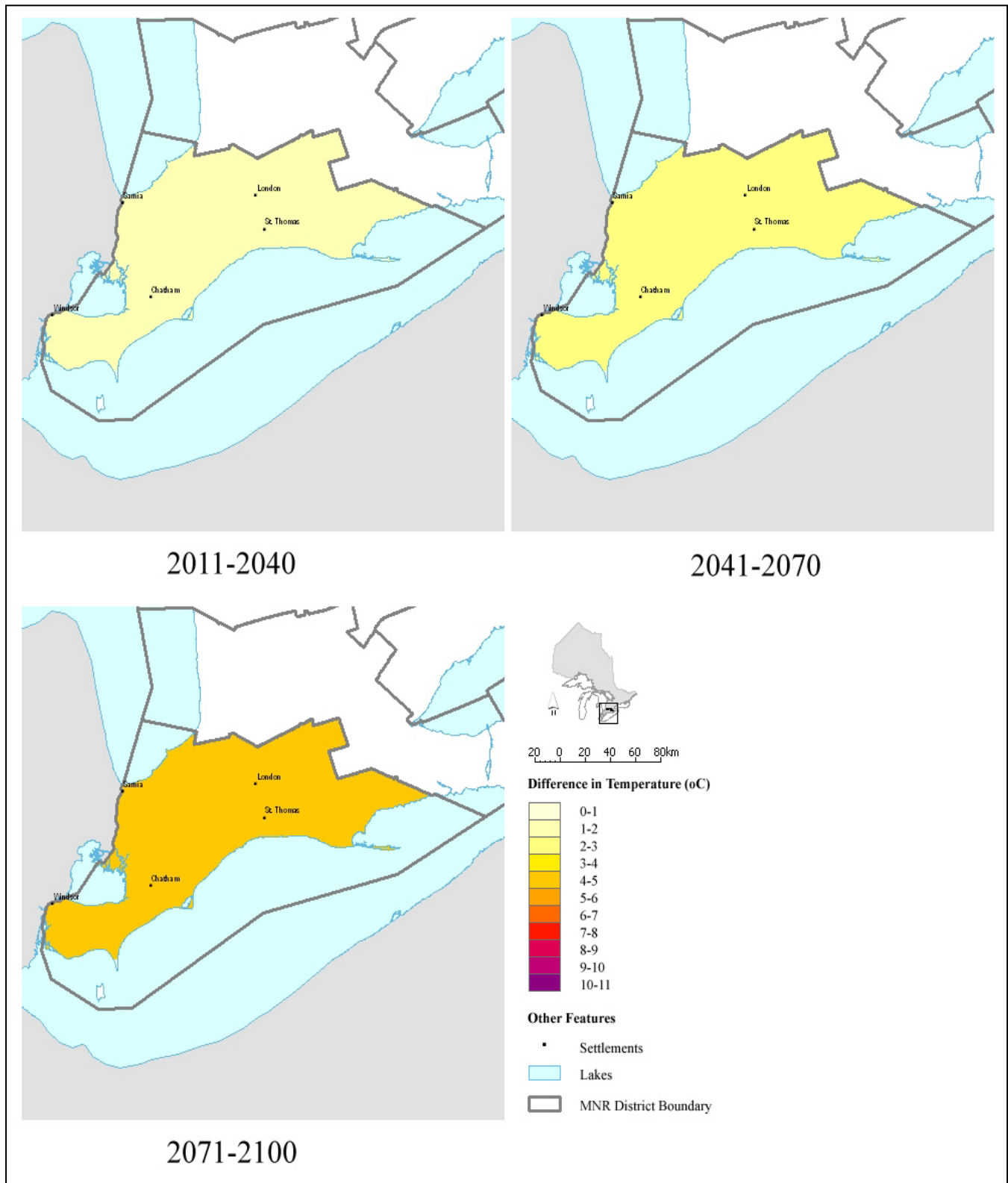


Figure 1. Ontario Ministry of Natural Resources Summer Temperature forecast under higher greenhouse gas emissions projections. (OMNR, 2010)

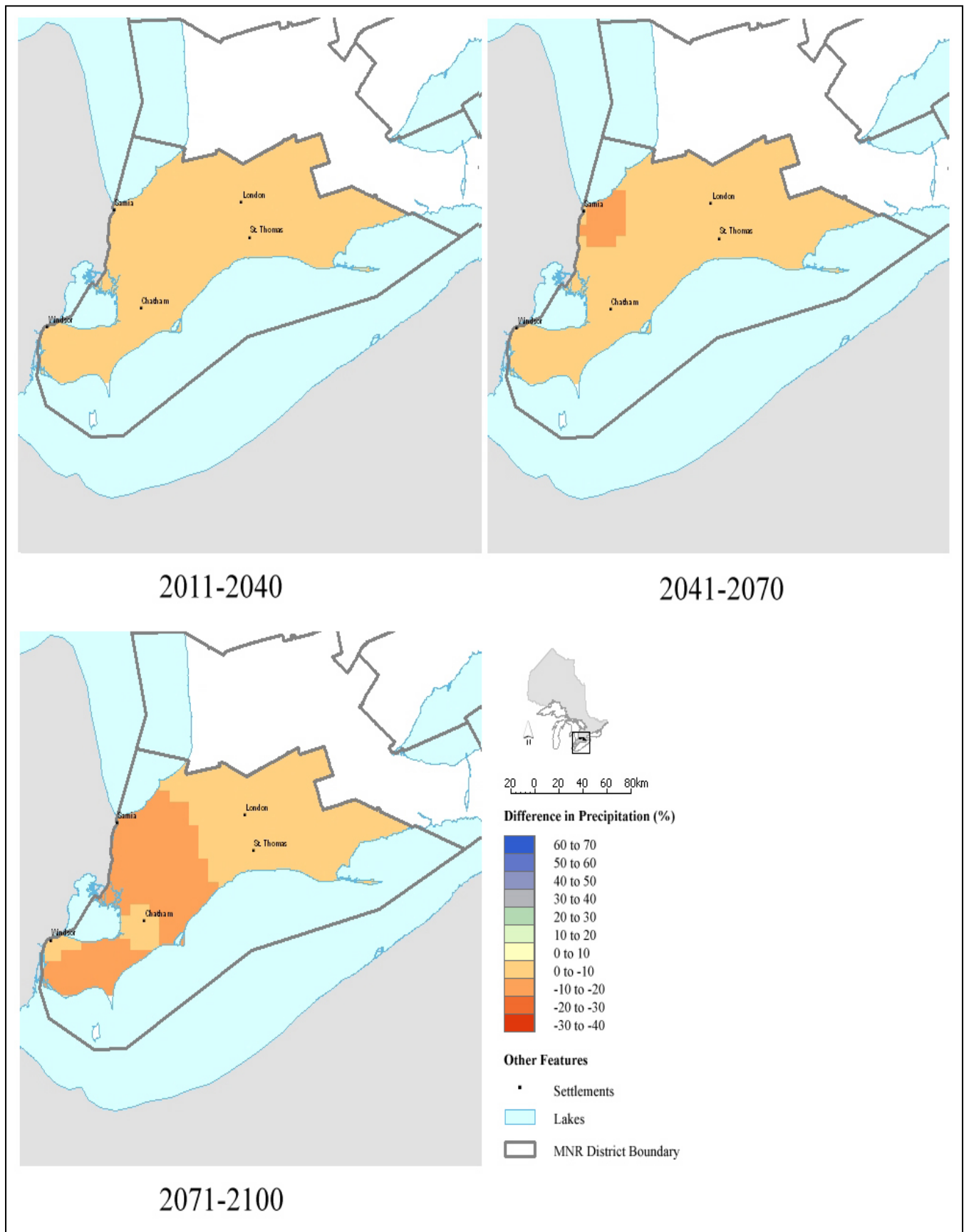


Figure 2. Ontario Ministry of Natural Resources Summer Precipitation forecast under higher greenhouse gas emissions projections. (OMNR, 2010)

2.6 SOILS

Soils are made up of a combination of weathered minerals, organic material and living organism (Cunningham, 2005). There are numerous soil types worldwide. The exact composition of the soil and relative mixture of elements is important in determining what types of vegetation the soil can support.

Soils are classified according to the particle size. This is called soil texture. The mineral particle size is a major determinant of how well water is retained and also affects the amount of mineral ions contained within the soil and the availability of oxygen in the soil (Cunningham, 2005). Soil texture can be classified according to the relative proportion of three types of particles: Sand, Silt, and Clay. Figure 3 shows the soil types based on the relative proportion of soil particles (Master Gardener Foundation).

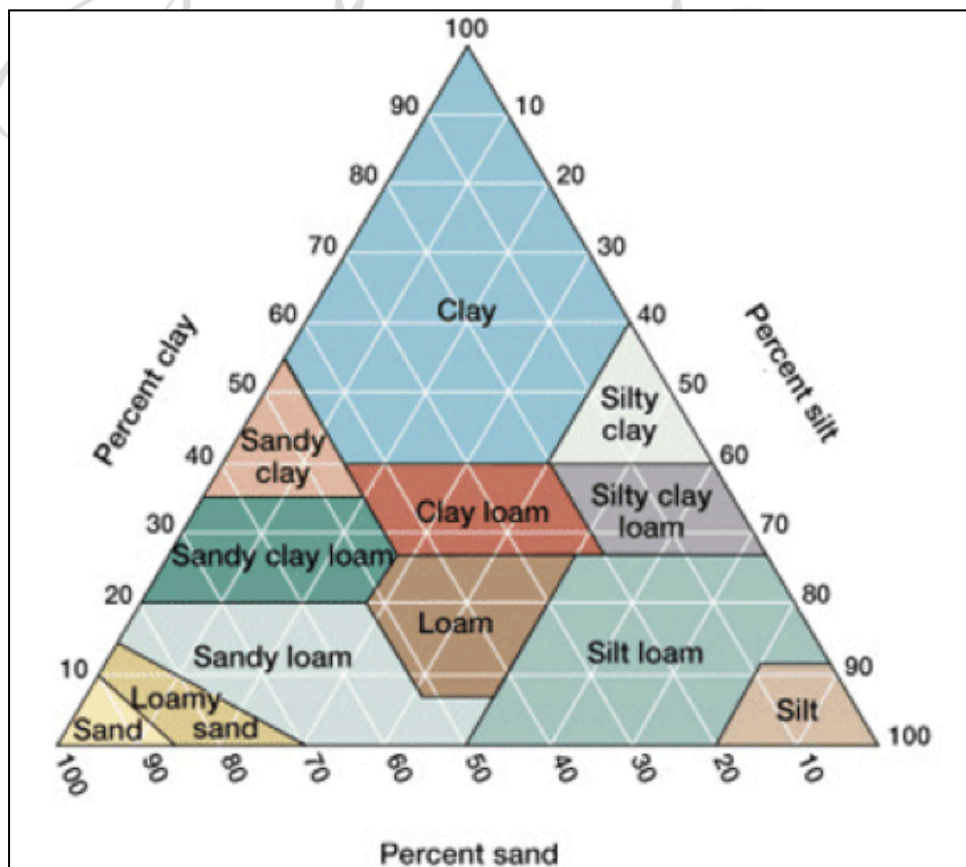


Figure 3. Soil Types and Soil Particles

(Master Gardener Foundation).

Loams are generally considered to be the best soils for gardening since they contain roughly equal portions of clay, silt, and sand (Master Gardener Foundation). The mixture of soil textures allows for the soil to retain water as well as allow for permeability. Soils with greater clay content are less permeable but retain water to a higher degree. Whereas, sandier soils have high permeability but little water retention. Silty soils retain more water than sandy soils but have less permeability (Master Gardener Foundation).

The following map (Figure 4) shows the soil types of the London area. The map is modified from the Ministry of Agriculture and Agri-Foods Canada's Middlesex County Soil Survey Map (1931).

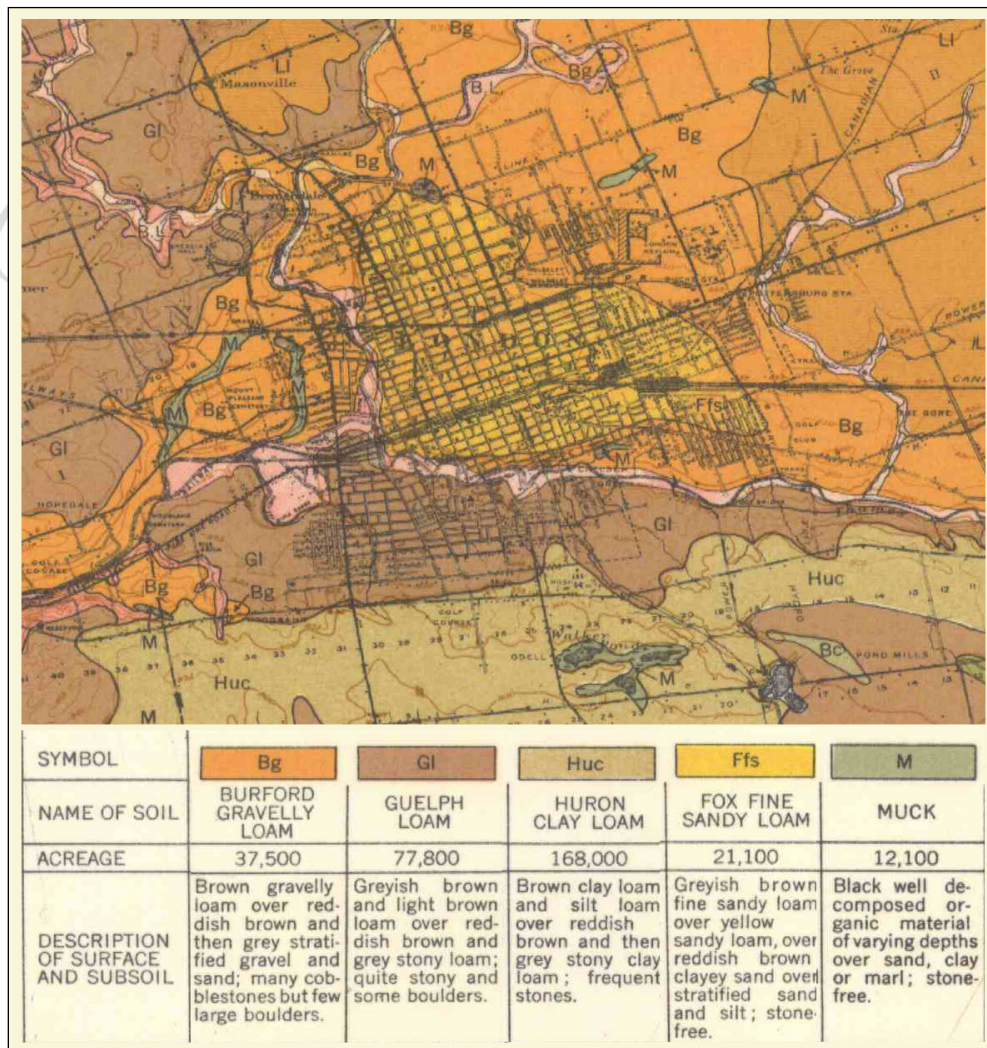


Figure 4. Soil Types in London, Ont.

(MCAFA 1931).

Soil composition varies throughout London. The downtown core has fine soil, where as the southern portion of the city has mixed loams and even clay loams. This will mean that each site will have to be evaluated according to its specific characteristics.

2.7 WATER CONSERVATION

Water conservation techniques have been identified as one way to minimize the costs associated with water management. Roughly 80% of water used to grow crops does not reach the root system of the intended plants (Cunningham, 2005). As water is applied to a garden it can be lost in several ways. Therefore, to improve irrigation efficiency, water loss needs to be acknowledged and understood. Burt et al. (1997) have described the destination of irrigation waters as follows:

Evaporation

Evaporation is the conversion of liquid water-to-water vapor. Water can evaporate from pools, the ground, or from plant surfaces. Evaporation rates are affected by:

- Irrigation method
- Irrigation frequency
- Climate
- Relative humidity
- Shading
- Wind
- Surface area
- Mulching

Transpiration

Transpiration identifies water that is lost to the atmosphere as vapour after passing through a plant's stomata. Although the plant has used this water, rates of transpiration can be altered by external factors and this can ultimately affect the water requirements of a crop. Transpiration can be affected by:

- Climate
- Relative humidity
- Wind
- Plant physiology
- Rates of evaporation on or near the plant

Deep Percolation

As water infiltrates the surface, it seeps through the soil and is either retained in the upper portions or continues to drain through to lower layers. The water that seeps past the root zone of plants and into deeper soils where it cannot be used by the plant is considered deep percolation loss. The rate of deep percolation is affected by:

- Soil composition
- Irrigation frequency
- Irrigation method
- Plant physiology
- Local groundwater table

Runoff

Runoff is defined as liquid water that leaves the region of application without infiltrating the soil surface. Runoff rates are affected by:

- Irrigation frequency
- Irrigation method
- Soil composition
- Topography
- Mulching

Drift

Drift is defined as liquid water that leaves an irrigation device and does not reach the intended area of application. The losses due to drift are affected by:

- Irrigation method
- Wind
- Height of irrigation device
- Irrigation system and operation

While it may not be possible to eliminate all forms of water loss, mindful irrigation strategies can minimize losses. The application of efficient irrigation water can conserve water and maintain healthy crops. This provides economic as well as environmental rewards. As noted in the section above, there are numerous factors affecting water loss. Some of the factors are more controllable than others.

Climatic and environmental conditions are not easily controlled, which can increase water loss. Some plants may benefit from shading but this is limited to specific crops that prefer these conditions. Similarly, plant physiology can have large effects on water demand. However, given the LCRC community gardens' social commitments, it does not seem appropriate to limit crop choices to meet water conservation goals. As a result, this review will focus on water conservation factors that can more easily be controlled by the LCRC.

2.8 IRRIGATION TECHNIQUES

The irrigation method used can dramatically affect the use of water. How water is applied to a crop can substantially affect the potential for water loss. Irrigation techniques have varying susceptibilities to the different forms of water loss.

Hand Watering

This is the system currently being used by the LCRC. Hand watering, using either a watering can or a hose is an economically appealing method because the capital costs of the system are minimal. Watering cans can be purchased cheaply, and hose systems can be shared among many gardeners. It is also beneficial for the LCRC, as it requires hands-on interaction by the gardeners to maintain the watering of the plants, helping to meet some of the social goals of the LCRC. Unfortunately, hand



watering is susceptible to high levels of water loss. If water is applied in a rather large amount over a short period of time, much of the water will evaporate from the soil or off the surface of the plants without ever reaching the root system.

Image 1: Hand watering method

Because hand watering has no control system, gardeners may also over-water areas, causing greater waste of water due to runoff and potentially damaging the soil and their crops. Depending on the handling of the water distribution device, water can also be lost to drift if it is blown off course. As a result, the operating costs of this system can be higher due to wasted water.

On the positive side, the gardeners have direct control of the water being applied. Where the water loss from hand watering can be controlled, gardeners are able to improve the efficiency of the system. This means that proper care and education are likely to greatly improve improper watering techniques and could potentially result in large water conservation gains.

Furrow Irrigation

Furrow irrigation is a surface irrigation method (Brouwer et al., 1988). The soil is cut into valleys and ridges. The plants are generally placed on top of ridges and the valleys are flooded with water. The water infiltrates the soil and seeps into the root zone of the plants. The size and shape of the furrow is highly dependent on the soil type. Furrows in sandy soil should be deep and narrow to ensure the water is able to reach the root system. With clay soil, the furrows are designed to be shallow and wide (Brouwer et al. 1988).

Furrow irrigation is generally used when water is easily available. It helps reduce the effects of over-watering and maintain a relatively constant moisture level. However, the large pools of water collected in the furrows sit in the open and are heavily affected by evaporation. Water is also lost to deep percolation since much of the water seeps into the soil below the root zone. In terms of water conservation furrow irrigation is not very useful.

Sprinkler Irrigation

There are numerous forms of sprinkler irrigation. Most sprinkler systems range from 50 – 80% water efficiency (USDA, 2008). Major factors affecting watering efficiency are water lost to drift, evaporation, runoff and watering unnecessary areas.



Image 2: Sprinkler Irrigation System

When designed properly, sprinkler systems can be scheduled to water at optimal times to reduce water loss due to evaporation and to maximize plant absorption rates.

A sprinkler system also reduces the time required by gardeners to maintain their plots. Rather than having to water their gardens daily, the gardeners can focus on maintaining weed free and well-tended plots.

A sprinkler system would provide some challenges to the LCRC garden setup. Traditional sprinkler systems require a relatively high level of water pressure. This is not available at most LCRC sites and would require the addition of pumps along with the irrigation system. Within an LCRC garden site, the numerous small plots have several varieties of plants with different watering requirements. This would require a more sophisticated system or changes in how the gardens are currently organized.

Micro Irrigation

Micro irrigation is generally considered to be one of the most effective ways of watering plants, with up to 90% irrigation efficiency (USDA, 2008). Micro irrigation is characterized by the frequent application of small volumes of water to the plant

base or to the root system (Smeal, 2007). Systems are run at low flow and low pressure, which significantly reduces water usage over other irrigation systems (Smeal, 2007). There are many forms of micro irrigation, including drip irrigation and micro sprinkler irrigation.

Since water is applied at low levels, the soil's water capacity is never exceeded and water quickly infiltrates the soil (Parsons et al.). This controls for evaporation, runoff, deep percolation and drift. By minimizing all these forms of water loss, the system is extremely effective in improving water conservation. Proper management of a micro irrigation system also improves the water-air balance in the soil, which in turn improves plant growth. The constant low-level application of water reduces the fluctuation between wet and dry soil conditions, which occurs through other watering methods (Parsons et al.). The highly targeted application of water to the soil reduces weed growth, which reduces competition for water resources and ensures proper wetting of the root zone. All these factors combined make micro irrigation systems extremely efficient.

Drip Irrigation

There are multiple varieties of drip irrigation systems. Some are permanent and installed subsurface, while others can be used seasonally and moved relatively easily. The cost of these systems varies widely. For the purposes of the LCRC, non-permanent, low cost systems are likely best suited. With proper management, a drip irrigation system can have greater than 90% efficiency (USDA, 2008).

Generally, a hose characterizes drip irrigation with emitters that allow low levels of water to trickle out slowly. The hoses are laid next to crops so that only the soil in the immediate area of the crop is watered. Drip irrigation is ideal for row crops, such as vegetables. Drip irrigation systems require very low flow rates from 0.5 to 2 gallons per hour (Hla and Scherer, 2003). Attaching to existing taps and applying a pressure regulating system can achieve this level of pressure. Several other

components are required to help regulate flow and maintain an effective system. Figure 5 is an example of a standard drip irrigation system.

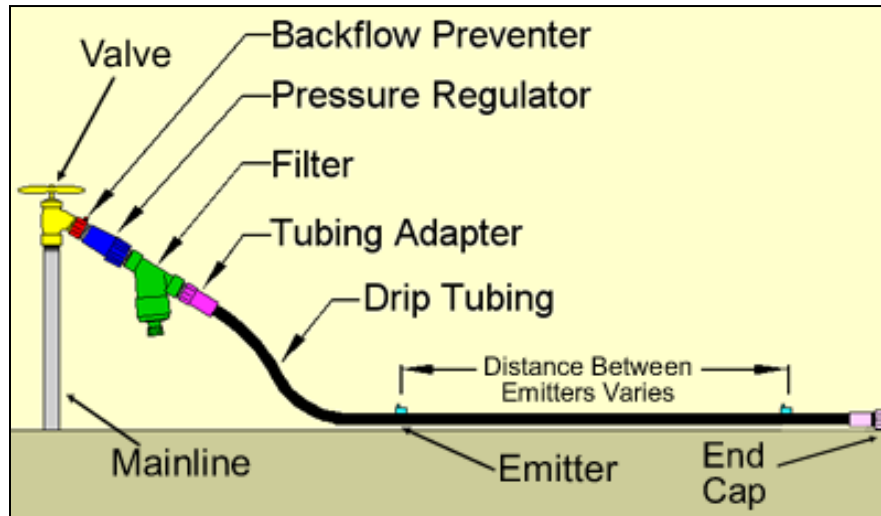


FIGURE 5: Standard Drip Irrigation System (Stryker).

Independent water containers raised from the ground can achieve the necessary water pressure using gravity. A gravity-fed system would allow drip irrigation to be used at LCRC gardens without onsite taps. The exact design of a drip irrigation system will vary depending on the garden setup and water supply possibilities. Gravity-fed systems reduce water supply issues but do not have the same uniform distribution as tap fed systems. To get ideal pressure, the water source should be 10.5 meters above the ground (Stryker). However, raising a water barrel three to four feet can work relatively well for small garden plots.

While drip irrigation systems are an effective form of watering that can improve water conservation efforts, there are some limitations. Drip irrigation systems require more knowledgeable management than standard hand watering. Proper management of irrigation scheduling, filtration systems and some knowledge of pressure and flow rates are necessary for a drip irrigation system to be successful (Smeal, 2007). The increased complexity may limit the practicality for many LCRC gardeners. The large systems necessary for drip irrigation are susceptible to

vandalism, which can increase cost and reduce the effectiveness of the irrigation system.

Micro Sprinkler

Micro sprinklers work under similar conditions as drip irrigation. Rather than having a single point-source emitting water, small sprayers are installed to spread the water application. Micro sprayers are better designed for wetting large areas. The systems will typically be slightly more costly than a drip irrigation system because small sprinkler heads must be purchased. However, cost per sprinkler is still low (generally less than a dollar or two depending on design). Micro sprinkler systems have slightly less efficiency (85%) than drip irrigation systems due to some evaporation off plant surfaces (USDA, 2008). While the flow required for a micro sprinklers is low 3 to 30 gph, it is greater than for drip irrigation (Hla and Scherer, 2003).

Micro sprinkler systems suffer from the same disadvantages as drip irrigation system, such as increase management complexity, need to filter water and cost. While micro sprinklers are an efficient irrigation system, drip irrigation is likely better suited to the LCRC gardeners. Largely because the pressure requirements are lower and drip irrigation is better suited to vegetable gardens, which tend to be grown as row crops.

Clay Pot Irrigation

Clay Pot irrigation is an ancient irrigation technique dating back at least 2,000 years in China (Bainbridge, 2001). Clay pots of roughly six litres are buried in the ground so that the pot's opening is level with the soil. The pots are then filled with water and covered with a tile or a tin pie plate. The water slowly seeps out through the clay and into the soil. The system's major benefit is to reduce evaporation from the watering process. Clay pot irrigation also eliminates water loss from runoff and drift as long as the pots are filled correctly. The clay pot system also eliminates water loss from deep percolation since water is released from the pots into the root

zone at a slow pace. As a result of these controls for water loss, it is not surprising that clay pot irrigation has been reported to have large potential for water conservation (Bainbridge, 2001).

There is a fairly high initial investment in a clay pot system since it requires the purchase or crafting of appropriate pots. This may be costly or technically difficult. The pots are also stationary and would require new tilling practices as they are used multi-seasonally. There could also be difficulties when regulating water needs of various crops because there does not appear to be an abundance of literature available. However, the system would still allow LCRC gardeners to interact with their crops when watering. Given the large reported water savings and historic value, some gardeners may be interested in testing this method.

2.9 WATERING EFFICIENCY IMPROVEMENTS

Mulch

Mulch is a protective layer placed over soil, which allows for water infiltration. The use of mulch can potentially create large improvements in water conservation. Mulch can be organic, such as wood chips or leaves, but it can also consist of inorganic materials such as gravel (Pinyuh, 2002). Applying mulch reduces soil temperature, which decreases evaporation. This can improve water penetration into soil and the root systems of crops, which improves watering efficiency. Mulch aids in reducing runoff by retaining water (Pinyuh, 2002). The barrier between the soil and sunlight also helps to suppress the growth of weeds, which compete for water with the intended crop.

Mulch can come in many varieties as mentioned above; however, the application and thickness required will vary depending on the chosen material. It should be noted that organic mulch has the additional bonus that it can help improve soil composition and nutrient levels. However, organic mulch decomposes and must be replaced over time. Inorganic mulch, on the other hand, will not decompose and can

be reused for multiple years provided it is not tilled under. Since the LCRC crops change frequently, organic mulch is better suited to their purposes.

Use of Furrows

Incorporating a furrow design to the soil can help collect runoff. By collecting and retaining excess runoff from either overwatering or heavy rain events, furrows make use of water that would otherwise have been lost. Furrows dug for surface flooding, when using a furrow irrigation system are relatively large and generally require large equipment to construct and maintain. However, for simple collection of runoff, the furrows do not need to be overly large and can be dug using a standard hoe. For large seed plants, such as corn or beans, a two- to three-inch furrow is satisfactory, whereas small seed plants such as onions, beets, or lettuce only require a half to one-inch furrow (Iowa State University, 2009). This size of furrow would not require large amounts of effort and could help to improve water conservation in the gardens, especially after larger rain events.

Scheduling Watering

Evaporation is largely effected by the temperature and sun intensity. If watering is limited to the early morning and evening, much less water will be on the soil surface when daytime temperatures and sun intensity are highest. This can significantly reduce the amount of evaporation that will occur after a watering event. As a result, a higher percentage of the water will reach the root system of the plants and less watering will need to take place to maintain a healthy garden. Early morning watering is generally preferred as large excesses of water can evaporate and this prevents fungus and mold growth (NRCS).

Monitoring Soil Water Content

Monitoring water content in the soil is another potential water conservation tool. Most people water a garden based on a time schedule rather than recent weather (OWWA, 2008). Although evapotranspiration in London exceeds rainfall for the

majority of the growing season, the majority of the precipitation tends to fall in a few large rainfall events (OWWA, 2008). A large rain event could moisten the soil for a greater period of time than gardeners expect, especially if other water retention methods are used such as mulching and furrows.

A rain gauge or soil moisture monitoring devices are ways to alert gardeners of recent rainfall and the subsurface water content of the soil (OWWA, 2008). Rain gauges are low cost and can be used by multiple gardeners at each site. Alternatively, soil moisture content can be estimated by touch or feel.

Improving Soil Water Retention

Although fertilizing will be discussed in more detail in a later section, it is important to realize that improving soil quality will also improve water management. Rich soil holds water and allows it to reach the roots of plants. Soils should be maintained to be high in organic matter and to have a mixed loam texture. Organic matter such as compost or peat can absorb water and retain it in the soil for plant use (Pinyuh, 2002). Mixed loams have micropores, which retain water for plant uptake, and macropores, which allow for water permeability into the soil and allow excess water to drain away (Master Gardeners Foundation). A mixed loam texture soil, high in organic matter creates optimal water retention and will improve the effectiveness of water applications.

2.10 TILLING PRACTICES

A proper examination of the environment and sustainability performance of a community garden must include an examination of tilling practices. Proper maintenance of the soil is vital to ensuring the long-term productivity of gardening projects. The top layer of soil (O-Horizon) contains the organic matter necessary for plant growth and vitality. The process of tilling has the potential to greatly affect the soil quality by altering its ability to hold organic matter and retain water. When determining proper tilling techniques, it is important to account for soil type and

organic horizon depth, as well as potential crop cover. For the purposes of the LCRC's community gardens, tilling must account for a relatively small sized plot and a variety of vegetable crops grown with non-uniform intensity levels.

Tilling can help increase the biological productivity of soil in temperate climates. Tilling is employed to manage weeds, prepare seedbeds and maintain residue cover (Robinson, Cruse, & Kohler, 1994; Kuepper & Gegner, 2004). The intention of tilling is to conserve biological residue in the upper biological active zones of the soil. When organic matter is maintained in the upper layers of soil, plant roots are able to access these nutrients to assist in growth. Tilling also contributes to crop residue management, soil aeration, conservation of manures and other fertilizers, hardpan reduction and sanitation (Kuepper & Gegner, 2004). Tillage affects both erosion rates and the decomposition rates of organic matter (Sullivan, 2004). Proper knowledge of tilling is vitally important for the ecologically aware gardener (Gershuny, 1993). Tillage practices and associated impacts are dictated by intensity and timing. A variety of effects can occur through turning over soil and exposing previously undisturbed particles to the elements. There are a wide variety of tilling techniques that can be used in community gardens. This portion of the literature review will organize the different options by level of intensity and their effect to the overall environmental health and sustainability of the soil.

No-Till

In small-scale agriculture, such as backyard and community gardens, it is commonly believed that little or no tilling is the most effective and most environmentally friendly level of intensity (Kuepper & Gegner, 2004; Sullivan, 2004; Ware, unknown). This method involves no working of the land either by hand or machine, rather soil nutrients are maintained through cover crops and mulching techniques. No-till farming ensures that the various soil horizons do not become mixed and therefore organic matter is not lost when exposed to anaerobic conditions at further depths. Through no-till systems, the stress of improper or over-intensive tillage is eliminated. When left undisturbed, soil communities tend to reach a balance that

preserves nutrients and organic matter (Gershuny, 1993). The more a field is tilled, the more reliant the soil becomes on frequent tilling. This practice essentially makes the soils 'addicted to tilling' (Robinson, Cruse, & Kohler, 1994). Reducing the intensity of tilling reduces the risk of soil deterioration and decreases overhead infrastructure costs for small-scale agriculture projects. It is also believed to



Image 3: No – Till Farming Method

increase the connection felt between gardeners and the land. The increased labour requirement for the weeding process and the crop cover process improves gardeners' awareness for soil quality (Flores, 2006). This method involves an increased time commitment by the individual gardener but

ensures a more in-depth connection to the gardening practice and respect for the soil.

No-Till agriculture relies on inputs of nutrients from external sources, either organic or conventional. Soil needs organic matter to be added in order to replenish the nutrients available for plant life (Flores, 2006). Without the movement of soil and aeration that occurs with tilling, the organic matter and nutrients must be introduced to the soils through other methods. This is done through off-season crop cover, maintenance of previous crop residue and the use of fertilizers before spring planting (Sullivan, 2004). These themes will be discussed further in the fertilizer section. The *Urban Farmer* outlined the five key principles necessary for no-till vegetable gardening:

- Zero-tillage – no cultivation of soils
- Permanent growing beds and permanent pathways

- Keep soils covered with mulches (crop residue, compost, straw, grass clippings, weeds, leaves) at all times
- Maximize soil organic matter and maintain biological diversity
- Crop rotation

No-till systems involving cover crops (green manure) and mulch cover, ensure nutrient availability to plants, while preserving topsoil characteristics when implemented properly. This type of tilling allows soil communities to reach a balance and helps minimize environmental consequences both on-site and externally.

Shallow and Deep Till

Increased tilling intensity requires some infrastructure, ranging from hand tools and roto-tillers to harrow tillers in small-scale farming operations. Tilling allows for relatively low maintenance and increased crop productivity. When tilling is employed, it is important for it to be responsibly managed to ensure lasting soil sustainability. Three basic principles to integrate into tilling practices are *not too wet*, *not too often* and *not too deep* (Flores, 2006).

The scheduling of tilling operations should occur at times dictated by ground cover and soil moisture content. Regularly scheduled tilling does not allow for the flexibility necessary to determine soil conditions before tillage occurs. Irresponsibly timed tilling can cause significant environmental harm through loss of organic matter and increasing the risk of erosion (Robinson, Cruse, & Kohler, 1994).



Image 4: Roto-Till Farming Method

Leaving bare and mixed soil available for rain or wind erosion increases the potential of many organic elements leaving the system. Deeper tilling causes a loss

of organic matter (Sullivan, 2004). Shallow tilling and other small-scale tilling, like 'double-digging,' ensures less disturbance and still allows for weed removal and aeration (Forge, 2004). Tilling is a common practice among large and small-scale farmers alike. This allows soils to properly aerate and mix between seasons. The depth and conditions are large factors when determining the environmental impact of bi-seasonal tilling.

The publications, books and websites examined in this portion of the literature review are all targeted to small-scale agriculture operations, most commonly associated with community gardens. These resources are heavily biased toward organic measures of cultivation. This bias is accepted, as the LCRC community gardens are run organically, as explained in the renter's agreement contract.

2.11 FERTILIZER TECHNIQUES

The addition of organic matter to agricultural plots is vital to the prolonged performance of the community garden soil quality. The growth and vitality of crops is dependant on available nutrients for uptake by the roots. The responsible replenishment of organics to the soil will allow for long-term sustainability of LCRC community gardens. These inputs of fertilizers and amendments are the primary tools for gardeners to build soil quality (Robinson, Cruse, & Kohler, 1994). The renter's agreement with the LCRC requires gardeners to use organic farming practices, including the exclusive use of organic fertilizers.

Conventional Organic Fertilizer

Organic fertilizers can be found in granular, liquid and powder forms for gardeners to apply to their plots. The proper application of fertilizers allows healthy plant growth and allows plants to defend themselves against insects and disease (Toronto Master Gardeners). Their use increases the soil composition and the overall 'workability' of the soil (Williams). This improves soil water retention and improves cohesion with plant roots (Flores, 2006). The use of fertilizers increases the amount

of nutrients in the soil, which can then be converted to an active water-soluble state by the organic matter present in the soils. This water-soluble state can be used by the plant roots to promote growth and vitality.

The three most important elements introduced into soils through fertilizer application are Nitrogen, Phosphorus and Potassium (Toronto Master Gardeners; Karlen, 1994). Nitrogen promotes the growth of stems, leaves and other vegetative parts of the plant. Phosphorus is necessary for healthy root development. Potassium increases plant vigor, which helps against cold and drought conditions (Toronto Master Gardeners). The nutrients present in organic fertilizers are released slowly, compared with synthetics (Williams; Toronto Master Gardeners). This allows gardeners to minimize the number of applications throughout the growing season.

Organic Fertilizers		
Fertilizer	Nutrients	Uses
Blood Meal	Excellent source of N	<ul style="list-style-type: none"> Side-dress leafy vegetables, water-in well
Bone Meal	Excellent source of P	<ul style="list-style-type: none"> In the bottom of planting holes of bulbs, shrubs and trees
Compost	Good all-round source of all three essential nutrients	<ul style="list-style-type: none"> Top-dress beds and borders in early spring or fall In the bottom of planting holes when transplanting perennials and planting annuals Work into the soil of vegetable beds each season
Fish Fertilizers (Liquid)	Good source of micronutrients	<ul style="list-style-type: none"> Feed container-grown plants every two weeks When transplanting or planting perennials
Kelp Meal	Rich in K, micronutrients and growth-enhancing hormones	<ul style="list-style-type: none"> Apply to soil surface around (but not touching) the crowns of plants
Manure (Composted)	N-P-K content varies depending on type; excellent soil conditioner	<ul style="list-style-type: none"> Dig into vegetable beds in early spring Top-dress beds and borders in early spring or late fall

Table 3: Varieties of Organic Fertilizers

(Toronto Master Gardeners, unknown).

Alternative Fertilizers

Beyond conventional organic fertilizer, many other methods can introduce nutrients to soils for plant use. Green manures, mulching and homemade compost provide adequate nutrients. These methods help build humus through the addition of organic matter to the soil. Where humus levels are high, soils have the ability to absorb rainfall and irrigation water more effectively, provide food for beneficial organisms, and help prevent vital nutrients from being washed away (Stell, 1998).

Mulching is employed to suppress weeds and protect soil from temperature extremes while building soil humus. This method ensures slow release of nutrients to the soil as it is mixed into topsoil through earthworm activity. This helps to strengthen the biological habitat of microorganisms necessary for plant health. Mulches can be made up of shredded bark, sawdust, spent hops, hedge clippings and other locally available yard waste (Fedor, 2001). This can be a permanent feature to the gardens to ensure soil protection and vitality through all seasons.

Growing green manures (cover crops) bring soil organic matter from deep in the soil closer to the surface for plant use. These can include plants such as alfalfa, legumes, sweet clover and many other local varieties. This practice contributes substantially to nitrogen, phosphorus and potassium nutrition for the crops that will grow next season. Cover crops also protect the soil during the seasons where cultivation is not occurring.

Composting offers a low-cost, non-polluting alternative for nutrient building in organic gardens. This method helps divert foodstuff and garden/lawn waste from landfills. When converted into compost, this type of fertilizer helps to moderate the pH balance of soils and provide necessary Nitrogen, Potassium and Phosphorus nutrients (Gershuny, 1993).

Many sources of organic fertilizer can be found with existing waste-streams, diverting organics from landfill. This practice should be explored and employed whenever possible. Nutrients for fertilization can be found in sources such as Jache and Compost Tea, which can both be produced with relative ease through introducing plant waste to waterlogged conditions. Other waste sources for fertilizer include biodynamic compost and animal waste inputs (Flores, 2006).



Image 5: Sample Compost Site

Nitrogen and Phosphorus are the active nutrients of primary concern from an environmental perspective (Karlen, 1994). While the gardener's contract with the LCRC states the need for 'organic farming' principles, it is important for individuals to responsibly manage their fertilization usage. If introduced at high levels, both Nitrogen and Phosphorus can have harmful effects downstream. This can be manifested in methemoglobin (from Nitrogen) and algae growth (Phosphorus) (Karlen, 1994). Due to land availability, many of London's community gardens are located within the floodplain, which increases the risk of fertilizer runoff into the Thames River.

A proper understanding of the above information will allow for a holistic understanding of the current possibilities for gardening techniques available to LCRC gardeners. This will provide the knowledge base in determining the *best-practices* recommendations. In order to ensure long-term environmental sustainability for the community gardens, the LCRC must determine their current environmental performance. After determining a baseline, future improvements can

be accurately assessed. The following Environmental Audit review will act as the starting point in developing a comprehensive audit system for the LCRC to use during the 2010 garden season.

2.12 ENVIRONMENTAL AUDITS

As part of the consulting project, environmental audit checklists will be provided to the client to evaluate and monitor the environmental performance and impact of the LCRC community gardens. A review of standardized environmental auditing literature and processes has been conducted in order to produce the optimal template for the LCRC.

An environmental audit framework can be understood as:

“A management tool comprising a systematic, documented, periodic and objective evaluation of the performance of the organization, management system and processes designed to protect the environment and the systematic examination of the interaction between any business operation and its surroundings.” (Holbrook, 1996).

Environmental audits are attempts by an organization to objectively examine operating locations, evaluate the effectiveness of business practices and verify that the defined performance criteria are being met or exceeded (Reed 1992). This can include emissions to air, land and water legal constraints, the effects on the neighbouring community, landscape and ecology and the public's overall perception of a company's operation in the area (Holbrook, 1996). An audit is essentially a diagnostic tool (Reed 1992).

Overall, environmental auditing can have a very broad and different meaning based on the type of organization or area being evaluated (Cheremisinoff & Cheremisinoff, 1993). Environmental audits are generally conducted to ensure compliance with federal, provincial or local environmental statutes and regulations. In the case of community gardens, the environmental audit checklist will be used to gauge the environmental components of the community gardens, which may or may not be directly related to local statutes or regulations (Cheremisinoff & Cheremisinoff,

1993). Environmental audits also provide a baseline overview of current environmental effects or impacts relevant environmental legislation and a statement of existing environmental performance. They can become part of an environmental management system to help implement the plan and serve as a 'Baseline Environmental Audit' (Holbrook, 1996).

An environmental audit can also be useful in optimizing resources and reducing wastes for the LCRC. Audits can help organizations to objectively examine operating locations, assess the overall effectiveness of their methodologies and verify compliance with outlined performance expectations (Reed, 1992). In terms of the LCRC, the audit framework will allow them to assess their impact on the environment by monitoring a number of key measures. The audit framework can serve as a diagnostic tool to:

- Enable environmental problems and risks to be anticipated and responses planned
 - To demonstrate that an organization is aware of its impact upon the environment through providing feedback
 - Provide increased awareness amongst stakeholders
 - Develop more efficient resource use and financial savings
- (Holbrook, 1996).

Other benefits for the LCRC in utilizing Environmental Audit Checklists include:

- Facilitating the comparison and exchange of information within and between other community gardens by allowing benchmarking between sites
- Increasing public awareness about the LCRC's environmental performance and possibly encouraging public involvement in environmental management
- Identifying cost recovery and saving opportunities through recycling, energy saving, and reductions in use of raw materials and waste, etc.

- Supporting and assisting the fostering of more open relations between the LCRC and the community garden network by providing information about the kind of procedures adopted and company environmental performance (Holbrook, 1996).

The LCRC will also benefit from the development of more sustainable community garden practices. In many organizations, there is a movement toward sustainable development and environmental protection standards. Some examples include the CPA's "Environmental Audit Guidelines for the Petroleum Industry," the Canadian Chemical Producers Association (CCPA) "Self-Assessment Program," and the International Loss Control Institute's (ILCI) "Environmental Protection Module." (Reed,1992). Many companies have developed their own internal standards of auditing, with examples from agencies like the Petroleum Association for the Conservation of the Canadian Environment's (PACE) "Environmental Performance Measures," CPA's "Environmental Operating Guidelines," and CCPA's "Responsible Care Program." (Reed,1992).

Key measures that are of initial consideration for the LCRC's environmental audit checklist are: Water Usage, Air Emissions, Plant/Crop Biodiversity, Recycling programs and Waste Management.

By utilizing these key measures, the LCRC will be able to establish baseline measurements that can be used to identify any changes in environmental performance or "hotspots." Hotspots can be defined as locations or activities of interest to a group or organization where human interactions with the environment are considered to be adverse to the sustainability of an ecosystem or the human activities dependent upon it (Glantz 2003). These hotspots essentially refer to adverse aspects of the interface between agricultural activities and existing environmental processes (Glantz 2003).

When evaluating small-scale agriculture like the LCRC community gardens, a number of environmental systems and subsystems must be considered. The

community gardens' activities have the potential to impact a number of environmental areas including, soil, water, air emissions, etc. Therefore, it is important to account for the effects the gardens can have on each of these systems. The environmental audit checklist and performance measures lists, should allow the LCRC to develop a better understanding of their impacts on these systems through developing baseline measurements. Table 4 highlights typical environmental systems/subsystems when examining small-scale agriculture.

Environmental critical points	Environmental subsystems	Environmental systems	System type
Nitrogen cycle	Water quality	Water	Stock and Flow Systems
Phosphorus cycle			
Water demand	Water balance		
Flood risk	Drainage system		
Water stagnation			
Soil erosion	Soil morphology and structure	Soil	
Salinity	Soil chemical components		
Organic matter			
Human activities management	Plant breeding	Human activities	
Landscape diversity			
Refuse management	Refuse		
Biodiversity	Flora	Flora & fauna	
	Fauna		
Nitrogen cycle	Nitrogen balance at farm level	Nitrogen balance	
	Nitrogen balance at soil level		
Phosphorus cycle	Phosphorus balance at farm level	Phosphorus balance	
	Phosphorus balance at soil level		
Soil fertility		Organic matter balance at soil level	
Soil erosion			
Non-replaceable energy demand		Energy balance at farm level	

TABLE 4: Environmental Systems & Subsystems (Pasini, Wossink, Vazzana, Omodei – Zorini, 2000).

Through the use of environmental audit checklists, the LCRC will be able to assess and monitor their environmental performance more effectively. The audits will also allow the LCRC to identify opportunities for improvement and plan their resources accordingly.

3.0 Methodology

The methodology used to create this report was based on both qualitative and quantitative information collected through face-to-face interviews, on-going consultation with key stakeholders, comprehensive document reviews of statistical information, researching for best practices in the municipal sector, personal observations, professional judgment and information gathered from LCRC and City of London staff.

3.1 BENCHMARKING QUESTIONNAIRE

Research was completed to examine best practices for gardening among other Ontario municipalities. The research was conducted in the form of a benchmark questionnaire. The questionnaire asked the surrounding gardens a series of questions about their practices and gardening techniques, such as the use of pesticides and fertilizers, tilling and watering techniques and the overall management of the gardens. The following municipalities and organizations were contacted and completed questionnaires: Hamilton, Kingston, Kinsbridge, Windsor, Sarnia, University of Western Ontario, University of Waterloo School of Architecture and York Region. Along with the municipal questionnaire, numerous follow-up telephone discussions and email samples were used to obtain data and information from these municipal sources.

3.2 OBSERVATIONAL RESEARCH

Cirrus Consulting completed extensive research through field observations of various garden sites located throughout London, Ontario. Selected community

garden sites were visited and observed to improve the consultant's understanding of various factors such as location, topography, placement and surrounding urban and natural environment.

3.3 STAFF CONSULTATION

LCRC staff were consulted throughout this project to provide information and direction regarding various aspects of their operation. City of London staff were also contacted and interviewed regarding their involvement in the development, planning and maintenance of the LCRC's community garden sites. This allowed Cirrus Consulting to obtain important stakeholder information and to assess the future direction for establishing new garden sites within the City.

3.4 BEST MAINTENANCE PRACTICES METHODOLOGY

The *Best Maintenance Practices Recommendations* have been based on the literature review and on the environmental performance of different watering, tilling and fertilization methods possible in London's community gardens. A decision matrix has been incorporated into the decision making process to ensure transparency in the recommendation process. This process allows the logic and professional judgment used to be apparent to the reader.

The decision matrix implements a Multi-Criteria Evaluation (MCE) using a Weighted Linear Combination. The various environmental factors were ranked against each other and evaluated as criteria. The watering methods, tilling practices, and fertilization techniques all employ unique factors and variables involved in their MCE. The considerations for *Environmental Criteria* and *Methods* for each factor are explained below

3.4.1 Irrigation Considerations

The *Environmental Criteria* for consideration when determining the *Best Practices Recommendations* for irrigation techniques are water loss from: evaporation, deep

percolation, drift, and runoff. These were determined through review of irrigation efficiency literature.

- (a) *Evaporation*: the conversion of liquid water-to-water vapor.
- (b) *Deep Percolation*: water that seeps past the root zone of plants and into deeper soils where it cannot be used by the plant.
- (c) *Runoff*: liquid water that leaves the region of application without infiltrating the soil surface.
- (d) *Drift*: liquid water that leaves an irrigation device and does not reach the intended area of application.

The Irrigation *Methods* for consideration in this project were determined based on the Gardening Agreement and the applicability for gardener's use in the community gardens. Methods considered were: Hand Watering; Sprinkler Irrigation; Furrow Irrigation; Drip Irrigation; Micro Sprinkler Irrigation; Clay Pot Irrigation. The method and environmental criteria are shown in table 5 below.

Irrigation Methods:	Water Loss Criteria:
Hand Watering	Evaporation
Sprinkler Irrigation	Deep Percolation
Furrow Irrigation	Runoff
Drip Irrigation	Drift
Micro Sprinkler Irrigation	
Clay Pot Irrigation	

TABLE 5: Irrigation Methods and Environmental Criteria

3.4.2 Tilling Considerations

The *Environmental Criteria* considered when determining the *Best Practices Recommendations* for tilling application are the disruptions to soil horizons, erosions effects, disruptions of organisms, soil moisture effects, conservation of nutrients, fossil fuel usage and soil bed prep. These criteria range from on-site (in garden) environmental consequences to external consequences to the greater eco-system beyond the garden plots.

These were determined through review of gardening and small-scale agriculture applications.

- (e) *Soil horizons*: Through the tilling the unique soil horizons can become mixed exposing organisms and nutrients to anaerobic conditions where they cannot survive. When this occurs the overall vitality of the soil is degraded, as nutrients are lost.
- (f) *Erosion effects*: As soil is turned over it changes the consistency and can potentially leave soil vulnerable to both wind and water erosion. This removes the top layer of soil and degrades the topsoil characteristics. Leaving bare and mixed soils available for wind or rain erosion increases the potential of many organics leaving the system
- (g) *Disruption of Organics*: The tilling process involves the physical disruption of soil within the top horizon. Depending on the level of intensity this can disrupt active organisms habitat and can physically harm the organisms themselves
- (h) *Soil Moisture*: As the soil is disrupted the ability to retain water changes. This can occur on both extremes with water logging and over-drying and is possible with different tilling practices. As the capillary functions change in soil through aeration, mixing and compaction the ability to retain appropriate amounts of water changes
- (i) *Nutrients*: The availability of nutrients in soil to plants is vital to the health of gardens and agriculture. The diverse tilling techniques have various impacts on nutrient availability based on there mixing techniques.
- (j) *Fossil Fuel Use*: The burning and consumption of carbon-based fossil fuels increases atmospheric CO₂ emissions. In order to ensure upmost

environmental performance the maintenance of the community gardens must account for the burning of CO₂ emissions, on-site for tilling practices.

(k) *Seedbed Prep*: A primary need for tilling is in its ability to prep the soil for seeds. Depending on the nature of the tilling practice, this can be done at various levels of effectiveness and must be considered with the overall environmental performance of the gardens.

The Tilling *Methods* considered for this report are based on their applicability in London's community gardens. These include no-till with mulch application, no-till with cover crop application, shallow till using hand tools, deep(er) till with rototiller, and deep(er) till with harrow tilling.

The method and environmental criteria are shown in table 6 below.

Tilling Methods:	Environmental Criteria:
No Till (with Mulch)	Disruption of soil horizons
No Till (w Cover Crops)	Erosions Effects
Shallow Till (with hand tools)	Disruption of Organics
Deep (er) till (with rototill)	Conservation of soil moisture
Deep (er) till (with harrow)	Conservation of nutrients
	Fossil Fuel Use
	Seedbed Prep

TABLE 6: Tilling Methods and Environmental Criteria

3.4.3 Fertilizer Considerations

The environmental criteria considered when determining the *Best Practices Recommendations* for fertilization application are nutrient release, the potential for application to 'burn' the plant, the energy it takes to produce the fertilizer, the collection method, the effects to soil moisture and the potential contamination. These criteria range from on-site (in garden) environmental consequences to external consequences to the greater eco-system beyond the garden plots. These were determined through review of gardening and small-scale agriculture applications.

- (a) *Nutrient release*: (On-Site impact) The primary function of fertilizers is to make nutrients available to plants to maximize growth. Between the various methods of fertilization, the rate of nutrient release is different with negative environmental effects visible when released too fast or too slow.
- (b) *Plant 'burning'*: (On-Site Impact) Plants become vulnerable to 'burning' when fertilization is used improperly. The vulnerability is dependant on the type of fertilizer used.
- (c) *Energy to produce*: (External Impact) Fertilizers vary on the method and energy used to produce. Some depend on petro-chemicals, while others require little to no energy input. The type and amount of energy taken to produce has environmental consequences outside the garden community, in the greater ecosystem.
- (d) *Collection method*: (External Impact) The way in which a fertilizer is sourced is an effective determination of its external environmental performance. Some techniques of fertilization use locally produced waste materials, while other methods employ production facilities to create new products. The environmental impacts vary depending on whether it is sourced from a waste stream or collected from a production facility.
- (e) *Soil moisture effects*: (On-Site Impact) The type of fertilization technique impacts the soils ability to hold and store water for the plants use. This can range from over-drying the soil, to potentially contributing to waterlogged conditions.
- (f) *Contamination Potential*: (External Impact) The application of external nutrients to a garden system creates the potential for down-stream effects. If nutrient levels are raised too high, too quickly these extra nutrients become

available for leaching or run-off out of the system. This can cause nutrient overloads in water bodies in the region or downstream.

The Fertilization *Methods* considered in this project were determined based on the Gardening Agreement and the applicability for gardener's use in the community gardens. Methods considered were conventional store-bought, organic store bought, cover crops, mulch application and homemade compost. The method and environmental criteria are shown in table 7 below.

Fertilizer Methods:	Environmental Criteria:
Conventional	Nutrient Release
Organic	Potential for 'plant burning'
Cover Crops	Energy to produce
Mulch	Local availability/ collection method
Homemade Compost	Soil moisture effects
	Possibility for runoff

TABLE 7: Fertilizer Methods and Environmental Criteria

3.5 MULTI-CRITERIA EVALUATION

An MCE was used to compare the various environmental criteria to determine the most environmentally friendly methods for London's community gardens. This type of evaluation allows for the assessment of different environmental factors to determine the most suitable method for a unique operation like the LCRC's community gardens (Bonneycastle 2006). The MCE used to determine the most environmentally friendly practice incorporates a Weighted Linear Combination. This method allows different environmental factors to be assigned relative weights and compared with each other. The relative weights provide overview of the importance each environmental criteria holds. This means, the environmental criteria are compared based on their importance to the environmental performance of the community gardens. The relative weights for watering, tilling and fertilization methods are shown in Appendix 2. These standardized scores show the level of importance out of one in comparison with the other factors. A Weighted Linear Combination allows for the comparison of numerous unrelated criteria (factors). To

standardize the comparisons of the criteria, a common numeric range is assigned to each factor. All the numeric values are then used within an MCE calculation (Jiang and Eastman, 2000; Malczewski, 2004). This system of 'simple additive weighting' is based on the concept of creating a weighted average (Malczewski, 2004).

Once the major environmental factors and methods are determined, this MCE follows three major steps:

- The first step assigns comparative weights to each environmental factor. This is done on a 1-0 scale, where 1 = 'more important', 0.5 = 'as important' and 0 = 'less important'. This is shown in Appendix 2, the outcome of this allows for a standardized score out of 1 to be created for each factor.
- The Second Step involves determining the environmental impact each method can have on the selected criteria of evaluation. This is shown in Appendix 2. In this table: 0 = environmentally benign; (+/-)1 = negligible impact; (+/-) 2 = minor impact; (+/-) 3 = severe impact
- The third step combines these two tables through multiplication to determine the final environmental score for each method. This is shown in Appendix 2.

This method of MCE evaluation was performed to determine the best practices for watering, tilling, and fertilizing the LCRC gardens. The final recommendations reflect the results of these evaluations along with the incorporation of additional factors, which pertain specifically to the LCRC community gardens.

3.6 WATER SUPPLY PROS AND CONS ANALYSIS

The various water supply methods used and proposed for garden sites were analyzed using a simple pros and cons analysis. The methods of water supply are: onsite taps; water tanks, rain barrels, wells and neighbour sourcing. The pros and

cons were developed based personal communications with LCRC and City of London staff, as well as additional research and through professional judgment.

- (a) *Onsite Taps*: A site with a tap located in the garden area that connects directly to municipal water lines.
- (b) *Water Tanks*: A site with a large water container, which is filled by City of London workers with a water truck.
- (c) *Rain Barrels*: A site with one or multiple rain barrel water containers either connected to a water catchment or free standing.
- (d) *Wells*: A site with a water well drilled to pump ground water.
- (e) *Neighbour Sourcing*: A site where water from a neighbouring property provides the water source. This method is not necessarily exclusive to other methods and may be used to supplement rain barrel water or may allow for an onsite tap. However, neighbour sourcing requires that the LCRC take on the cost of the neighbour's water in return for the use of water.

3.7 ENVIRONMENTAL AUDIT CHECKLIST

A number of steps were taken in order to develop the environmental audit checklists and key performance measures. As discussed, there is currently very limited literature on the environmental auditing or performance of community gardens operations. In order to collect information that would be relevant for the LCRC in developing audit checklists, a literature review of environmental audit practices and guidelines was completed. This review mainly focused on the benefits of completing such audits, the key components of an audit structure and various methodologies of implementation. Literature regarding environmental audits of small-scale agricultural operations was then more specifically examined.

After reviewing the available literature, a hybrid list of assessment criteria was developed for the LCRC. The first audit checklist, used for a pre-construction assessment, was developed to focus on materials and the environmental impact of creating a new garden site. The information used for this checklist was obtained by examining sample audit checklists for new construction sites and then combined with urban agriculture assessment criteria. Once an initial list was developed, consultation with Dr. Ouda and the client helped to further tailor the list criteria.

In order to create the seasonal audit checklist, a review of literature revealed various methods for developing an appropriate list of criteria. The seasonal audit checklist was created to focus on four main criteria that would be considered of primary importance to the community gardens: soil, water, waste and plant biodiversity. Reviewing other urban garden assessment forms and researching key monitoring criteria for small-scale agricultural operations developed these criteria.

The key performance measures were identified by assessing the inputs and outputs being utilized by the community gardens. These performance measures were designed to develop baseline measurements of LCRC's environmental performance. These measurements focus on typical inputs on weekly basis, such as the summer student's CO₂ emissions from driving and more infrequent activities, such as pre and post season roto-tilling CO₂ emissions.

3.8 WEBSITE REVIEW METHODOLOGY

The website recommendations were created by researching current website practices and taking a website design tutorial by Alan Flum of Celestial Graphics Inc. The website recommendations were based on literature and online research of current website best practices. The results showed that effective websites should be evaluated by the following criteria: navigation, visual attractiveness and organization. The Celestial Graphics tutorial was a step-by-step guide to creating and organizing a compelling website that draws the audience to the site on

numerous occasions. It was an effective method to properly evaluate the LCRC Website.

In addition to the online research and tutorial. Many community garden websites were analyzed and evaluated on the criteria above. The community garden websites that were successful in meeting most or all of the recommendations were suggested as a way for the LCRC to observe and evaluate from other community websites.

4.0 Results

A best practices watering supply and techniques section was developed for water sourcing and usage. As well, best practice guides for tilling and fertilizer use are presented to ensure the optimal performance of the gardens. Environmental audit checklists have also been created for the pre-construction phase of new garden sites, and a seasonal checklist for garden sites that are currently in operation. Finally, the results of a benchmarking questionnaire are presented and discussed, as well as an assessment of the LCRC's current website structure and design.

4.1 BEST PRACTICE RESULTS

The *Best Practice Recommendations* shown below are based on the outcome of the MCE. The environmental scores examined below give an indication as to where the LCRC can improve its watering, tilling and fertilizing environmental performance. These results of the MCE evaluation only indicate the environmental performance, marginalizing economic and social factors; this discussion will follow.

4.1.1 Watering Best Practice

The final water conservation scores for the six types of tilling practices are found in table 8.

Irrigation Method	Final Score/MCE outcome	Environmental Rank
Drip Irrigation	2.75	1
Clay Pot Irrigation	2.50	2
Micro Sprinkler Irrigation	2.25	3
Hand Watering	-0.25	4
Furrow Irrigation	-0.50	5
Sprinkler Irrigation	-1.00	6

TABLE 8: Irrigation Methods Final Scores and Environmental Rank

Based solely on water conservation, potential drip irrigation or clay pot irrigation would be the best practice for the LCRC. Given that there is not extensive literature on clay pot irrigation, a drip irrigation system should be the best choice.

Additional considerations for the various irrigation methods have been compiled in Table 9. This information is based on the data collected through the literature review.

	Water Conservation Ranking	Equipment Cost	Management Complexity	Other
Hand Watering	4	Low	Low	Watering efficiency can be improve with proper knowledge Allows for gardener interaction with watering
Furrow	5	Low	Low to Moderate	Furrows may help improve other irrigation techniques
Sprinkler	6	Moderate to Very High	Moderate	Requires pressure Would reduce gardener interaction with the watering
Drip Irrigation	1	Moderate to Very High	Moderate to Very High	Potential for vandalism Would reduce the gardener interaction with the watering
Micro Sprinkler	3	Moderate to Very High	Moderate to Very High	Potential for vandalism Would reduce the gardener interaction with the watering
Clay Pot	2	Moderate to Very High	High	Little information available Would require changing tilling techniques

TABLE 9: Water Conservation Rankings

Although drip irrigation and clay pot irrigation have the highest potential for water conservation, they are challenged by cost and management complexity. Clay pot

irrigation would also require the changing of tilling practices so that the pots could be used multi-annually. These systems would also reduce the gardener interaction with the watering.

4.1.2 Tilling Best Practice

The final environmental scores for the five types of tilling practices under review are presented in table 10.

Tilling Method	Final Score/MCE outcome	Environmental Rank
Mulch	1.78	1
Cover Crops	1.63	2
Hand-tools	0.71	3
Harrow-till	-0.26	4
Roto-till	-0.44	5

TABLE 10: Environmental Scores for Tilling Methods

The best environmental practices for Tilling in London's community gardens are No-Till maintenance with Mulch Cover and Cover Crops.

The environmental benefits and drawbacks of no-till (mulch and cover crops) and shallow till (use of hand tools) are shown in table 11. This summarizes the findings in the literature review above and organizes it based on the Environmental Criteria used in the MCE decision-making process.

	No-Till (Mulch Cover)	No-Till (Cover Crops)	Hand-tools
Disruption of Soil Horizons	- Does not disturb soil	- Does not disturb soil	- Low impact to soil - When conducted at inappropriate conditions, tilling can destroy structural conditions of soil
Erosion Effects	- Actively reduces erosion through protection	- Actively reduces erosion through protection	- Low impact - With increased intensity: less nutrient residue left at the surface
Disruption of Organisms	- Doesn't disturb soil - When left undisturbed, soil communities tend to reach a balance that preserves nutrient and organics	- Doesn't disturb soil - When left undisturbed, soil communities tend to reach a balance that preserves nutrient and organics	- Has potential to be destructive to earthworms and their tunneling
Effects to Soil Moisture	- Retains soil moisture and does not allow for high evaporation rates - Can lead to fungal and other water-saturated based diseases	- Retain soil moisture and does not allow for high evaporation rates	- No major effect due to low impact
Effects to Nutrients	- No-till offers least amount of loss of nutrient - Helps 'build community' increases topsoil	- No-till offers least amount of loss of nutrient - Helps 'build community' increases topsoil	- Conserves crop residue in upper biological active soil zones - Excessive tilling can 'burn-up' humus reserves - The deeper the till the higher chance of nutrient loss
Fossil Fuel Use	- No fossil fuel use	- No fossil fuel use	- No <i>direct</i> fossil fuel use
Seedbed Prep	- No seedbed prep	- No seedbed prep	- Weed control - Soil aeration - Low intensity, but positive results

TABLE 11: Environmental Factors for Tilling Consideration

The use of No-till methods will result in the higher potential for positive environmental performance. This method of gardening/agriculture ensures the highest nutrient availability and avoids the use of synthetic fertilizers. This method, when properly maintained, allows for healthy crops and reduces the potential danger that pests can create for gardeners. No-till helps to replenish and encourage topsoil without increasing its vulnerability to erosion or over-mixing. This method of gardening relies on high maintenance levels with more intensive labour needed.

This recommendation does not account for the social and economic considerations the LCRC must incorporate into decision-making. Where possible, individual gardeners who are able to increase their maintenance and labour levels should be encouraged to adopt no-till or shallow till methods. This could include the use of roto-tilling only on certain tracts of the gardens, while leaving others untouched for individual gardener maintenance.

The current use of roto-tilling in London's community gardens allows for easy seedbed prep in the spring season and the mixing of crop residue in the fall season. This method of tilling is seen as less environmentally favorable compared with less intensive methods as it increases the vulnerability of soils to be mixed too deep, loose organic matter, increase erosion through compaction and relies on the use of fossil fuels for running. The vulnerability of roto-tilling methods can be reduced dramatically if soil conditions are well known by maintenance crews to ensure tilling only occurs at appropriate depths and when there are appropriate soil moisture conditions. Table 12 shows the environmental benefits and drawbacks of deep(er) tilling methods in respect to the environmental criteria used. It must be noted that some of the drawbacks are not absolute impacts, but rather show higher chances of occurrence with deep(er) tilling methods.

	Roto-Tilling	Harrow Tilling
Disruption of soil horizons	<ul style="list-style-type: none"> - dangers of soil compaction (the larger the machine the more likely for compaction) - when conducted at inappropriate soil-water contents, tilling can destroy structural conditions - can cause compaction through downward force of their blades beating on the soil - can destroy soil structure, leaving it the form of a fine powder 	<ul style="list-style-type: none"> - dangers of compaction (the larger the machine the more likely for compaction) - when conducted at inappropriate soil-water contents, tilling can destroy structural conditions
Erosion effects	<ul style="list-style-type: none"> - can leave soil bare and vulnerable to erosion (wind and rain) - compaction of soils can lead to erosion - with increased intensity: less residue at surface (benefits of residue in .doc) - pulverizes the soil and leaves it available for erosion 	<ul style="list-style-type: none"> - can leave soil bare and vulnerable to erosion (wind and rain) - compaction of soils can lead to erosion - with increased intensity: less residue at surface
Disruption of Organisms	<ul style="list-style-type: none"> -Can be directly destructive to earthworms and their tunneling - kills fungi and chops up large critters 	<ul style="list-style-type: none"> -Can be directly destructive to earthworms and their tunneling - kills fungi and chops up large critters
Effects to Soil Moisture	<ul style="list-style-type: none"> - Compaction of soils can lead to waterlogging - Severs the top layer of soils from contact with lower layers, preventing capillary action from bringing up soil moisture 	<ul style="list-style-type: none"> - Can expose soil to higher rates of evapotranspiration
Effects to Nutrients	<ul style="list-style-type: none"> - Can burry crop residues in anaerobic soil zones - Excessive tilling can 'burn up' the humus reserves - The deeper the till the higher rate of nutrient loss - The more intensive the tillage the more reliant the soil becomes to increased tillage 	<ul style="list-style-type: none"> - Can burry crop residues in anaerobic soil zones - Excessive tilling can 'burn up' the humus reserves - The deeper the till the higher rate of nutrient loss - The more intensive the tillage the more reliant the soil becomes to increased tillage
Fossil Fuel use	- Uses fossil fuel	- Uses fossil fuel
Seedbed prep	<ul style="list-style-type: none"> - Weed Control - Soil Aeration 	<ul style="list-style-type: none"> - Weed Control - Soil Aeration

TABLE 12: Environmental Considerations for Deeper Tilling

4.1.3 Fertilizer Best Practice

The final environmental scores for the different methods of fertilization are shown in table 13.

Fertilization Method	Final Score/MCE outcome	Environmental Rank
Compost	1.13	1
Mulch	0.99	2
Cover Crops	0.30	3
Organic	0.27	4
Conventional	-0.57	5

TABLE 13: Fertilization Methods: Final Environmental Score

Homemade Compost and Mulch Cover are the Best Environmental Practices for Fertilization in London's community gardens.

The environmental benefits and drawbacks of compost, mulch and cover crops are shown in table 14. These non-conventional fertilizers are not bought at garden centres but rather found locally and can eliminate waste from landfills. Table 14 below, summarizes the findings from the literature review above and organizes it based on the Environmental Criteria used in the MCE decision-making process.

	Compost	Mulch	Cover Crops
Nutrient Release	- Slow release of nutrient	- Helps build soil humus - Will decompose gradually (through earthworm actively)	- Contributes substantially to nitrogen, phosphorus and potassium nutrition of crops
Potential for 'plant burning'	- Helps to maintain soil ph levels - Less danger of burning plants	- Protects soils from temperature extremes - Less danger of burning plants	- Protects soils from temperature extremes - Less danger of burning plants
Energy to produce	- Requires no fossil fuel use to produce	- Requires no fossil fuel use to produce	- Requires no fossil fuel use to produce
Local availability/ collection method	- Diverts household waste from landfill	- Can be yard waste from previous fall or newspapers etc...	- Locally available, as it relies on native seeds
Soil moisture effects	- Aerates soil, increasing pore space for good air and water movement	- Worsens drainage, can lead to fungal diseases - Aerates soil, increasing pore space for good air and water movement	- Protects soil from wind, sun, rain - Aerates soil, increasing pore space for good air and water movement
Runoff Possibility	- Organic matter improves soil's ability to absorb rainfall or irrigation water while reducing surface runoff	- Organic matter improves soil's ability to absorb rainfall or irrigation water while reducing surface runoff	- Decreases runoff capacity - Organic matter improves soil's ability to absorb rainfall or irrigation water while reducing surface runoff

TABLE 14: Environmental Considerations for Fertilization Application

These less-conventional fertilizer methods had the highest environmental scores from the criteria, which measure 'on-site' performance as well as impacts on the greater ecosystem. These methods allow for greater plant health, require less energy to produce and can reduce the amount of waste diverted to landfills. They ranked highest in environmental performance and in many cases can be implemented responsibly within London's community gardens with proper education. The use of homemade compost and associated byproducts, such as 'compost tea,' allow gardeners to re-use garden waste and kitchen organic waste to create healthier gardens. This 'cradle-to-cradle' technique ensures little-to-no loss of nutrients from the topsoil. This also helps create a balanced level of Nitrogen, Phosphorus and Potassium in garden plots. With proper application of compost, much of the guesswork involved with conventional synthetic fertilizers is eliminated. This ensures a smaller likelihood of 'plant burning,' where nutrients concentrations are in too high at one time. The use of homemade compost also reduces the potential for nutrient runoff, which can lead to nutrient overloading in surrounding water systems.

Composting systems can be added to the existing infrastructure of all 22 community gardens. In order for effective compost systems to be incorporated, education and organization at each site must be present. With proper methods, timing and management compost systems can benefit the overall environmental performance of the gardens and allow the garden systems to alleviate the strain and transportation of conventional fertilizers, both synthetic and organic.

4.2 WATER SUPPLY PRO AND CON ANALYSIS

The LCRC has identified water supply as a major challenge to their operation. The LCRC gardens require a reliable water source to support garden activities. The LCRC must also consider the capital costs for introducing a water supply and the ongoing operational cost of a water supply system. Other considerations include the environmental impacts of the system, the awareness of water conservation needs

and the availability of water pressure. To help evaluate the water supply possibilities a pro and con analysis was used to examine onsite taps, water tanks, rain barrels, wells, and neighbour sourcing. Table 15 summarizes the supply method analysis.

Water supply Method	Pros	Cons
Onsite Tap	<ul style="list-style-type: none"> -Low operating cost -No water availability issues -Moderate pressure -No water truck hours or LCRC student hours 	<ul style="list-style-type: none"> -Moderate to high capital cost -Less incentive for water conservation -Environmental impacts of installation
Water Tanks	<ul style="list-style-type: none"> -Low capital cost -Provides water to otherwise unusable gardens -Visual reminder of water conservation needs -Low environmental impact for installation 	<ul style="list-style-type: none"> -Need for regular water truck visits -High operating cost -Affects city worker budget -Low water pressure
Rain Barrels	<ul style="list-style-type: none"> -Low capital cost -Collects some additional water -Visual reminder of water conservation needs -Low environmental impact for installation -Better plant growth 	<ul style="list-style-type: none"> -Requires large collection area (often not available) -Need for regular LCRC student visits -High operating cost -Low water pressure -Rain generally occurs in large burst cannot support regular supply
Neighbour Sourced Water	<ul style="list-style-type: none"> - Low capital cost - No water truck hours - No environmental impact for installation - Social connection 	<ul style="list-style-type: none"> - Higher operating cost - Additional neighbour water costs - Not a permanent solution - May require LCRC student hours
Well	<ul style="list-style-type: none"> -Low operating cost -No water availability issues -Moderate water pressure -No water truck or LCRC student hours 	<ul style="list-style-type: none"> -Environmental concerns -Source water protection -Less incentive to conserve water -Moderate to high capital cost

TABLE 15: Water Sourcing Considerations

Onsite Taps

Onsite Taps represent an ideal solution to water supply needs. They allow the gardeners to have easy access to plentiful water. Since the taps are standalone this means there are few ongoing maintenance needs. The onsite taps also eliminate the need for LCRC students to fill rain barrels or for the City of London staff to fill water tanks. This in turn reduces the environmental impact by minimizing transportation emissions to supply the gardens with water. Since no workers need to fill water

containers, this also minimizes operation costs. Rather than having to pay for work hours, either by LCRC students or City of London workers, the water supply is dealt with directly by the gardeners. Additionally, the water costs include only water used by the LCRC gardeners, rather than the added residential use when using neighbour water.

The major complication with onsite taps is the high cost of installation. Many gardens are located on open land and are not necessarily close to existing water lines. Installation costs will vary at each garden site due to differences in proximity to existing water lines. In general, capital costs of tap installation will be high because significant work must be undertaken to lay the water lines. The efforts necessary for laying water lines will have some environmental impacts. However, the impacts are short-term and can be minimized through proper planning and remediation efforts. In addition, onsite taps can minimize gardeners' visual connection with water use. Easy access to water from onsite taps could lead to water waste.

Water Tanks

Water Tanks allow the LCRC to provide water to sites that do not have access to onsite taps or a suitable catchment to allow for rainwater harvesting. The upfront costs to water tanks are minimal. A specific cost for a water tank could not be obtained. Based on the fact that water tanks are larger and less widely manufactured than rain barrels, it can be assumed that the unit cost is greater for water tanks. However, the large size of water tanks means that one or two tanks can meet the water needs of an entire garden. As a result, capital cost of water tanks is assumed to be relatively low and comparable with rain barrel sites.

Operational costs of water tanks are high. Each site with a water tank requires one to two visits by City of London workers and a water truck to maintain a sufficient supply for gardeners. The hourly wages and city budget for these activities could

not be obtained, because the City of London contact was not able to provide that information. However, due to the need of paying for workers hourly wages and maintaining city water vehicles to supply the water, it can be assumed that the operating costs are relatively high. It should be noted that these costs are taken on by the City of London rather than the LCRC. For the LCRC to be sustainable in the future, the full cost of water supply should be considered. Through talks with city officials, it has been found that there is no distinct budget set aside for meeting the community garden needs. As a result, the use of water tanks in future expansion of the gardens could strain the City of London's budget and time availability to helping LCRC operations.

Rain barrel

Rain barrels allow the LCRC to capture water and do not require a large upfront capital cost. Rain barrels cost \$80-200+ each, depending on size and features. Most gardens will need several barrels to store an appropriate amount of water. The need to supplement water to the rain barrels means that LCRC students have to regularly visit sites, which will increase the operational costs dramatically. If it is assumed that roughly half the LCRC student's time is spent driving to gardens in order to refill water barrels (the other half would be associated with maintenance) operational cost for water filling was over \$3,000 in 2008.

While it is true that rain barrels cannot meet all the gardens' water needs without supplementations, harvesting rain water still does reduce water inputs. A 10-foot by 10-foot area can collect over 235 liters of water from a 1-inch rainfall event (Greater Good, 2008). Adding a 100 sq foot collection area could collect over 3000 liters of water between May and August, based on historic rain values. While this certainly would not eliminate the need for additional water supplies, it could reduce the need for several trips a year (not a huge amount of savings but a notable one nonetheless). However, it should be noted that the majority of precipitation in Southern Ontario during the summer months occurs in a small number of rainfall events. Catchments need to be appropriately designed to deal with high levels of

precipitation in one event. This means that large collection facilities should be available. After larger rainfall events, rainwater may be able to meet water needs for a garden for several days.

Additionally, rain barrel catchments are not exclusive to other water supply methods. Rain harvesting can occur at any garden site and this will reduce water consumption from other sources. Aside from the positive affect on water consumption, it is reported that rainwater can have positive effects on plant growth.

Wells

The cost of installing a well depends on the specific site. The quoted cost for installing a well at the Proudfoot garden was roughly \$10,000. For a moderate to high capital investment, wells are able to meet most of the water supply needs of a garden. A well would allow for plentiful access to water with little ongoing operational costs aside from routine maintenance and energy to run a pump, although a solar power system was being considered.

The major concern with wells is that they provide a route for contaminants to enter ground water. Generally, water is filtered as it drains through multiple layers of earth before reaching a ground water system. Drilling a hole for a well to pump ground water up creates a route for contaminated water to drain down without being filtered. Source water protection has been an issue of growing concern in environmental circles. As such, there is generally some hesitation to constructing new wells. While, it is true that wells can provide some solutions to water supply problems at garden sites, they also create a source of environmental concern.

If the LCRC believes it is necessary to install a well, the Ontario Ministry of the Environment has detailed regulations for well construction best practices. Well construction should be sourced to regulated well contractors who can insure the minimum standards under Ontario Wells Regulation 903 are met or preferably

exceeded to protect ground water. Although, the ground water concerns can never be fully eliminated, taking these precautions can substantially reduce the risks.

Neighbour Sourced Water

Many of the LCRC garden sites are supplied water by connecting to neighbour's water lines. This is a great way to supply garden sites with water without having to make large up front capital investments. Many of the garden sites are currently supplied in this way. However, at some sites the gardeners can freely use hoses, whereas at other gardens, LCRC students use the neighbour's water source to fill rain barrels. This means that the operational costs vary heavily between neighbour-sourced sites. Some will include LCRC student hours and travel, while others will be limited to the water bills. The water costs at these sites will be greater than if the LCRC paid only for their water use since the neighbour water bills are fully covered. In 2008, the LCRC paid \$1,675 in water costs from neighbours.

4.3 ENVIRONMENTAL AUDIT CHECKLISTS

The following audit checklists have been provided to allow the LCRC to evaluate the environmental performance of their gardens and to identify areas for possible improvement.

The first checklist will be used for assessing the pre-construction phase of new community garden sites to ensure that there is minimal impact on the environment and surrounding ecosystems. The focus of this checklist will be on the sourcing of the materials used for creating a community garden site, their impact on the environment and their ultimate recyclability. As well, this checklist will be able to raise awareness to any potential negative effects to the landscape, soil and plant and animal species in the area. (See Appendix 3).

Similarly, the second checklist can be used to conduct an audit of the community gardens at the beginning of each growing season and assess levels of improvement

or highlight areas of concern. This environmental audit checklist will focus on four key environmental factors for the community gardens: soil, water, waste materials and plant biodiversity. The checklist should be completed prior to a new growing season in order to develop a “picture” of the current status of these key factors. (See Appendix 4).

The purpose of both environmental audit lists is to provide the LCRC a way of assessing their overall impact on the environment from the development of new community garden projects, while also monitoring current performance of gardens already in operation. By assigning a weighted score, the LCRC will be able to highlight areas that need improvement and plan their resources appropriately. As well, through the completion of these audit checklists, new issues or concerns may be brought to the attention of the administration that had not previously been considered.

4.4 KEY ENVIRONMENTAL PERFORMANCE MEASURES

In order to continually measure the performance of the LCRC’s community gardens, the following performance measures should be recorded. The results can be used to identify areas of improvement and to help develop sustainable practices. The measures have been separated into two sections. The first list is comprised of measures that the LCRC could begin using with data that is currently available. The second list contains measures that would need to be further developed in partnership with the City of London and the LCRC summer employees. Both lists have the potential to develop optimal baseline measurements for the LCRC that can be used in monitoring their environmental performance.

List of Measures for Immediate Implementation:

Air Emissions - Weekly Operations

CO2 Emissions from Weekly Operations

CO2 Emissions from Watering Truck:

KM's by City Watering Truck () (KMs) x .19 kg of CO2

Amount of Carbon Dioxide Emissions = Kg of CO2

CO2 Emissions from Summer Personnel:

KMs' traveled by staff () (KMs) x .19 kg of CO2

Amount of Carbon Dioxide Emissions = Kg of CO2

Total Amount of CO2 Emissions for Weekly Operation = Kg of CO2

Materials and Maintenance

Materials and Operations

Compost Used in Gardens:

Estimated % of organic compost added to community gardens at beginning of season %

Plant Species Biodiversity in Gardens:

Number of Vegetable Species Types Planted in Gardens

Organic Fertilizers Used:

Number of Organic Fertilizer Types Used in Gardens:

Water Source/Supply Inspections:

Frequency of Water Source/Supply Site Inspections (#)

Total number of site inspections conducted of water source/supply, such as hoses, taps, rain barrels and water tanks. (Total for Growing Season)

**** Co2 Emissions per Kg based on Natural Resources Canada Estimations****

(OEE 2009).

List of Measures for Future Implementation:

Air Emissions – Annual Growing Season	
CO2 Emissions from Roto-tilling	
<u>Beginning of Season Roto-tilling</u>	
Amount of fuel used by tractor () (Litres) x 2.4 kg of CO2	
Amount of Carbon Dioxide Emissions =	Kg of CO2
<u>End of Season Roto-tilling</u>	
Amount of fuel used by tractor () (Litres) x 2.4 kg of CO2	
Amount of Carbon Dioxide Emissions =	Kg of CO2
Total Emissions from Roto-tilling for Season =	Kg of CO2
<u>CO2 Emissions from Weed Trimming Equipment:</u>	
Amount of fuel used () (Litres) x 2.4 kg of CO2	
Amount of Carbon Dioxide Emissions =	Kg of CO2
Total Amount of CO2 Emissions for Season =	Kg of CO2
Water Usage	
Water Usage from Weekly Operations	
<u>Water Usage In Rain Barrels</u>	
() Litres of water used x () Frequency of Fills per Week	
Amount of Water Usage (Litres) =	Litres
<u>Water Usage in City Owned Tanks</u>	
() Litres of water used by truck x () Frequency of Fills per Week	
Amount of Water Usage (Litres) =	Litres
Total Amount of Known Water Usage (Litres)	Litres

** Co2 Emissions per Kg based on Natural Resources Canada Estimations**

(OEE 2009)

4.5 COMMUNITY GARDEN COMPARISON QUESTIONNAIRE

A questionnaire was created focusing on the surrounding regions community garden practices. Many communities in the area were contacted and the following eight responded to the questionnaire:

- Hamilton
- Kingston
- Kinsbridge
- Windsor
- Sarnia
- University of Western Ontario
- University of Waterloo School of Architecture
- York Region

The questionnaire asked the gardens a series of questions about their practices and gardening techniques, such as the use of pesticides and fertilizers, tilling and watering techniques and the overall management of the gardens. Each question will be explored and analyzed in more detail below (To see a full list of the questions and answers see Appendix 5).

The questionnaires were helpful in determining the management and practices of surrounding community gardens. It was beneficial to see how surrounding regions have chosen their management styles and if any of their styles could be applied to the LCRC. The gardens surveyed varied in size, number of plots, years running and management practices. Table 16 lists the communities contacted and provides basic background information on the gardens.

Community Garden Questionnaire Summary:

Community	Years Running	Number of Plots	Cost per Plot (\$)	Management
Hamilton	20	142	Dundas- 27.43-38.40 Churchill- 87.78 Victoria- 19.38 or 80.58	Business initiatives Coordinator and Horticultural staff
Kingston	4	Sunny side- 27 beds	20	Gardeners
Kinsbridge	2	12	25	Centre Staff, Community members, Schools, Neighborhoods
Windsor	First year	81	30- 50	Volunteer Committee – Windsor Garden Club
Sarnia	35	52	30	City of Sarnia
UWO	1	1 communal	5	Enviro Western
Waterloo	3	1 communal	0	2 student volunteers
York Region	16	3 different communities with many plots	0	Coordinator and charity staff

TABLE 16: Community Gardens Questionnaire Response

4.6 FERTILIZER AND PESTICIDE USE:

The questionnaire asked the gardens their policy on pesticides and fertilizers. There is an overall consensus that only organic fertilizers are allowed, if any. Of the eight communities surveyed, six have banned the use of pesticides. The remaining two communities have no official policies but strongly discourage the use.

4.7 TILLING:

Figure 6 represents the tilling practices chosen for the eight communities surveyed. It is clear that the most common type of tilling is roto-tilling, which is usually completed at the beginning and end of the growing season by a City representative. Two communities have no till because they have raised beds and one community individually tills their own plots because they are a newer garden. The following

chart below is a representation of the tilling practices in the surround community gardens.

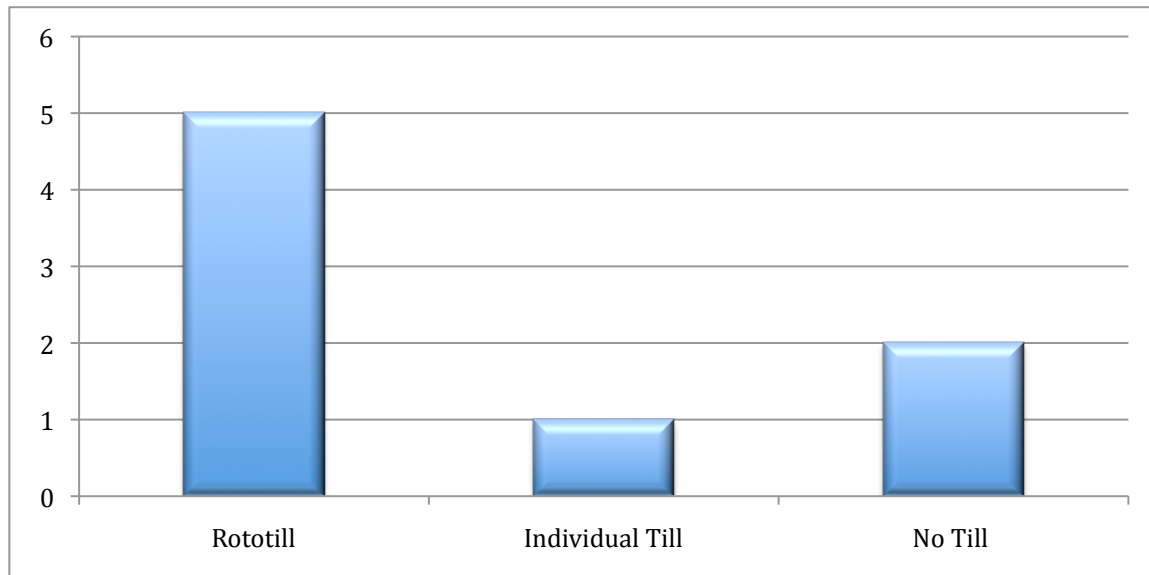


FIGURE 6: Community Gardens Tilling Practices (Questionnaire Survey Data).

4.8 WATER MANAGEMENT:

The questionnaire asked the communities where the water was sourced from to water the gardens and their irrigation techniques. Water sourcing is where the garden receives its water. Some of the sourcing techniques include hoses, taps and rain barrels, these are also the most common forms used in the surrounding regions. However, the University of Western Ontario community garden sources their water from the river.

Irrigation refers to the way in which the water comes from the source and is applied to the crops. In terms of irrigation, the most common form was by hand; this is because it is the most social and economically viable choice in terms of community gardens. However, one garden in Hamilton waters their gardens with a sprinkler system. As well, Windsor has implemented a professionally laid out drip irrigation system. Figure 7 below represents the different types of water sources community gardens use. Please note that many of the gardens source their water from two separate types. All communities use hand watering from the source except for

Windsor, which uses the drip irrigation system and Kingston, which uses a sprinkler system.

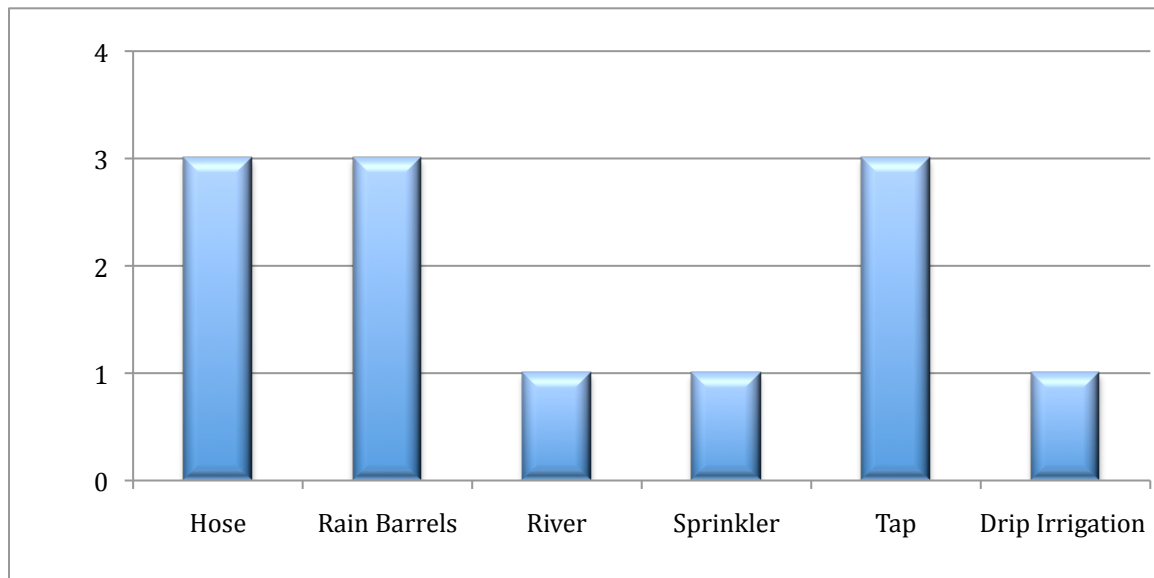


FIGURE 7: Community Garden Water Source Methods (Questionnaire Survey Data).

The results from the questionnaires showed that many of the community gardens in the surrounding regions have similar management practices. They all forbid the use of fertilizers and promote organic growing. Many of the questionnaires stated that the gardens were community based and were created from a grass roots level. Almost all of the areas receive their water from their city or municipality but may not be staffed by member of the city. Overall, it is clear that every garden is managed in a specific fashion that is suitable to the needs of the community. To view the individual questionnaires see Appendix 5.

4.9 WEBSITE REVIEW:

The LCRC website should be organized in a manner that is easy to follow and interactive. In order to achieve a website that is memorable and engaging, there are three main criteria that need to be taken into consideration when creating or updating a website: navigation, visual attractiveness and organization (Eymam, 2008; Future Quest, 2010; Vadnelay Design Inc, 2010).

Navigation:

A website should be easy to follow and have large headings for the viewer to find exactly what they are looking for (Kumar-Ja, 2005). The headings should be in bold and at the top or the left hand side of the website so the viewer can find the topic or information that they seek in a quick and efficient manner (Figure 8). If they have to look for the information, chances are they will not take the time and go to another site (Eymam, 2008). The initial home page of the website should not be cluttered and should only contain the most important headings and information. When developing the navigation for a website, one must consider what pages are most likely to be wanted by visitors, which pages are most critical for the purposes of the website, how visitors will want to move from one page to the next, what visitors will expect in terms of link location and pages linked, and how many clicks it will take visitors to get from the homepage to any other specific page (Vandelay Design, 2010).

Visual Appearance:

The overall visual appeal of a website should be bold and complementary. The color schemes should not exceed more than three colors and less detail can be more appealing to the audience than an over powering and detailed website. The use of logos and sponsors are very common, however they should be aligned at the bottom of the site or along the left and right margins of the page (See Figure 8). A successful website is in an orderly fashion and follows a simple grid pattern (Kumar-Ja, 2005). When a viewer clicks on a website the overall visual appeal is the first thing they see, in order for them to stay and browse, it is important to make the appearance fit with the overall theme of the website (Bille, unknown). For a community garden website, the color scheme and overall feel of the website should be based around its motives and goals.

Organization:

The organization of the website should be the main focus in the design. When designing an effective website, according to Future Quest Graphics, it should follow a hierarchical format. This is much like the technique used when creating an organizational chart for a company. By providing the information in this manner, the most important or recent information is the first thing the browsers sees when they log in. The website then organizes it information in this order. Once the website is organized there are some key icons that help with the overall accessibility of the website. This includes a website with easily searchable content and a “search engine” box in case the viewers cannot find exactly what they are looking for (Bille). Contact information is a very important component of a website, that way if the viewer does not find what they are looking for, they can contact someone for help or inquiries. As stated above, large headings and bold lettering is key to the organization of a website. A blog or viewer feedback section is not necessary but a bonus to a well thought out website.

Below is a list of community garden websites that have excellent organization, navigation and visual attractiveness.

Examples of Community Garden Websites:

Windsor Community Gardens:

http://www.telcs.com/cgarden/Windsor_Community_Garden/Welcome.html

Carville Community Gardens:

<http://www.carrvillecommunitygarden.com/>

Strathcona Community Gardens:

<http://strathconagardens.ca/>

As well, Figure 8 is a screenshot of a sample webpage demonstrating an effective layout and design that highlights some of the key points discussed above. As

demonstrated below, the navigation, visual appearance and organization make the page concise and user friendly.



FIGURE 8: Website Design Example

5.0 Recommendations & Conclusions

This report outlined several environmental considerations for the LCRC's 22 community gardens. The recommendations provided below serve as a guide to the ideal environmental practices and operations. Acknowledgements have been made by Cirrus Consultants as to the social and economic limitations faced by the LCRC in widespread implementation. These acknowledgements are shown in the recommendation alternatives, which are created based on the most practical environmental considerations. These alternatives were created after consultation with the client who explained some of the additional considerations, which the LCRC must include in their decision-making process.

It is the intention of Cirrus Consultants that the implementation of any or all of the recommendations will further improve the overall environmental performance of the community gardens. As the LCRC pursues future improvements to the infrastructure of the gardens, the information provided within this document can be used as a point of reference to help the organization assess the best alternatives moving forward. As well, best practice techniques for everyday operations, such as tilling and watering, will help to ensure the longevity and long-term productivity of the garden sites.

5.1) BEST MAINTENANCE PRACTICES: IRRIGATION, TILLING & FERTILIZATION

5.1.1) Irrigation Recommendation:

Installation of drip-irrigation or a clay pot irrigation system would result in the lowest loss of water and improve water conservation. These systems may be tested by enthusiastic gardeners in early stages of implementation.

Based solely on environmental factors of water conservation, a drip-irrigation system would be the most efficient method of watering for London's community gardens. Clay pot irrigation also performed well in terms of water conservation

goals but since little literature is available on clay pot irrigation, drip irrigation is likely easier to implement into the LCRC operation.

However, the LCRC must consider numerous factors aside from water conservation. It would be unfortunate to exclude community garden users in an effort to improve water conservation. The widespread implementation of more complicated and more costly drip irrigation systems could exclude some gardeners. Based on some of the challenges associated with drip irrigation systems and clay pot irrigation, it would be prudent to attempt the implementation of these systems on trial garden sites.

Perhaps a simple drip irrigation or clay pot system could be installed on one or two plots by particularly keen gardeners. The water use and management complexity could be compared with other gardeners to see if this might be worth expanding. If the trials are successful these gardeners could act as resources for other community gardeners.

5.1.2) Irrigation Recommendation (Alternative):

Where hand watering continues, increase education in water conservation and awareness to gardeners to help ensure the most responsible water use.

Since hand watering is the dominant form of irrigation at LCRC garden sites, efforts should be made to improve gardener application. The efficiency of hand watering can be improved through informed gardeners using proper techniques. The LCRC should focus on educating gardeners about when and how much to water their crops. Not only would this help reduce the LCRC's financial costs, it would also help reduce environmental impact.

Gardeners should be encouraged to attend meetings with Master Gardeners, so that they can learn the water requirements for their crops and group like plants together to reduce waste. Gardeners should be highly encouraged to use appropriate levels of mulch throughout the season, since this can substantially reduce evaporation, runoff, and weed competition for water. Gardeners should also be encouraged to use

furrows as means of trapping excess water that is applied when irrigating or during heavy rain events, so that the water improves soil moisture rather than being lost. Gardeners should be encouraged to water in the morning or late afternoon when evaporation will be minimized. The addition of rain gauges at garden sites might be considered to inform the gardeners about recent precipitation. By focusing on these strategies the LCRC can maximize water conservation without large changes to the irrigation methods.

Simply making the issue of water conservation known to the gardeners may improve results. The LCRC should inform gardeners that water conservation is an important issue for the program. Placing signs emphasizing the importance of water conservation at water sources may be an effective way to remind gardeners of the issue every time they fill up. Although simple this could provide meaningful returns.

5.1.3) Tilling Recommendation:

Implement No-Till methods in community gardens through mulch cover or cover crops.

No-till gardening allows for the highest environmental performance levels for LCRC's community gardens. This promotes the health of soil communities, ensuring long-term health of microorganisms, nutrients and humus within the A-horizon. Proper implementation would mean considerable work on behalf of LCRC to educate and inform gardeners about how to properly implement no-till methods to garden plots. This method is far more labour intensive and requires more diligent gardening by individuals. This would include having to apply mulches and cover crops in the fall, as well as manually preparing the seedbed in the spring. While more labour intensive and time-consuming, this method ensures long lasting soil health, while minimizing external environmental effects. Reducing compaction and improving soil resilience allows this method to be viewed in the highest environmental regard. This can viewed as the most environmentally positive

method as on-site improvements are made and external consequences are minimized.

5.1.4 Tilling Recommendation (Alternative):

Implement shallow-till method, using hand-tools for use in community gardens.

Shallow-till methods allow for high levels of environmental performance from the soil communities. This low-intensity method allows for the pro-longed health of the topsoil communities and decreases the chances for soil horizon mixing. This method increases the resilience of soils and when implemented responsibly can greatly reduce the vulnerability of the soils to erosion and run-off. The implementation of this method would involve education for gardeners on how to properly time tilling and practice responsibly. This would also require higher capital costs by either LCRC or individual gardeners to purchase additional garden tools. This method would also involve more labour on the end of the gardener and may exclude some gardeners who are unable to adapt to the increased physicality of this method of gardening.

5.1.5) Tilling Recommendation (Alternative 2):

Ensure proper timing with roto-tilling and inspect soil quality bi-annually.

The use of roto-tilling allows for seedbed prep and turnover in the fall, without individual gardener participation. Deep tilling methods, through the use of roto-tillers, increases the vulnerability of soils to degradation. This can be minimized through careful examination of the soils before any tilling is completed. This would involve education on the side of maintenance staff, as well as flexibility in tilling timing to ensure climatic conditions are proper for tilling to occur.

Additionally partial-tilling could be explored by the LCRC. This could include using the roto-tiller on tracts of the garden where participants request tilling and leaving tracts available for those who wish to participate in less-intensive methods of tilling.

5.1.6) Fertilization Recommendation:

Promote the use of home-made compost for fertilization in community gardens.

Organic compost ensures the highest environmental performance for the LCRC's community gardens. This method of fertilization displaces organic matter, which would otherwise travel to landfill and provides a nutrient rich fertilizer. This would involve the installation of compost shed or bins on each garden site. Proper education by Master Gardeners, with active gardener participation would allow this method the maximum success. Any opportunity for organic fertilizers, which come from locally available sources, should be further explored.

5.2 BEST MAINTENANCE PRACTICES: WATER SUPPLY

5.2.1) Water Supply Recommendation:

The water supply needs of the LCRC are best addressed by onsite taps, which have less environmental risk than installing water wells.

The best solution for addressing the LCRC water supply needs is the installation of onsite taps. The major challenge is the capital cost of installation. Creating an open dialogue with the City of London water engineers will help to navigate the potential for tap installation at the garden sites. The availability of onsite taps or the potential expenditure for installing taps systems should be considered of primary importance when selecting future garden sites. Creating a system that helps gardeners acknowledge water usage could align the positives associated with onsite taps with water conservation and environmental efforts of the LCRC. Examining methods of connecting gardeners to the water costs of the site is one potential approach moving forward.

Investing in onsite taps is highly recommended over the installation of wells. Both systems manage to meet the water supply needs of the LCRC garden sites at relatively similar prices (although both varying heavily based on specific sites). However, wells pose a permanent environmental concern, whereas tap installation

has only small short-term effects. Although it is possible to minimize the environmental dangers associated with well construction and use, the potential risk does not align well with the LCRC's goals to reduce their environmental impacts.

5.2.2) Water Supply Recommendation (Alternative):

Rainwater harvesting can help to reduce the environmental impact of the LCRC garden sites and reduce water bills.

Rain barrels and water tanks play a meaningful role in supplying water to LCRC garden sites. Although these systems are not ideal and they suffer from some water supply issues and high operational cost, they will need to be used since onsite taps are costly to install. Using these systems to increase rainwater harvesting is one way the LCRC can improve their environmental performance. Even sites with taps could benefit from collecting rainwater. Rooftop catchments can supply a significant amount of water, this reduces worker hours needed to refill tanks or barrels, or they can reduce costs where taps are available. Moving forward, improving water collection at sites should be considered, it might also be possible to create water catchments that are designed to attach to water tank sites. This will reduce the amount of time and money that has to be spent on filling water containers at garden sites. The University of Waterloo School of Architecture is currently looking into this watering technique for the spring.

5.2.3) Water Supply Recommendation (Alternative 2):

Creating communication systems may allow for fewer trips by LCRC students and City of London workers to refill rain barrels and water tanks.

Another way to reduce time and energy spent traveling to garden sites with rain barrels or water tanks is to create a means of communication between the LCRC staff and gardeners. Potentially, a representative at each garden could be responsible for informing the LCRC when water levels are low. A system could be developed which would take into account the LCRC student availability and the City

of London worker schedules. This could be particularly valuable if water catchments are incorporated into sites.

5.2.4) Water Supply Recommendation (Alternative 3):

Neighbour sourced water is an effective short-term solution to water supply issues but should be considered temporary and these sources will need to be addressed to insure the sustainability of the water supply.

To date, neighbouring sourced water has been an effective way to address water supply issues at many of the garden sites. However, it does not represent a permanent solution to these issues. Neighbours may move or for other reason decided they no longer wish to assist in the LCRC program. Some sites such as those on church properties may be considered slightly more permanent as long as strong social connections are made with those involved. On the other hand, churches sites may create more volatility in the year to year water costs for the LCRC, because there is less consistency in whether they will absorb the water costs or not. The neighbour sources need to be evaluated on a case-by-case basis. In general, neighbour water sources should be considered to be an effective but temporary solution.

5.3) BEST PRACTICE RECOMMENDATION: ENVIRONMENTAL AUDIT

5.3.1) Environmental Audit Recommendation

In order to minimize the environmental impact of the community gardens and their operations, a pre-construction and seasonal environmental audit checklist should be utilized by the LCRC. As well, key performance measures of the LCRC should be captured with currently available data in the short-term, and long-term as data capture strategies become available.

The pre-construction audit of new garden sites will allow the LCRC to give a high level assessment to their development techniques for garden sites and assess which areas of the process may have the largest environmental impact. This will allow the LCRC to develop an understanding of where the main strengths and weaknesses of their garden development site techniques.

The implementation of the seasonal garden audit checklist should be utilized pre-season in order to develop an overview of how their gardens and operations are positively and negatively effecting the local environment. By assigning weights to the four primary areas of review, soil, water, waste and plant biodiversity, the LCRC will be able to better identify areas of their management and operational strategies that need further evaluation or resources.

The use of the key performance measures will allow the LCRC to develop baseline and continuous measurements of key input and outputs to operating and maintaining the community gardens. While some measures, such as the roto-tilling pre and post season, will only need to be done twice a year; the CO2 emissions from summer employees, the city watering truck and water usage can be measured on a weekly basis. While some measures can be easily acquired and are currently captured by the LCRC at this time, such as the kilometers driven by summer students, other measures will have to be developed over time in partnership with the City of London. For example, the LCRC or the city do not record the amount of water used to fill the city water tanks on community garden sites. As well, the LCRC's summer students do not record how much water is used to refill rain barrels.

While water used by individual gardeners may not be measured, since it is based on their personal use, water refilling by LCRC summer students could be captured by evaluating the size and frequency of the rain barrels being filled. This level of detail may not be required by the LCRC at this time, but could be pursued in the future to provide in depth measurements of resource use should it be desired.

By implementing both environmental audit checklists and integrating the performance measures into their operations, the LCRC should be able to continually move toward environmentally sustainable practices.

5.4) BEST PRACTICE RECOMMENDATION: WEBSITE REVIEW

In order to improve the current LCRC website and make it more user friendly and effective, the LCRC should consider re-organizing their home page, taking into consideration the overall navigation, organization and appearance of the website.

The LCRC should consider the following improvements to their website (Figure 9):

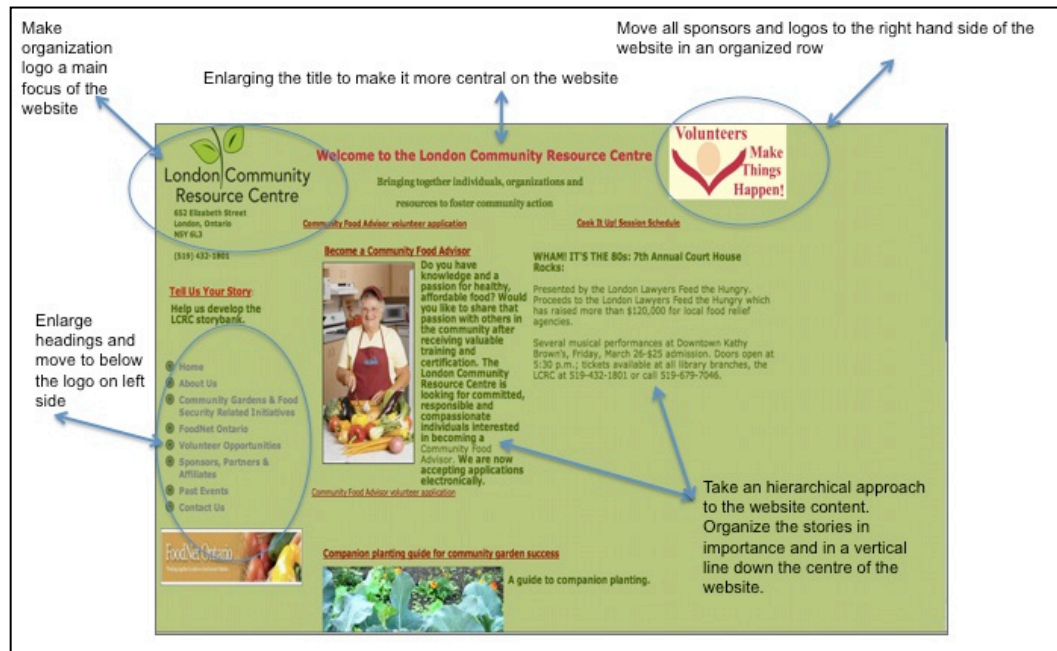


FIGURE 9: Website Recommendations

The color scheme and content is well done. By doing these simple organizational changes the LCRC website will be user friendly, easy to navigate while still fulfilling its resource needs.

6.0 Conclusion

It is important for all organizations to acknowledge the environmental impacts that their activities may have on the environment and larger ecosystems. In their pursuance of environmental excellence, the LCRC has taken a positive first step through their investigation of this issue with Cirrus Consultants. Through the environmental audit checklists and implementation of *Best-Practices Recommendations*, a proper baseline on impacts will be generated by the LCRC. This information will allow the gardens to continue to grow in size and popularity, while ensuring positive environmental impacts. This report will allow the LCRC to further manage the environmental impact of both their existing and future operations as community gardening practices continue to expand, develop and grow.



References

- Armstrong, D. (2000). *A Survey of Community Gardens in Upstate New York: Implications for Health Promotion and Community Development*. Health and Place, 319-327.
- Baker, L. (2004). *Tending Cultural Landscapes and Food Citizenship in Community Gardens*. Geographical Review, 24 (3), 26-39.
- Bonnycastle A., Yang, W., & Rowlands, L. (2006). *Introduction to Spatial Analyst in ArcGIS (First Ed.)*. Guelph, ON: Department of Geography.
- Bremmer, A., Lenkins, K., & Kanter, D. (2003). *Community Gardens in Milwaukee: Procedures for Long Term Stability*. University of Wisconsin, Department of Planning.
- Brouwer, C., Prins, K., Kay, M., and Heible, M. (1988) *Irrigation Water Management: Irrigation methods: Chapter 3 Furrow irrigation*. FAO-Food and Agriculture Organization of the United Nations. Accessed from <http://www.fao.org/docrep/S8684E/s8684e00.htm> on March 20, 2010.
- Burba, G., Hubbart, J.A., and Pidwirny, M. (2006). *Evapotranspiration*. The Encyclopaedia of the Earth. Accessed from <http://www.eoearth.org/article/Evapotranspiration> on February 26, 2010.
- Burt, C.M., Clemmens, A.J., Strelkoff, T.S., Solomon, K.H., Bliesner, R.D., Hardy, L.A., Howell, T.A., Members, ASCE, Eisenhauer, D.E. (1997) *Irrigation Performance Measures: Efficiency and Uniformity*. Journal of Irrigation and Drainage Engineering 123:6 pp.423-442.
- Cheremisinoff, N., Paul. & Cheremisinoff, P., Nicholas. (1993). *Professional Environmental Auditor's Guidebook*. Noyes Publications: New Jersey.
- City of Toronto. (unknown). *Reducing Pesticides: it's perfectly natural*. Toronto: Toronto Health Connection.
- Cunningham, W.P., Cunningham, M.A., Saigo, B.W., Baily, R., and Shrubsole, D. (2005). *Environmental Science: A Global Concern, Canadian Edition*. McGraw-Hill Ryerson Limited. Toronto, Ontario, Canada.
- Environment Canada (1997) *The Canada Country Study: Climate Impacts and Adaptations*. The Ontario Executive summary. Accessed from <http://www.on.ec.gc.ca/canada-country-study/> on February 26, 2010.
- Environment Canada (2009) *National Climate Data and Information Archive*. Canadian Climate Normals 1971-2000: London International Airport. Accessed from

- http://www.climate.weatheroffice.gc.ca/climate_normals/results_e.html?Province=ALL&StationName=london&SearchType=BeginsWith&LocateBy=Province&Proximity=25&ProximityFrom=City&StationNumber=&IDType=MSC&CityName=&ParkName=&LatitudeDegrees=&LatitudeMinutes=&LongitudeDegrees=&LongitudeMinutes=&NormalsClass=A&SelNormals=&StnId=4789 on February 25, 2010.
- Eyman, K. (2008). *Top 3 Criteria That Makes a Good Web Site*. Accessed March 27, 2010, from <http://ezinearticles.com/?Top--3--Criteria--That--Makes--a--Good--Web--Site&id=1210704>
- Fedor, J. (2001). *Organic Gardening for the 21st Century*. New York: Readers Digest.
- Ferris, J., Norman, C., & Semik, J. (2001). *People, Land and Sustainability: Community Gardens and the Social Dimensions of Sustainable Development*. *Journal of Social Policy and Administration* , 35 (5), 559-568.
- Flores, H. (2006). *Food Not Lawns: How to Turn Your Yard into a Garden and Your Neighborhood into a Community*. White River Junction, VT: Chelsea Green Publishing Company.
- Forge, F. (2004). *Organic Farming in Canada: An Overview*. Ottawa: Library of Parliament. Parliament Research Service.
- Gershuny, G. (1993). *Start With Soil*. Pennsylvania: Rodale Press.
- Glantz, H. Michael. (2003). *Guidelines for Establishing Audit of Environmental Hotspots*. Food and Agriculture Organization of the United Nations. Accessed from www.fao.org/docrep/006/y5086e/y5086e00.htm on March 15, 2010.
- Greater Good. (2008). *Rain Barrel Calculator*. Accessed from <http://www.gretergoods.com/rainbarrelcalc.html> on March 23, 2010.
- Hayhoe, K., and Shuter, B. (2003) *Ontario: Findings from Confronting Climate Change in the Great Lakes Region*. The Union of Concerned Scientist and the Ecological Society of America. Accessed from <http://www.ucsusa.org/greatlakes/glregionont.html> on February 24, 2010.
- Harding, G. (2010). *Community Gardens Policy*. City of Sydney , Department of Environment and Heritage , Sydney.
- Heffron, S. (2009). *Semi Annual Growth Report*. Growth Report, Youth Garden Project, Utah .
- Hla, A.K., and Scherer, T.F. (2003) *Introduction to Micro-Irrigation*. North Dakota State University. (NDSU). Accessed from <http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae1243w.htm> on March 20, 2010.

- Holbrook, Julian. (1996). *An Introduction to Environmental Auditing*. Scottish Natural Heritage. Accessed from <http://www.snh.org.uk/publications/online/advisorynotes/45/45.htm> on February 24, 2010.
- Holland, L. (2004). *Diversity and Connections in Community Gardens: A Contribution to Local Sustainability*. *Local Environment*, 9 (3), 285-305.
- INTOSAI. (2008). *About Environmental Auditing*. Working Group of Environmental Auditing. Accessed from <http://www.environmental-auditing.org/Home/LearningCentre/AboutEnvironmentalAuditing/tabid/122/Default.aspx> on February 24, 2010.
- Iowa State University. (2009). *Planting a Home Vegetable Garden*. Extension University. Accessed from <http://www.extension.iastate.edu/Publications/PM819.pdf> on March 20, 2010.
- Jiang, H., & Eastman, R. (2000). Application of fuzzy measures in multi-criteria evaluation in GIS. *Geographical Information Science*, 14(2), 173-184.
- Karlen, D. L. (1994). *Management Strategies for Sustainable Soil Fertility*. In J. Hatfield, & D. C. Karlen, *Sustainable Agriculture Systems*. Ames, Iowa: CRC Press.
- Kuepper, G., & Gegner, L. (2004). *Organic Crop Production Overview: Fundamentals of Sustainable Agriculture*. National Sustainable Agriculture Information Service. Fayetteville, Ark: ATTRA.
- Kumar-Jha, Niraj. (2005). *Criteria for a Good Website*. Technology Today.
- (LCRC) London Community Resource Centre. (Unknown). *London Community Resource Centre About Us*. Accessed from http://www.lcrc.on.ca/About_Us.html on February 26, 2010.
- Liddicoat, K., & Krasny, M. (2005). Education in Community Gardens in South Africa. *North American Association for Environmental Education*, 6 (12).
- Lorincz, T. (2009, August 19). *Growing Gardens and Creating Community*. Retrieved February 2010, from Nova Scotia Environmental Network: www.nsen.ca
- Malczewski, J. (2004). GIS-based land-use suitability analysis: a critical overview. *Progress in Planning*, 62(1), 3-65.
- Master Gardeners Foundation. (unknown) *Gray Harbor and Pacific Counties, Washington*. Soils. Accessed from <http://pnwmg.org/mgsoils.html> on February 26, 2010.

- Mazereeuw, B. (2005). *Urban Agriculture Report*. Region of Waterloo. Waterloo: Region of Waterloo Public Health.
- Ministry of Agriculture and Agri-Foods Canada (1931) *Soil Survey Map of County of Middlesex Province of Ontario: Soil Survey Report NO.6*. Accessed from <http://sis.agr.gc.ca/cansis/publications/on/index.html> on February 24, 2010.
- Natural Resource Conservation Service (unknown) *Water Conservation*. Accessed from <http://www.nrcs.usda.gov/feature/backyard/watercon.html> on February 24, 2010.
- (OEE) Office of Energy Efficiency. (2009). *The Fuel Consumption Guide*. Natural Resources Canada. Accessed from <http://oee.nrcan.gc.ca/publications/transportation/fuel-guide/2009/comparing-vehicles.cfm?attr=8> on March 14, 2010.
- Ontario Water Works Association (2008) *Outdoor Water Use Reduction Manual*. Ontario Water Works Association Water Efficiency Committee.
- Pacini, C. – Wossink, A. – Vazzana, C. – Zorini, L. O.: (2000) *Environmental Accounting in Agriculture: A Theoretical Overview with Special Reference to Tuscany. Annual Meeting of AAEE, Tampa, Florida, July 30 – August 2. 1-22*. Accessed from ideas.repec.org/p/ags/aaea00/21870.html on March 22, 2010.
- Parsons, J., Cotner, S., Roberts, R., Finch, C., Welsh, D., and Stein, L. (2002). *Efficient Use of Water in the Garden and Landscape*. AgriLife Extensions Texas A&M system. Accessed from <http://aggie-horticulture.tamu.edu/extension/homelandscapes/water/water.html> on March 20, 2010.
- Pinyuh, G.J. (2002) *Watering Home Gardens and Landscape Plants*. Washington State University Cooperative Extension and U.S. Department of Agriculture. Accessed from <http://pnwmg.org/pdf/mgwatering.pdf> on February 27, 2010.
- Reed, W. J. (1992). *Environmental Auditing: Canadian Industry Perspectives*. Edwards, N. Felicity. (Ed.) University of Calgary Press. Calgary, Alberta.
- Robinson, C., Cruse, R., & Kohler, K. (1994). *Soil Management*. In J. Hatfield, & D. (. Karlen, Sustainable Agriculture Systems. Ames, Iowa: CRC Press.
- Schukoske, J. E. (2000). *Community Development Through Gardening: State and Local Policies Transforming Urban Spaces*. *Legislation and Public Policy*, 3 (35), 351-392.

- Smeal, D. (2007). *Drip irrigation for small plots: a low-tech, low-cost, gravity system*. Agriculture Science Center at Farmington. New Mexico Organic Farming Conference. Albuquerque, New Mexico.
- Stell, E. P. (1998). *Secrets to Great Soil*. Canada: Storey Communications, Inc.
- Stryker, J. (2009). *Drip Irrigation Design Guidelines*. Accessed from <http://www.irrigationtutorials.com/dripguide.htm> on March 23, 2010.
- Sullivan, P. (2004). *Sustainable SOil Management*. ATTRA. Fayetteville, Ark: NCAT.
- Toronto Master Gardeners. (unknown). *Organic Fertilizers - The Basics*. Retrieved February 28, 2010 from www.toronto.ca/health/pesticides/pdf/gardening_organicfertilizer.pdf
- Tree Canada. (2007). *Homeowner's and Traveller's CO2 Emissions Offset Calculator*. Natural Resources Canada. Accessed from <http://www.treecanada.ca/calculator/index.htm> on March 11, 2010.
- Twiss, J., Dickinson, J., Dumas, S., Kleinman, T., Paulsen, H., & Rilveria, L. (2003). *Community Gardens: Lessons Learned from California Healthy Cities and Communities*. American Journal of Public Health, 93 (9), 1435-38.
- United States Department of Agriculture. (2008). *Comparing Irrigation Systems*. Natural Resource Conservation Service. Accessed from http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/NM_IWM_Field_Manual/Section21/21k-Comparing_Irrigation_Systems.pdf on February 26, 2010.
- Upper Thames River Conservation Authority (2003) *The Middlesex Natural Heritage Study*. Accessed from <http://www.thamesriver.on.ca/MNHS/MNHS.htm> on February 24, 2010.
- Urban Farmer. (unknown). *No-till Vegetable Gardening*. Retrieved 2010 22-Feb from Urban Farmer: www.theurbanfarmer.com
- Vandelay Design. (2010). *Custom Website Design Services*. Accessed from <http://vandelaydesign.com> on March 28, 2010.
- Voicu, I., & Been, V. (2008). *The Effect of Community Gardening on Neighboring Property Values*. Real Estate Economics, 36 (2), 241-283.
- Ware, L. (unknown). *Prepare Your Soil: Learn about tillage methods on the small farm*. From about.com:small farms: <http://smallfarm.about.com/od/landpreparation/a/tillsoil.htm>

Williams, S. (unknown). *Fertilizer: Application (Organic vs Inorganic)*. Accessed from University of Saskatchewan: <http://gardenline.usask.ca/misc/ferti2.html> on February 24, 2010.

Williamson, E. A. (2002). *A Deep Ecology: Community Gardens in the Urban Environment*. University of Delaware , Urban Affairs and Public Policy.



Appendices

APPENDIX 1: THORNTHWAITE EQUATION

$$PET = 16 \left(\frac{L}{12} \right) \left(\frac{N}{30} \right) \left(\frac{10T_{\alpha}}{I} \right)^{\alpha}$$

Where,

T_{α} is the average daily temperature of the month being calculated

N is the number of days in the month being calculated

L is the average day length of the month being calculated

$$\alpha = (6.75 \times 10^{-7})I^3 - (7.71 \times 10^{-5})I^2 + (1.79 \times 10^{-2})I + 0.49$$

$$I = \sum_{i=1}^n \left(\frac{T_{\text{m}}}{5} \right)^{1.514}$$

APPENDIX 2: MCE TABLES

Irrigation:

Weighted Linear Combination Comparison:

	Evaporation	Deep Percolation	Runoff	Drift	Score	
Evaporation		0.5	0.5	0.5	1.5	0.25
Deep Percolation	0.5		0.5	0.5	1.5	0.25
Runoff	0.5	0.5		0.5	1.5	0.25
Drift	0.5	0.5	0.5		1.5	0.25
					6.0	1

Environmental Impact Table:

	Hand Watering	Furrow	Sprinkler	Drip Irrigation	Micro Sprinkler	Clay Pot
Evaporation	-1	-3	-1	2	1	2
Deep Percolation	0	-3	0	3	3	2
Runoff	0	2	-1	3	3	3
Drift	0	2	-2	3	2	3

Final Score Table:

Hand Watering	Furrow	Sprinkler	Drip Irrigation	Micro Sprinkler	Clay Pot
-0.25	-0.75	-0.25	0.5	0.25	0.5
0	-0.75	0	0.75	0.75	0.5
0	0.5	-0.25	0.75	0.75	0.75
0	0.5	-0.5	0.75	0.5	0.75
-0.25	-0.5	-1	2.75	2.25	2.5

Fertilizer:

Weighted Linear Combination Comparison:

	Nutrient release	'Plant burning'	Energy to produce	Local Availability	Soil moisture	Downstream	SUM	Standardized Score
Nutrient Release		1	0	0.5	0.5	1	3	0.2
Plant burning	0		0	0	0	0.5	0.5	0.033333333
Energy to produce	1	1		1	1	1	5	0.333333333
Local availability	0.5	1	0		0.5	1	3	0.2
Soil moisture effect	0.5	1	0	0.5		1	3	0.2
Runoff...downstream effects	0	0.5	0	0	0		0.5	0.033333333
							15	1

Environmental Impact Table:

	Conventional	Organic	Cover Crops	Mulch	Compost
Nutrient Release	1	2	1	2	1
Plant burning	-2	0	0	1	0
Energy to produce	-2	-1	-1	1	1
Local availability	-1	0	1	2	2
Soil moisture effect	1	1	1	-1	1
Runoff...downstream effects	-1	0	1	1	0

Final Score Table:

	Conventional	Organic	Cover Crops	Mulch	Compost
Nutrient Release	0.2	0.4	0.2	0.4	0.2
Plant burning'	-0.066	0	0	0.033	0
Energy to produce	-0.666	-0.333	-0.333	0.333	0.333
Local availability	-0.2	0	0.2	0.4	0.4
Soil moisture effect	0.2	0.2	0.2	-0.2	0.2
Runoff...downstream effects	-0.033	0	0.033	0.033	0
FINAL SCORE	-0.565	0.267	0.3	0.999	1.133

TILLING:

WLC table:

	Organisms	Soil Horizons	Erosion	Aeration	Soil Moisture	Nutrients	Seed Bed Prep	Fossil Fuel Use	SCORE
Disruption of Organisms		0.0	0.0	1.0	1.0	1.0	1.0	1.0	5.000
Disruption of Soil	1.0		0.5	1.0	1.0	1.0	1.0	1.0	6.500

Horizons									
Erosion Effects	1.0	0.5		1.0	1.0	1.0	1.0	1.0	6.500
Aeration	0.0	0.0	0.0		0.0	0.0	1.0	1.0	2.000
Soil Moisture	0.0	0.0	0.0	1.0		0.5	1.0	1.0	3.500
Nutrients	0.0	0.0	0.0	1.0	0.0		1.0	1.0	3.000
Seed Bed Prep	0.0	0.0	0.0	0.0	0.0	0.0		0.5	0.500
Fossil Fuel use	0.0	0.0	0.0	0.0	0.0	0.0	0.5		0.500
									27.500

	No-Till		Shallow-Till		Deep-Till	
	Mulch Cover	Cover Crops	Hand Tools	Roto-tiller	Harrows	Standardized score
Disruption of Organisms	2	2	1	-2	-1	0.18
Disruption of Soil Horizons	1	1	0	-1	0	0.24
Erosion Effects	3	3	1	0	-1	0.24
Aeration	0	0	2	2	2	0.07
Soil Moisture	2	1	1	0	0	0.13
Nutrients	2	2	0	0	0	0.11
Seed Bed Prep	-1	-2	1	2	3	0.02
Fossil Fuel use	0	0	0	-1	-2	0.02

	Mulch	Cover Crops	HandTools	Roto-till	Harrow till
Disruption of organisms	0.36	0.36	0.18	-0.36	-0.18
Disruption of Soil Horizons	0.24	0.24	0.00	-0.24	0.00
Erosion Effects	0.72	0.72	0.24	0.00	-0.24
Aeration	0.00	0.00	0.14	0.14	0.14
Soil Moisture	0.26	0.13	0.13	0.00	0.00
Nutrients	0.22	0.22	0.00	0.00	0.00
Seed Bed Prep	-0.02	-0.04	0.02	0.04	0.06
Fossil Fuel use	0.00	0.00	0.00	-0.02	-0.04
	1.78	1.63	0.71	-0.44	-0.26

APPENDIX 3: PRE-CONSTRUCTION ENVIRONMENTAL AUDIT CHECKLIST

<u>SITE IMPACT:</u>	<u>SCORE</u>
<u>Pre-Construction & Site Assessment:</u>	
1. When applicable, priority is given to the use of existing on-site materials over the importing of materials from off-site.	
2. Landscape construction materials will be renewable and/or recyclable.	
3. Landscape construction materials are locally produced.	
4. Landscape construction materials (for fences, pathways, features, etc.) will be salvaged or recycled.	
5. Landscape construction materials have relatively <i>low embodied energy</i> (energy used in their creation) and <i>low embodied affect</i> (i.e. pollution, destruction of eco-systems, negative social consequences, etc.).	
6. Landscape construction methods and on-going maintenance will use low amounts of fossil fuels (i.e. hand tools over heavy machinery).	
7. Hard-scapes (fences, watering sources, plots) will be designed and constructed with longevity and flexibility in mind.	
8. Proposed development of garden sites will not alter natural drainage flow or patterns, or surface water runoff.	
9. Development of new garden sites will not impact any threatened or endangered species of plants or animals.	
10. The community garden project will not remove or disturb any critical components of a wildlife habitat.	
11. Development of this garden site will not produce operating noise exceeding the local ambient noise levels for noise outside of structures.	
12. The construction of the new garden site will not remove natural noise barriers, such as trees or shrubbery, from the landscape.	
<u>TOTAL</u>	

1 – Not true

2 – Somewhat true

3. - Very true

4. - Neutral

5. – Completely true

Score Totals:

0 – 10: Very Low: landscape may be having a very negative environmental impact.

10 – 20: Somewhat Low: There are many positive changes you could still consider

30 - 40: Good: Heading in the right direction.

40 – 50: Very Good: A few areas need further review.

50 - 60: Excellent. Sustainable construction practices will be implemented.



APPENDIX 4: PRE - SEASON ENVIRONMENTAL AUDIT CHECKLIST

Site Impact:	SCORE
Soil:	
1. Organic matter such as compost is added to soils at least once per year.	
2. Non-organic fertilizers and pesticides are avoided to protect soil biology.	
3. Soils are not excessively cultivated or disturbed by such practices as rototilling and are not overly compacted by heavy machinery or cultivation when wet.	
4. Soils are protected from erosion by the use of mulches or cover crops.	
5. Gardens are strategically surrounded by trees or windbreaks to minimize soil erosion.	
6. Existing soils are improved and protected rather than importing soils from off-site.	
TOTAL	
Water:	
1. Soils have a high level of organic matter (more than 5%) to retain moisture.	
2. The landscape is contoured efficiently to deliver water to areas and plants that need it.	
3. Mulches are used to reduce moisture loss from soils through evaporation.	
4. Rain water is collected and stored for use on the landscape.	
5. Drought tolerant plants (including grasses and ground covers) are used in dry areas of the landscape.	
6. Plants are grouped together according to their water needs.	
7. Grey water is appropriately and safely used in the landscape.	
8. Water taps and hoses are inspected on a regular basis to ensure there are no leaks, dripping or cracks resulting in unnecessary water loss.	
9. Trees, shrubs and vines are sited appropriately to provide a cooling	

effect to the garden in summer by maximizing shading and minimizing evapotranspiration.	
<u>TOTAL</u>	
<u>Waste:</u>	
1. Waste materials from construction are minimized and are absorbed/utilized on-site or recycled whenever possible.	
2. Composting of all appropriate garden waste takes place within the landscape and finished compost is incorporated back into the soil.	
3. No toxic or otherwise harmful chemicals (i.e. pesticides, herbicides, synthetic fertilizers) are required or used within the landscape and the landscape does not leech any harmful substances into the surrounding environment.	
4. Leaf litter and grass clippings are left on the ground wherever possible.	
6. A waste audit has been completed to identify the types and quantities of waste, and the disposal costs generated from the community gardens.	
<u>TOTAL:</u>	
<u>Plant Biodiversity:</u>	
1. Garden plants are a diverse number of species including many native species.	
2. Selected plants are well adapted to the local climate and geography, require few if any external “in-puts”, and are appropriately sited in the landscape.	
3. Micro climates (i.e. warm spots, wet spots, protected spots) are effectively used and/or created to extend the growing season.	
4. Plants for attracting beneficial insects (i.e. pollinators and pest predators) are dispersed throughout the landscape.	
5. Plants that perform a soil-building function (i.e. nitrogen fixation, green manures, compost crops) are integrated into the landscape.	
6. Additional features to support bio-diversity such as leaf-littered areas,	

6. Additional features to support bio-diversity such as leaf-littered areas, "wild areas", downed logs," snags", water sources are integrated into the landscape.	
7. Seed-saving is encouraged through workshops, information resources and website discussion.	
<u>TOTAL:</u>	

1 - Not true at all
2 - Somewhat true

3. - Very true
4. - Completely true

Score Totals:

0 - 20: Very Low: landscape may be having a very negative environmental impact.
20 - 40: Somewhat Low: there are many positive changes you could still consider
40 - 60: Good: heading in the right direction – keep moving forward.
60 - 80: Very Good: A few areas need review.
80- Greater than 100: Excellent. Sustainable garden practices have been implemented.

Comparative Community Garden Questionnaire:

- 1) How long has the program been running in your community?
- 2) How many plots do you have in your community?
- 3) How is each garden managed? by one administrator, volunteers, city employees etc?
 - a. Why was this management style chosen?
- 4) What role does your municipality play in maintaining, watering, and managing your community gardens?
- 5) How much does it cost to rent a plot for the season?
- 6) How many employees do you have working for the Gardens? (Seasonal and full-time)
- 7) What are the roles of the individual gardeners in terms of maintenance?
- 8) What is your policy on fertilizers and pesticides?
 - a. Is there anything controlling their use by individuals?
- 9) What are typical tilling practices for your community gardens?
 - a. Why was this method decided on?
 - b. Who's responsibility is the tilling (individuals or organization?)
- 10) How do you supply water to the community gardens? (Is water sourced from wells, rain barrels, hoses, groundwater etc?)
 - a. Why was this method of watering chosen?
- 11) What types of irrigation do you use in the gardens? Drip, hand watering, clay pot?
 - a. Why was this method of water irrigation chosen?
- 12) Have you ever conducted any type of audit, checklist or best practice research to assess the environmental impact of the gardens?
- 13) Do you measure the water usage, fertilizer use, energy inputs such as gasoline, etc. on a regular basis? If so, what are your key measures?
- 14) If so, would you be able to forward any of this information for our project?

- 15) What do you feel are the main strengths of your community gardens and operations? Why?
- 16) Do you have any other comments, recommendations or documents regarding the management, maintenance or watering of community gardens that you could expand on?

Community Garden Questionnaire Results:

5.1 Hamilton:

- 1) Garden in Dundas has been running for over 20 years. Churchill not as long and our third garden will start up this year.
- 2) City Of Hamilton Community Gardens will have 142 plots this year. There are several other gardens run by different group. I am not sure their Plot #'s
- 3) The 3 Gardens the City runs are supported through user fees
- 4) n/a
- 5) Dundas \$27.43 or \$38.40
Churchill Park \$87.78
Victoria Pak \$19.38 or \$80.58
- 6) The Business Initiatives Coordinator organizes the administration of the gardens as part of ongoing duties and the Horticulture staff prepare the sites in the spring and fall clean-up as required.
- 7) Look after their own plots.
- 8) No Chemical pesticides allowed.
- 9) We till in the spring and fall.
- 10) Water is available; gardeners water their plots themselves. Churchill has an automatic sprinkler system.
- 11) N/A
- 12) N/A
- 13) N/A
- 14) N/A
- 15) N/A
- 16) I can only speak to the 3 gardens the City Of Hamilton operates. There are several others within the community each taken care of differently.

5.2 Kingston:

- 1) Sunnyside Community Garden in Kingston Ontario: 4th year.
- 2) **Sunnyside** has 27 beds.
- 3) Sunnyside: consensus of its members, non-hierarchical.
- 4) n/a
- 5) 20\$
- 6) Zero
- 7) Responsible for all maintenance.
- 8) Organic fertilizer only, no pesticides.

- 9) Raised beds. No tilling.
- 10) Water tap courtesy of Utilities Kingston
- 11) N/A
- 12) N/A
- 13) N/A
- 14) N/A
- 15) N/A
- 16) No

5.3 Kinsbridge:

- 1) 2 years
- 2) Twelve
- 3) The Garden is managed by Centre staff, volunteers, schools, community groups and neighborhood residents.
 - a) This is a grass roots organizing initiative that was generated by resident in the neighborhood
- 4) They gave me permission to use the land. They will cut the grass around the garden perimeter
- 5) 25.00
- 6) 0.02 ft equivalent
- 7) Each individual is responsible for their own plot. Everyone participates in maintain the overall garden
- 8) Pesticide Free
 - a) Each other
- 9) We are only in our second year and this process is not formalized. The individuals will be tilling their plots when the weather permits
 - a) Beginning practices
 - b) Individuals with support from organization
- 10) Hoses, rain barrels
 - a) Only option available at the present time
- 11) Hand watering
 - a) First method available
- 12) Not at this time
- 13) Not at this time, gardens are at infancy stages
- 14) N/A
- 15) Yes, our garden is not a standard rectangular garden. It was designed by residents to be a place to gather, socialize and remove isolation barriers. There are benches to sit and relax, plants to attract birds and butterflies and an area to walk amongst the plots. It is located near three schools, which allows for various classes to participate in the garden.
- 16) No.

5.4 Windsor:

- 1) We are currently under construction.

- 2) 81
- 3) We are an all volunteer committee as part of the Windsor Garden Club, a 501(c)3 organization.
- a) The Town of Windsor was not able to provide management services.
- 4) The Town of Windsor does not maintain nor manage the community garden. The Town of Windsor acts as leasing agent for the property and to the Windsor Garden Club (WGC), and the WGC pays for water and insurance.
- 5) A small 4'x4' plot is \$30/year, a 4'x8' plot is \$50/year, however some plots are donated to needy families, and larger plots have negotiable fees for other not for profit organizations.
- 6) There are no employees, only volunteers. Being under construction, we do not have a set schedule at this time.
- 7) Gardeners are responsible for maintaining their individual plots so to not shade or extend into other garden or pathways.
- 8) Thus far, the policy is strictly for organic practices.
- a) Not at this time
- 9) All beds are raised planters, therefore no tilling at grade at this time.
- a) Partly aesthetic, partly to assist those with bad backs.
- b) Should the garden choose tilling practices in the future, such responsibility will be in the hands of the volunteers and coordinated by the Community Garden Committee.
- 10) All water at this time is provided by the municipality, which has been designed as a professionally laid out system using drip irrigation. Hoses will be supplemental. There are discussions regarding rainwater capturing systems, but there is not budget for consideration at this time.
- a) The site is a downtown site with no other practical options. Municipal was already accessible on site.
- 11) Drip irrigation set on an irrigation controller, with supplemental hand watering when needed.
- a) Optimizing water conservation and budgeting practices.
- 12) No, other than preliminary water budgeting based on irrigation design calculations.
- 13) Not in practice until build out is complete. At that time, we will be monitoring water usage, but have not set up other measuring policy. The property is "off grid", meaning all power to the irrigation controller and security lighting will be by a solar system.
- 14) Not at this time
- 15) We have been told that we are "cutting edge", because we are a non-governmental organization providing community members with a community garden. Local town governments manage all other countywide community gardens. We will also be one of the few with a pre-designed, professional irrigation system powered by solar.
- 16) We do not have sufficient data at this time.

5.5 University of Waterloo- School of Architecture:

- 1) 3 years
- 2) 1, it is communal
- 3) By two student volunteers
 - a) We were interested in starting a garden, and so made it happen, no one else has stepped up to take over as of yet.
- 4) The city of Cambridge is allowing us to use their land, and we are currently using water from the University building
- 5) N/A (ours is communal)
- 6) None
- 7) They can do as little or as much as they wish
- 8) We have no official policy, however since it is communal, it would be discussed before anything would be used.
 - a) Group discussion
- 9) Initially we used a rototiller, majority now by hand
 - a) Rototilling because we needed a quick method, by hand now, because a lot of the garden is perennial – don't need to do a lot of tilling.
 - b) Both (since it's communal)
- 10) Mostly city water, sourced through the University of Waterloo, 200' hose
- We have a few rain barrels as well, although we haven't got the system set up to collect from a roof yet...
 - a) Easiest
- 11) Hand watering
- 12) No
- 13) No
- 14) No
- 15) Best part about the garden is that it has created a place of exchange between the school community and the community at large
- 16) N/A

5.6 Sarnia:

- 1) 35 years
- 2) 52 plots
- 3) City of Sarnia
 - a) Continuity of services and enforcement of rules.
- 4) Gardens are tilled each spring and fall. Water is available and compost is delivered every year.
- 5) \$30.00. Four plots are left open for non-profit organizations growing for food banks and those in need. There is no charge for these plots.
- 6) Mostly the work of 3 summer students and 1 full-time staff. We basically maintain the grass in between the two rows of plots and monitor the garden plots for weeds and those on the ends tend to extend their gardens when they can. They plots are 20' x 20'.

7) They are to keep their plots free of weeds, garden tools must be supplied by gardeners, and plots are limited on a basis of one plot per family. The plots must be cleared completely of all plant top growth by the end of October in order for us to till the ground. Failure to comply will result first, in a letter of warning: if the situation is not corrected, rights of plot will be forfeited.

8) No pesticides

9) Tiller run by PTO from small Kubota tractor in spring and fall.

a) Easiest for us to transport on a trailer to the two different sites.

b) The plot owners sometimes bring their own in if they aren't able to plant their gardens right away and the soil settles.

10) Hoses (city water)

11) Hand watering. Depending on the usage that day, some will hook up a sprinkler.

a) Has been in place for 35 years

12) No

13) No

14) No

15) The gardens provide a great place for those that live in apartments, those who are retired and people that have small lots and are not able to garden in their back yards. It's a meeting ground for people that enjoy the outdoors and still want to be connected to the earth by providing for themselves and others. They love to share their rewards with family and friends. The people take great pride in their gardening efforts and are rewarded greatly for them. I have spoken to many of the older people that garden and they are grateful to continue their work in the gardens. Many of them have gone into apartments from farms and more rural spaces. We're seeing more young people renting them as well.

16) No

5.7 York Region:

1) Since 1994

2) 3 different communities in York region

3) Coordinator and charity staff

4) Varies- in charge of tilling, provide water and maintenance to the water lines

5) Free- they are mainly a charity for hunger

6) 1 Katimavik volunteer, 1 summer student- through funding

7) Planting, weeding, watering, harvesting

- Members also have to participate in community activities- open house, registration, closing day etc.

8) No strict guidelines

Participants are strongly encouraged not to

9) Town- does it at the beginning of the season

- Till for the first three years and then hope to not have to afterwards
- Two options- rents a router tiller for individuals or for those who cannot the city does it
- Don't recommend it

10) For New Market- barrels of rain water

- Taps and canisters at most gardens

11) Hand watering

12) No

13) No

14) N/A

15) Gardeners- social networking

16) Encourage gardeners to donate to the local food banks and charity

5.8 University of Western Ontario:

1) 1 year or so

2) For the last few years, we've organized the garden as one large communal plot.

3) The garden is managed by one volunteer administrator

a) The garden is a project of EnviroWestern, a group of UWO students. EnviroWestern's projects each have a "project team leader", who are also executive members of the organization.

4) None – although we get lots of help from the physical plant department at UWO. They provide us with water tanks, fill them with water from the river nearby, erected a fence, provided us with a garden shed, etc.

5) \$5; this includes seed purchases and equipment replacement

6) 0

7) Gardeners are responsible for keeping the shed and garden neat and maintaining the compost pile

8) So far we have only used compost and composted horse manure; organic fertilizers may be considered in the future

9) The garden is tilled once in the fall.

a) At a university, people tend to get very busy in around October and the supply of volunteers runs out. So far, the use of a rototiller has been the best option.

b) The project team leader, usually with some assistance

10) Previously it has been river water. That may change this year to groundwater.

a) We rely on what physical plant can supply.

11) Hand watering

12) No

13) No

14) No

15) It is great to be able to garden on campus and provide a space for people with no other gardening options. The garden has also been visited by classes focusing on sustainability, and brings people with similar interests together.

16) No