SPECIALTY CROP GREENBELT STUDY REPORT
FOR THE TOWN OF GRIMSBY

Prepared for: The Town of Grimsby

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October 28, 2016.

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1.0 INTRODUCTION

AgPlan Limited was retained by the Town of Grimsby in July, 2016 to complete a study and provide an independent opinion on specialty crops. The study was:

- to examine the agricultural characteristics of the designated *specialty crop area* within the Town of Grimsby objectively, that is, in a reasoned and reasonable way; and,
- to evaluate whether lands below (north) of the Niagara Escarpment can appropriately be removed from the *specialty crop area* designation.

In short, this study on the *specialty crop area* in the Town of Grimsby (Map 1) results because the Town wishes to remove two smaller areas below the Niagara Escarpment from the *specialty crop area* and has proposed an area to be added to the Greenbelt. These three areas are shown on Maps 2 through 6 as well as Map 8

For purposes of this study and report, specialty crops have been defined as fruit and vegetable production.

The following report sections predominantly describe physical characteristics as well as socio-cultural characteristics to demonstrate that the two smaller areas north of the Niagara Escarpment within Grimsby, which are designated as *specialty crop area*, have several limitations for the production of fruits and vegetables and can therefore reasonably be removed the designation.

MAP 1 STUDY LOCATION

2.0 POLICIES, GUIDELINES AND THEIR INTERPRETATION

All of policy from the provincial through to the local scales are governed by the definition of *specialty crop area* as outlined in the provincial policy statement (PPS, 2014) which is stated as follows:

> *Specialty crop area: means areas designated using guidelines developed by the Province, as amended from time to time. In these areas, specialty crops are predominantly grown such as tender fruits (peaches, cherries, plums), grapes, other fruit crops, vegetable crops, greenhouse crops, and crops from agriculturally developed organic soil, usually resulting from:*

a) soils that have suitability to produce specialty crops, or lands that are subject to special climatic conditions, or a combination of both;
b) farmers skilled in the production of specialty crops; and
c) a long-term investment of capital in areas such as crops, drainage, infrastructure and related facilities and services to produce, store, or process specialty crops.

The definition can be interpreted to mean that there are seven tests to be applied when designating *specialty crop areas*:

1. Current production of fruits and vegetables (land-based and/or in greenhouses) where,
2. greater than 50% of a given area is used for that production,
3. where soils are suitable (interpreted to mean have the potential for relatively high yields) for the production of those crops,
4. where climate conditions allow for fruit and vegetable production (and that climate is unusual in the context of the Province),
5. where the farm population has skills and experience in fruit and vegetable production, in addition to
6. where there is capital investment in infrastructure related to that specialty crop production and,
7. where there are facilities to produce, store or process specialty crops.

The PPS (2014) is mute with respect to how many of the seven tests need to be met in order to be able to designate a *specialty crop area* and does not provide any guidance with respect to the relative importance (weighting) of the seven characteristics. Additionally, the PPS (2014) provides no guidance with respect to a minimum size of area designated as *specialty crop area*.

3.0 METHODS

The findings, described in the following sections, result, for the most part, from an analysis of existing Statistics Canada and Ontario Ministry of Agriculture Food and Rural Affairs databases (OMAFRA). Mapping is based on Land Information Ontario (LIO) information. Soil potential for the production of fruits and vegetables is adapted from the Niagara Region soil survey (Kingston and Presant, 1989).

Several different methods have been used to characterize Grimsby, its farm operations and its agricultural land. The first principle method combined different layers of map information using a Geographic Information System (GIS). In general terms, GIS systems allow for an examination of spatial correlation amongst observed physical and sociocultural characteristics which, in the past, used to be accomplished with a manual technique called “sieve mapping” as described by McHarg (1969). In this Grimsby study, information on, soil series, agricultural land use and grape climatic zones were combined to identify the relative agricultural characteristics and value of different areas following a process outlined as a simple graphic in Figure 1. This information was subsequently subdivided using an additional layer of information on agricultural and non-agricultural designations to allow agricultural information to be subdivided into evaluation units that follow designation areas as outlined conceptually in Figure 2.

FIGURE 1   GIS MAP LAYERS SCHEMATIC

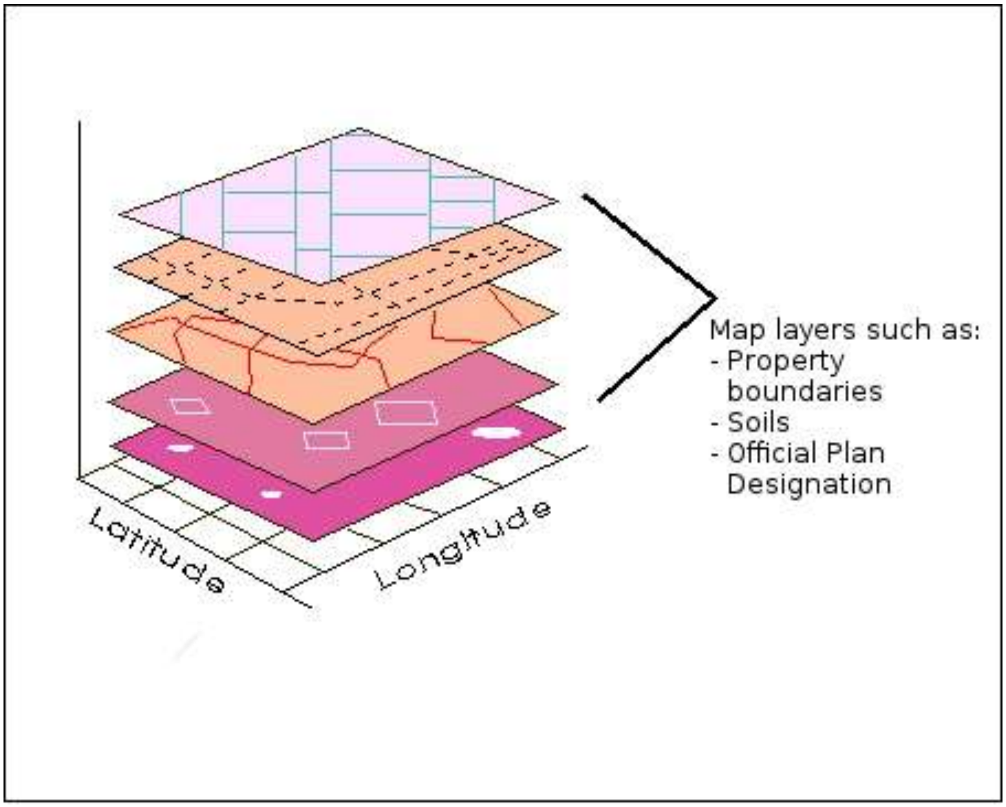
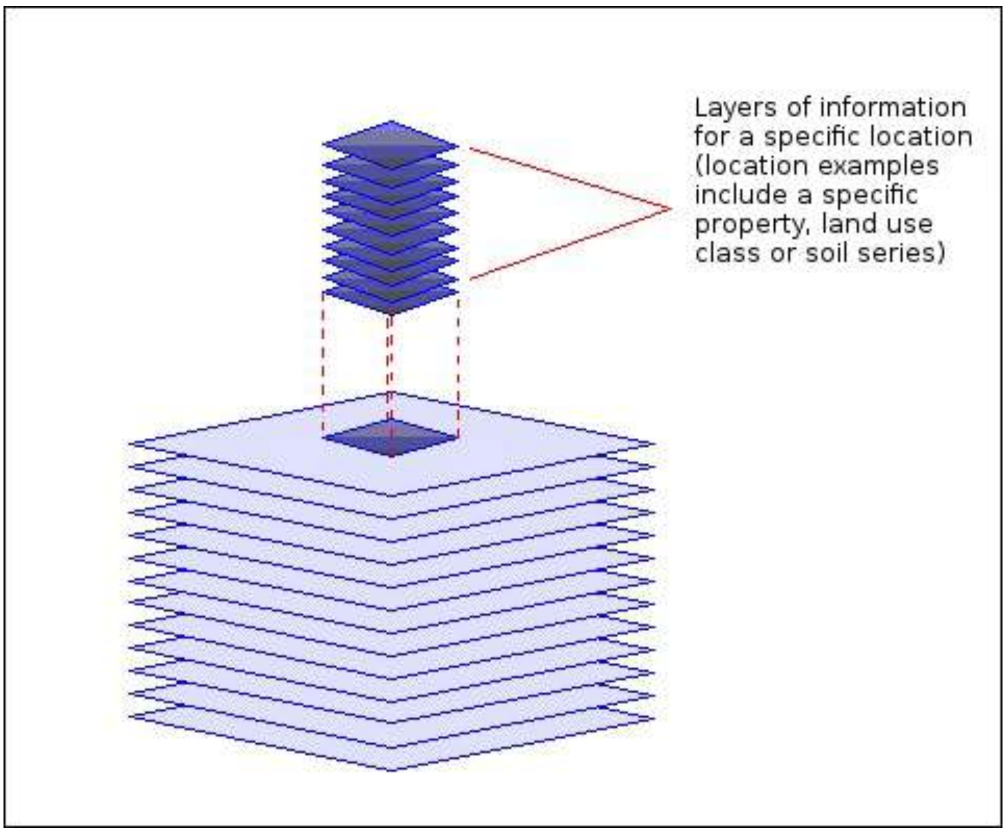


FIGURE 2   GIS SCHEMATIC SHOWING SUBSET RELATIONSHIP FOR A SPECIFIC AREA



The agricultural and designation information generated using GIS was then graphed to summarize the relative differences based on different designations and/or specific geographic locations.

In addition, single factor analysis as well as the use of multi-attribute data analysis was used to compare the agricultural performance of Grimsby relative to other sub-tier municipalities/townships in Niagara Region. The multi-attribute data analyses were completed using two methods; simple additive weighted, and concordance which are described in more detail in Appendix 5.

4.0 DISCUSSION OF AGRICULTURAL CHARACTERISTICS IN, AND INFLUENCING, GRIMSBY

4.1 Introduction

As described previously in the section on policy, the PPS (2014) can be interpreted to provide seven tests for the identification of *specialty crop areas*. Based on those seven tests, the following questions were used to guide the analyses and to subsequently put the Specialty Crop Area within Grimsby in context.

1. What are the predominant crops grown in Grimsby and Niagara?
2. Of the specialty crops (fruits and vegetables) grown in Grimsby and Niagara, which of those are predominant?
3. Are the specialty crops grown in Grimsby similar to those grown in Niagara?
4. Have the number of farms producing fruits and vegetable crops as well as the absolute and relative amount of specialty crop production area in Grimsby and Niagara changed over time?
5. Are there other areas in southern Ontario which produce more and a broader cross-section of fruits and vegetables than does Niagara Region and Grimsby?
6. How is specialty crop production distributed geographically within Grimsby and within Niagara?
7. What is the soil capability of Grimsby and Grimsby's specialty crop area?
8. What is the soil potential of Grimsby and Grimsby's specialty crop area?
9. What are the climate characteristics of Grimsby and Niagara in the context of southern Ontario?
10. Is there evidence that Grimsby provides specific agricultural economic characteristics that would benefit farmers producing fruits and vegetables relative to other parts of Niagara Region and the Province of Ontario?
11. Are there sociocultural characteristics within Grimsby that provide incentives/disincentives related to the production of fruit and vegetable crops?

These questions will be repeated as an introduction in the following subsections of the findings summarized within this report. Additionally, the report uses 4 phrases which are defined as follows:

- **Soil Capability Class** - This term is the one most often used in rating agricultural soils and is defined as part of the Canada Land Inventory Soil Capability Classification for Agriculture - Soil Capability for Common Field Crops. It is an interpretive classification of the soils maps produced within Canada where soils are identified by texture, drainage class, layers (diagnostic horizons) etc. following the Canadian System of Soil Classification (1978, third edition 1989 http://sis.agr.gc.ca/cansis/references/1998sc_a.html). The soil capability rating is a seven-class system consisting of a class number (1 (best) – 7 (poorest)) and a subclass limitation component such as stoniness, slope or erosion (represented by an alphabetic code P, T, E, etc.). The best soils with no limitations for production of common field crops are ranked as class I and soils unsuitable for agriculture are rated as class 7. This information concerning capability classes and subclass limitations is provided as part of the relational database included with the soil mapping digitized by OMAFRA and provided by Land Information Ontario (LIO).

- **Soil Productivity Index** - The original soil capability classification classes one through seven have been converted from an ordinal to a ratio scale based on crop yields. For common field crops, such as grain corn, oats and barley, a relationship was measured to demonstrate that if class I land was assigned the soil productivity index value 1.00, then class 2 would be 0.80 and class 3 would be 0.64 etc. The use of the ratio scale allows for a mathematically acceptable measurement of mean value. Therefore, a given study area can have a single average value of a soil productivity index. When comparing different site alternatives, the use of the soil productivity index allows comparison of the alternatives using a single value. The use of the soil productivity index also provides a way to deal with soil complexes - where a soil complex is represented by a single polygon (in the past this was called a map unit) where there are two or more soil series/types present and mapped and where there is some likelihood to be a combination of soil capability classes such as 60% class I and 40% class 2T, for example.
- **Soil Potential Index** - Like the aforementioned Soil Productivity Index, the Soil Potential Index provides an "average" (single value) soil potential for agricultural production for a given area when that area contains more than one soil potential rank or rating. The Soil Potential Index is based on ranks which are part of an ordinal scale and provide a potential rating for the production of fruit and vegetable crops.
- **Agricultural Performance** - Agricultural performance is a single relative comparative measure that combines many agricultural characteristics of a given area in comparison to another given area (for example, one Region or County relative to another Region or County). The scoring, ranking or relative difference is quantitative. Agricultural performance includes economic, socio-cultural and physical variables and is described in more detail in Appendix 5.

4.2 General Context, Grimsby Niagara Region and Southern Ontario

What are the predominant crops grown in Grimsby and Niagara?

Niagara Region and Grimsby produce a broad range of agricultural crops. The predominant crops (based on area), that are grown in Grimsby and Niagara, are forage crops (alfalfa and alfalfa mixtures, tame hay and fodder) and common field crops (soybeans, corn and wheat). Fruit and vegetable crops account for 15% and 0.5% percent, respectively, of census farm area reported in Grimsby for the census year

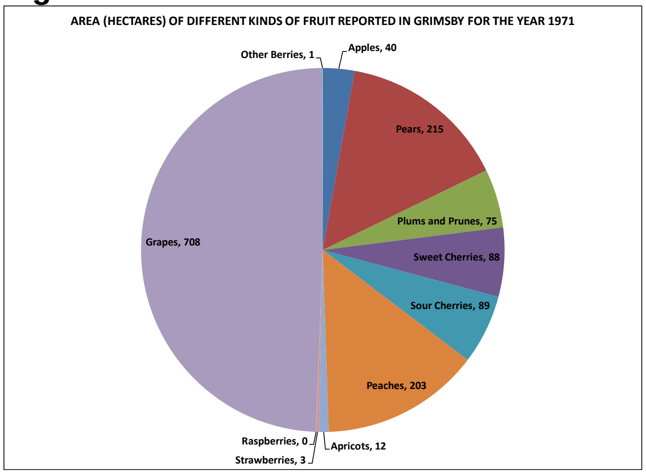
2011. For Niagara Region, fruit production is found on 12% and vegetable production (excluding greenhouse vegetable production) on 8% of census farm area in 2011.

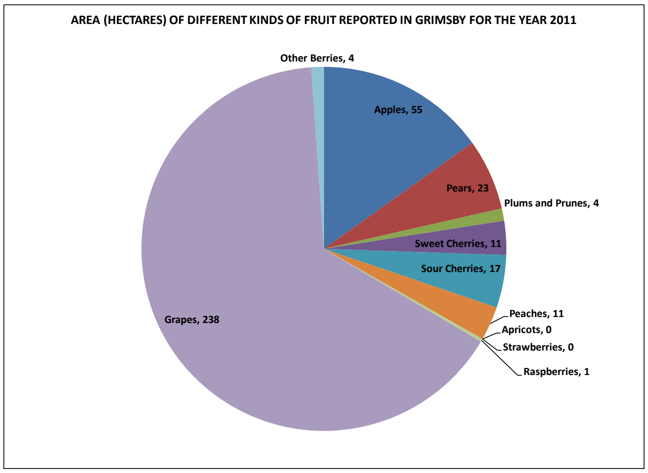
Of the specialty crops (fruits and vegetables) grown in Grimsby and Niagara, which of those are predominant?

Fruit and vegetable production in Niagara Region and in the Town of Grimsby is unequal given that vegetable production accounts for only 6% of the total specialty crop (fruit and vegetable) area in Niagara in 2011. In Grimsby, vegetable production represented 3% of the total area reported producing specialty crops in 2011. The predominant vegetable crop in Niagara was sweet corn in 2011 and the relatively low levels of vegetable production in Grimsby and the resultant data suppression prevent a reasonable examination of vegetable crop predominance. Therefore, the following discussion relates to fruit production.

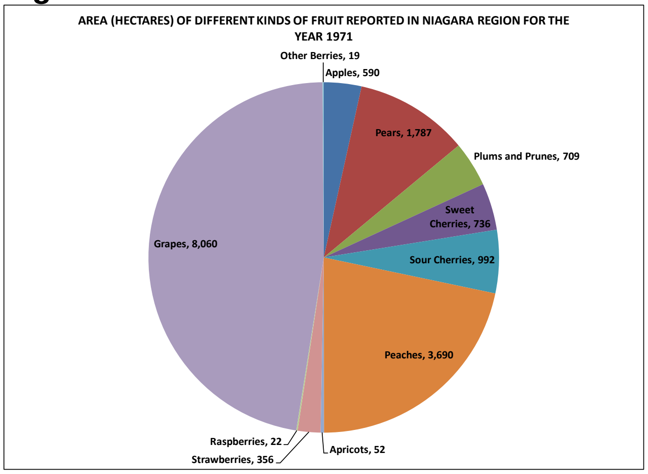
On an areal basis, grape production is predominant in both Grimsby and Niagara and that predominance has been present for over 30 years. Grape production area has increased from the census years 1971 to 2011 as summarized in Figures 3, 4, 5 and 6.

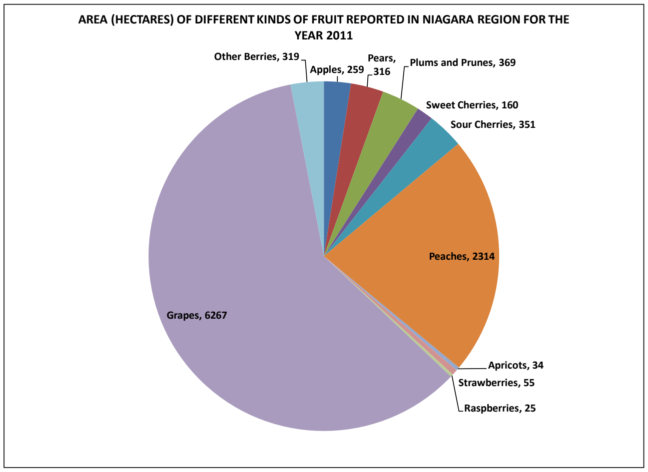
Figures 3 and 4





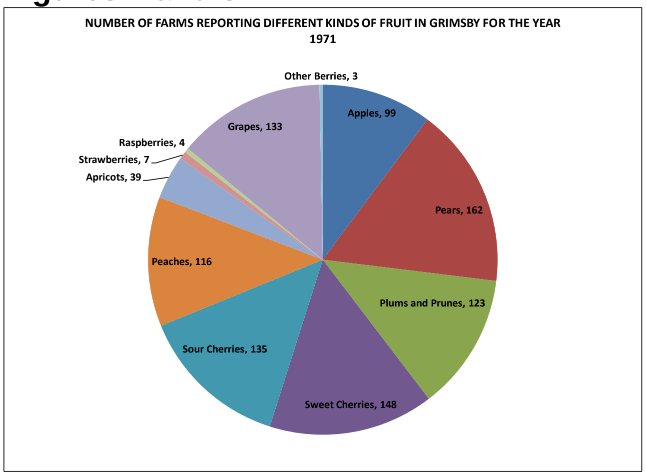
Figures 5 and 6

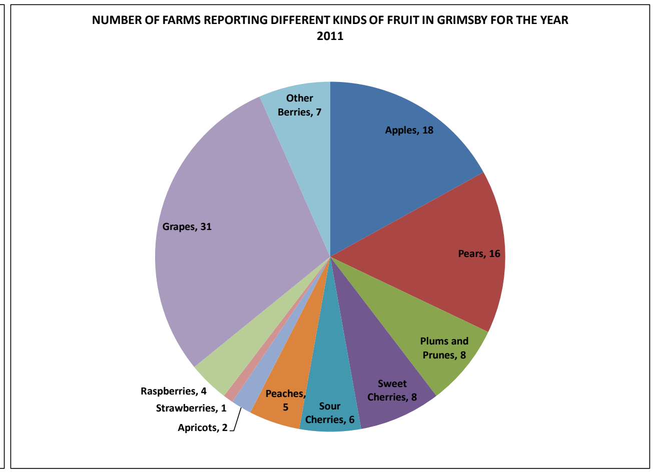




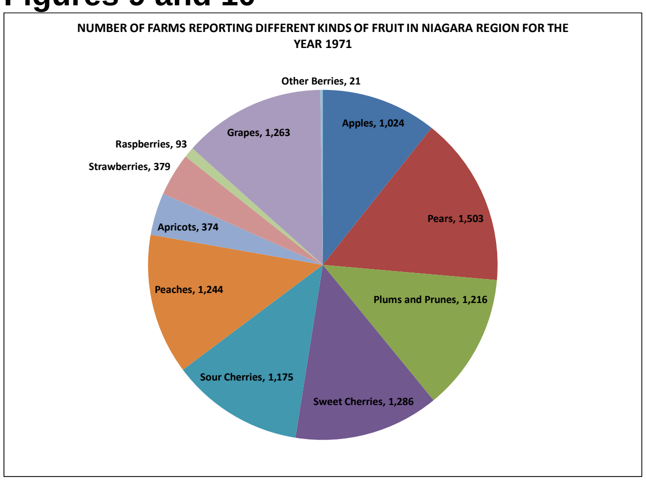
The number of farms reporting fruit production also indicates that more farms in 2011 report grape production than other fruit crops in both Grimsby as well as Niagara. However, in 1971, more farms were reporting sweet as well as sour cherry production than were reporting grapes in Grimsby. In 1971, in Niagara, more farms were reporting pears and sour cherries than were reporting grapes. Information on farms reporting different kinds of fruit production is summarized in Figures 7, 8, 9 and 10.

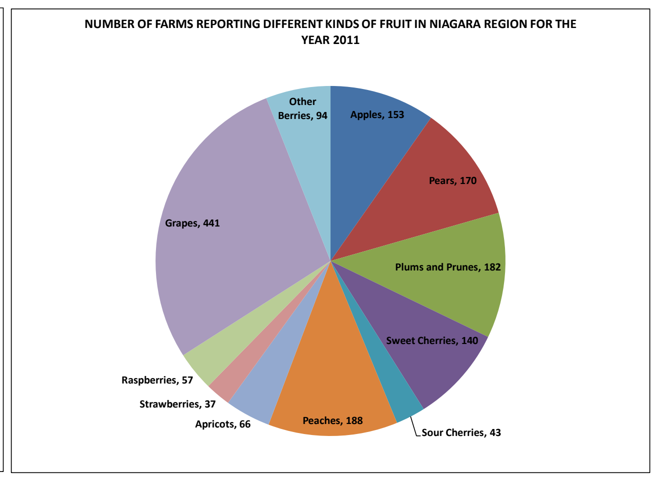
Figures 7 and 8





Figures 9 and 10



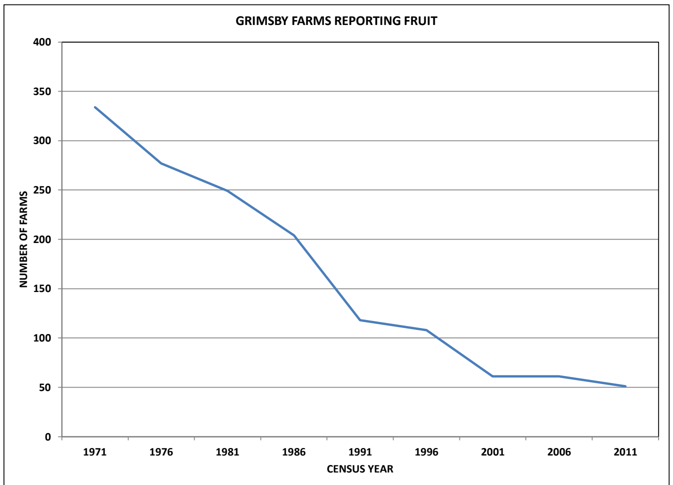


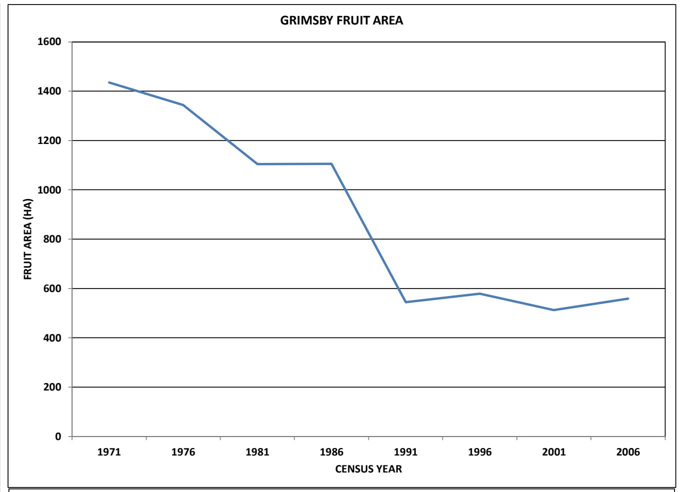
Are the specialty crops grown in Grimsby similar to those grown in Niagara?
A review of Figures 3 through 10 indicates that similar fruit and vegetable crops are grown in both Grimsby and Niagara. However, the relative area and the number of farms reporting different kinds of fruit and vegetable production vary over the past 30 years and between Niagara and Grimsby.

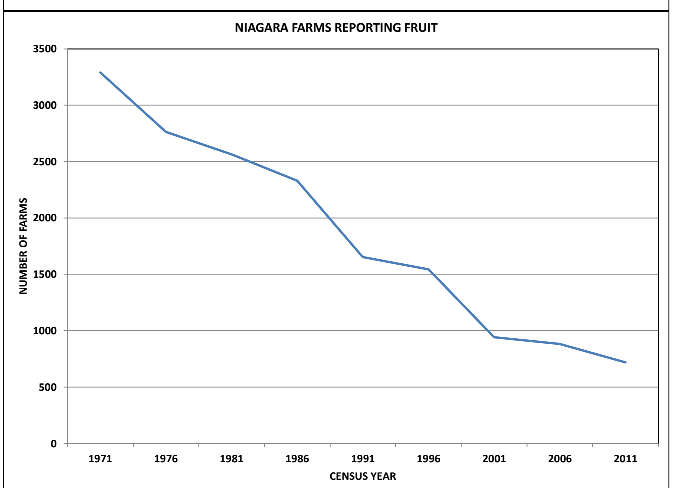
Have the number of farms producing fruits and vegetable crops as well as the absolute and relative amount of specialty crop production area in Grimsby and Niagara changed over time?
The area of fruit production and the number of farms reporting fruit production have diminished in both Grimsby and Niagara between 1971 and 2011. In Grimsby, approximately 340 farms reported fruit production in 1971 and by 2011 slightly over 50

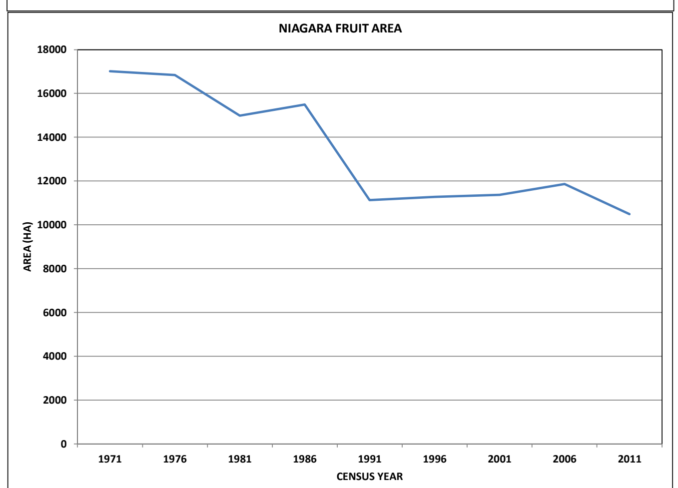
farms reported fruit production. Fruit area reported was above 1400 ha in 1971 and is just below 600 ha in 2011.

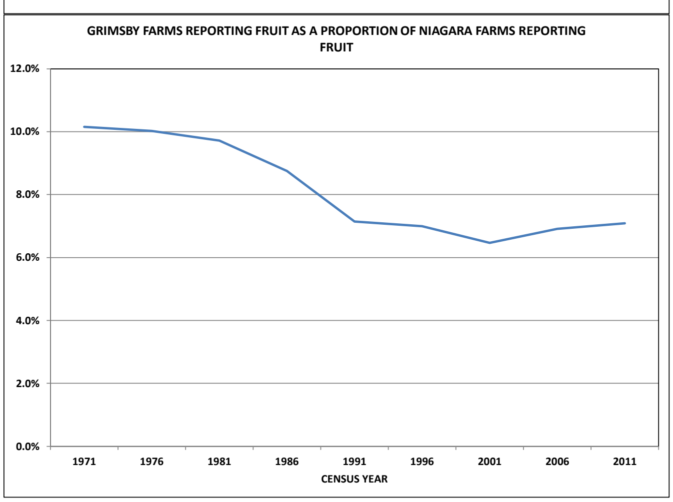
Figures 11, 12, 13, 14, 15 and 16

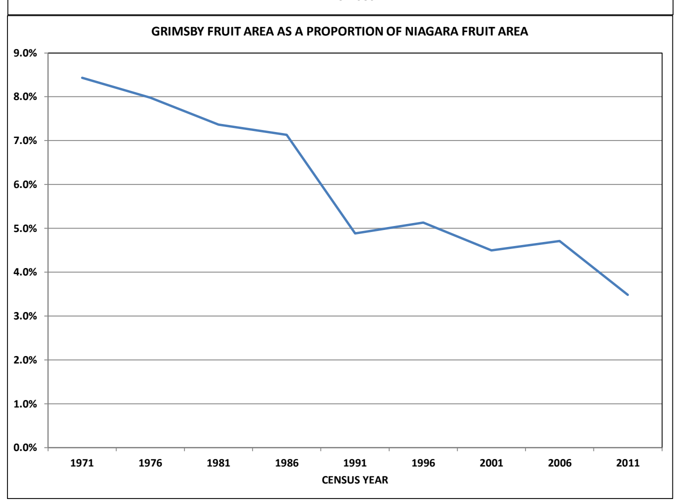










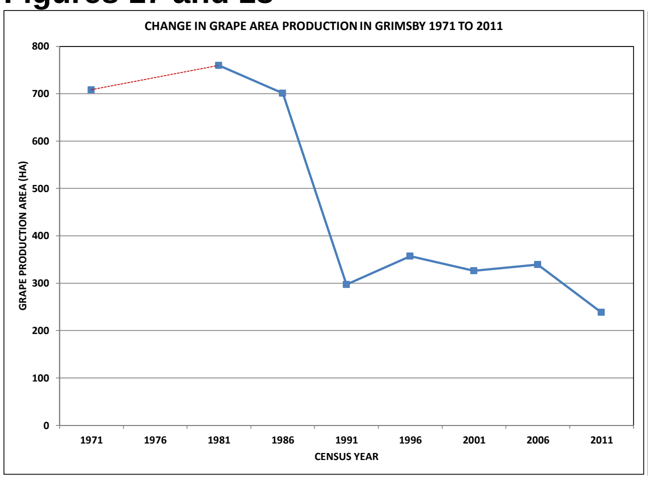


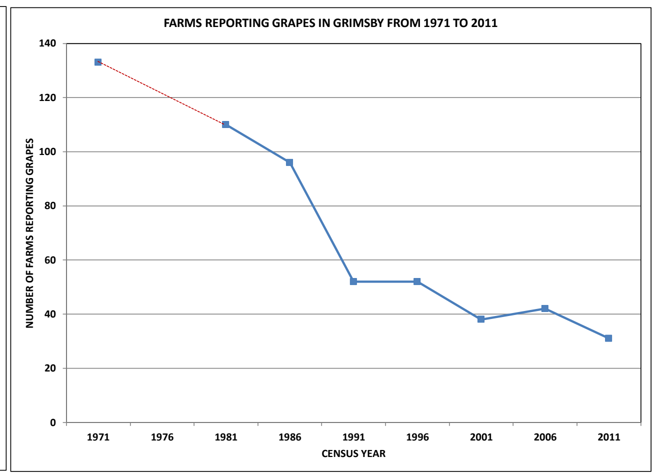
Approximately 3300 farms reported fruit production in 1971 in Niagara Region and by 2011 the number farms reporting fruit production had decreased to approximately 700.

Grimsby's number of farms reporting fruit production as a proportion of Niagara's fruit farms had decreased from 10% to approximately 7% from 1971 to 2011. Grimsby's proportion of Niagara's area in fruit production decreased from 8.5% to 3.5% from 1971 to 2011. Therefore, Grimsby's fruit farm number reduction and reducing area of production happened at a greater rate than that for Niagara. The data supporting the aforementioned farm number and area for fruit production are taken from Statistics Canada information and are summarized in Figures 11 to 16.

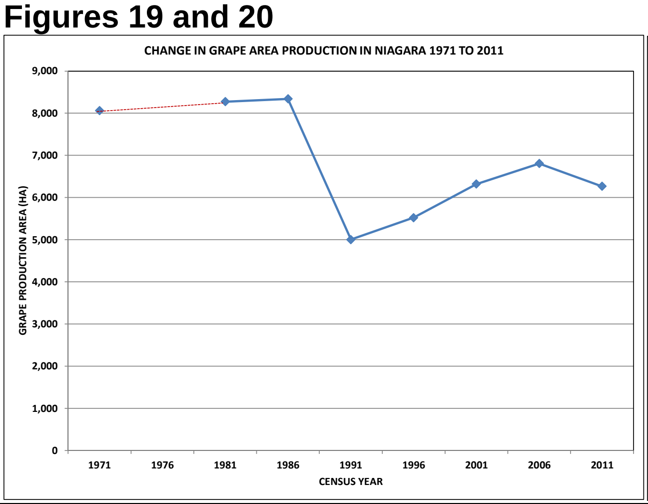
Because of the increasing importance of great production and wineries in Niagara, a separate analysis on great production has been completed. Figures 17 and 18 demonstrate a decline in area in grape production and the number of farms reporting grapes in Grimsby between 1971 and 2011. Niagara Region also shows a decline in grape area production as well as farms reporting grapes (Figures 19 and 20). The decline in grape area production is more marked in Grimsby than it is in Niagara. Grimsby's grape production area as a proportion of Niagara's grape production area is diminishing as summarized in Figure 21. The number of farms reporting grapes as a proportion of the Niagara farms reporting grapes is also diminishing as shown in Figure 22. Therefore, Grimsby's grape farm number reduction and reducing area of production happened at a greater rate than that for Niagara between 1971 and 2011.

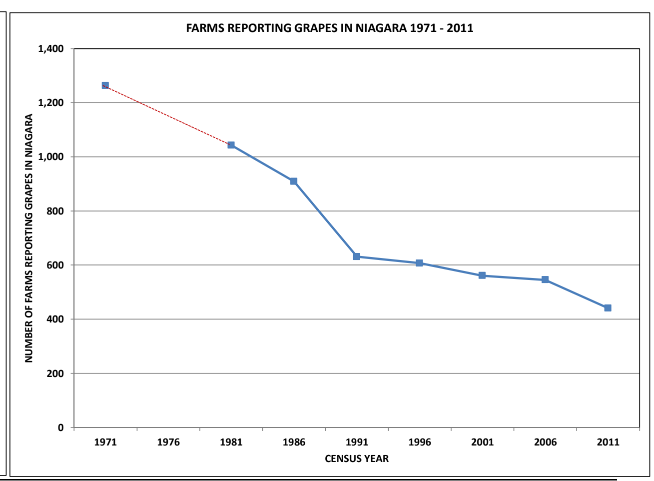
Figures 17 and 18



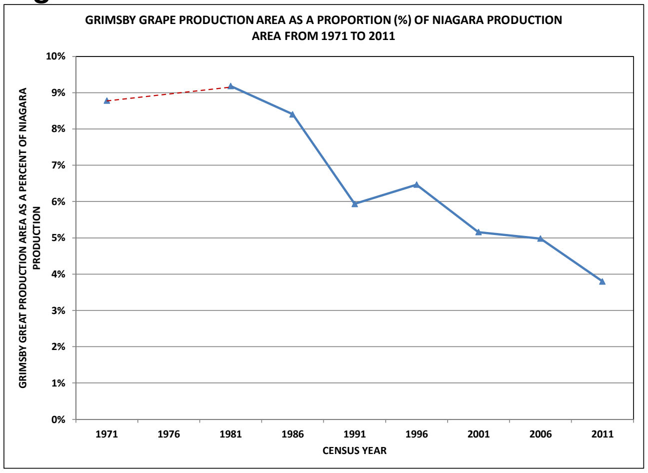


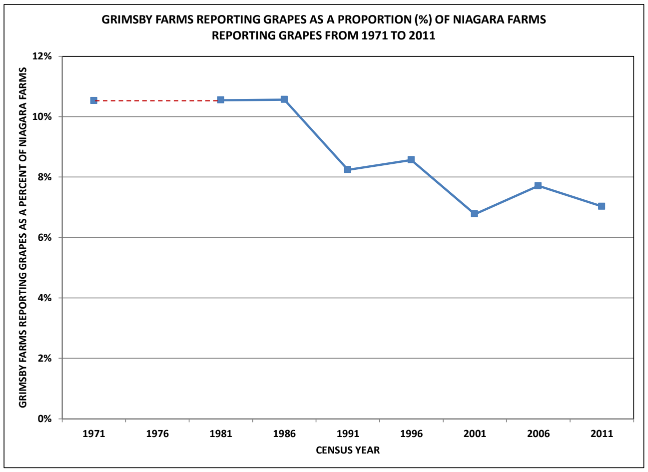
Figures 19 and 20





Figures 21 and 22



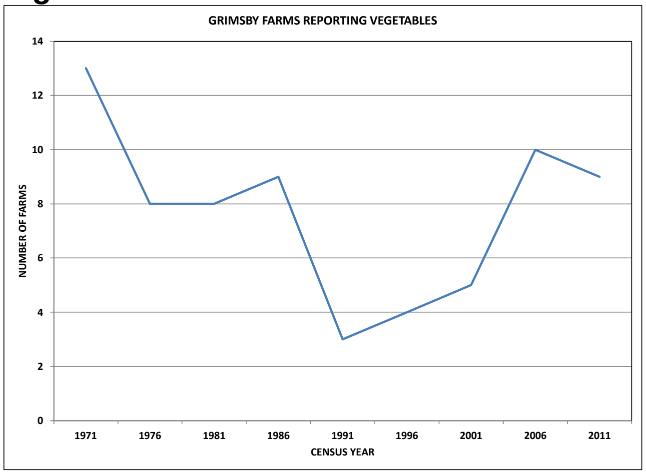


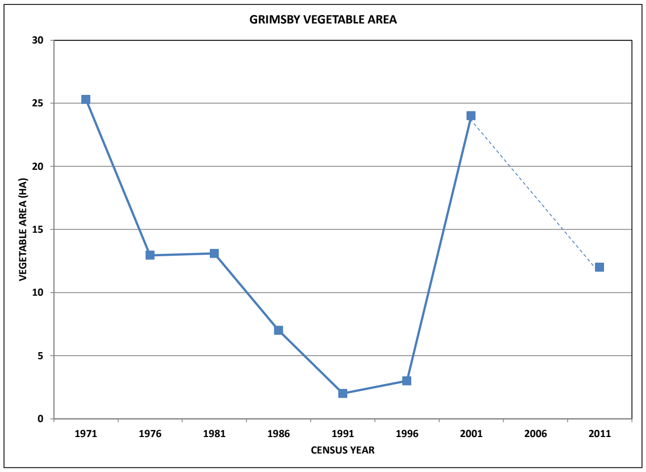
Vegetable production occurs less often than fruit production in both Grimsby and in Niagara. For example, in 1971, Grimsby had 13 farms reporting vegetable production and 334 reporting fruit production. In Niagara, in 1971, 516 farms reported vegetable production relative to approximately 3290 farms reporting fruit. With respect to area of specialty crop production, vegetable production area in Grimsby was 25 ha in 1971 and relative to 1435 ha of fruit production and in Niagara vegetable area was 885 ha relative to 17014 hectares of fruit production in 1971.

Grimsby has relatively few farms reporting vegetable production and, as a result, the actions of one or two farmers making decisions about the area to be planted can significantly affect the total area of vegetable production reported for Grimsby. As well, low farm numbers can result in data suppression for reasons of confidentiality and that occurred in 2006. Where data suppression has occurred, the line shown in the graph is dashed (Figure 24).

Vegetable production in Grimsby shows a relatively erratic pattern but there is a reduction in the number of farms reporting vegetable production and in the area of that production from 1971 to 2011 as shown in Figures 23 and 24.

Figures 23 and 24

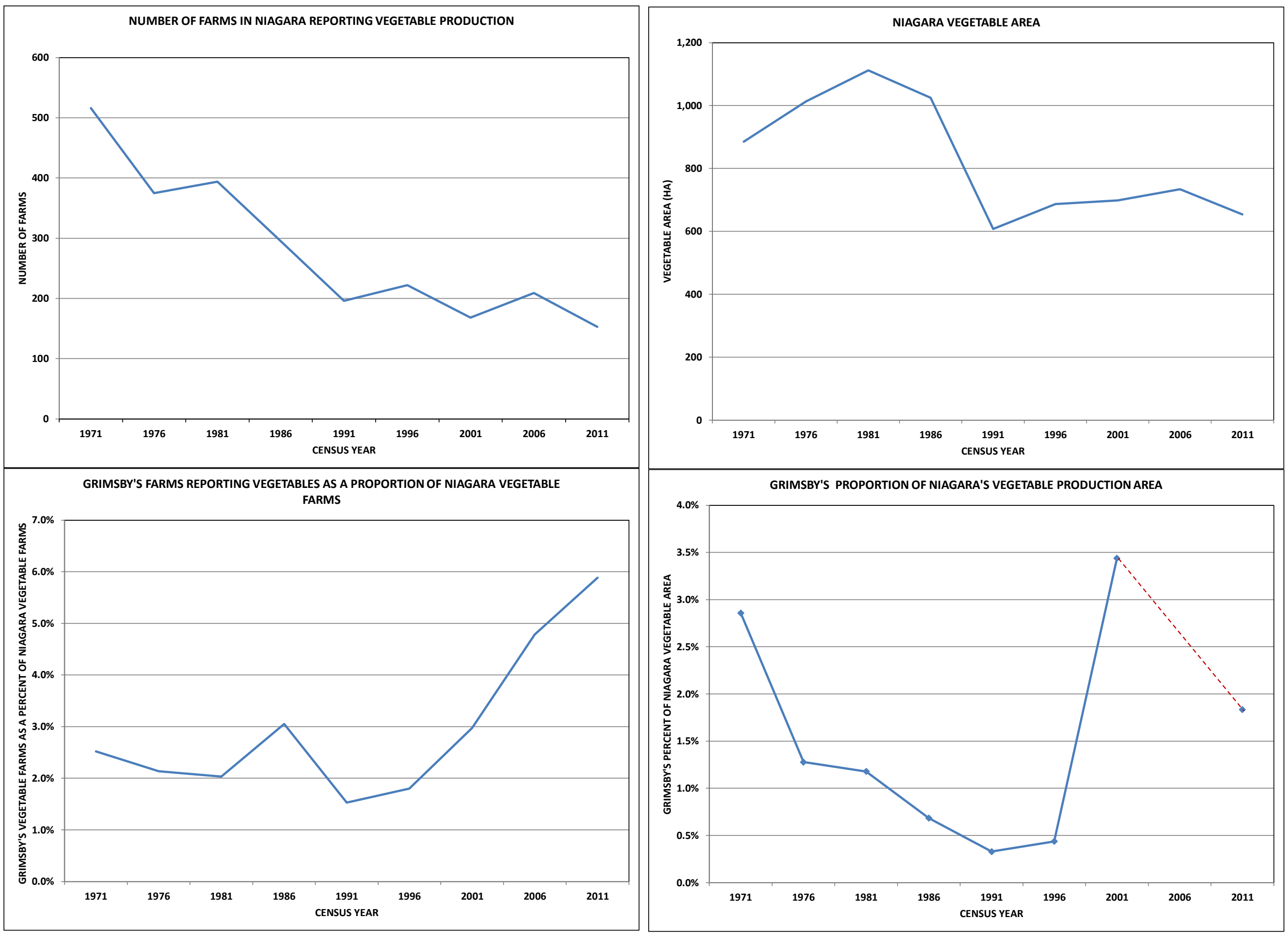




Niagara Region shows a distinct pattern where the number of farms reporting vegetable production has decreased from 516 in 1971 to 153 in 2011 (Figure 25). Vegetable production area in Niagara reached a high in 1981 of 1112 ha and diminished to 654 ha in 2011 (Figure 26).

Grimsby's farms reporting vegetables has increased as a proportion of Niagara's farms reporting vegetable production from approximately 2.5% to almost 6% between 1971 and 2011 (Figure 27). Grimsby's proportion of Niagara's vegetable production area decreased from 1971 to 1991 to a low less of than 0.5%, increased to 2001 and has decreased again in the last census year where information is available (2011) to less than 2% (Figure 28).

Figures 25, 26, 27 28



Vegetable production in Grimsby and Niagara is relatively low and is not as significant as production in other Regions/Counties. The level of significance of fruit versus vegetable production is discussed in the following.

Are there other areas in southern Ontario which produce more and a broader cross-section of fruits and vegetables than does Niagara Region and Grimsby?
Historically, Niagara can be differentiated from most of southern Ontario based on the amount of its tender fruit and grape production. Several analyses using 2011 census

data are outlined in the following in support of Niagara's importance for fruit production. An additive multi-attribute analysis of area of fruit production, as described in Appendix 4, supports this historical perspective. Figure 29 shows Niagara as having the highest standardized score when compared to other Regions/Counties in southern Ontario

If the area measurements are proportional to the total census farm area of each Region or County, then Niagara ranks as fourth as summarized in Figure 30. Where Niagara Region is clearly unique is in grape production, where greater than 80% of the production area for grapes is located as summarized in Figure 31.

With respect to area of vegetable production, Niagara is less important, ranking 11th when the data are proportional to total census farm area (Figure 32). When the proportion of Ontario's total vegetable production area is calculated, Niagara ranks as 13th producing 13% as summarized in Figure 33.

Figure 29

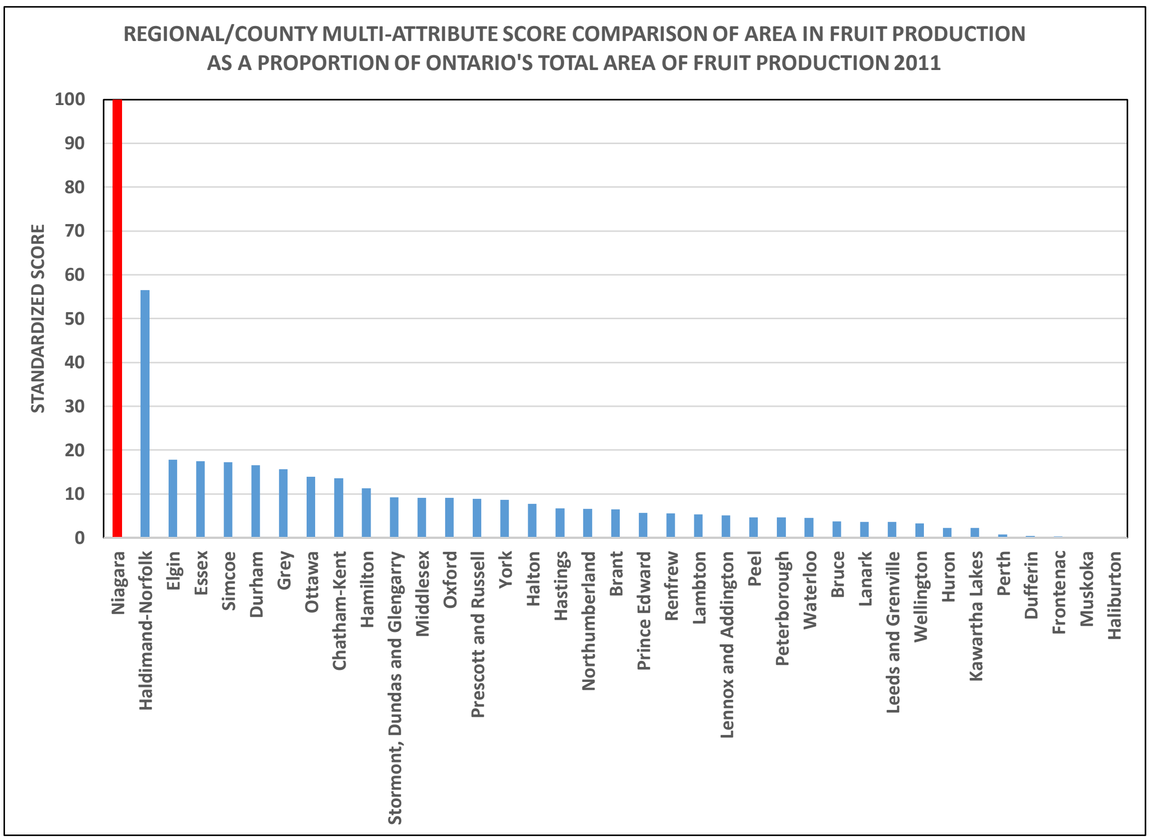


Figure 30

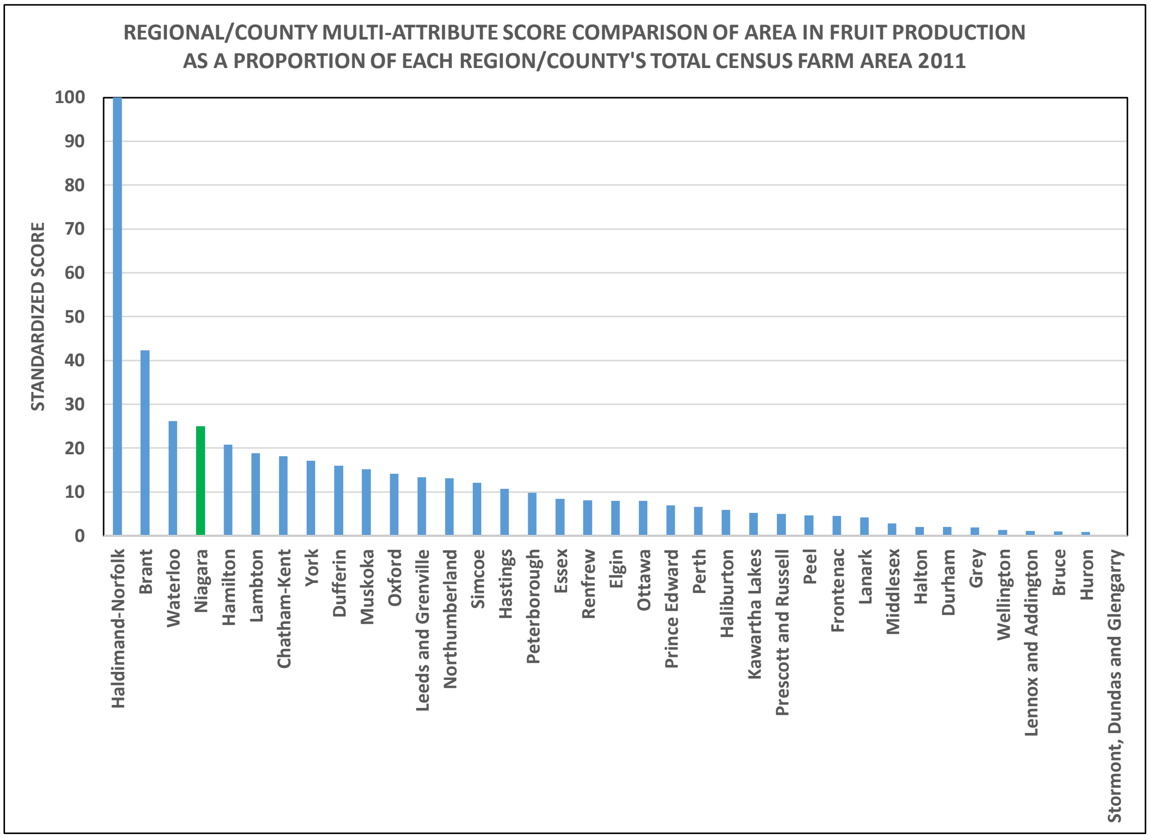


Figure 31

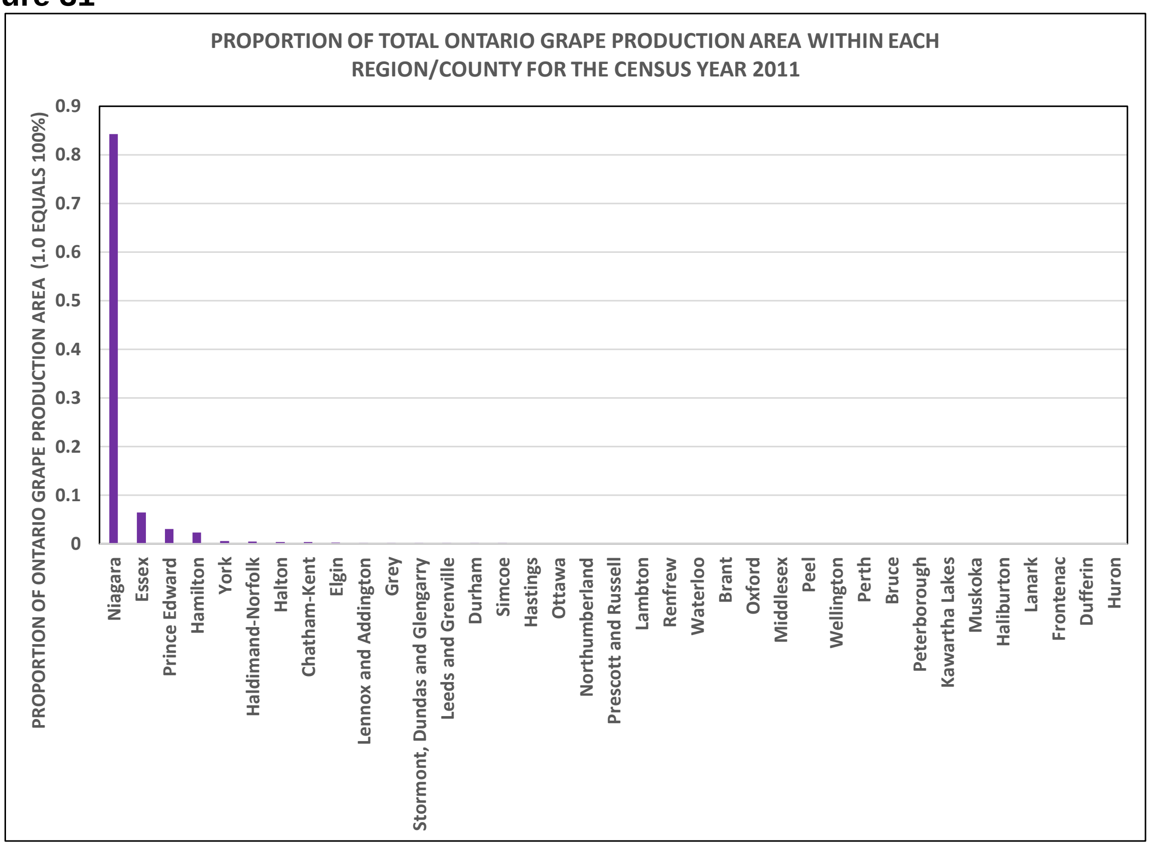


Figure 32

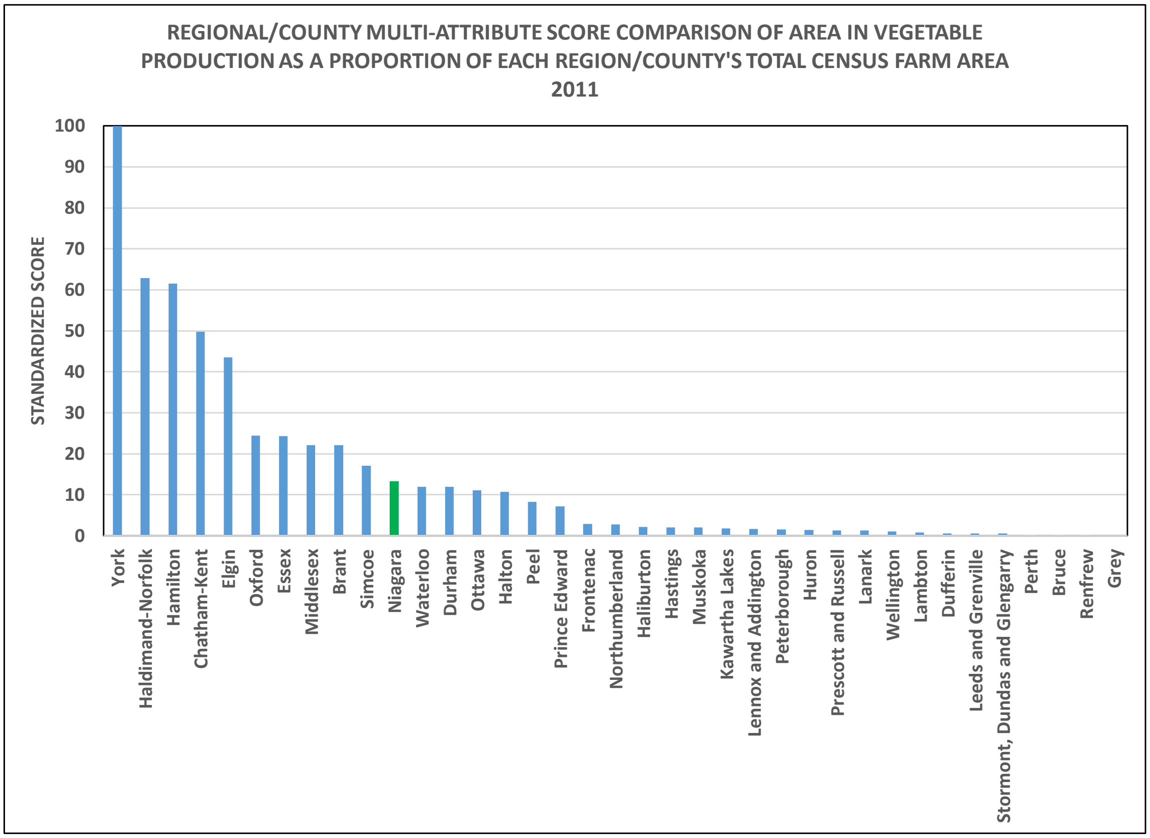
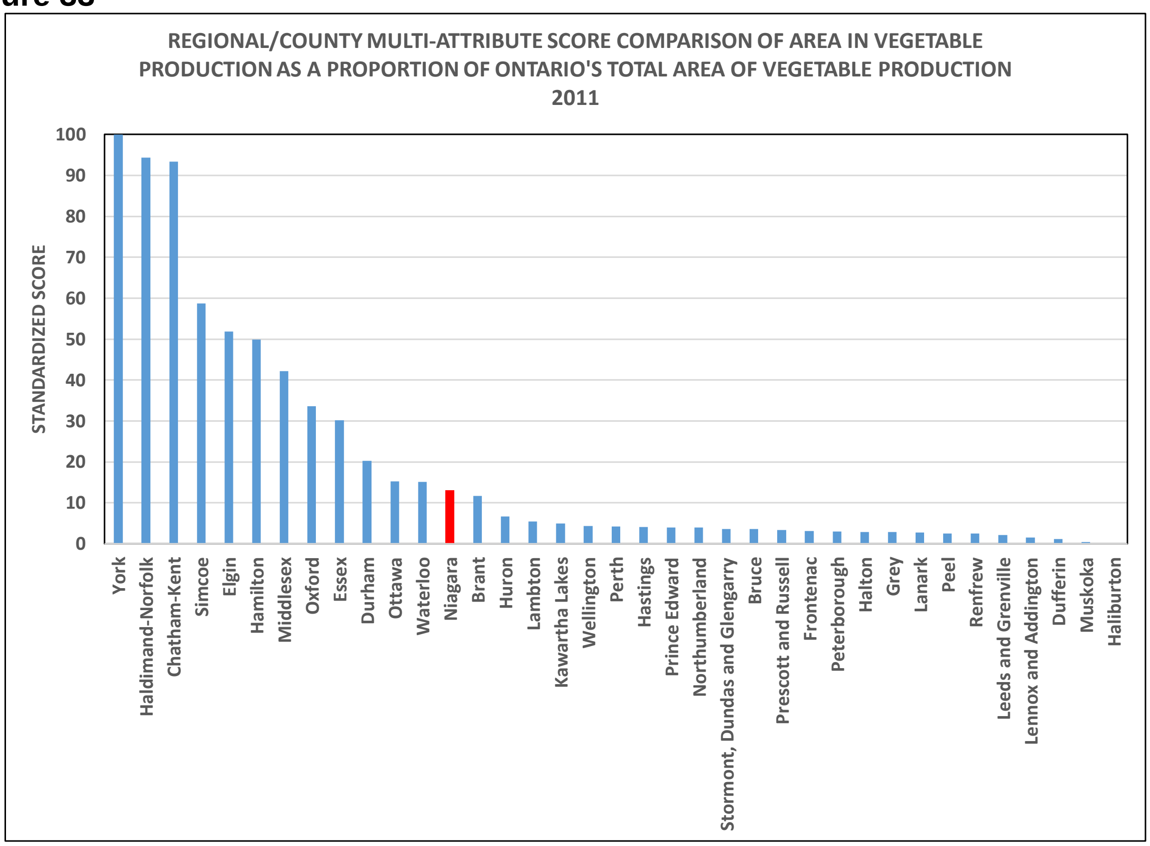


Figure 33



4.3 Agricultural Land Use

How is specialty crop production distributed geographically within Grimsby and within Niagara?

The previous sections of this report have outlined the absolute and proportional changes and/or relative ranking of Grimsby and Niagara with regards to fruit and vegetable production based on Census of Agriculture data. The following discussion will review the geographic distribution of specialty crop production within Grimsby based on a data set other than the census.

Agriculture and Agri-Food Canada (AAFC) produces agricultural land use maps for Canada and the portion of that mapping for Grimsby is presented as Map 2 within this report. The legend associated with the AAFC mapping is more extensive than that reproduced in Map 2. The generalization of the AAFC information was done primarily to differentiate specialty crops. Areas of nurseries were included in the following analysis because nurseries produce rootstock, vines and orchard tree stock in Niagara. However, nothing in the agriculture census or in the AAFC land-use information allows for the differentiation of specialty crop nursery stock versus landscaping stock.

The AAFC land-use mapping and subsequent area calculations are not comparable to the area values presented within the agricultural census. For example:

- the census differentiates dry field peas, chickpeas and green peas, whereas the AAFC has a single category labelled as peas;
- the census differentiates grain corn, silage corn and sweet corn, whereas the AAFC has a single category for corn;
- the census includes potatoes but groups them with field crops rather than as a vegetable and the AAFC has potatoes as a separate category;
- the AAFC has five vegetable categories including sugarbeets whereas the census as 26 vegetable categories providing area information with no category for sugarbeets;
- neither the AAFC nor the census differentiate between vinifera and labrusca grapes.

Regardless, the AAFC agricultural land use information can be used to compare production in different geographic areas within Grimsby. Therefore, measurement of vineyard area and area of fruits and vegetables based on Map 2 have been summarized for different planning area designations within Grimsby.

As summarized in Figure 34, the *specialty crop areas* one and two north of the Escarpment (the 2 areas that Grimsby proposes to be removed from the *specialty crop area* designation), have relatively small amounts of vineyards of 0.13 and 7.16 ha respectively. The highest amount of the vineyard area (greater than 50%) is present in the *specialty crop area* designation (outside of areas one and two). Similarly, relatively small amounts of berries, nursery, orchards, other fruits and vegetables are found in the specialty crop areas one and two (0.66 and 14.04 ha respectively). When a proportionate measure is made, as summarized in Figure 35, *specialty crop areas* one and two have less than 1% and slightly more than 4% of their total area in vineyards. When all vineyards fruits and vegetables areas are combined, *specialty crop areas* one and two have 1% and 13% of their total area in specialty crops. Interestingly, proportionately, more specialty crops are grown in the general agricultural designation as opposed to the *specialty crop area*.

Figure 34

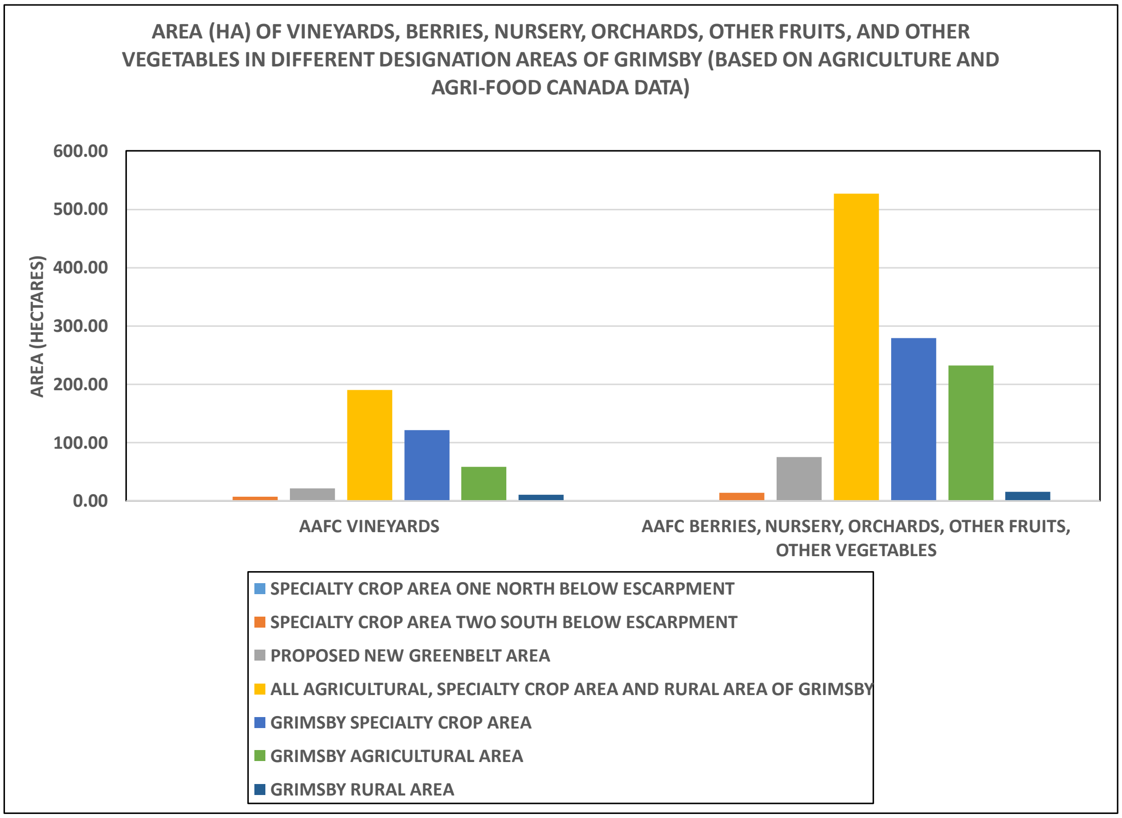
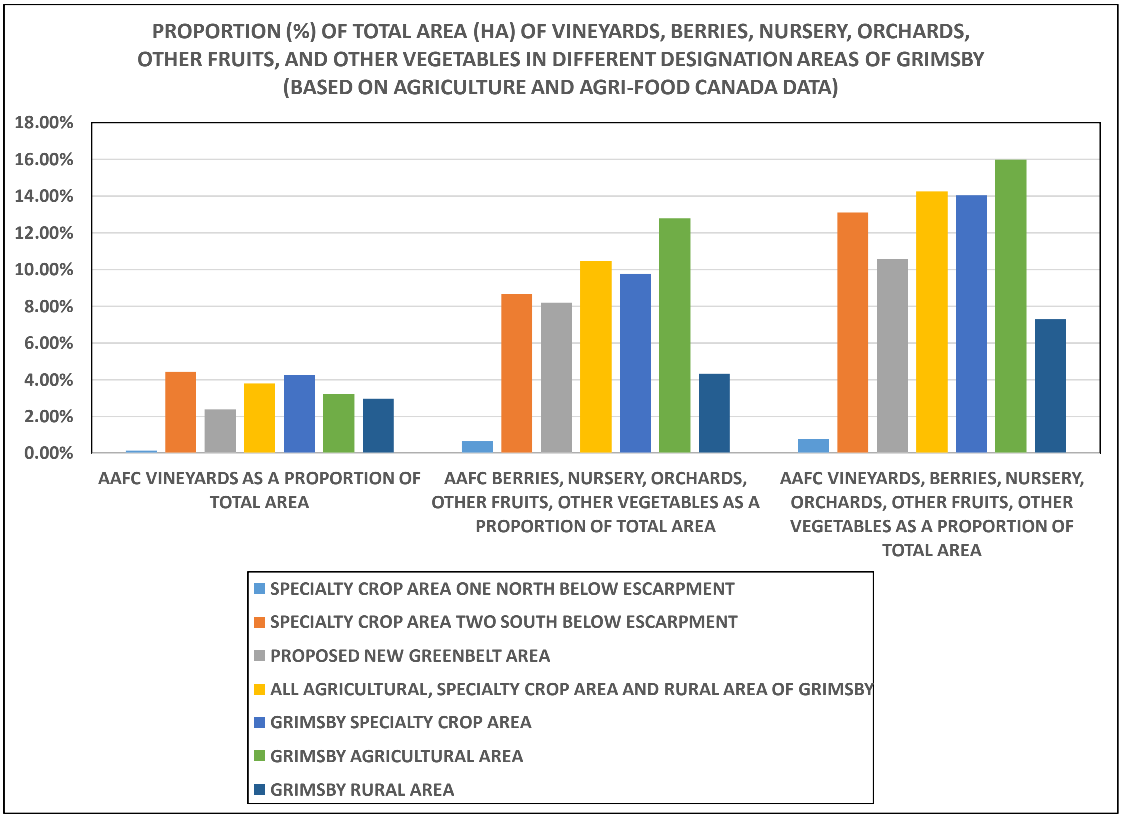
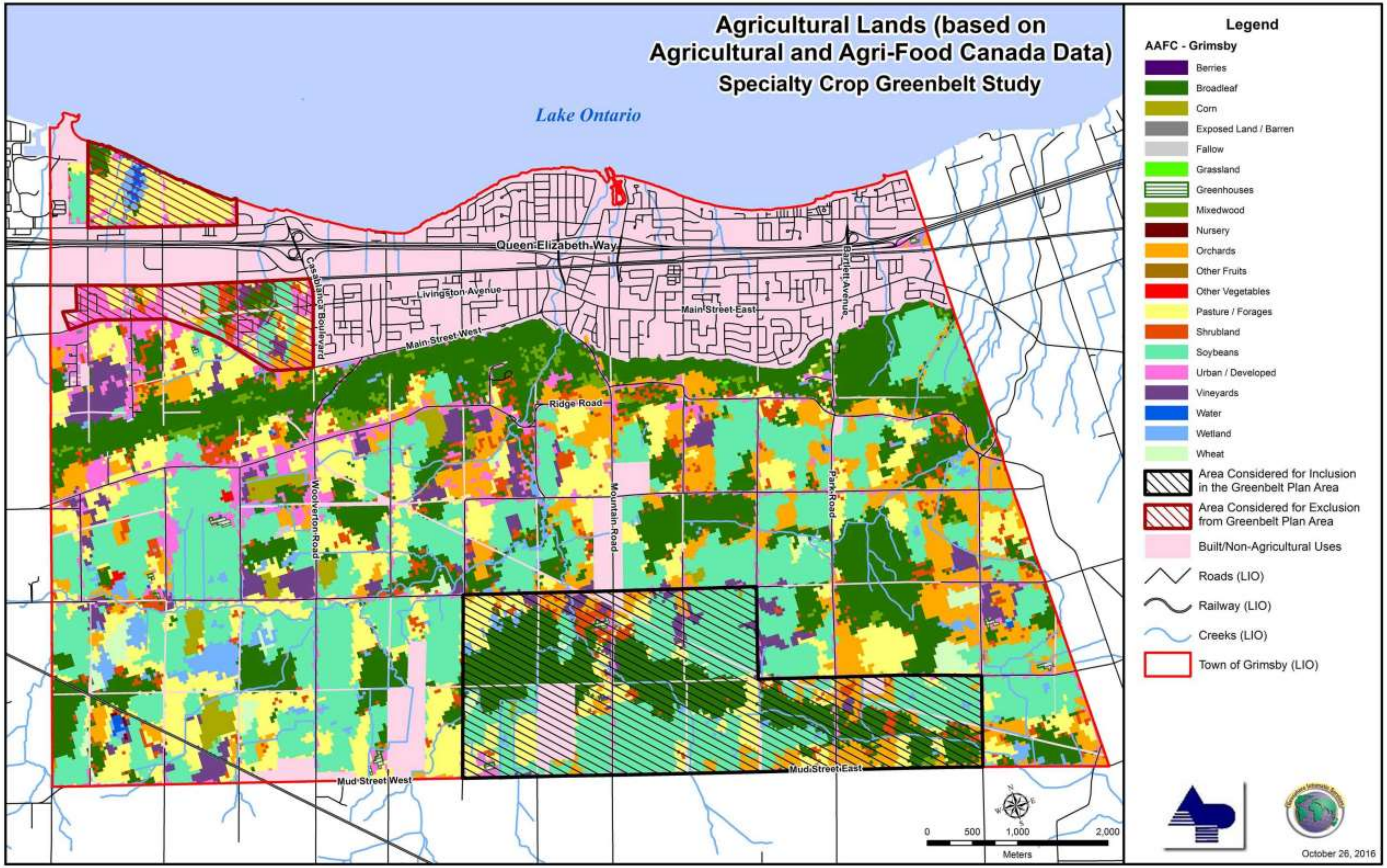


Figure 35



MAP 2

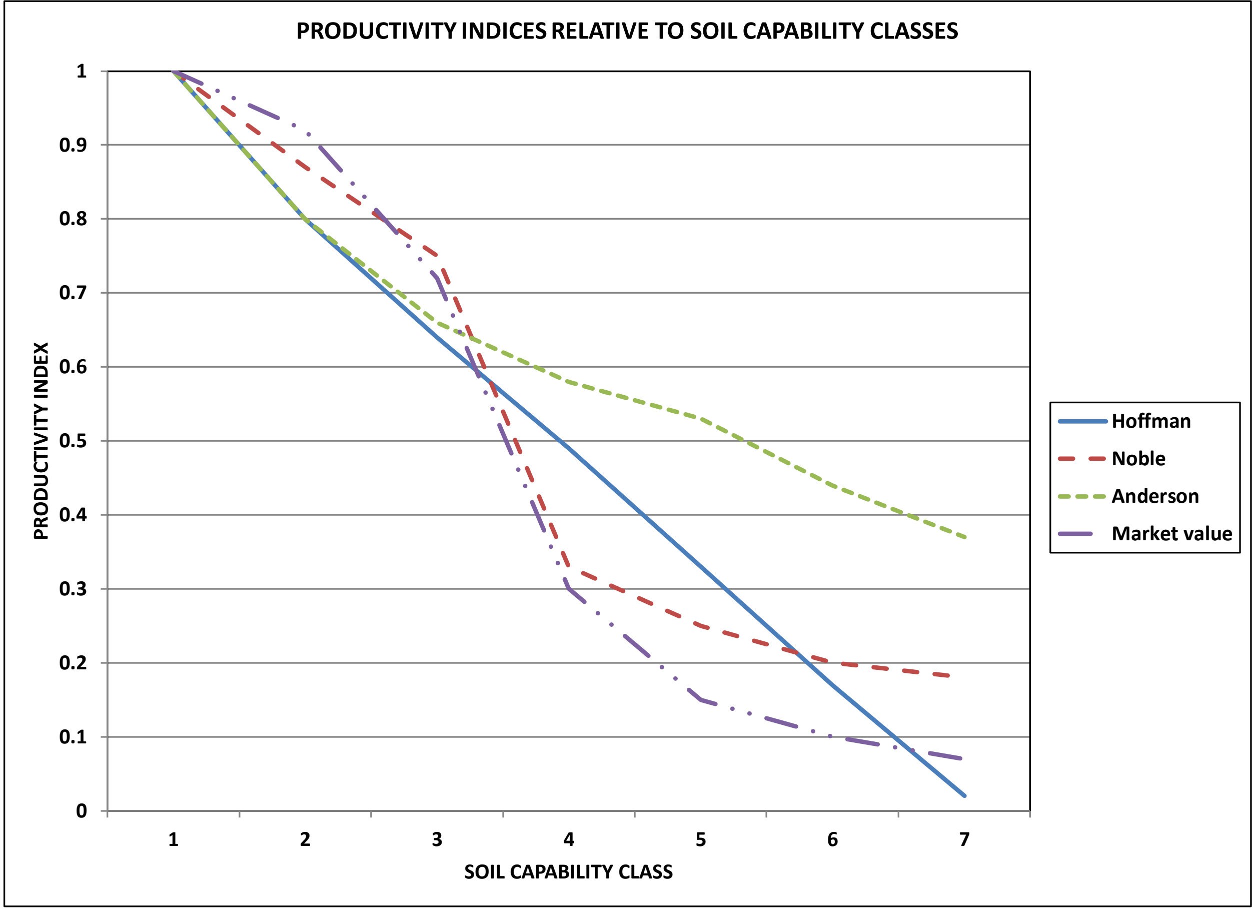


Agricultural Lands (based on Agricultural and Agri-Food Canada Data)
Specialty Crop Greenbelt Study
Lake Ontario
Queen Elizabeth Way
Casablanca Boulevard
Livingston Avenue
Main Street West
Main Street East
Bartlett Avenue
Ridge Road
Woolverton Road
Mountain Road
Park Road
Mud Street West
Mud Street East
0 500 1,000 2,000
Meters
Legend
AAFC - Grimsby
Berries
Broadleaf
Corn
Exposed Land / Barren
Fallow
Grassland
Greenhouses
Mixedwood
Nursery
Orchards
Other Fruits
Other Vegetables
Pasture / Forages
Shrubland
Soybeans
Urban / Developed
Vineyards
Water
Wetland
Wheat
Area Considered for Inclusion in the Greenbelt Plan Area
Area Considered for Exclusion from Greenbelt Plan Area
Built/Non-Agricultural Uses
Roads (LIO)
Railway (LIO)
Creeks (LIO)
Town of Grimsby (LIO)
October 26, 2016

4.4 Soils, Soil Capability and Soil Potential

What is the soil capability of Grimsby and Grimsby's *specialty crop area*?
The soil capability classification is described more fully in Appendix 3. It is a system for rating soils based on their continuing limitations for common field crop production where common field crops include, for example, corn, wheat, oats, barley etc. Soil capability classes have been linked to various productivity indices for common field crops, forage crops, farm assessment and economics. The Hoffman indices for field crops and the Anderson indices for forage crops provide an indication of yield variation with soil capability class. Noble's work relates economics of farming in Eastern Ontario to soil capability class and the Committee on Farm Assessment links soil capability class to assessed value. These 4 different indices are summarized by Hoffman (1973) and reproduced here as Figure 36.

Figure 36



Niagara Region has relatively good average soil capability/soil productivity for the production of common field crops with an average soil productivity index of 0.71which is equivalent to soil capability class 3 based on the 1975 data summarized by Hoffman and Noble. There are several County/Regions with a higher average soil productivity index as summarized for central and southwestern Ontario in Figure 37. Using the soil survey produced in 1989, the average soil productivity index four Niagara Region is slightly lower at 0.67 but still equivalent to soil capability class 3 (Figure 38).

Grimsby is similar with an average productivity index of 0.68 which is equivalent to soil capability class 3 (based on 1975 data). Using the 1989 soil survey by Kingston and Presant, the average productivity index is slightly higher at 0.69, again, equivalent to an average soil capability class 3 as summarized in Figure 38. The difference between the productivity indices from the old data versus the 1989 data result because less class 2 and more class 3 lands were mapped in 1989 as shown in Figure 39.

The distribution of soil capability classes in Grimsby is shown in Map 3 where the predominant capability class in a soil polygon, formerly map unit, is shown. Because many of the soil polygons have more than one soil series and/or phase per polygon, soil productivity indices have been calculated and a soil productivity map for Grimsby created as Map 4.

Figure 37

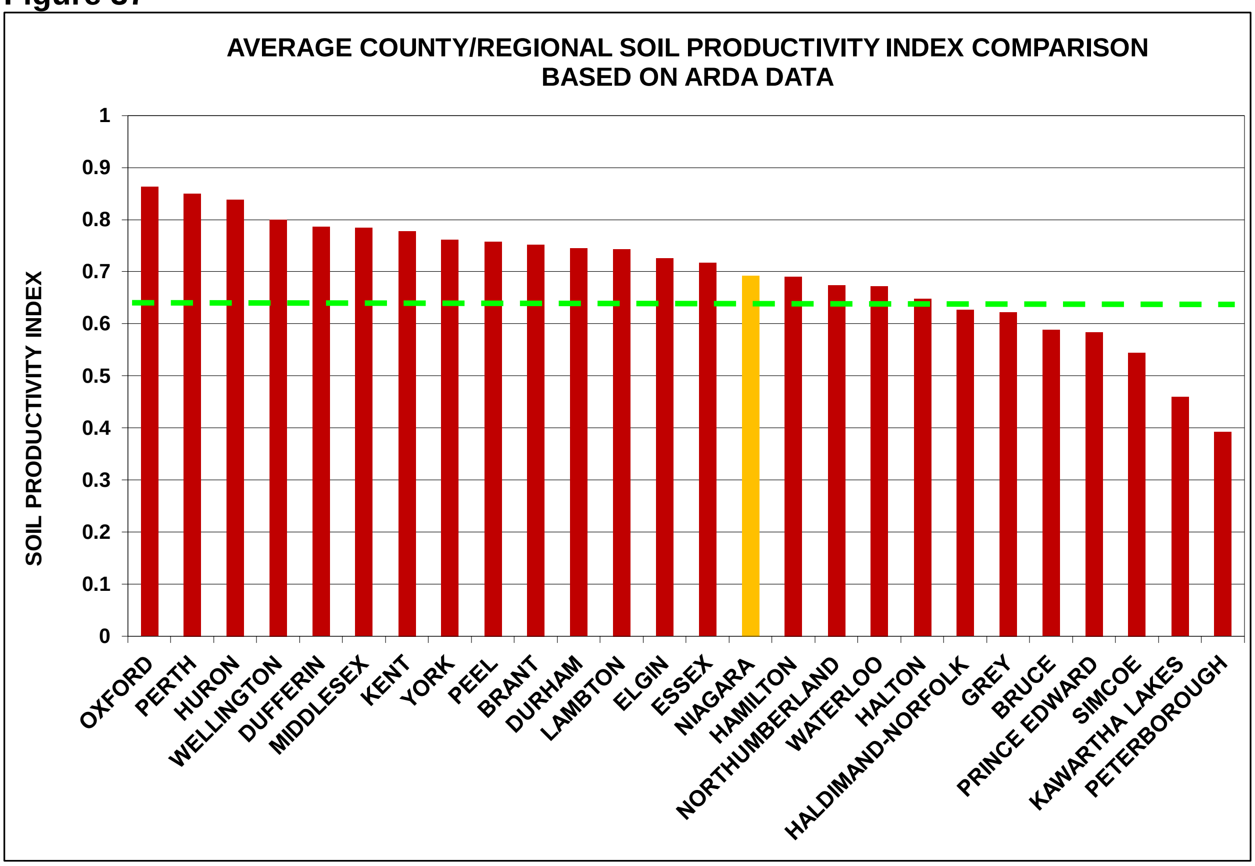


Figure 38

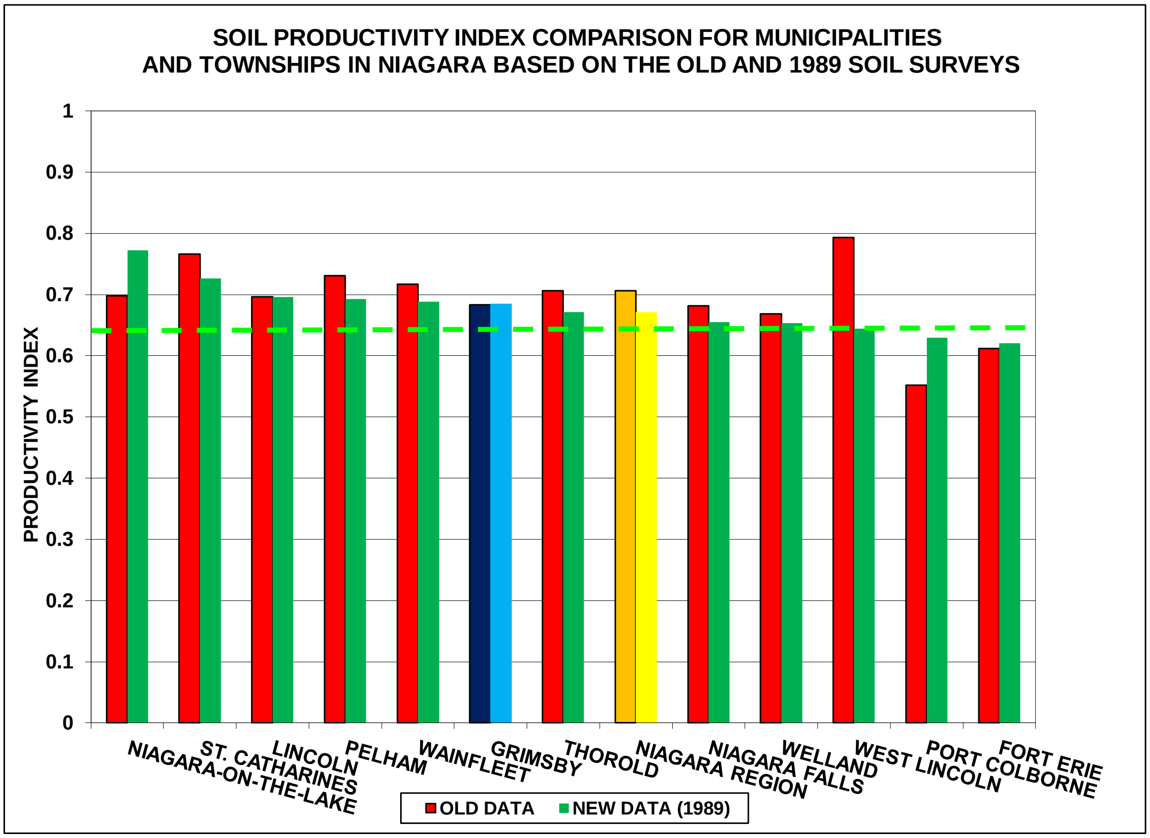
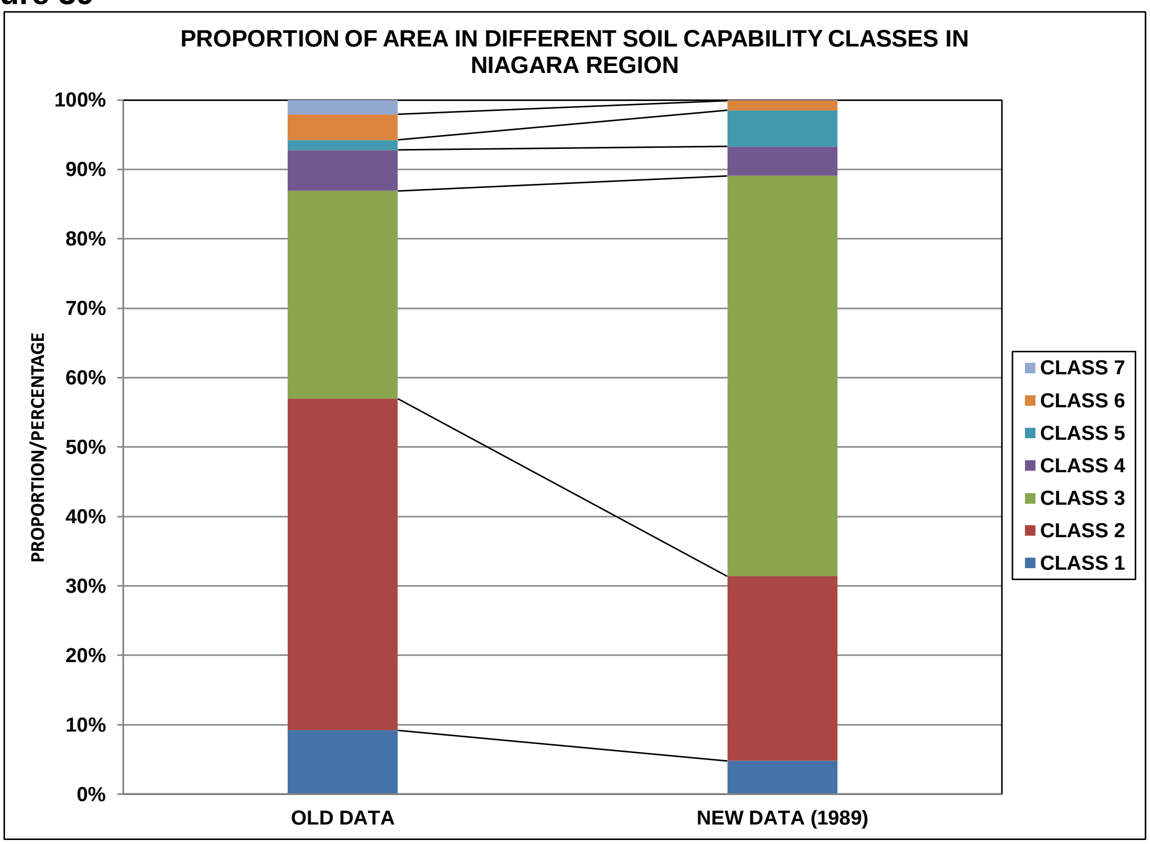
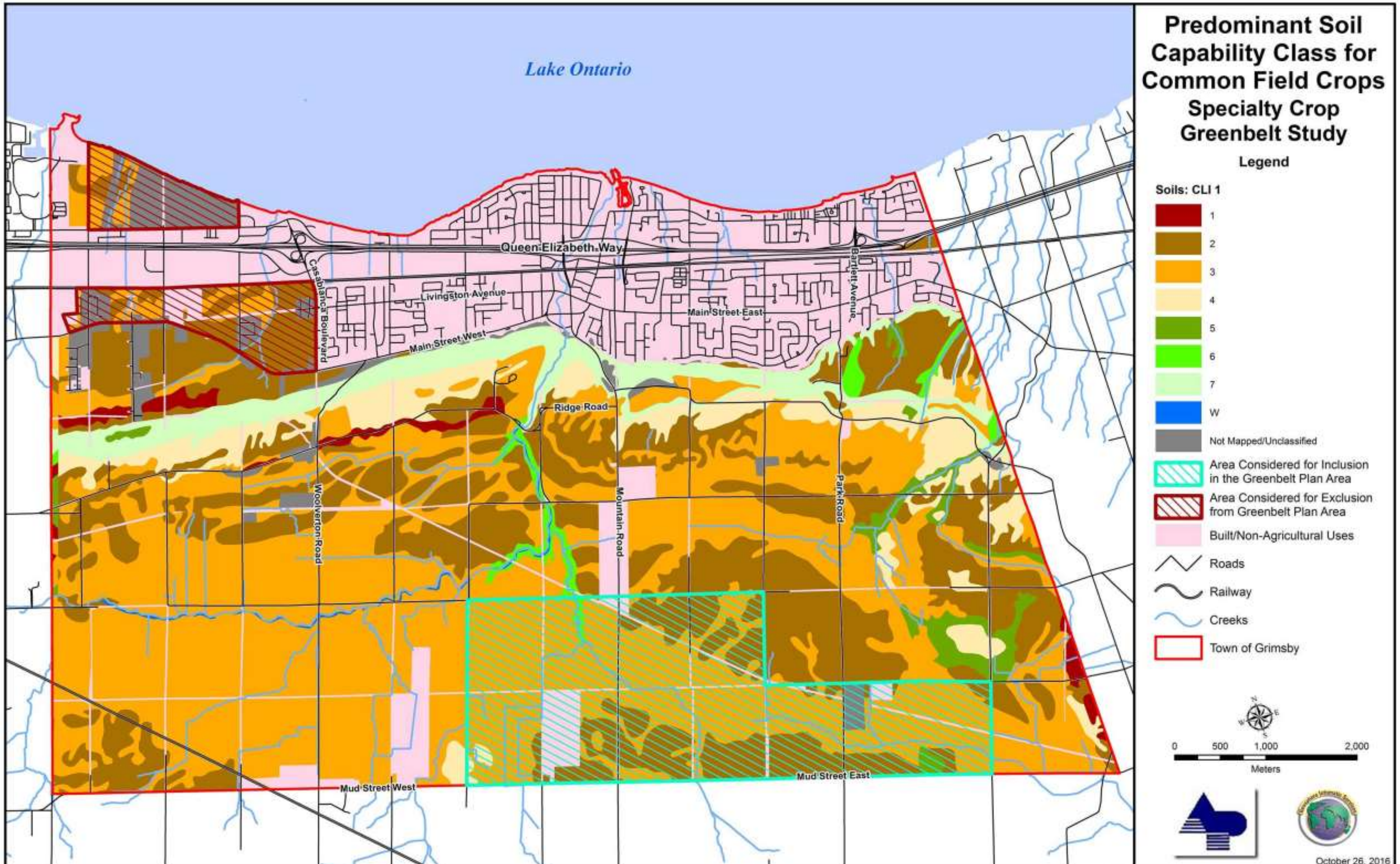


Figure 39

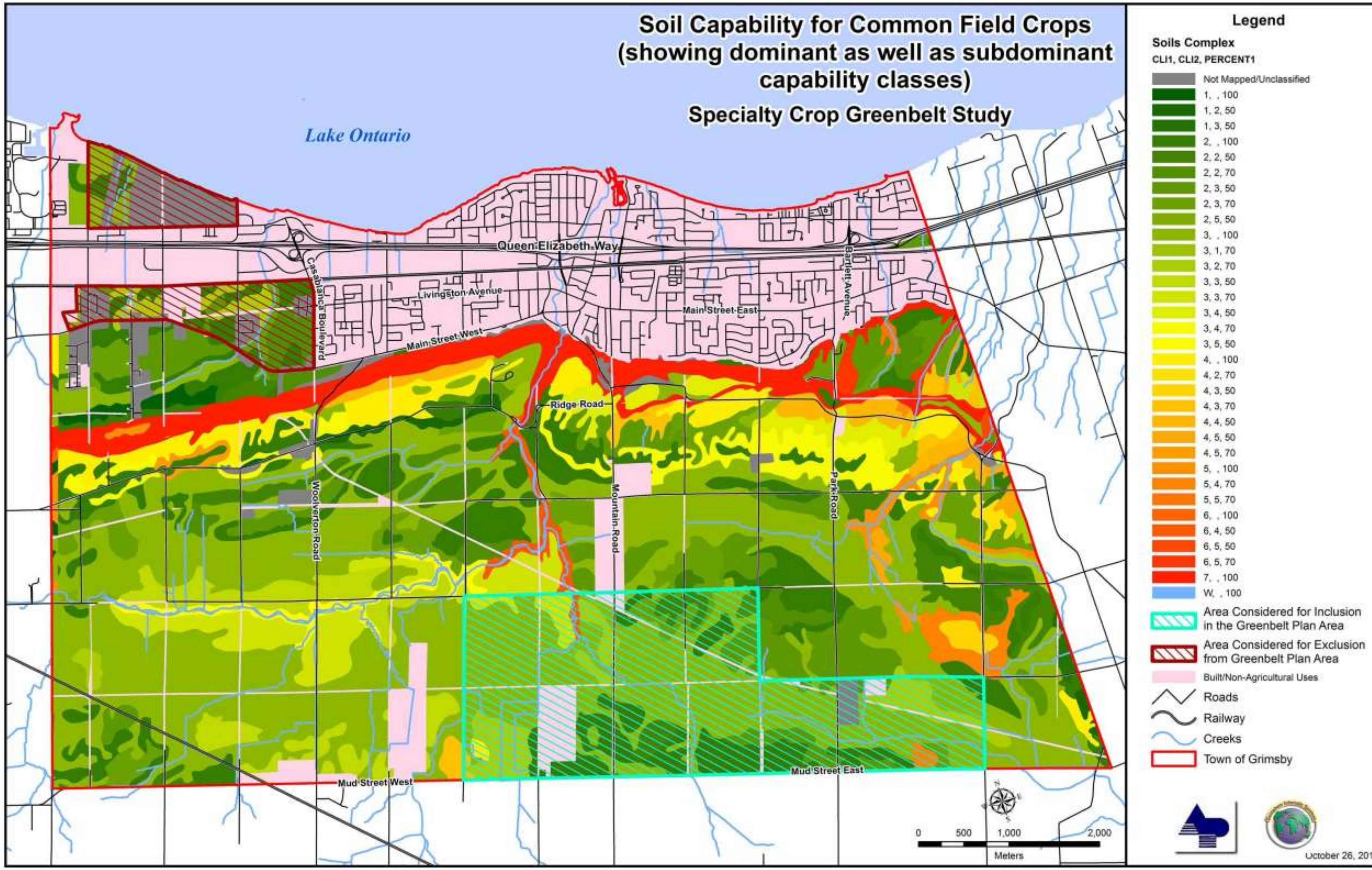


MAP 3



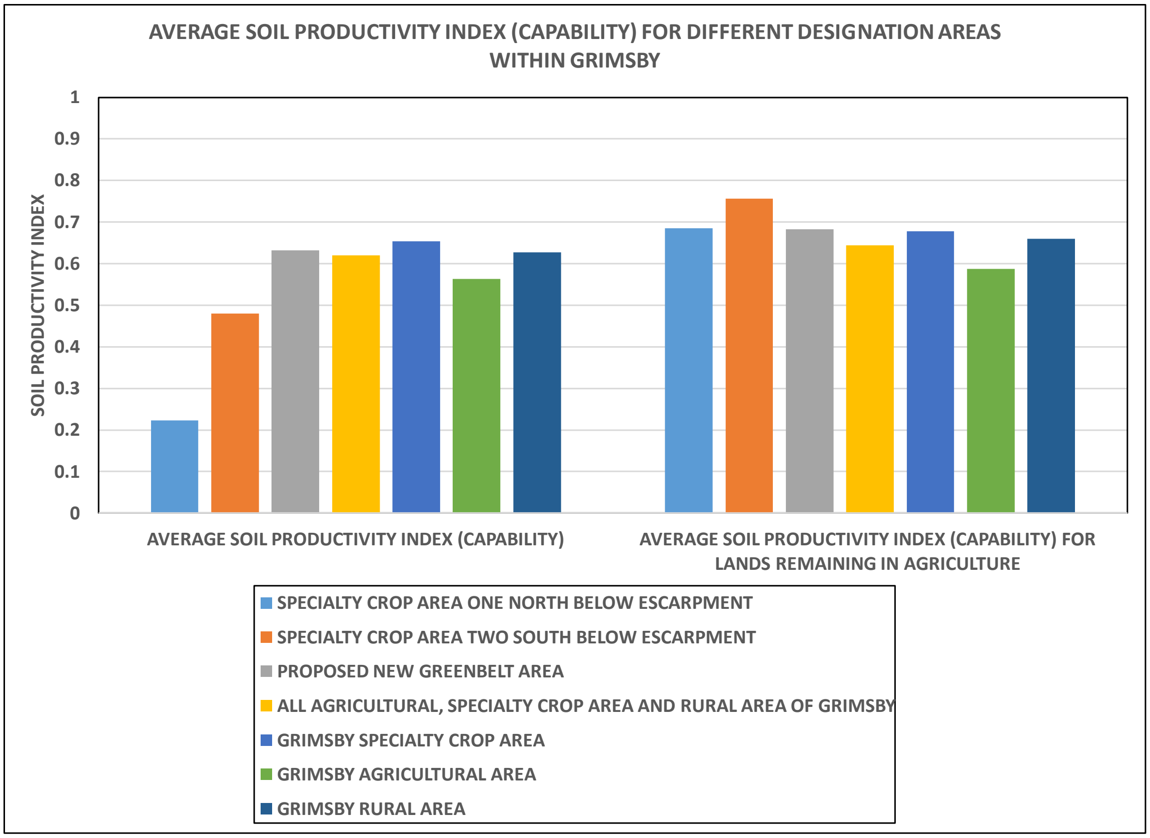
Predominant Soil Capability Class for Common Field Crops
Specialty Crop Greenbelt Study
Legend
Soils: CLI 1
1
2
3
4
5
6
7
W
Not Mapped/Unclassified
Area Considered for Inclusion in the Greenbelt Plan Area
Area Considered for Exclusion from Greenbelt Plan Area
Built/Non-Agricultural Uses
Roads
Railway
Creeks
Town of Grimsby
0
500
1,000
2,000
Meters
October 26, 2016
Lake Ontario
Queen Elizabeth Way
Casablanca Boulevard
Livingston Avenue
Main Street West
Main Street East
Bartlett Avenue
Ridge Road
Woolverton Road
Mountain Road
Park Road
Mud Street West
Mud Street East

MAP 4


Soil Capability for Common Field Crops
(showing dominant as well as subdominant capability classes)
Specialty Crop Greenbelt Study
Lake Ontario
Queen Elizabeth Way
Casablanca Boulevard
Livingston Avenue
Main Street West
Main Street East
Bartlett Avenue
Ridge Road
Woolverton Road
Mountain Road
Park Road
Mud Street West
Mud Street East
Legend
Soils Complex
CLI1, CLI2, PERCENT1
Not Mapped/Unclassified
1, , 100
1, 2, 50
1, 3, 50
2, , 100
2, 2, 50
2, 2, 70
2, 3, 50
2, 3, 70
2, 5, 50
3, , 100
3, 1, 70
3, 2, 70
3, 3, 50
3, 3, 70
3, 4, 50
3, 4, 70
3, 5, 50
4, , 100
4, 2, 70
4, 3, 50
4, 3, 70
4, 4, 50
4, 5, 50
4, 5, 70
5, , 100
5, 4, 70
5, 5, 70
6, , 100
6, 4, 50
6, 5, 50
6, 5, 70
7, , 100
W, , 100
Area Considered for Inclusion in the Greenbelt Plan Area
Area Considered for Exclusion from Greenbelt Plan Area
Built/Non-Agricultural Uses
Roads
Railway
Creeks
Town of Grimsby
0 500 1,000 2,000
Meters
October 26, 2016

Average soil capability for different designations and Grimsby has been summarized in Figure 40 (longer bars in the graph indicate better soils).

Figure 40



What is the soil potential of Grimsby and Grimsby's specialty crop area?

As previously described, the soil capability classification does not include fruit and vegetable crops. Thus, various classifications on the potential of various soils to produce fruits and vegetables have been published more recently for some Regions/Counties in southern Ontario. Specialty crop classification systems are described more fully and summarized in tabular form in Appendix 2. Niagara Region does have soil potential ratings for fruits and vegetables and these have been adapted within this report. There are 20 crop groupings in this specialty crop rating system and three different maps have been prepared to show the average for all 20 crop groupings, an average for tender fruit and vinifera grapes as well as a single factor map for vinifera grapes. The average 20 crop grouping map was produced because soils that have the potential to produce a broad cross section of different crops well, allow farmers to adapt to changes in consumer preferences and to changes in the market. Because Niagara Region has historically been used for tender fruit crop production, a separate map addressing those characteristics was produced. Finally, because grape production area (as a proportion of total fruit and vegetable production area) in Niagara and Grimsby has been increasing (as have associated wineries), the vinifera grape soil potential map was produced.

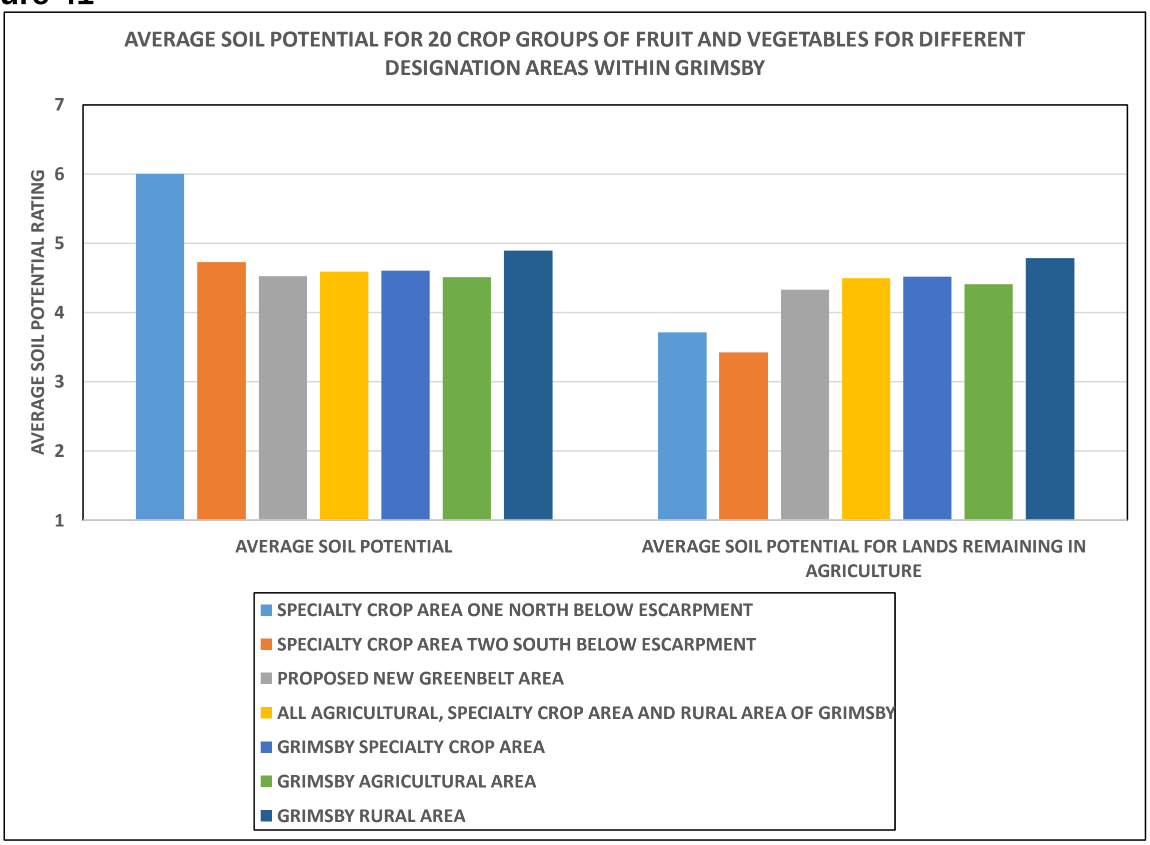
Some of the lands within Grimsby do not have information on soil potential for fruits and vegetables for two reasons:

- there is existing non-agricultural development and/or,
- the lands were not in agricultural use when the soil mapping was done by Kingston and Presant in 1989 and therefore were not mapped for soils.

This non-agricultural development is particularly important in the two *specialty crop areas* north of the Escarpment that Grimsby wishes to have removed from the *specialty crop area* designation. In *specialty crop area* one, 70% of the area has unclassified soils and/or has existing non-agricultural development. In *specialty crop area* two, 37% is unclassified and/or has existing non-agricultural development.

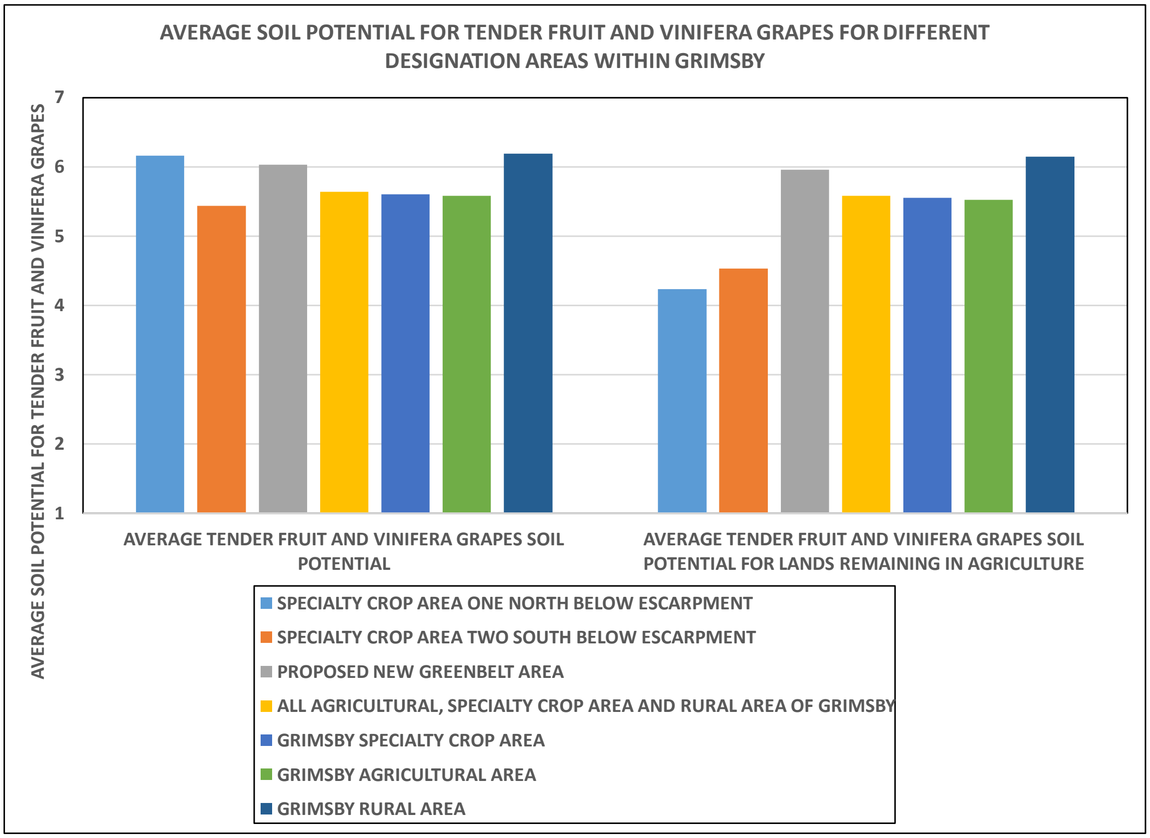
Very little average soil potential rating one soils are found within Grimsby and their distribution is shown on Map 5. Much of that rating one land, comprising approximately 28 ha, is found within *specialty crop area* two and is located immediately adjacent to non-agricultural development on three sides. The average soil potential rating for 20 crop groups in *specialty crop area* one and *special crop area* two is rating 6 and 5 respectively based on assigning a rating 7 (unsuitable for production) to the lands in non-agricultural development. If the fact that much of *specialty crop areas* one and two can't be used for agriculture is ignored, then the lands remaining have an average soil potential rating for fruits and vegetables of 4 and 3 respectively as summarized in Figure 41. In Figures 41, 42 and 43 shorter bars indicate better soils potential.

Figure 41



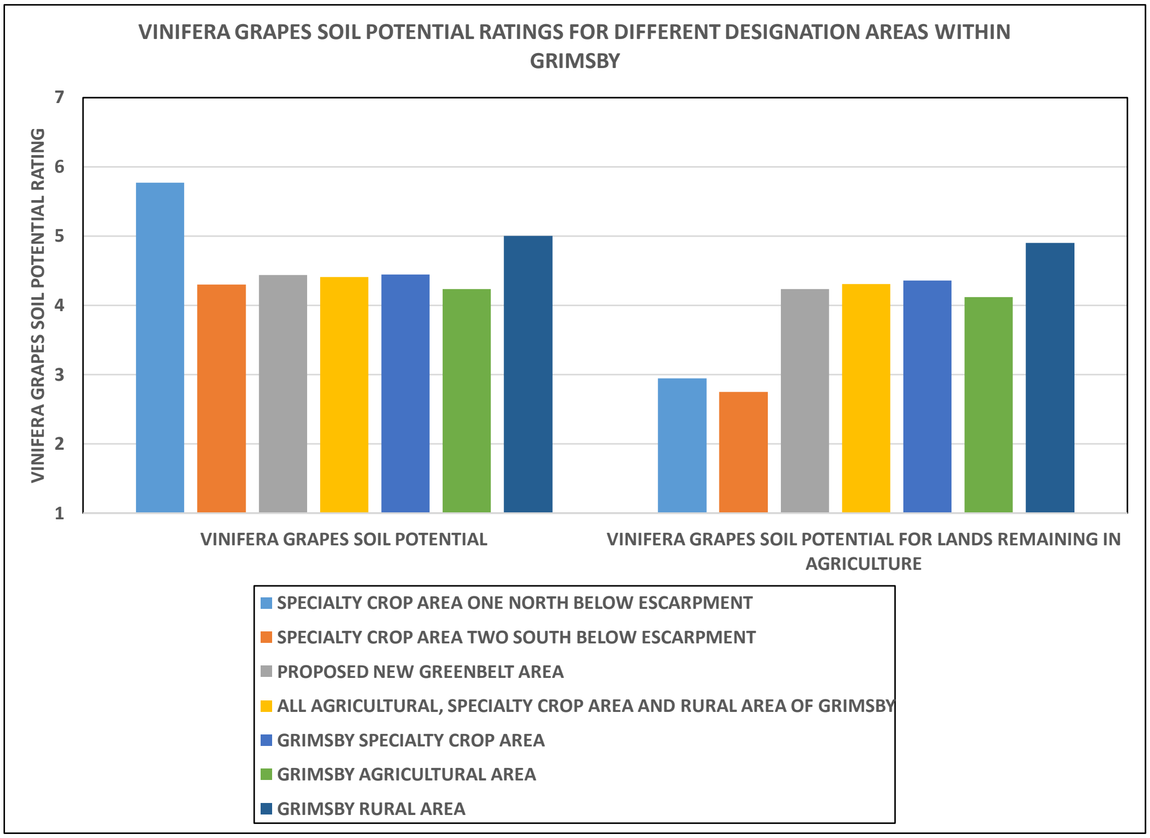
If the soil potential analysis is restricted to tender fruit and vinifera grapes, the average soil potential is relatively poor with all designated areas having a rating between 5 and 6 (Figure 42). If the lands not mapped and/or in non-agricultural use are not considered in the calculation of the average soil potential for tender fruit and vinifera grapes, then the *specialty crop areas* one and two have an average soil potential for tender fruits and vinifera grapes between class 4 and 5 (Figure 42).

Figure 42



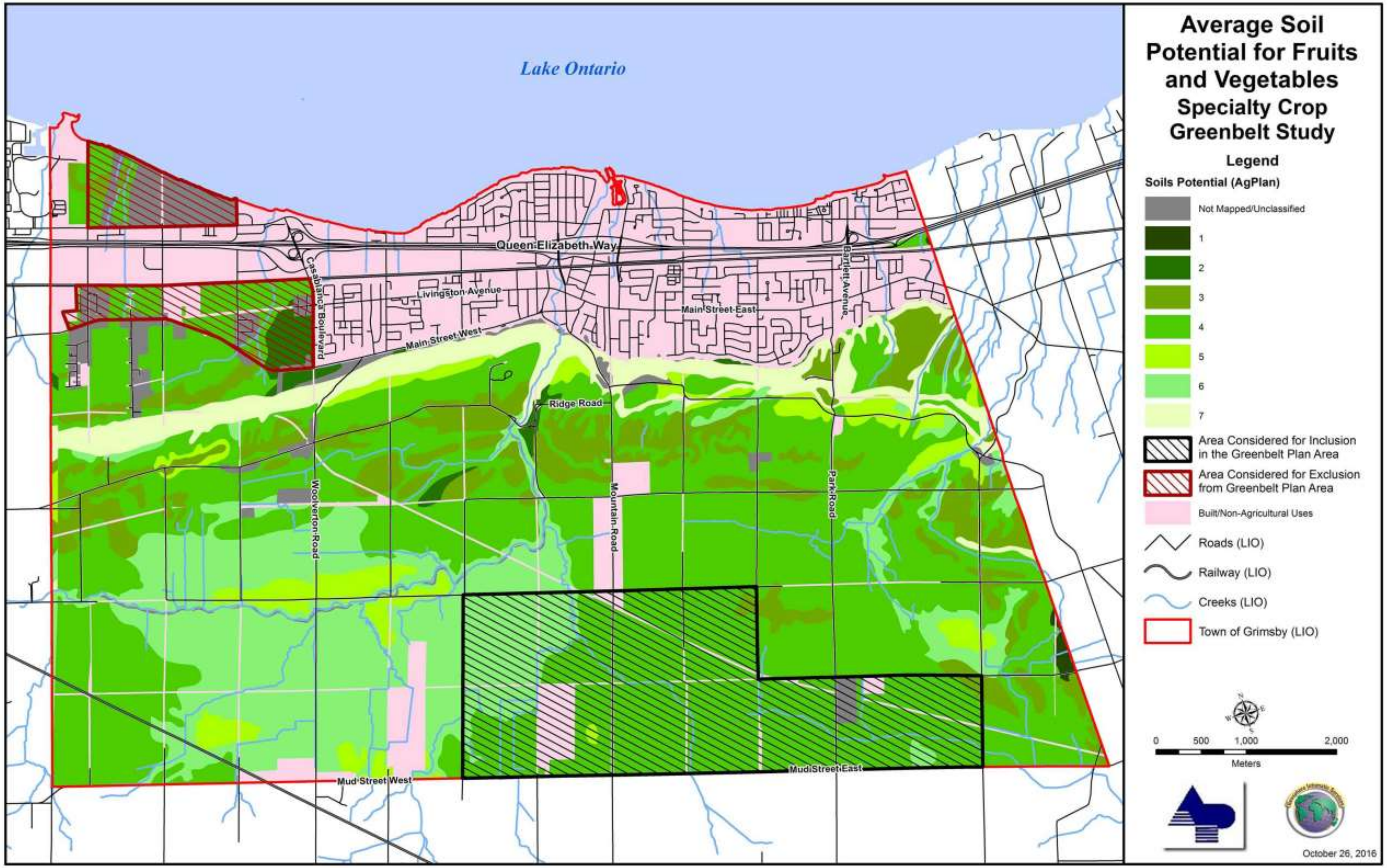
When soil potential for vinifera grapes is produced as a single factor map and an average is calculated for various designations, soil potential rating ranges from class 4 through 6. As has been done previously, if the fact that much of the land in *specialty crop areas* one and two is not agricultural is ignored, that is, it is treated as if it will be returned to agricultural use and therefore has potential for that agricultural use, then the soil potential for grapes of these two specialty crop component areas is ranked as between 2 and 3 (Figure 43).

Figure 43



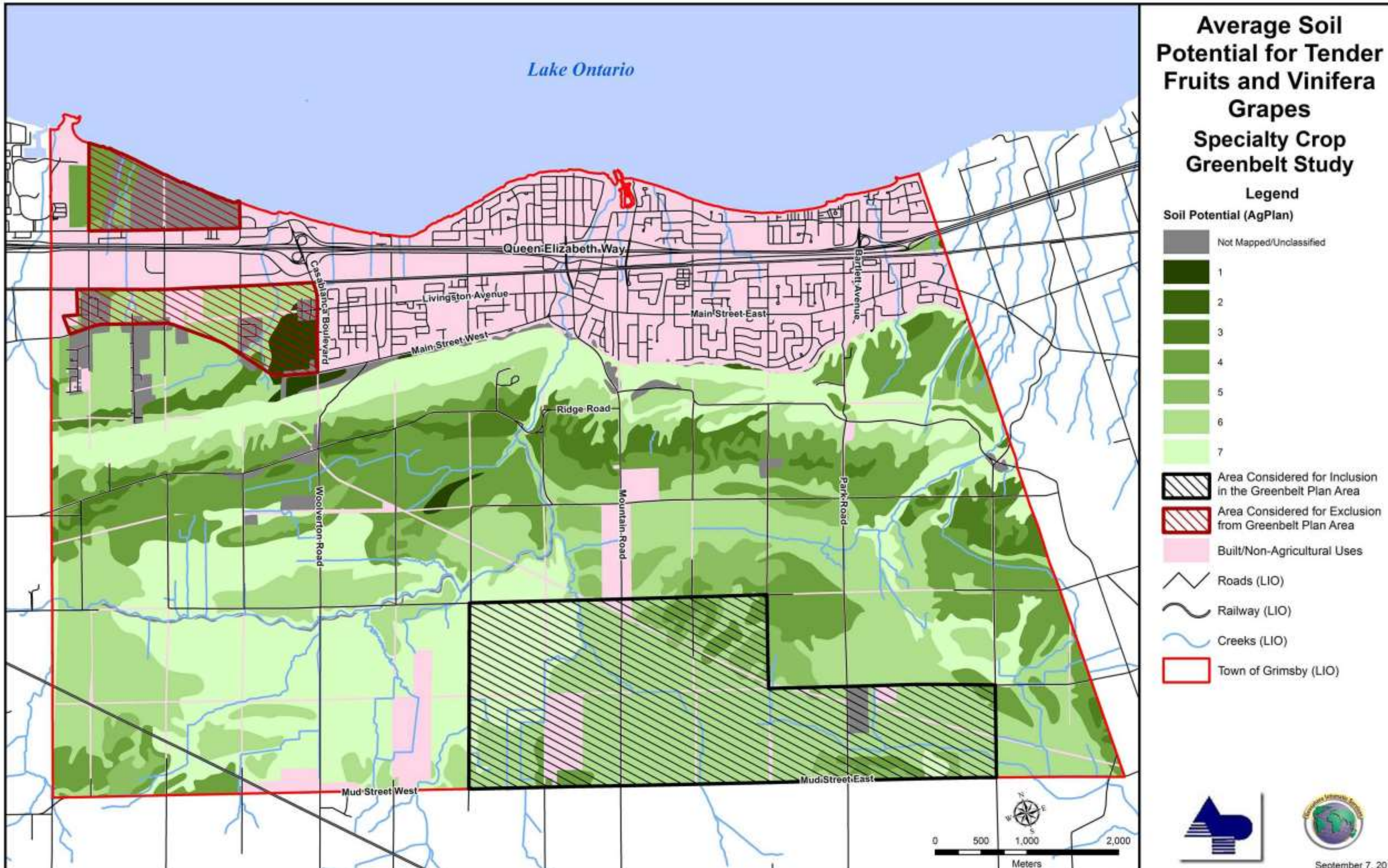
The very best soils having the "highest", that is, having a soil potential between 1 and 1.99 are found relatively less within Grimsby. Map 7 shows the location of those better soils with the soil potential rank between 1 and 1.99 for fruits and vegetables (including vinifera grapes) within Niagara Region. Most of these better soils are not located within Grimsby. Those higher potential soils found within Grimsby tend to be located to the south above the Escarpment. The better soils for fruits and vegetables have an area of approximately 109 ha in Grimsby and comprise 1.5% of the better specialty crop soils found in Niagara.

MAP 5



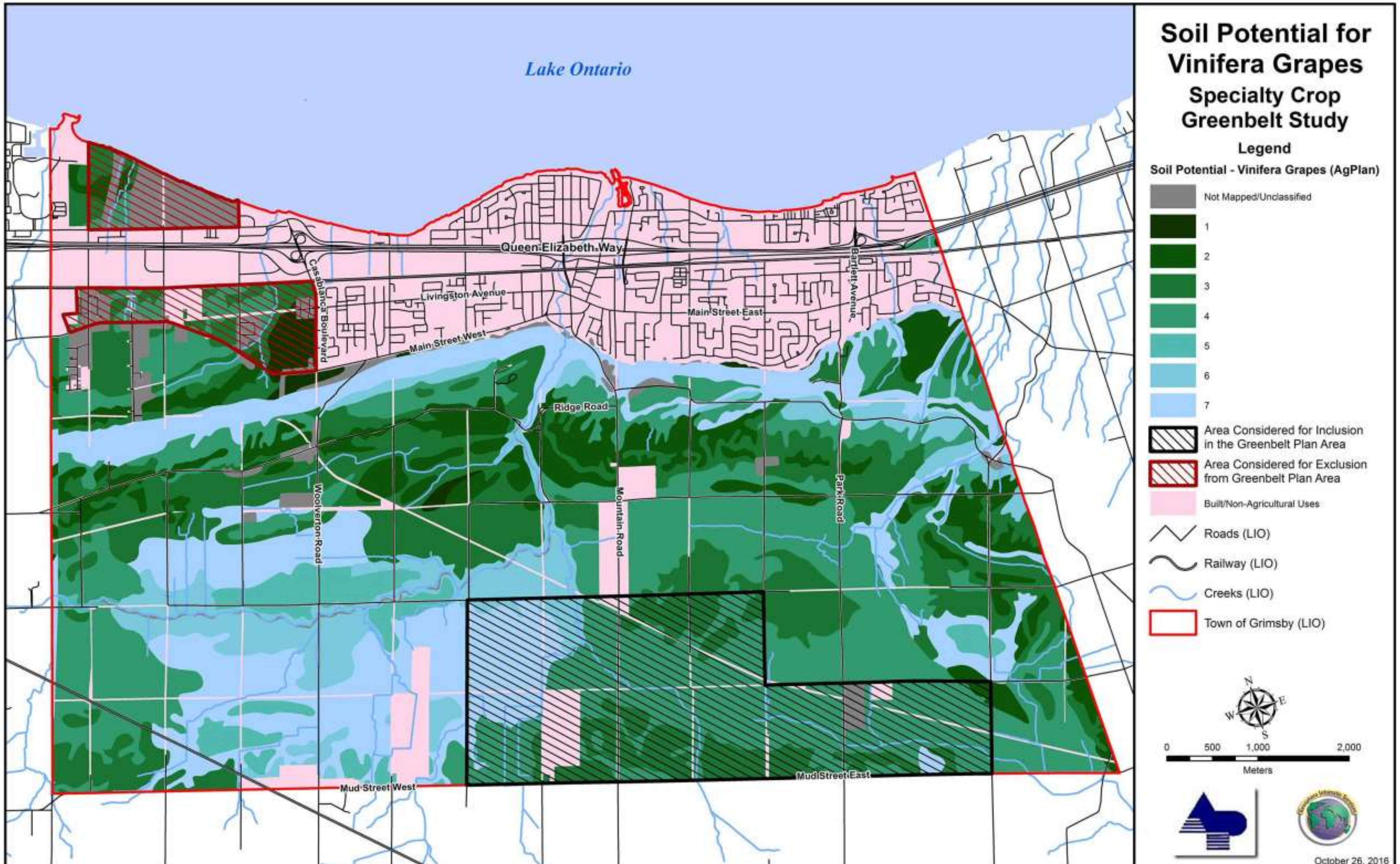
Lake Ontario
Queen Elizabeth Way
Casablanca Boulevard
Livingston Avenue
Main Street West
Main Street East
Bartlett Avenue
Ridge Road
Woolverton Road
Mountain Road
Park Road
Mud Street West
Mud Street East
Average Soil Potential for Fruits and Vegetables
Specialty Crop Greenbelt Study
Legend
Soils Potential (AgPlan)
Not Mapped/Unclassified
1
2
3
4
5
6
7
Area Considered for Inclusion in the Greenbelt Plan Area
Area Considered for Exclusion from Greenbelt Plan Area
Built/Non-Agricultural Uses
Roads (LIO)
Railway (LIO)
Creeks (LIO)
Town of Grimsby (LIO)
0
500
1,000
2,000
Meters
October 26, 2016

MAP 6



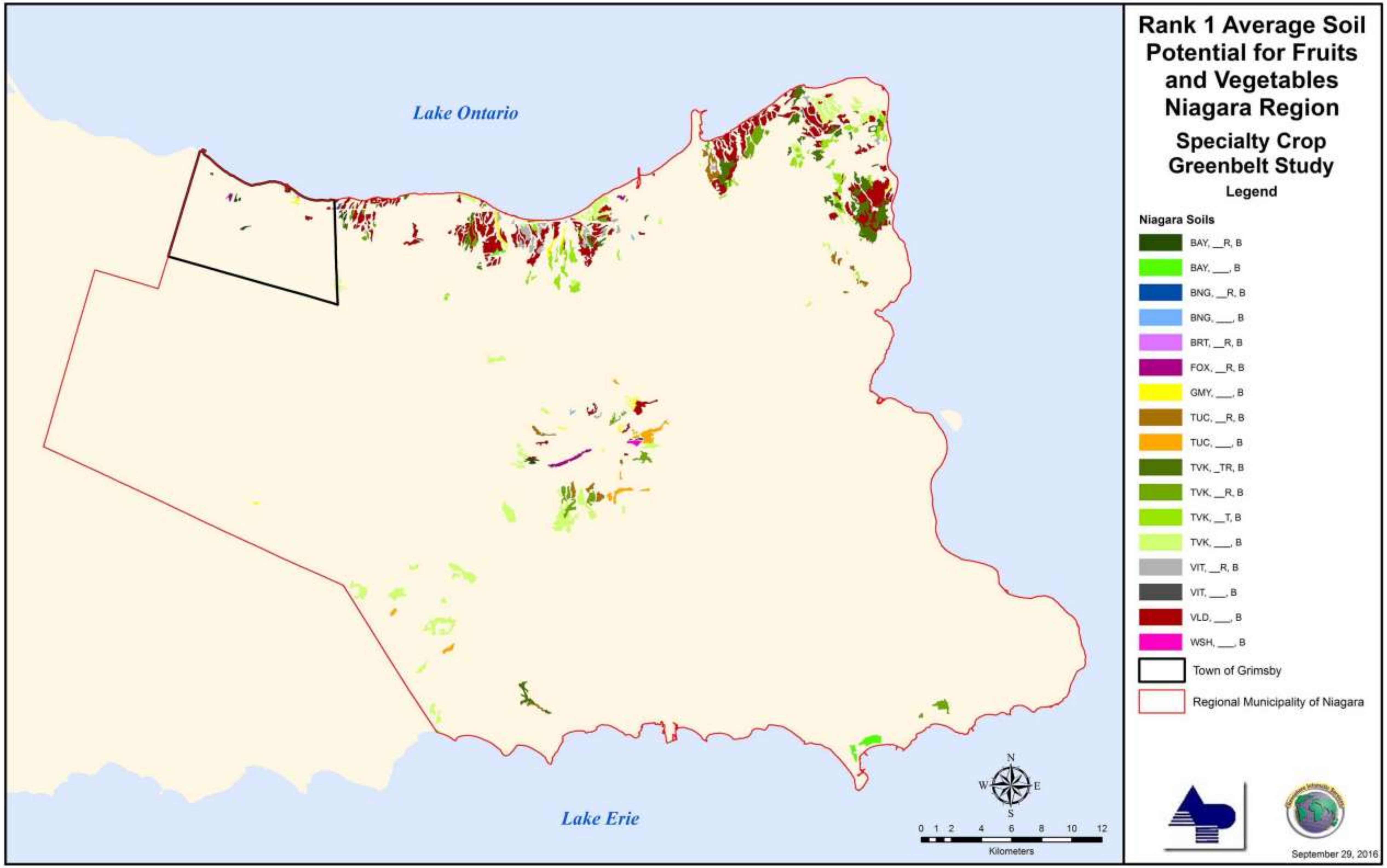
Average Soil Potential for Tender Fruits and Vinifera Grapes
Specialty Crop Greenbelt Study
Legend
Soil Potential (AgPlan)
Not Mapped/Unclassified
1
2
3
4
5
6
7
Area Considered for Inclusion in the Greenbelt Plan Area
Area Considered for Exclusion from Greenbelt Plan Area
Built/Non-Agricultural Uses
Roads (LIO)
Railway (LIO)
Creeks (LIO)
Town of Grimsby (LIO)
Lake Ontario
Queen Elizabeth Way
Casablanca Boulevard
Livingston Avenue
Main Street West
Main Street East
Bartlett Avenue
Ridge Road
Woolverton Road
Mountain Road
Park Road
Mud Street West
Mud Street East
0
500
1,000
2,000
Meters
September 7, 2016

MAP 7



Lake Ontario
Queen Elizabeth Way
Casablanca Boulevard
Livingston Avenue
Main Street West
Main Street East
Bartlett Avenue
Ridge Road
Woolverton Road
Mountain Road
Park Road
Mud Street West
Mud Street East
Soil Potential for Vinifera Grapes
Specialty Crop Greenbelt Study
Legend
Soil Potential - Vinifera Grapes (AgPlan)
Not Mapped/Unclassified
1
2
3
4
5
6
7
Area Considered for Inclusion in the Greenbelt Plan Area
Area Considered for Exclusion from Greenbelt Plan Area
Built/Non-Agricultural Uses
Roads (LIO)
Railway (LIO)
Creeks (LIO)
Town of Grimsby (LIO)
N
E
S
W
0
500
1,000
2,000
Meters
October 26, 2016

MAP 8


Rank 1 Average Soil Potential for Fruits and Vegetables Niagara Region
Specialty Crop Greenbelt Study
Legend
Niagara Soils
BAY, __R, B
BAY, ___, B
BNG, __R, B
BNG, ___, B
BRT, __R, B
FOX, __R, B
GMY, ___, B
TUC, __R, B
TUC, ___, B
TVK, _TR, B
TVK, __R, B
TVK, __T, B
TVK, ___, B
VIT, __R, B
VIT, ___, B
VLD, ___, B
WSH, ___, B
Town of Grimsby
Regional Municipality of Niagara
Lake Ontario
Lake Erie
N
W
E
S
0 1 2 4 6 8 10 12
Kilometers
September 29, 2016

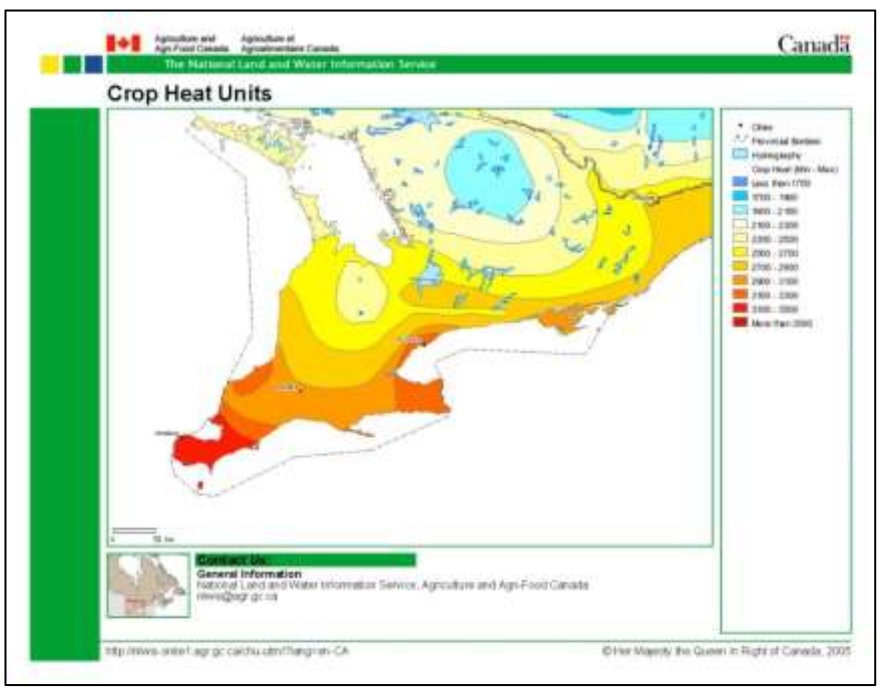
5.3 Climate

What are the climate characteristics of Grimsby and Niagara in the context of southern Ontario?

The climate of Niagara Region is relatively warm in the context of Ontario (but is not as warm as Essex County) as can be seen on Map 9. The higher average temperatures in Essex have resulted in the greatest amount of greenhouse production in Canada, where much of that production is for vegetables. The crop heat units information has been supplemented by additional mapping in both the Niagara Region and Essex County. In Niagara, Grape Climatic Zones were originally mapped by Weibe and Anderson (1976) and updated by Fisher and Anderson (2002). The Fisher and Anderson map has been reproduced in this report as Map 10. A review of this map clearly indicates that *specialty crop areas* one and two have a better climate for the production of specialty crops where that climate is modified by the presence of Lake Ontario.

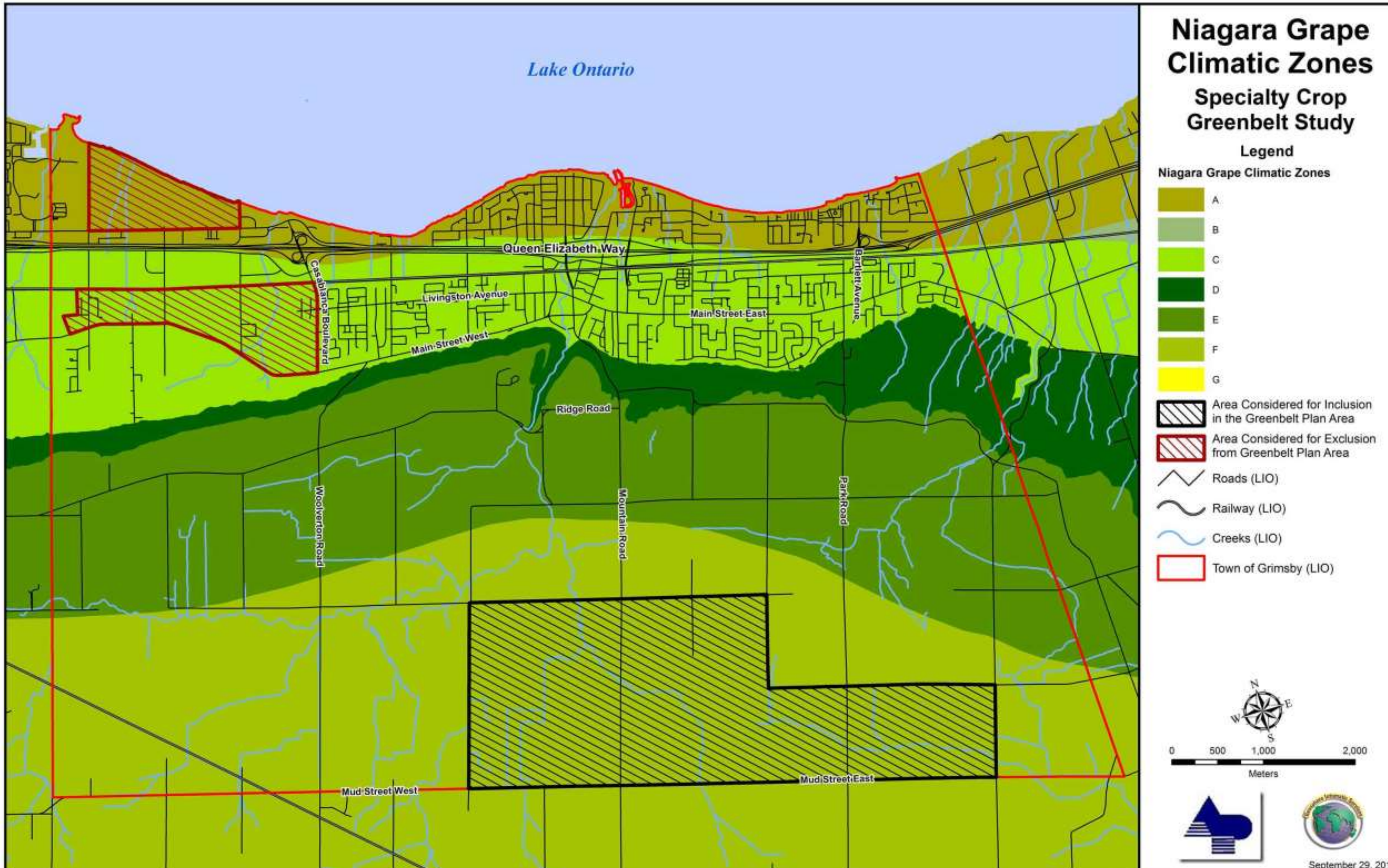
Nevertheless, the grape growers of Ontario (2011) state that there is risk in each zone from A through to E for the production of grapes. For example, in Zone A, "sites have cooler conditions due to the lake effect which may result in higher risk of delayed fruit maturity for late-season cultivars" and in Zone E, the area "as the highest risk of winter injury due to cold midwinter temperatures" and "has the shortest growing season with highest risk of spring and/or fall frosts, effectively limiting tender and/or late maturing cultivars". The George Morris Centre (Mussell et al., 2010) notes that "there is a notable distinctness regarding climate conditions across wine regions in Ontario. However, it is not evident that varietal choices have been driven by these climatic differences." The AAFC land use data on vineyards supports this conclusion by Mussell et al. (2010) as vineyards are present in the general agricultural designation as well as the *specialty crop area* designation.

Fruits and vegetables benefit from good cold air drainage. This cold air drainage can be reduced or stopped by the presence of woodlots of high density and/or urban development. *Specialty crop areas* one and two in Grimsby have already been affected by urban development.



MAP 9

MAP 10
(Fisher and Slingerland, 2002)



5.6 Economics

Is there evidence that Grimsby provides specific agricultural economic characteristics that would benefit farmers producing fruits and vegetables relative to other parts of Niagara Region and the Province of Ontario?

In general, it is difficult to make sufficient income from farming alone. In Ontario, 80% or greater of farms have greater off-farm income than net on farm operating income as summarized in Figure 44. The proportion of net on-farm income relative to off-farm income tends to be less as summarized in Figure 45.

Figure 44

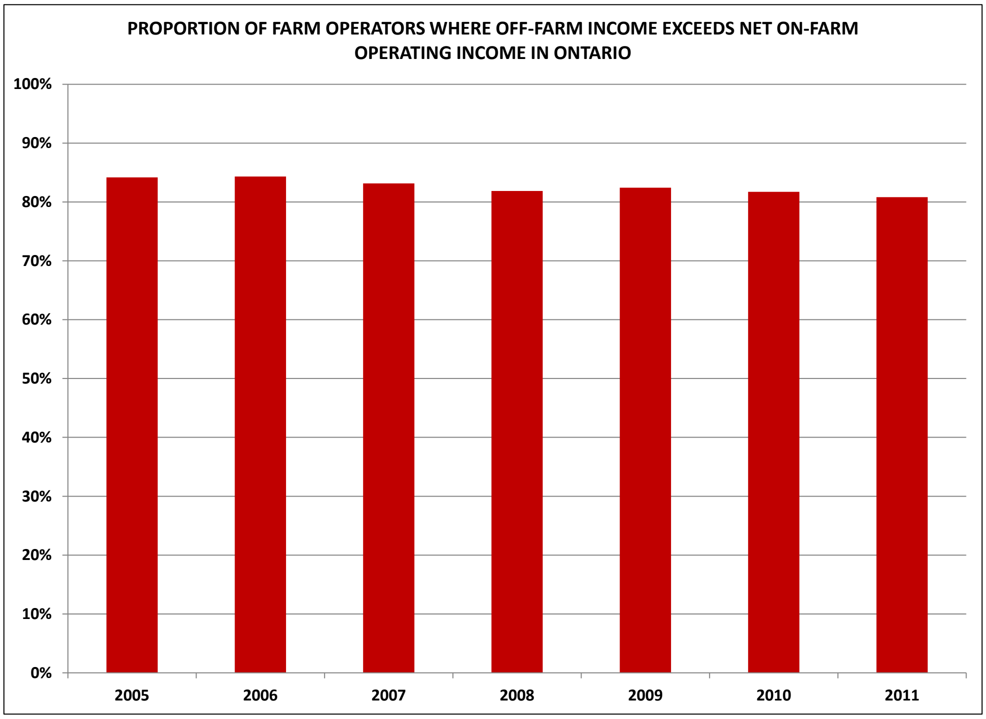
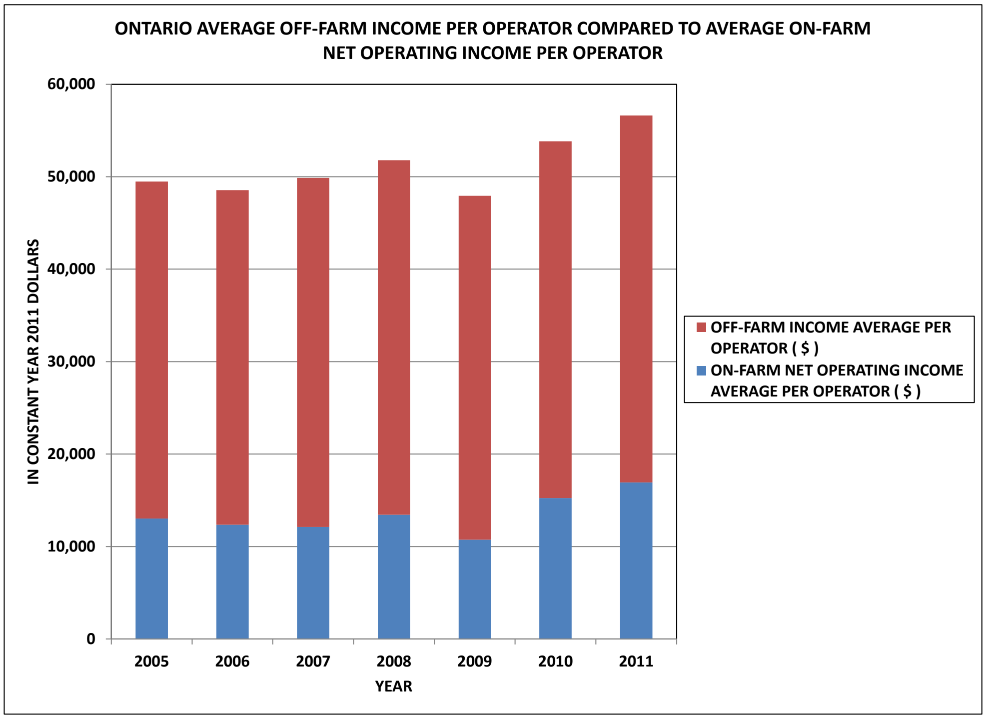


Figure 45



Products for direct human consumption (fruit and vegetables) have higher gross income per unit area as summarized in Figure 46. Marginal returns and net income associated with fruits and vegetables vary with the particular fruit and/or vegetable produced but also tend to be higher per unit area than what would be received for small grains. Prices received for various agricultural products can be presented differently from that shown in Figure 46. Average gross income and net income, based on data from 1981 to 2014, for some of the crops produced within Niagara Region, are summarized in Figure 47. In this graph, the average value over more than 30 years is plotted and the changes in that monetary value are represented by the standard deviation in price received (where standard deviation is the square root of variance). More specifically, there are significant variations in gross dollars from year to year for apples and grapes as noted by the standard deviation "whiskers" in Figure 47. Alternatively, soybeans and wheat have relatively low variations from year to year as shown by relatively low levels in standard deviation in price as shown by relatively short "whiskers" in Figure 47.

The gross income per acre values shown in Figures 46 and 47 are province wide. A single test was done to ascertain whether these values vary significantly within the Province. At least in the case of grapes (the most predominant specialty crop in Niagara Region), relatively little difference in gross income per unit area is present as summarized in Figure 48. This lack of variation is not surprising given that most of the Province's grape production occurs in Niagara.

Figure 46

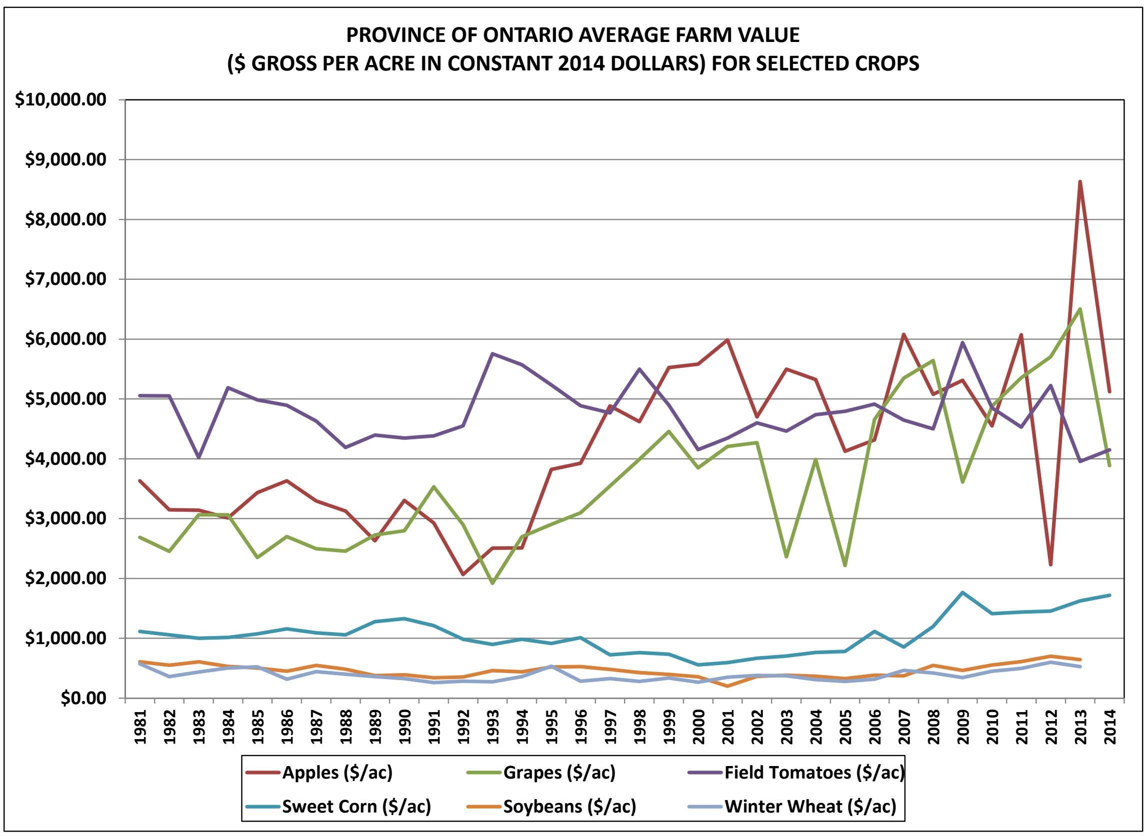


Figure 47

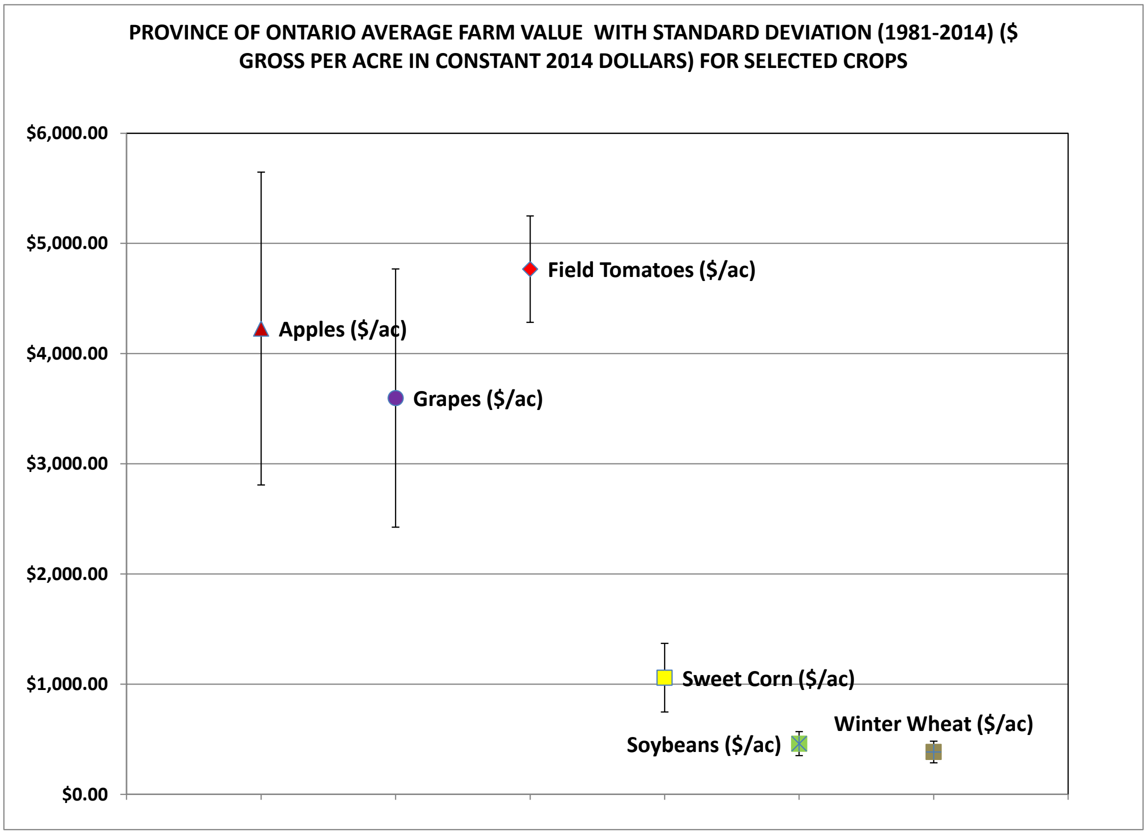
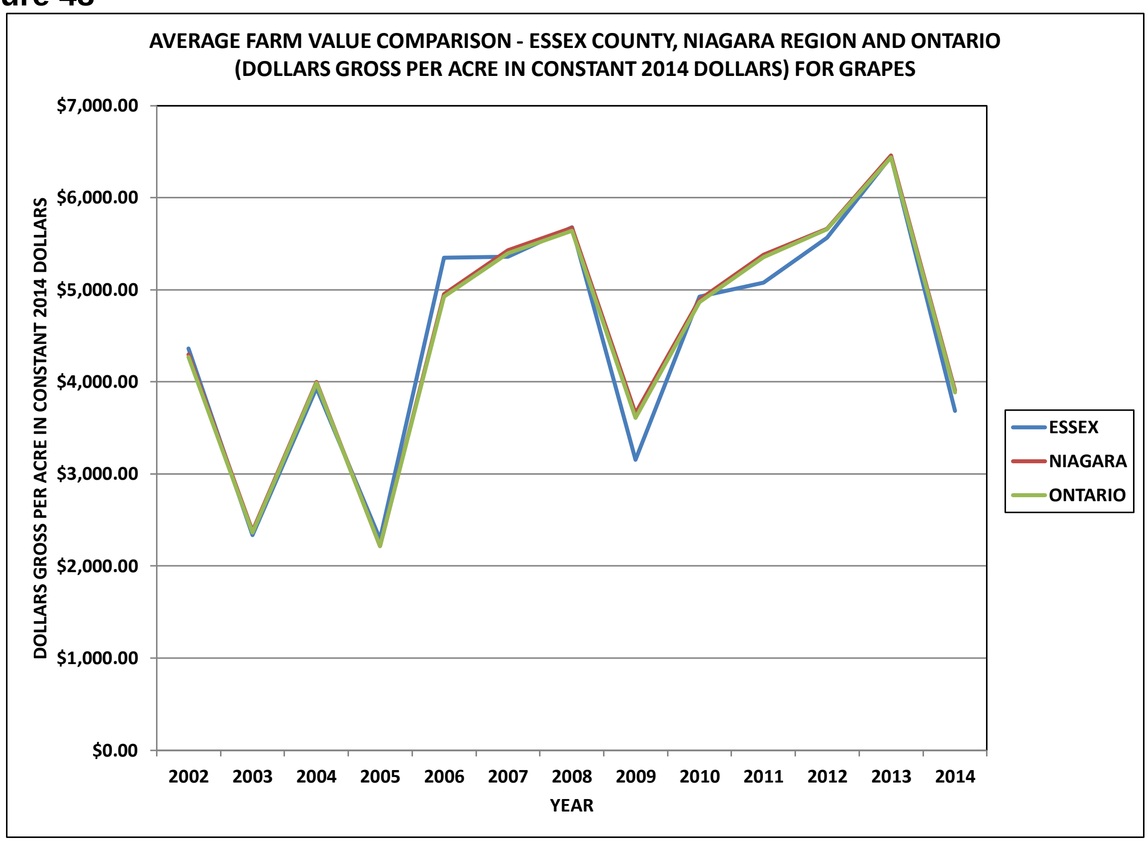
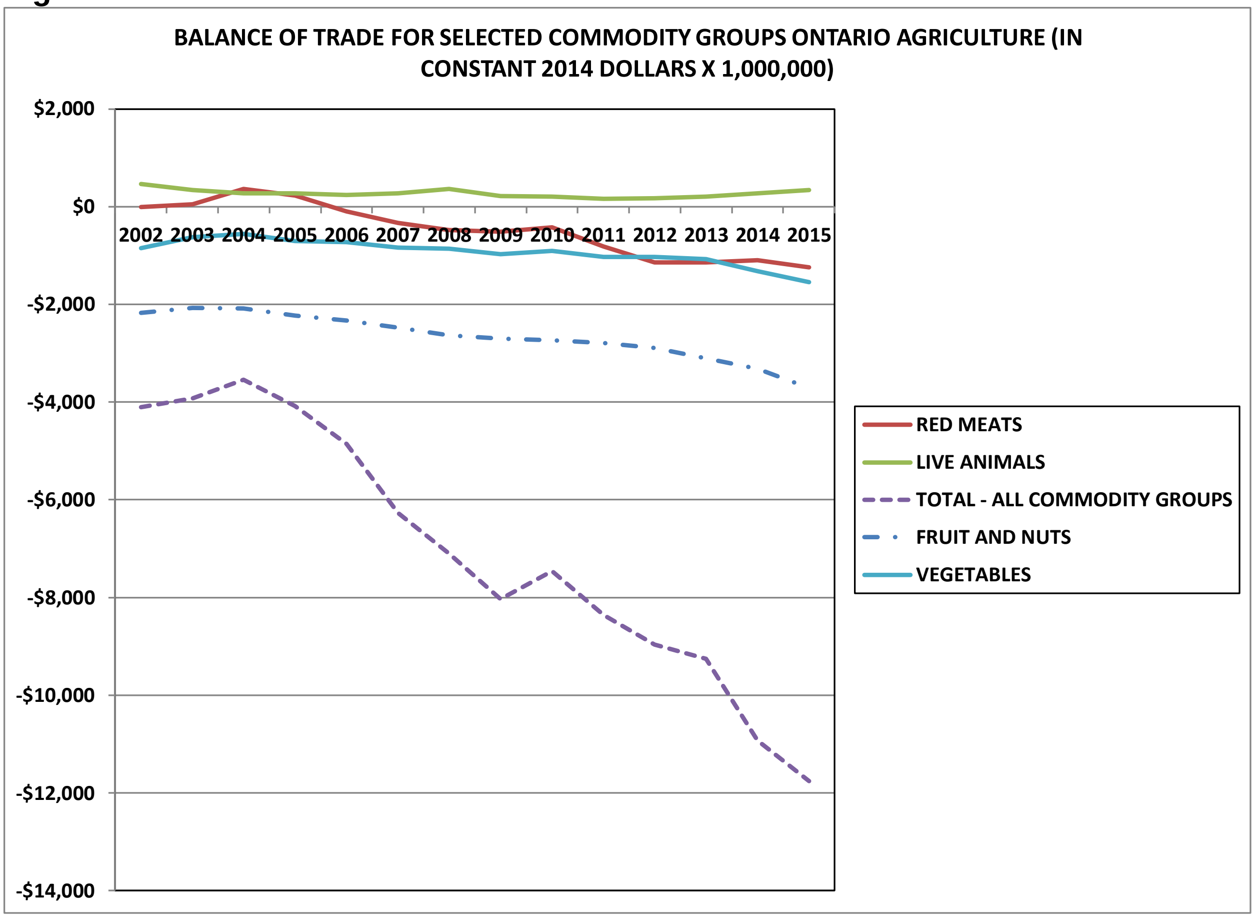


Figure 48



Given the relatively higher net income associated with fruit and vegetable production, one might hypothesize that more farmers would be producing specialty crops. However, as discussed previously, the number of fruit and vegetable farms in Grimsby and Niagara is diminishing. Balance of trade data (Figure 49) provide some insight into why this reduction might be occurring. Over time, more money is being spent on fruit, nuts and vegetable imports than is received from exporting those same commodities. With respect to Ontario's grape and wine sector, Mussell et al. (2010) state that the sector "is experiencing pressures related to production costs, increased import competition, and constraints on household budgets that influence consumer purchasing patterns".

Figure 49



An analysis of economic data specific to Grimsby and Niagara Region is presented in the following paragraphs to ascertain whether it is likely that Grimsby and/or Niagara are special cases that tend not to follow the provincial data presented previously in Figures 44 to 49. Statistics Canada data for total/gross farm receipts, net income (defined as gross farm receipts minus farm business operating expenses), and total farm capital were evaluated on a "per unit area" as well as "per farm basis" at the regional scale for southern Ontario, Niagara Region and for the townships and municipalities within Niagara as summarized in Figures 50 through 57.

Figure 50

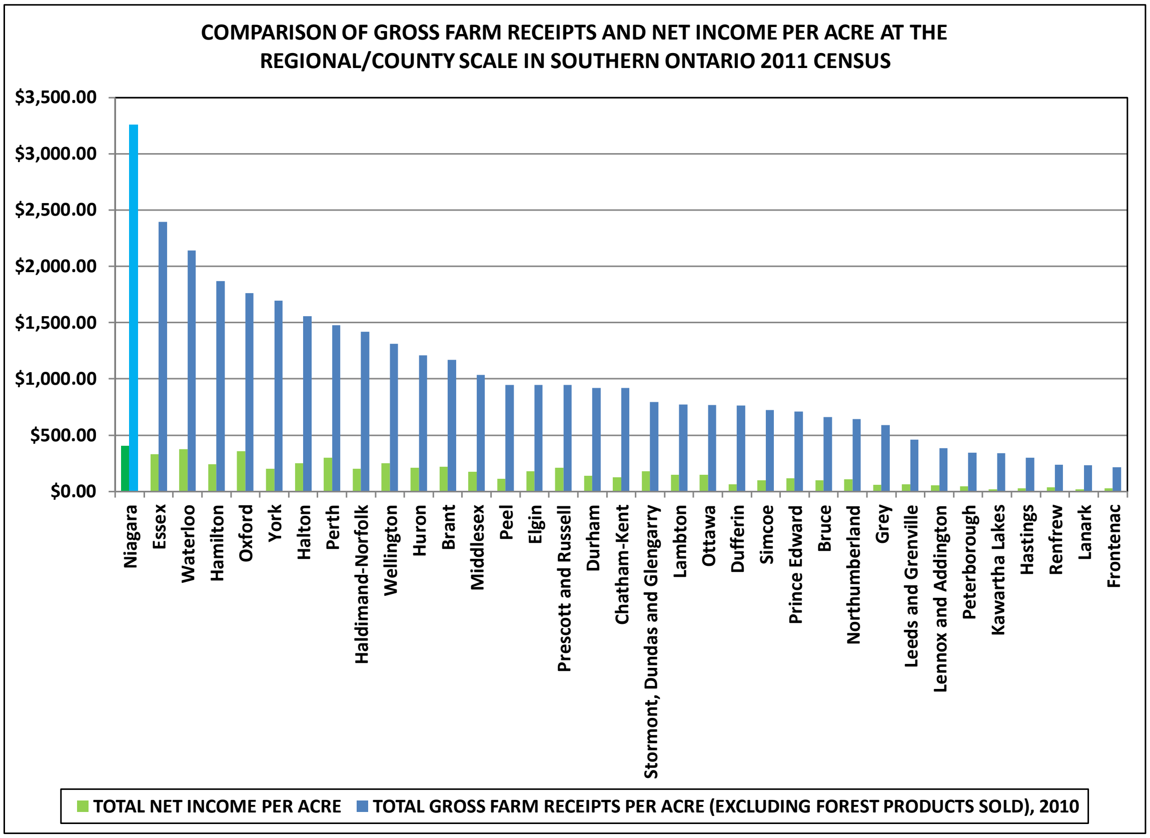
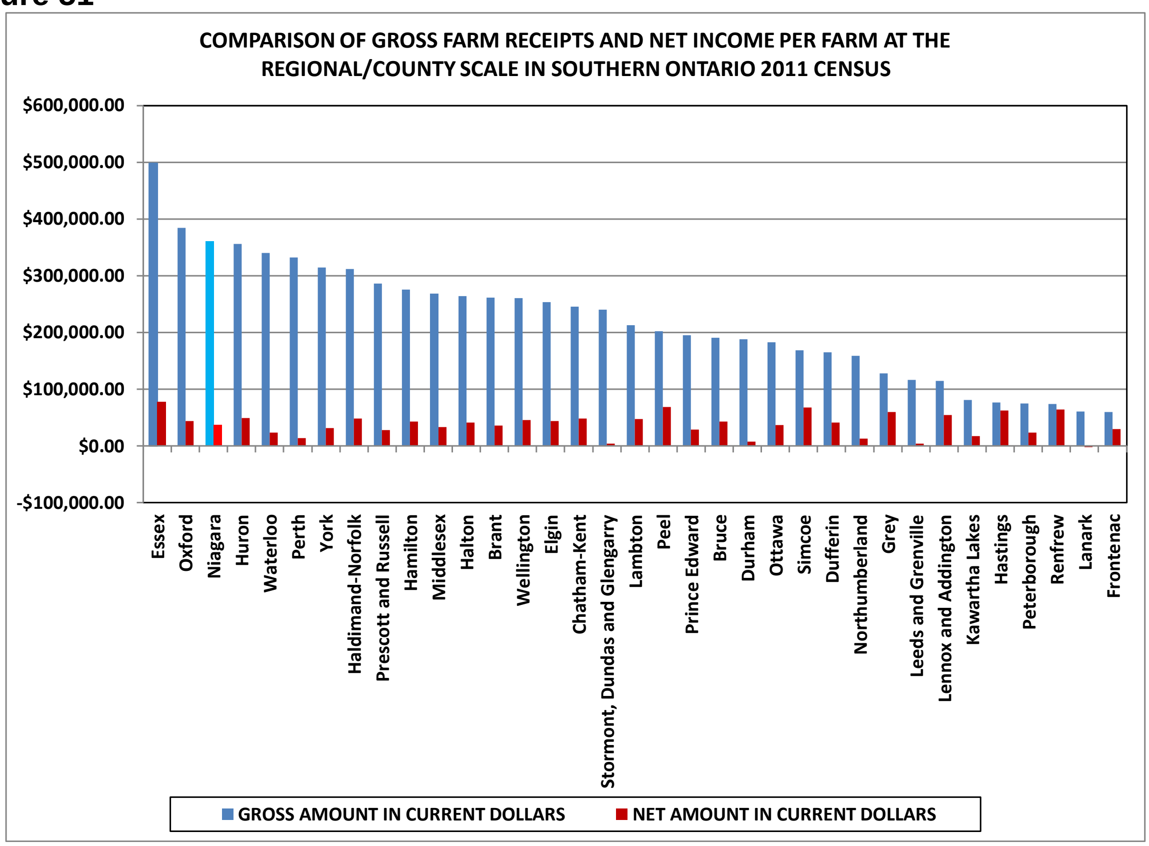
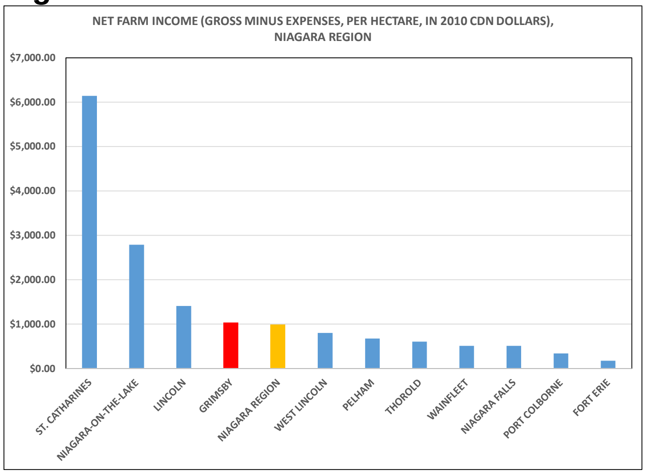
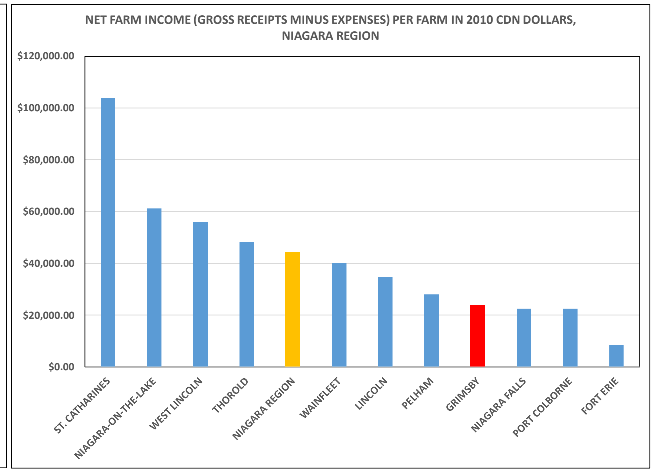


Figure 51

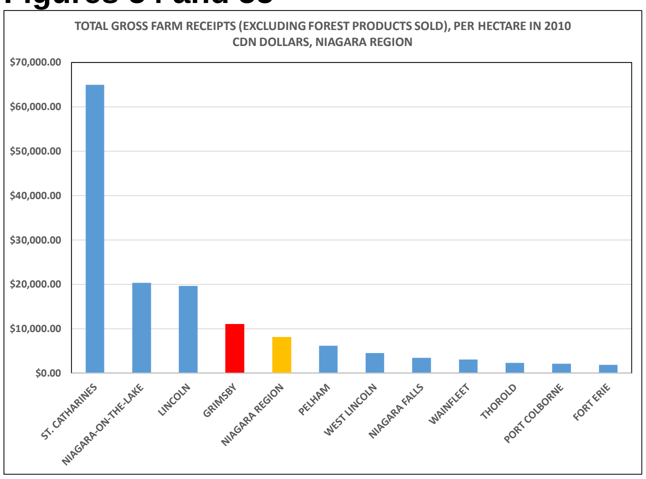


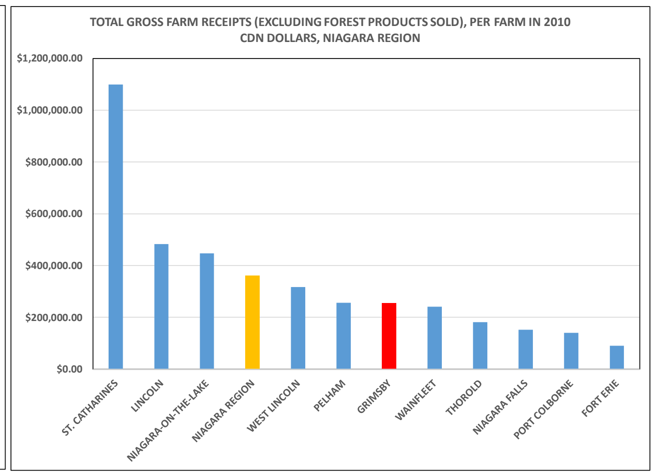
Figures 52 and 53



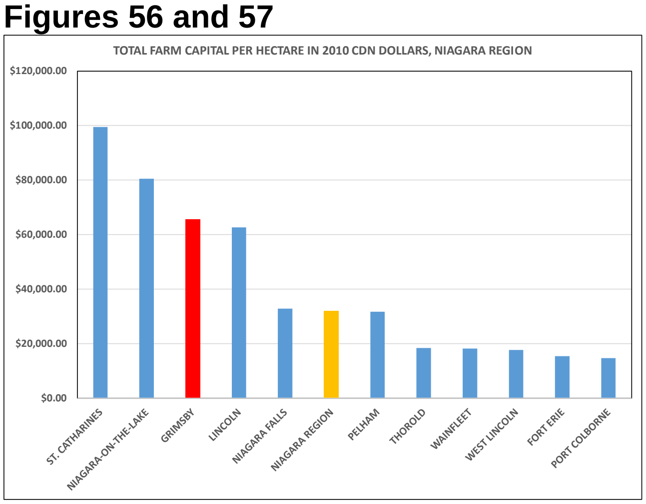


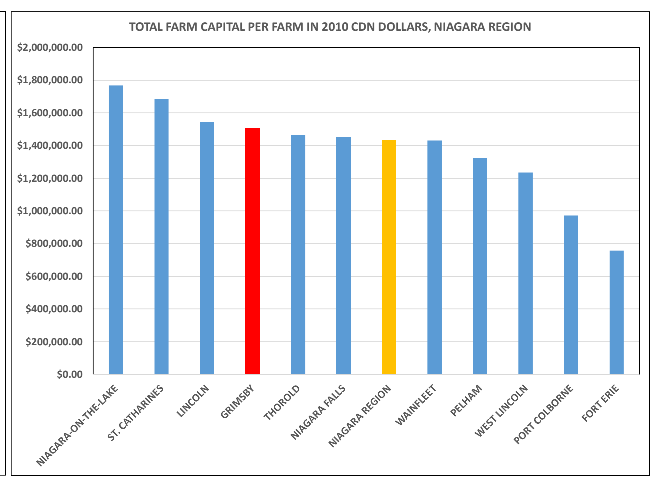
Figures 54 and 55





Figures 56 and 57





Niagara has relatively higher net incomes and gross farm receipts on a per unit area basis as well as on a per farm basis when compared to other Regions/Counties as summarized in Figures 50 and 51. However, the relatively large differences amongst

Regions/Counties is in gross farm receipts rather than the more important (from a business perspective) net income values. The net income values for Niagara support the view that Niagara farmers need to supplement their on-farm income with income from non-farm sources.

Grimsby's net farm income is slightly above the average for Niagara Region on a per unit area basis (Figure 52) but is much lower than the average for Niagara on a per farm basis (Figure 53). Gross farm receipts follow the same trend where they are slightly above the average for Niagara Region on a per unit area basis (Figure 54) but is much lower than the average for Niagara on a per farm basis (Figure 55).

Grimsby's total farm capital is relatively higher than that for Niagara Region both on a per unit area basis (Figure 56) and on a per farm basis (Figure 57). However, total farm capital is not very high in the context of the value of housing in Toronto, for example.

The data for Grimsby do not indicate that farmers in Grimsby are spared from the general perspective that "it's difficult to make a dollar farming".

5.7 Conflict

Are there sociocultural characteristics within Grimsby that provide incentives/disincentives related to the production of fruit and vegetable crops?

The Town of Grimsby has already documented land use characteristics within Grimsby and have included information specific to the *specialty crop area* in a letter sent to the 2015 Co-ordinated Review Panel (April 30, 2015). It is not the intent of this report to repeat the contents of this letter. However, I do agree with the statement within the letter that:

> *Some lands designated as tender fruit have not been tender fruit growing or used for agricultural purposes for decades (i.e. Radio Tower Lands), some have had soils stripped and are surrounded by uses such as residential which render the lands inappropriate for tender fruit and good grape production.*

Grimsby's specialty crop areas one and two contain much non-agricultural development and are near or adjacent to urban development. The production of fruits and vegetables does require significant levels of management and these levels are outlined in detail by OMAFRA, (2016 a). This management is protected by legislation as a *normal farm practice* but those living adjacent to wind turbines being used to prevent frost damage, or within 2 km of farms using bird bangers to minimize bird damage to fruit, tend to complain about this kind of management which they find to be upsetting and/or intrusive (based on a web search of newspaper articles). The probability of complaint tends to make farming more difficult and to render some areas less desirable for crop production. Therefore, the 2 segments of *specialty crop area* below and North of the escarpment in Grimsby are less desirable given their proximity to non-agricultural uses.

The decline in the number of farms producing fruit and vegetables, in the area in fruit and vegetable production, as well as in the balance of trade, has not been halted by the "buy local" initiative/marketing nor by farmers' markets such as the summer/fall market held on Thursdays on the Main Street in Grimsby.

6.0 FINDINGS SUMMARY

In summary, the agricultural data examined as part of this study indicate that:

- Grimsby's fruit and vegetable production area has diminished from the census years 1971 to 2011;
- fruit and vegetable production area for Grimsby as a proportion of the fruit and vegetable production in Niagara Region has decreased from 1971 to 2011;
- the diversity of fruit and vegetable production within Grimsby and Niagara Region has been diminishing with more production area used for grape production (1971 - 2011);
- the areas proposed to be removed from the *specialty crop area* designation have a relatively small amount of fruit and vegetable production;
- the north section of lands proposed to be removed from the *specialty crop area* designation has 70% of the area not mapped for soils (in 1989 the land use was non-agricultural and therefore not mapped) or developed for non-agricultural uses;
- the south section of lands proposed to be removed from the *specialty crop area* designation has 37% of the area not mapped for soils (in 1989 the land use was non-agricultural and therefore not mapped) or developed for non-agricultural uses;
- in aggregate, the lands proposed to be removed from the *specialty crop area* designation have 51% of the area not mapped for soils (in 1989 the land use was non-agricultural and therefore not mapped) or developed for non-agricultural uses;
- the approximately 31 ha of land left in the north segment of the *specialty crop area* located below the Escarpment has an average soil capability between classes 2 and 3, but, if the lands developed for non-agricultural uses are given the appropriate soil capability class of seven, the average soil capability of the north segment is class 6;
- the approximately 103 ha of land left in the south segment of the *specialty crop area* located below the Escarpment has an average soil capability between classes 2 and 3, but, if the lands developed for non-agricultural uses are given the appropriate soil capability class of seven, the average soil capability of the south segment is class 4;
- the approximately 31 ha of land left in the north segment of the *specialty crop area* located below the Escarpment has an average soil potential for fruits and vegetables between rating 3 and 4, but, if the lands developed for non-agricultural uses are given the appropriate soil capability class of seven, the average soil potential for fruits and vegetables of the north segment is class 6;
- the approximately 103 ha of land left in the south segment of the *specialty crop area* located below the Escarpment has an average soil potential for fruit and vegetables between rating 3 and 4, but, if the lands developed for non-agricultural uses are given the appropriate soil capability class of 7, the average soil capability of the south segment is 5;
- the lands proposed to be removed from the *specialty crop area* designation are near urban development thereby increasing the probability of complaint related to factors such as noise (e.g. bird bangers, wind turbines) and pesticide spray drift.

7.0 CONCLUSIONS/OPINIONS

The findings of this study demonstrate that the lands proposed to be removed from the *specialty crop area* in Grimsby are relatively poor for the production of specialty crops. Several of the tests for the designation of a *specialty crop area* are not met:

- specialty crop production is not predominant,
- soil capability and soil potential in Grimsby is not the best found in Niagara and in some areas is diminished due to non-agricultural development,
- fewer farms and farmers are producing fruits and vegetables within Grimsby and, as a result, there is diminishing infrastructure as well as fewer farmers skilled in the production of fruits and vegetables.

Given the characteristics of the lands in Grimsby proposed to be removed from the *specialty crop area* (areas identified within this report as one and two and located north of the Niagara Escarpment), I am of the opinion that the lands can reasonably be removed from that *specialty crop area* designation.

AgPlan Limited

Michael K. Hoffman

8.0 REFERENCES

Acton, C. J. 1989. *The Soils of Brant County*. Report no. 55 of the Ontario Institute of Pedology.

Agriculture and Agri-Food Canada (AAFC). 2014. Agricultural land use mapping.

Brown, D. M and R. E. Place. 1989. Rating climate in southern Ontario for horticultural crops. *Can. J. Plant Sci*. 69: 325-336.

Canada Soil Survey Committee (CSSC), Sub-committee on Soils Classification. 1978. *The Canadian System of Soil Classification*. Canadian Department of Agriculture Publication 1646. Supply and Services Canada, Ottawa.

Centre for Resources Development, University of Guelph. 1972. *Planning for Agriculture in Southern Ontario*. ARDA Report No. 7.

Ecologistics Limited and Smith, Hoffman Associates Limited. 1984. *Soil Rating System for Specialty Crops*. Prepared for Ontario Hydro.

Environment Canada. 1972. The Canada Land Inventory Report No. 2, *Soil Capability Classification for Agriculture*.

Fisher, Helen and Ken Slingerland. 2002. Site Selection for Grapes in the Niagara Peninsula.

Gillespie J. E., R. E. Wicklund and M. H. Miller. 1971. *The Soils of Halton County.* Report No. 43 of the Ontario Soil Survey.

Government of Ontario. 2005, 2014. *Provincial Policy Statement.* Queen's Printer for Ontario.

Grimsby, Town of. April 30, 2015. Letter to Mr. David Crombie Chair 2015 Co-ordinated Review Panel Re: 2015 Co-ordinated Land Use Planning Review - Town of Grimsby Submission. Letter signed by Mr. Robert Bentley, Mayor - Town of Grimsby

Grimsby, Town of. 2016. Shapefiles Associated with Maps/Schedules for the Town of Grimsby Official Plan and Zoning Bylaw.

Hagerty T. J. and M. S. Kingston. 1992. *The Soils of the Middlesex County*. Volume 1 and 2. Report no. 56 of the Ontario Centre for Soil Resource Evaluation.

Hoffman, D. W., 1971. *The Assessment of Soil Productivity for Agriculture*. ARDA Report No. 4.

Hoffman, Douglas Weir. 1973. *Crop Yields of Soil Capability Classes and Their Uses in Planning for Agriculture*. PhD Thesis, University of Waterloo.

Hoffman, D. W., B. C. Matthews and R. E. Wicklund. 1964. *Soils Associations of Southern Ontario*. Report No. 30 of the Ontario Soil Survey.

Hoffman, D. W., and H. F. Noble. 1975. *Acreages of Soil Capability Classes for Agriculture in Ontario*. ARDA Report Number 8.

Irwin, Ross W. 1999. *Twenty Year Record of Drainage Benefit*. Prepared as a factsheet for the Land Improvement Contractors of Ontario.

Kingston, M. S., and E. W. Presant. 1989. *The Soils of the Regional Municipality of Niagara*. Volumes 1 and 2. Report no. 60 of the Ontario Institute of Pedology.

McBride, Raymond A. 1983. *Agronomic and Engineering Soil Interpretations from Water Retention Data*. PhD Thesis. University of Guelph.

Mussell, Al, Jim Willwerth and Helen Fisher. December, 2011. *Grape Varieties in Ontario Wine Regions*. *Understanding the Potential and the Risks*. Grape Growers of Ontario.

Mussell, Al, Kate Stiefelmeyer, Anatoliy Oginskyy, Claudia Schmidt and Bob Seguin. December, 2010. *Aligning the Ontario Grape Supply and Demand: A Varietal*

Plan for the Grape and Wine Industry. Executive summary. George Morris Centre.

Land Information Ontario (LIO). 2016. Map shapefiles and associated databases for soils and soil capability.

Ontario Institute of Pedology. 1992. *Field Manual for Describing Soils*. Ontario Institute of Pedology, Guelph, Ontario.

Ontario Ministry of Agriculture, Food and Rural Affairs. 2016 a. *Guide to Fruit Production*. Publication 360.

Ontario Ministry of Agriculture, Food and Rural Affairs. Statistics Branch. 2016 b. Various financial, trade statistics available to September 2016. OMAFRA Web Site.

Pennsylvania State University. 2004. Cluster Analysis Ward's Method. http://sites.stat.psu.edu/~ajw13/stat505/fa06/19_cluster/09_cluster_wards.html .

Presant, E. W. and R. E. Wicklund. 1971. *The Soils of Waterloo County*. Report number 44 of the Ontario Soil Survey.

Presant, E. W. and C. J. Acton. 1984. *The Soils of the Regional Municipality of Haldimand-Norfolk*. Volumes 1 and 2. Report number 57 of the Ontario Soil Survey.

Richards, N. R., A. G. Caldwell and F. F. Morwick. 1949. *Soil Survey of Essex County*. Report No. 11 of the Ontario Soil Survey.

Schut, L. W. and E. A. Wilson 1987. *The Soils of the Regional Municipality of Ottawa-Carlton (excluding the Ottawa Urban Fringe)*. Volumes 1 and 2. Report no. 58 of the Ontario Institute of Pedology.

Schut, L., W. 1992. *The Soils of Elgin County*. Volumes 1 and 2. Report no. 63 of the Ontario Center for Soil Resource Evaluation.

Schut, L. W., E. A. Wilson and P. A. Roberts. 1994. *State of the Resources for the Duffin-Rouge Agricultural Preserve*. Ontario Ministry of Agriculture and Food.

Statistics Canada. 1981 - 2011. Census of Agriculture data.

Statistics Solutions. 2015. Conduct and Interpret a Cluster Analysis. http://www.statisticssolutions.com/cluster-analysis-2/.

Tan, Pang-Ning, Michigan State University, Michael Steinbach, University of Minnesota, Vipin Kumar, University of Minnesota. 2006. *Introduction to Data Mining.* Chapters 4, 6 and 8. http://www-users.cs.umn.edu/~kumar/dmbook/index.php .

Weibe, J. and E. T. Anderson. 1976. *Grape Climatic Zones in Niagara*. Ontario Ministry of Agriculture and Food.

APPENDIX 1
GIS ALGORITHMS

ALGORITHM 1 GENERAL PROCEDURE/PROTOCOL LIST FOR GIS MAPPING

Work Description/List

Part One - existing published information

1 Obtain information (geo-referenced shape files and relational data bases) for the broadest scale used in the study (usually the County or Regional scale) from the municipality/Township, Region/County, MNR, LIO or OMAFRA for:

1a base map information such as roads, rivers, lakes, site and/or study area boundaries political boundaries, climate etc. (LIO, Region)

1b agricultural soils and Canada Land Inventory (CLI) information (LIO)

1c geo-referenced aerial photo base (various sources)

1d property boundaries and property area database (MPAC, County)

1e agricultural land use (LIO, AAFC)

1f farm tax rated parcels or agricultural land use fields (OMAFRA, LIO, Agricultural Atlas)

1g planning designation and zoning (with emphasis on specialty crop areas, prime agricultural lands and rural areas), settlement area boundaries, natural heritage resource areas and other databases as necessary (Region/County, Municipality/Township).

2 Combine information from steps 1 a to g in appropriate layers.

3 Produce summary results of the data base matrices for soils, soil capability, agricultural land use, land use, planning designation, zoning, property size, farm tax rating, in the form of a multi-tabbed Excel chart (or as separate Excel files, whichever works best); these matrices will be used at 2 different scales, County/Region, Municipality/Township and will include all data layer polygons and their characteristics for a given area or a set of areas.

4 Produce single factor map examples for review.

Part Two - change and/or add information to database(s)

5 Examine each data layer singly and combined with other layers for correlations, anomalies/errors and modify information (if required). The data checking method for the soils map is part of a separate algorithm related to the production of a unique soil symbol list (algorithm 2).

6 Add new information to newly created columns in the database(s) (for example, add soil potential ratings for specialty crops to soil map database where such information is available. There will likely be changes to the agricultural land use map with emphasis on what areas are currently used for specialty crop production.)

Part Three - measurement

7 Planning designation information should be used to "blackout", where blacked out areas are not included in the calculations (those areas which are not agricultural or rural (e.g. urban settlement areas, industrial, commercial, institutional, residential uses in agricultural areas). Depending on whether agriculture can occur within natural heritage features, some natural heritage features may also need to be removed from the calculations.

8 Prepare a metabase of results from layer combinations, for example, soil capability class and soil productivity by property or property class, in Excel format at the broadest to the site-specific scales that are being used within the assessment (County and Township scales). The specific requirements are outlined in algorithm 3.

9 Prepare summary maps (formatted as PDF files, minimum size 11" x 17") that show the results of the combination of different data layers. For example, soil capability by property or by property class; property size in specialty crop areas versus common field crop and livestock areas. Interpret the distribution of the information within a county or study area.

10 Make newly created databases and maps available for public review and modify databases, metabases, maps, as necessary, based on local knowledge.

11 Repeat steps 7 and 8 to provide new or modified databases, metabases and mapping.

Part Four - Additional single factor and/or interpretive maps

12 There may be a requirement to produce single factor maps or additional interpretive maps. These maps would be based on a column or columns already part of the existing databases or metabases.

13 There may also be a requirement to add a map variable such as climate to subdivide a study area. Subsequently, separate interpretive classifications will need to be produced for each of the new areas subdivided based on the new variables such as climate added to the analysis

ALGORITHM 2 CREATING A UNIQUE SOIL SYMBOL LIST

1 Obtain/use the soils database for all soil map polygons (LIO/OMAFRA) provided with the shape files for the soil map.

2 Reduce database to columns providing data for soil series name, soil series symbol, slope gradient, slope class, stoniness class, soil capability class, drainage class, surface texture (SOIL_NAME1, Symbol1, SLOPE1, CLASS1, STONINESS1, CLI1, DRAINAGE1, ATEXTURE1, SOIL_NAME2, SYMBOL2, SLOPE2, CLASS2, STONINESS2, CLI2, CLI2_1, CLI2_2, DRAINAGE2, ATEXTURE2) for a total of 16 columns (for some Regions/Counties there are 3 possible soils in a soil complex; therefore, there would be 24 columns of information).

3 Set up the reduced database (only 16 columns have been selected but all soil polygons on the map are listed) from step 2 so that the 2nd component of soil complexes identified in the previous step with the suffix “2” are effectively listed sequentially within the 8 columns identified for the sole or primary (where primary and secondary soils are present for soil complexes) soil series information listed with the suffix “1”. This could be done by “blocking on” the 8 columns for the 2nd part of soil complexes (all having the suffix “2”) and physically moving it to occupy the rows “underneath” the soil information listed with the suffix “1”. This database can be defined as the “all polygons data”.

4 Program GIS to:

a) Choose 1st row of this 8-column data and “save” to the unique symbol list.

b) Choose the 2nd row in the “all polygons” data and compare it to the 1st row and if any one or more of the components in the 8 columns are different, “save” the information to the unique symbol list.

c) For each subsequent row in the “all polygons data” as set out in step 3, compare the values in the all polygons data to the 8 columns found within the unique symbol list and if any of the data in the 8 columns all polygons data is different from that in any row of the unique symbol list, “print” the information in that row to the unique symbol list.

d) Continue the comparison for all polygons identified on the soil map.

e) Produce the unique symbols list (that is, a list with no duplicates).

Subsequent steps

5 Send the unique symbol list in Excel format to the agrologist for review.

6	Analyze unique symbol list for soil capability values that are incorrect given information in the remaining 7 columns (i.e., look for inconsistencies).
7	Change soil capability based on Canada Land Inventory for Agriculture “rules” and/or newer published soil capability ratings.
8	Add a column to the data for changes/corrections in soil capability class if errors are observed.
9	Modify soil capability map based on corrections.
10	Produce specialty crop group soil potential ratings for each unique symbol if this rating is part of the analysis.

APPENDIX 2
SOIL PRODUCTIVITY INDEX and SOIL POTENTIAL INDEX CALCULATION

Soil potential ratings for fruits and vegetables have data limitations associated with soil rating systems and climate as described in the following paragraphs. All the databases evaluated have limitations associated with scale, data availability or alternatively, data suppression. For example, a soil rating system for specialty crops was developed by Hoffman and Cressman in 1984 for Ontario Hydro (Ecologistics and Smith, Hoffman, 1984). This is a three-class system – good, fair or poor which uses crop groupings but has not been applied on a broad scale to the Province. The Ontario Institute of Pedology and subsequently the Ontario Center for Soil Resource Evaluation has compiled specialty crop capability systems for some areas within Ontario. However, the Province has not a single specialty crop soil potential rating for all of Ontario. Given this lack of comprehensive soil potential information for specialty crops, it is not possible to reasonably differentiate which soils are most unique for specialty crop production within the Province.

However, some soil potential ratings for fruit and vegetables have been produced for Haldimand-Norfolk, Niagara, Elgin, Middlesex and Brant. Unfortunately, the fruit and vegetable crop groupings used in different soil surveys are dissimilar in number as well as in the kinds of fruits or vegetables included in each group. For example, Niagara has 20 crop groupings (9 for fruits and 11 for vegetables) whereas Haldimand-Norfolk has 15 groups that do not always separate fruit and vegetables into separate categories. More details about the soil potential ratings for specialty crops are outlined in a summary in the table following in this Appendix. In addition, both five as well as seven class soil potential rating systems have been used in published soil survey reports in Ontario.

As a second example of information limitations, climate data is limited due to scale and a lack of integration. Several single factor maps produced on a broad scale are available for crop heat units, plant hardiness zones, temperature minima and maxima as well as precipitation. More specific maps such as the map for *Site Selection for Grapes in the Niagara Peninsula* (Fisher and Slingerland, 2002) are not available for the province of Ontario. Additionally, specific studies on irrigation such as that done for Niagara Region (Stantec, 2007) are not available for southern Ontario.

ONTARIO SPECIALTY CROP SOIL CLASSIFICATIONS SUMMARY

Crop Grouping Description 1	Niagara Crop Grouping	Crop Grouping Description 2	Haldimand-Norfolk Crop Grouping	Crop Grouping Description 3	Middlesex and Elgin Crop Grouping	Crop Grouping Description 4	Brant Crop Grouping
	Seven Class System		Seven Class System		Five Class System		Seven Class System
Tree Fruits, Grapes and Small Fruits:	**Tree Fruits, Grapes and Small Fruits:**	**Tree Fruits, Grapes and Small Fruits:**	**Tree Fruits, Grapes and Small Fruits:**	**Tree Fruits, Grapes and Small Fruits:**	**Tree Fruits, Grapes and Small Fruits:**	**Tree Fruits, Grapes and Small Fruits:**	**Tree Fruits, Grapes and Small Fruits:**
Peaches, Apricots, Nectarines	A	Apricots, Sour Cherries, Sweet Cherries,	D1				

Crop Grouping Description 1	Niagara Crop Grouping	Crop Grouping Description 2	Haldimand-Norfolk Crop Grouping	Crop Grouping Description 3	Middlesex and Elgin Crop Grouping	Crop Grouping Description 4	Brant Crop Grouping
		Peaches					
Sweet Cherries	B						
Sour Cherries	C						
Labrusca Grapes	D	Hybrid and Vinifera Grapes, Labrusca Grapes	D3				
Vinifera Grapes	E						
Apples	F	Apples	D4	Apples	2	Apples	D1
Pears, Plums	G	Pears, Plums	D2	Pears, Plums	3		
Strawberries, Raspberries	H	Peppers, Raspberries, Rhubarb, Strawberries	B3	Raspberries, Strawberries	1	Strawberries	B3
Currants, Gooseberries	I						
				Rutabagas	3		
		Peanuts	A2	Peanuts	2		
				Heart Nuts, Filbert Nuts	3		
				Walnuts	2		
Vegetable Crops:	**Vegetable Crops:**	**Vegetable Crops:**	**Vegetable Crops:**	**Vegetable Crops:**	**Vegetable Crops:**	**Vegetable Crops:**	**Vegetable Crops:**
Crop Grouping Description 1	Niagara Crop Grouping	Crop Grouping Description 2	Haldimand-Norfolk Crop Grouping	Crop Grouping Description 3	Middlesex and Elgin Crop Grouping	Crop Grouping Description 4	Brant Crop Grouping
Broccoli, Brussels Sprouts, Cauliflower	J	Cabbage, Cauliflower, Canola, Sweet Corn, Tomatoes, Turnips	C3	Brussels Sprouts, Cauliflower, Cabbage	8	Cabbage, Cauliflower	C2
Bulb Onions, Garlic	K	Onions, Beets, Carrots	B1				
Green (Bunching) Onions	L						
Eggplant, Peppers	M	Peppers, Raspberries, Rhubarb, Strawberries	B3	Peppers	6	Peppers	B2
Cucumbers	N			Cucumbers	4		
Muskmelon	O	Ginseng, Muskmelon, Watermelon	B2			Ginseng	B1
Potatoes	P	Potatoes	A3	Irish Potatoes	3	Potatoes	A1
Tomatoes	Q					Tomatoes	C2
Sweet Corn	R			Sweet corn	7	Sweet Corn	C2
Celery, Lettuce	S	Cucumber, Lettuce, Radish	C4				
Pumpkins, Squash	T	Green Beans, Peas, Pumpkins, Squash	C2				
		Asparagus	A1	Asparagus	1		
		Fava Beans, Soybeans, White Beans	C1	Soybeans	4	Beans	C1
				Sweet Potatoes	2		
				White beans	5		

SOIL PRODUCTIVITY INDEX CALCULATION

The soil productivity index is an arithmetic mean that expresses the relative occurrence of soil capability classes 1 to 7 on selected properties or within specified boundaries. The index is most often based on soil productivity ratings (Hoffman, 1973). Areas with the highest soil capability index will have mainly class 1 land. Areas with a low index will consist of lower soil capabilities. The productivity index method has been used because it provides a single number derived from a listing, by proportion, of the soil capability classes 1 through 7 which allows for direct comparison among different areas or sites. Impacts on soil capability will generally be greatest on an area with a high soil capability index; that is, impacts will be highest when good (higher capability land) is lost to development.

Method

Soil Productivity Index = *(proportion of area of class 1 soils x 1.0) + (proportion of area of class 2 soils x 0.8) + (proportion of area of class 3 soils x 0.64) + (proportion of area of class 4 soils x 0.49) + (proportion of area of class 5 soils x 0.33) + (proportion of area of class 6 soils x 0.17) + (proportion of area of class 7 soils x 0.02)*

The area of each soil map unit was measured and areas of similar soil capability were summed for CLI classes 1 to 7 lands. The area was calculated for each CLI class and subsequently multiplied by a productivity index corresponding to each soil class. The productivity index is specific to each capability class. The proportion of each area occupied by each soil capability class was multiplied by the corresponding soil productivity value (following Hoffman, 1973) and products were subsequently summed to obtain a soil productivity index for lands affected by or potentially affected by development.

SOIL POTENTIAL RATING FOR FRUITS AND VEGETABLES

Soil potential ratings are based on crop groupings and classes described for Brant County by Acton (1989) and for Niagara Region by Kingston and Presant (1989). Crop suitability class descriptors in the original Kingston and Presant's report have been placed in an ordinal scale for soil potential as outlined in the following:

- Good (G) – 1
- Fair to Good (F-G) – 2
- Fair (F) – 3
- Poor to Fair (P-F) – 4
- Poor (P) – 5
- Very Poor (VP) – 6
- Unsuitable (U) - 7

A matrix is created having rows which are the different soils found within a given area in the columns are for the crop groupings. The highest or best rating is class 1 and those soils that are unsuitable rated lowest as class 7. Climate has been assumed to limit the production of peaches, nectarines, apricots, cherries and vinifera grapes within some Counties/Regions and the soil potential rating has been modified to class 7 (unsuitable) based on that climate limitation. An average specialty crop soil potential rating was calculated by adding the classes for the separate crops or crop groupings and dividing it by the total number of those crop groups (8 crop groupings following Acton and 20 crop groupings following Kingston and Presant).

The application of this average soil potential rating is limited to comparisons at a provincial and regional/county scale at its broadest extent but depending on variations in climate may only be suitable as a relative rating at the municipal or township level.
It should also be noted that the soil potential rating is an average and that there may be individual crops that will grow very well on a particular soil. In other words, a soil with an average specialty crop potential class 4 rating may actually contain one or two crop groupings with soil potential ratings at a higher level - that is, soil potential subclass 2, for example.

Soil Potential Index

The average soil potential index is an arithmetic mean that expresses the relative occurrence of soil potential ratings 1 to 7 on selected properties or within specified boundaries. Areas with the highest soil potential index will have mainly rating 1 land. Areas with a low index will consist of lower soil potential (5-7) for specialty crops. The potential index method has been used because it provides a single number derived from a listing, by proportion, of the soil potential ratings 1 through 7 in a given area which allows for direct comparison among different areas or sites.

Method

Soil Potential Index = *(proportion of area of rating 1 soils x 1) + (proportion of area of rating 2 soils x 2) + (proportion of area of rating 3 soils x 3) + (proportion of area of rating 4 soils x 4) + (proportion of area of reading 5 soils x 5) + (proportion of area of rating 6 soils x 6) + (proportion of area of class 7 soils x 7)*

The area of each soil map unit was measured using GIS and areas of similar soil potential were summed for potential ratings 1 to 7 lands. The soil productivity index and the soil potential index both tend to correlate with soil capability class.

APPENDIX 3
SOIL CLASSIFICATION AND SOIL SURVEY

Ontario's published soil surveys follow a hierarchical system of soil classification to represent a three-dimensional area called a pedon (see http://www.pedosphere.ca/resources/CSSC3rd/chapter02.cfm). This three-dimensional area is intended to be represented as a two-dimensional map polygon usually shown as the soil series on soil maps in Ontario. Soil characteristics such as texture and particle size are a part of a continuum and the soil map also must present a landscape continuum as part of a discrete map polygon. In short, soils are represented as discrete units on a map even though the soils themselves are not discrete. As a result, there can be, and there have been, different ways of representing changes in soils that have been mapped within Ontario and within parts of the rest of the world. Not surprisingly, the opportunity to represent soils in different ways has resulted in significant changes in the approach to mapping soils over the time within which soil surveys have been published in Ontario. The older soil surveys tend to lump large areas into soil map polygons, whereas newer soil surveys have smaller more detailed polygons. Newer soil surveys also tend to have complexes (which are soil map polygons containing 2 or more soil series and/or two a more soil capability classes and subclass limitations). Examples of more recent soil surveys include Niagara, Haldimand-Norfolk, Brant, Kent, Middlesex, Ottawa urban fringe, Ottawa-Carlton and the soils component within the report titled *State of the Resources for the Duffin-Rouge Agricultural Preserve*. A review of older as well as newer Ontario soil reports indicates the following:

- soil series with the same name may not have the same characteristics between Counties and/or Regions,
- some soil series identified in detailed field studies are not always represented in the County/Regional published soil survey within which the detailed work is being completed; and,
- not all the soil capabilities assigned to a particular soil series are consistent from one soil report to another soil report.

The significance of the difference between old mapping styles and newer ones can be illustrated by using an old soil report and comparing the old soil map to a newer map. Both maps were produced by government staff. Within Durham Region, as well as a part of York Region, an area identified as an Agricultural Preserve was remapped (Schut *et al*) at a scale of 1: 20,000 in 1994 relative to two maps produced in 1956 (Olding et al.) and 1955 (Hoffman and Richards) both at a scale of 1: 63,360. A review of these older and newer maps shows that:

- there are differences in the number and size of soil polygons and the differences in the soil polygons represent differences in soil series and soil phases, and
- soil capability values assigned to each of the soil polygons are different from older map to newer map.

When the soil capability information is calculated as a productivity index, the old map assigned a productivity index of 0.91 (equivalent to capability class 1 soils) to that part of the Agricultural Preserve located within Durham Region whereas the new map has a productivity index of 0.66 that is relatively equivalent to capability class 3 (0.64). This information demonstrates that the soil productivity within the Preserve is significantly lower than the original mapping by Olding *et al.* (1956) would indicate. Given that some of the soils mapped in the Preserve by Schut et al. (1994, OMAF) require tile drainage, this tile drainage would need to be in place to reach the average productivity index value of 0.66.

RATING FOR COMMON FIELD CROPS

The original soil capability classification is part of the Canada Land Inventory (CLI) and used an ordinal scale having the numbers 1 through 7. (A discussion of the definition of different scales is available in many mathematics texts. Siegel (1956) outlines a good summary matrix of the definitions for different scales that can be related to statistical tests). Alternatively, Velleman and Wilkinson (1993) describe mathematical scales as part of a continuum and argue that the use of specific statistical tests for specific scales is inappropriate. Irrespective of scale, the CLI capability interpretation was derived based on "*research data, recorded observations, and experience*" and was not intended for use as an indicator of the "*most profitable use of land*".

The class, the broadest category in the capability classification, is a grouping of subclasses that have the same relative degree of limitation or hazard. The limitation or hazard becomes progressively greater from class 1 to class 7. The class indicates the general suitability of the soils for agricultural use.

Class 1 - Soils in this class have no significant limitations in use for crops.

Class 2 - Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.

Class 3 - Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices or both.

Class 4 - Soils in this class have severe limitations that restrict the range of crops or require special conservation practices or both.

Class 5 - Soils in this class have very severe limitations that restrict their capability of producing perennial forage crops, and improvement practices are feasible.

Class 6 - Soils in this class are capable only of producing perennial forage crops and improvement practices are not feasible.

Class 7 - Soils in this class have no capability for arable agriculture or permanent pasture.

Agricultural soils information is currently available in old-style printed format as well as in digital format. The original information with all presented as soil survey reports with accompanying soil maps. Some more recent soil survey publications include a separate interpretive map for soil capability following the rules outlined in the Canada Land Inventory Soil Capability Classification for Agriculture. However, most reports contain a section that has a matrix summarizing soil capability classes for different soil series and phases relative to slope class. The very early soil reports prior to the 1960s tend to have a descriptive summary of the relative merits of different soil series for common field crop production - a precursor to the CLI soil capability classification. When the CLI soil capability classification work was started, a list of all the soil series was compiled and a soil capability class assigned to each soil series having a given set of limitation such as slope class and stoniness class. This information served as a base and blueprint maps, produced by projecting soil polygon/map unit boundaries on to topographic maps at a scale of 1 to 50,000, summarized capability on a County basis. When the County work was being done, additional detailed soil surveys were completed in several smaller sample areas to assist in assigning soil capability classes to the soils/soil polygons found within the County. The blueprint maps served (without edit) as the base for the production of generalized 1: 250,000 scale soil capability maps by the Federal Government in Ottawa. The same blueprint maps were also used as a data source when the soil surveys for Ontario were digitized by OMAFRA. The digitizing included matching soil polygon series and soil capability information at the boundaries between Counties/Regions. Additionally, several more detailed soil surveys have been completed and the soil capabilities outlined in these published reports do not always match the soil capability values assigned on the blueprint maps. Thus, soil capability values can come from several different sources as follows:

- the unpublished summary of capability classes assigned to all of the soil series present as a result of mapping up to the 1960s;
- the blueprint map soil capability classes;
- the separate County summary data prepared as the base for the blueprint maps;
- the soil capability classes assigned within published soil reports after the 1960s some of which result because of published scientific information about the effects of soil characteristics such as density on soil capability.

Other soil capabilities have been derived because of the identification of new soil series, new soil phases and differing opinions about the capability of different soils

Subsequently, research by Hoffman (1973) indicated that soil capability class was an indicator of common field crop yields and productivity (yield) indices could be derived based on those yields. The indices, described more specifically in Appendix 1, are used as an "average" for three crops: oats, barley, and corn.

The soil capability class ordinal scale could then be converted into an interval scale using Hoffman's (1973) data. The data used to create the interval scale are based on older soil surveys and the soil capability class summaries associated with the older surveys are summarized by Hoffman and Noble (1975). New surveys have been completed for Regions such as Middlesex, Elgin and Niagara. In these new surveys, because of work by McBride (1983), the soil capability classes for some soils have been changed to a lower class, particularly for soils with a high clay content. While McBride's work has been related to average yield data, on a County or Regional basis, no site-specific yield data has been used to confirm that the newer changes to soil capability class is supported by specific yields as was completed in Hoffman's (1973) research. Therefore, the capability classes used in the newer soil surveys, such as the one for Niagara, might better be described as being part of an ordinal scale.

Regardless of the difference of opinion concerning arithmetic scale, yield data, and productivity indices, both data sources and methods have been investigated as part of the work described in this report.

The original soil capability rating report (Environment Canada, 1972) has assumptions which have been applied to the interpretation of soil capability. Two of these assumptions (Environment Canada, 1972) are germane to a discussion on the capability of the subject lands and are as follows:

- *Good soil management practices that are feasible and practical under a largely mechanized system of agriculture are assumed.*
- *Soils considered feasible for improvement by draining, by irrigating, by removing stones, by altering soil structure, or by protecting from overflow, are classified according to their continuing limitations or hazards in use after the improvements*

have been made. The term "feasible" implies that it is within present day economic possibility for the farmer to make such improvements and it does not require a major reclamation project to do so. Where such major projects have been installed, the soils are grouped according to the soil and climatic limitations that continue to exist. A general guide as to what is considered a major reclamation project is that such projects require co-operative action among farmers or between farmers and governments. (Minor dams, small dykes, or field conservation measures are not included).

Therefore, these assumptions have been considered in the evaluation of soils in this specialty crop study. Soil capability mapping has been based on the original soil map which is now available in digital format from LIO based on information originally supplied by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).

As discussed previously, the Canada Land Inventory (CLI) originally assumed that soil management that could be applied by a farmer would occur. Therefore, improvements such as irrigation and adequate drainage (both surface and subsurface) were already assumed to be applied in the rating of soils into capability classes.

Tile Drainage

As noted previously, soil capability and therefore productivity makes assumptions about tile drainage (that is, that tile drainage is applied where it is needed and that capability class ratings reflect the fact that the drainage is already assumed to be in place). There are some differences of opinion about which soil drainage classes would benefit from tile drainage. However, it is likely that imperfectly and poorly drained soils would show improved yields when tiles had been installed. There is no doubt that poorly drained soils have better yields when tile drained. As well, it is likely that the imperfectly drained soils would benefit from tile drainage. Unfortunately, the newer soil surveys do not indicate how soil capability class levels would change if imperfectly drained soils are not tiled.

Some information is available to assist in estimating how productivity is diminished in areas requiring tile drainage. For example, yield data collected over 20 years and that were summarized and evaluated by Irwin (1999) indicate that, because of tile drainage, average yields have improved within a range where the least improvement was a 10 percent increase for coloured beans in contrast to a high increase of 38 percent for wheat. The summary by Irwin (1999) did not differentiate by soil series, soil drainage class, or by location in the Province. Based on a general interpretation of the data from Irwin (1999), it can be estimated that imperfectly drained soils in an undrained state could be poorer by a single capability class. However, the installation of tile drainage on the imperfectly drained soils is less likely than installation on poorly and very poorly drained soils.

APPENDIX 4
MULTI-ATTRIBUTE ANALYSIS AND AGRICULTURAL PERFORMANCE

MULTI-ATTRIBUTE ANALYSIS

Any multi-attribute analysis, including a LEAR analysis, may have different results based on:

- the number and kind of variables considered,
- the analysis method,
- the weights applied to the variables,
- whether the data was standardized, and
- whether all the data was presented consistently to mean that a high number is intended to indicate a high importance value.

A review of the literature did not present information suggesting that a single multi-attribute analysis method is the best method. Even the wording employed for the quantitative methods used to combine information varies. The University of Redlands and the Spatial Decision Support Consortium (2012) have prepared a summary of the language and definitions associated with Multi-Criteria Decision Analysis (MCDA). Some of the work described by the University of Redlands is based on work by Malczewski (2006). Multi-attribute Combination Methods is a subset of MCDA having subcategories of Analytical Hierarchy Process, Concordance Methods, Fuzzy Aggregation Operation, Ideal/Reference Point Method, Value/Utility Function Method and Weighted Linear Combination. A LEAR analysis fits in to the subcategory of Weighted Linear Combination which is described on the Redlands website as "the most often used technique for tackling spatial multi-attribute decision making".

AgPlan Limited and Michael Hoffman have carried out various multi-criteria decision analyses at different scales throughout the Province of Ontario. The following paragraphs briefly describe the methods used to evaluate agricultural performance within different Regions or Counties in central to southwestern Ontario. Most of the variables used in the regional scale analyses are outlined in the Agricultural Census for Ontario. Additional variables for soil productivity and crop yields are available through OMAF(RA) for the years used in the analyses. The early census years had relatively few variables (in the order of 30) while later census years used many variables (in the range of hundreds). Some environmental variables used in the later analyses first appeared in 1996. There is the potential for an infinite number of ways to modify the data using the three ways described. Therefore, individual databases were designed to include some relatively different measures of agricultural performance/achievement.

<u>Regional Comparison</u>

At the regional scale for example, environmental, economic, and production viewpoints were separated for some databases. In other instances, a modified characterization within a single category such as production was completed. For example, production was characterized as using total production values (volumetric or gravimetric) for some data sets and as production per unit area (yield) in other data sets. Multiple characterisations were used to represent different perspectives as well as different values associated with the agricultural indicators/metrics. Therefore, for example, total production values were included because they give a relative indication of a County's contribution to the total food production that occurred within a given year within southern to central Ontario. However, this production indicator tends to be correlated with the area of the County. Therefore, yield data was included and/or emphasized to minimize any effect associated with a Region/County's size on that Region/County's performance rating. As well, each of the data sets was modified using different weighting schemes to represent disparate views about which indicators are better predictors of agricultural performance.

Different agricultural variables were grouped into databases to emphasize different parts of each year's agricultural indicators. In general terms, one database was prepared for fruits and vegetables and the second database produced so that the area and farm number data from the first a database was proportional to the total census farm area or total number of census farms.

Methods and Standardization

The combination of different variables to produce a single value has traditionally presented problems and colloquially is known as the "combining apples and oranges" problem. The problem of combination has been reduced by choosing methods that compare indicators using a standardized quantitative scale. As described previously, each data set could be analysed using two different methods as follows:

(1) Simple additive weighting (SAW);
(2) Concordance (CCD); and

For the simple additive weighting and concordance methods, the data were standardized based on the maximum and minimum indicator values for each variable. Standardization used the following formula:

$$\text{Standardized Score} = 100 \times \frac{\text{(Raw Data Value)} - \text{(Minimum Raw Data Value)}}{\text{(Maximum Raw Data Value)} - \text{(Minimum Raw Data Value)}}$$

Therefore, all scores range between the values 0 and 100.

In addition to different data sets, and different agglomeration analysis methods, different weights were considered. However, in this instance all variables were given equal/unit weight. The agricultural analysis methods were also set up to allow for the calculation of the inverse of any variable. No inverse calculations were used in this analysis.

Fruit and Vegetable Southern Ontario Proportional	
farms reporting	Apples total area
acres	Apples total area
farms reporting	Pears total area
acres	Pears total area
farms reporting	Plums and prunes total area
acres	Plums and prunes total area
farms reporting	Cherries (sweet) total area
acres	Cherries (sweet) total area
farms reporting	Cherries (sour) total area
acres	Cherries (sour) total area
farms reporting	Peaches total area
acres	Peaches total area
farms reporting	Apricots total area
acres	Apricots total area
farms reporting	Grapes total area
acres	Grapes total area
farms reporting	Strawberries total area
acres	Strawberries total area
farms reporting	Raspberries total area
acres	Raspberries total area
farms reporting	Cranberries total area
acres	Cranberries total area
farms reporting	Blueberries total area
acres	Blueberries total area
farms reporting	Saskatoons total area
acres	Saskatoons total area
farms reporting	Other fruits, berries and nuts total area (47)
acres	Other fruits, berries and nuts total area (47)

Fruit and Vegetable Southern Ontario Proportional	
farms reporting	Potatoes
acres	Potatoes
farms reporting	Sweet corn
acres	Sweet corn
farms reporting	Tomatoes
acres	Tomatoes
farms reporting	Cucumbers
acres	Cucumbers
farms reporting	Green peas
acres	Green peas
farms reporting	Green and wax beans
acres	Green and wax beans
farms reporting	Cabbage
acres	Cabbage
farms reporting	Chinese cabbage
acres	Chinese cabbage
farms reporting	Cauliflower
acres	Cauliflower
farms reporting	Broccoli
acres	Broccoli
farms reporting	Brussels sprouts
acres	Brussels sprouts
farms reporting	Carrots
acres	Carrots
farms reporting	Rutabagas and turnips
acres	Rutabagas and turnips
farms reporting	Beets
acres	Beets

Fruit and Vegetable Southern Ontario Proportional	
farms reporting	Radishes
acres	Radishes
farms reporting	Shallots and green onions
acres	Shallots and green onions
farms reporting	Dry onions, yellow, Spanish, cooking, etc.
acres	Dry onions, yellow, Spanish, cooking, etc.
farms reporting	Celery
acres	Celery
farms reporting	Lettuce
acres	Lettuce
farms reporting	Spinach
acres	Spinach
farms reporting	Peppers
acres	Peppers
farms reporting	Pumpkins
acres	Pumpkins
farms reporting	Squash and zucchini
acres	Squash and zucchini
farms reporting	Asparagus, producing
acres	Asparagus, producing
farms reporting	Asparagus, non-producing
acres	Asparagus, non-producing
farms reporting	Other vegetables
acres	Other vegetables
farms reporting	Greenhouse vegetables
square feet	Greenhouse vegetables
Apple Average Yield ('000lbs/acre)	
Grapes Average Yield ('000lbs/acre)	

Fruit and Vegetable Southern Ontario Proportional
Peaches Average Yield ('000lbs/acre)
Strawberries Average Yield ('000lbs/acre)
Sweet Cherries Average Yield ('000lbs/acre)
Sour Cherries Average Yield ('000lbs/acre)
Pears Average Yield ('000lbs/acre)
Plums and Prunes Average Yield ('000lbs/acre)
Raspberries Average Yield ('000lbs/acre)
Cabbage Average Yield ('000lbs/acre)
Green and Wax Beans Average Yield ('000lbs/acre)
Carrots Average Yield ('000lbs/acre)
Sweet Corn Average Yield ('000lbs/acre)
Dry Onions Average Yield ('000lbs/acre)
Peppers Average Yield ('000lbs/acre)
Field Tomatoes Average Yield ('000lbs/acre)
Asparagus Average Yield ('000lbs/acre)
Beets Average Yield ('000lbs/acre)
Brussels Sprouts Average Yield ('000lbs/acre)
Broccoli Average Yield ('000lbs/acre)
Cauliflower Average Yield ('000lbs/acre)
Celery Average Yield ('000lbs/acre)
Field Cucumbers and Gherkins Average Yield ('000lbs/acre)
Total Lettuce Average Yield ('000lbs/acre)
Green Peas Average Yield ('000lbs/acre)
Radishes Average Yield ('000lbs/acre)
Rutabagas Average Yield ('000lbs/acre)
Spinach Average Yield ('000lbs/acre)