State of the Aggregate Resource in Ontario Study (SAROS)

Paper 1 - Aggregate Consumption and Demand

Independent Real Estate Intelligence

December 18, 2009

Altus Group

MNR Number 52654
ISBN 978-1-4435-3791-9

State of the Aggregate Resource in Ontario Study (SAROS)
Paper 1 - Aggregate Consumption and Demand

Prepared for:

Ontario Ministry of Natural Resources

Prepared by:

Altus Group Economic Consulting

1580 Kingston Road Toronto Ontario M1N 1S2

Phone: (416) 699-5645 Fax: (416) 699-2252

economics@altusgroup.com

altusgroup.com

in conjunction from

MHBC Planning

LVM-Jegel

Golder Associates

December 18, 2009

EXECUTIVE SUMMARY

The focus of this report is the nature and extent of use of aggregate in Ontario and 8 geographic areas of the province.

Over the past 20 years, Ontario has consumed over 3 billion tonnes of aggregate - or about 164 million tonnes per year on average. Given expected levels of economic and population growth, Ontario's consumption of aggregates is projected to average about 186 million tonnes per year on average over the next 20 years, 13% higher than in the past 20 years. Most of the 8 geographic areas within Ontario considered in this study are expected to consume more aggregate over the next 20 years than past 20 years.

The Greater Toronto Area (GTA) uses about one-third of the aggregate consumed in Ontario each year.

On a per capita basis, Ontario's aggregate consumption has been on a longer-term decline and this downward trend is expected to continue going forward.

Available data suggests that Ontario's per capita consumption of aggregate is broadly similar to other provinces but somewhat higher than western European countries (except for Ireland and Finland), Australia, New Zealand and the U.S., although the degree of the difference is not conclusive given data comparability issues. Factors which may contribute to lower per capita aggregate consumption in European countries compared to Ontario include:

- Being more densely populated than Ontario
- Having slower rates of population growth than Ontario
- Have slightly lower rates of economic growth than Ontario over the period examined
- Having somewhat higher mean temperatures than Ontario
- Having somewhat higher rates of use of recycled and other secondary sources of aggregate than Ontario

The aggregate that Ontario uses comes mainly from primary sources of material extracted from Ontario pits and quarries.

Imports from other countries play only a small role. Secondary sources of material (primarily recycled materials) have played an increasing role, at about 7% of supply in the past 10 years (up from about 4% in the early 1990s) and recycled material is expected to continue to gradual increase its contribution to total aggregate consumption over the next 20 years. However, assuming no constraints on availability, the main source of aggregate supply is expected to continue to be primary aggregate from Ontario pits and quarries (an average of roughly 171 million tonnes per year compared to 154 million tonnes per year over the past 20 years).

For most of the 8 geographic areas of the province considered in this study, the aggregate consumed mainly comes from primary and secondary aggregate produced locally within those areas. However, that is not the case for the GTA, which obtains approximately half of the aggregate it uses from neighbouring areas.

Both sand and gravel, and crushed stone, are important sources of primary aggregate in Ontario. While crushed stone currently accounts for less than half of the primary aggregate consumed, its role has been increasing and is expected to continue to increase over the next 20 years, given trends in construction standards towards use of higher quality stone.

Aggregate is used for a wide range of applications in Ontario, however the primary use is in construction work - either directly on construction sites, or in the manufacturing of concrete and other building products. Roads (provincial highways, as well as municipal and private roads) account for the largest share of aggregate used in construction work. Some examples of typical amounts of aggregate used in various construction applications include:

- 18,000 tonnes per kilometre of a 2 lane highway in Southern Ontario
- 250 tonnes for a 185 m^2 (2,000 sq. ft.) house
- 114,000 tonnes per kilometre of a subway line

Good data exists on local production of primary aggregates in different areas of the province. However, there is currently no comprehensive information available on the internal movements of aggregate between different geographic areas, which makes it

difficult to pinpoint the amounts of aggregate being used in various areas of the province, and in particular the GTA. Estimates of consumption in each geographic area could benefit from a formal survey process undertaken on a periodic basis (similar to one conducted in the UK), to establish movements of aggregate within the province. Such an undertaking would require the buy-in and support of the provincial government, as well as the aggregate industry and possibly key major purchasers of aggregate (such as municipalities) to determine where these consumers obtain their aggregate.

In addition, research by LVM-Jegel suggests that recycled material currently fills roughly 7% of aggregate supply on a province-wide basis, and that the proportion is likely higher in the GTA and major urban areas, and lower in smaller centres. Additional research to better understand the variation in use of recycled material by geographic area in the province would be beneficial.

An initial thought piece on the potential impact of various development patterns and trends was undertaken for this study by MHBC Planning, which showed that there are a wide range of factors that could potentially impact future aggregate consumption per capita – some increasing and some decreasing. Further work in this area to quantify some of these impacts would be beneficial in the projection exercise, in particular to differentiate between short-term and long-term impacts, and between per capita needs for new development versus on-going maintenance and repair.

It is recommended that the projections of aggregate consumption be monitored on a periodic basis (such as every other year) to see how they are tracking, as well as to incorporate where relevant updated projections of economic and population growth.

TABLE OF CONTENTS

LIST OF FIGURES

Page

1.0 INTRODUCTION

The Ontario Ministry of Natural Resources has undertaken a comprehensive study entitled the **State of the Aggregate Resource in Ontario Study**, hereafter referred to as simply **SAROS**. The study request for proposal indicated that:

"The objective of the study [SAROS] is to gain a better understanding of aggregate resources by gathering the most up to date information and current science on the consumption, demand, availability, analysis of alternatives, current reserves, rehabilitation, transportation, recycling/reuse and the value of aggregate to the province of Ontario."

The broader SAROS work is divided into 6 smaller studies, of which this current report is **Paper 1: Aggregate Consumption and Demand**.

1.1 REPORT OUTLINE

In addition to this Introduction, the main report contains the following main sections:

- Section 2: Ontario's Aggregate Consumption Patterns
- Section 3: Aggregate Consumption in Ontario Compared to Other Areas
- Section 4: The Ways in Which Aggregate is Used in Ontario
- Section 5: The Future Consumption of Aggregate in Ontario
- Section 6: Key Findings and Suggestions for Future Work

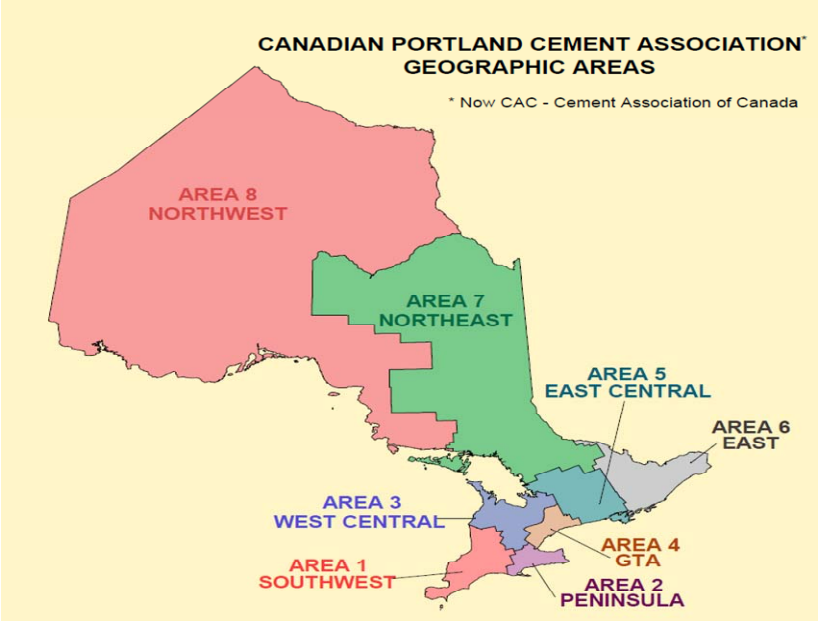
In addition to the main report, there are a series of separate appendices:

- Appendix A: Projection Model Background
- Appendix B: Aggregate Factors for Specific Construction Applications – Background Calculations
- Appendix C: Analysis of Impact of Development Trends on Aggregate Consumption

1.2 GEOGRAPHIC AREAS

The study examines aggregate consumption for the province as a whole, as well as for the province divided into 8 geographic areas. These geographic areas, and their constituent upper or single tier municipalities, are shown on Figure 1- 1.

Figure 1- 1 SAROS Geographic Areas



Area 1 Southwest	Area 2 Peninsula	Area 3 West Central	Area 4 GTA
Essex Chatham-Kent Lambton Elgin Middlesex Huron Perth Oxford	Niagara Brant Haldimand- Norfolk Hamilton- Wentworth	Bruce Grey Simcoe Dufferin Wellington Waterloo	Toronto Peel York Durham Halton
Area 5 East Central	**Area 6 East**	**Area 7 Northeast**	**Area 8 Northwest**
Kawartha Lakes Peterborough Haliburton Northumberland Hastings Prince Edward Muskoka	Prescott & Russell Leeds & Grenville Stormont, Dundas, & Glengarry Frontenac Ottawa Lanark Renfrew Lennox & Addington	Nipissing Parry Sound Timiskaming Cochrane Sudbury District Sudbury Region Manitoulin	Algoma Thunder Bay Kenora Rainy River

1.3 STUDY LIMITATIONS

This report relies on information from a variety of secondary sources. While every effort is made to ensure the accuracy of the data, we cannot guarantee the complete accuracy of the information used in this report from these secondary sources.

In addition, due to the lack of comprehensive data for some of the series analyzed, it was necessary as part of this exercise to prepare estimates based on more limited available information.

This report has been prepared solely for the purposes outlined herein and is not to be relied upon or used for any other purposes or by any other party without the prior written authorization of Altus Group Economic Consulting and the Ontario Ministry of Natural Resources.

1.4 DEFINITIONS

This section provides definitions for some terms used throughout the report.

1.4.1 Aggregate related terms

- **Aggregate** - includes sand, gravel, limestone, dolostone, crushed stone, rock other than metallic ores, and other prescribed material. In this report, aggregate is considered in total, as well as broken into two main groups: 1) sand and gravel 2) crushed stone and other (primarily limestone and dolostone).
- **Aggregate consumption** – the number of tonnes of aggregate (from both primary and secondary sources, see additional definitions below) used in various applications in a given geographic area during a given time period. As discussed in the report, aggregate consumption in a particular area of Ontario may derive from a variety of sources, including new locally produced aggregate, imports from other provinces and countries, aggregate produced in other areas of Ontario.
- **Aggregate demand –** see Section 1.5 below.
- **Per capita aggregate consumption** – total consumption divided by total population.

- **Primary aggregate production** – newly produced aggregate, taken directly from pits and quarries (sometimes also referred to as “virgin” aggregate to differentiate it from recycled and substitute materials). In Ontario, high quality data on primary aggregate production is compiled and reported each year by The Ontario Aggregate Resources Corporation (TOARC).
- **Secondary aggregate** – recycled aggregate and substitute materials. Data on secondary sources of aggregate are less readily available than for primary aggregate production. In this report, recycling estimates rely on work conducted by LVM Jegel (see **Paper 4: Re-use and Recycling**).

1.4.2 Acronyms

- **GGH** - Greater Golden Horseshoe
- **GDP -** gross domestic product (the value of all goods and services in a given time period; used as a measure of the total size of an economy; “real” GDP expresses output in constant dollar terms that is, adjusts for price inflation)
- **GTA** – Greater Toronto Area (comprised of the City of Toronto, and the Regional Municipalities of Durham, York, Peel and Halton)
- **MNR** – Ontario Ministry of Natural Resources
- **MNDMF** – Ontario Ministry of Northern Development, Mines and Forestry
- **OECD** – Organisation for Economic Co-operation and Development
- **StatCan** – Statistics Canada
- **TOARC** – The Ontario Aggregate Resources Corporation
- **UEPG** – Union Européenne des Producteurs de Granulats (European Aggregates Association)
- **USGS** – U.S. Geological Survey

1.5 A NOTE ON AGGREGATE CONSUMPTION VS. AGGREGATE DEMAND

The title of the current study, as was outlined in the study Request for Proposal, is “Aggregate Consumption and Demand”.

As outlined in the definitions section, “aggregate consumption” is the term used in reference to the number of tonnes of aggregate actually used in a given area during a given time period.

“Demand for aggregate” is a related, but different, concept. Demand is an economics term which essentially measures how much of a product or service would be purchased/consumed at varying price points (this relationship is the “demand curve”).

As the study progressed, it became clear that the scope of required work as indicated in the Request for Proposal was primarily related to the “consumption” definition – that is, how much aggregate has been used in the past, and might be expected to be used in the future. As such, the term consumption is used almost exclusively in this report.

2.0 ONTARIO'S AGGREGATE CONSUMPTION PATTERNS

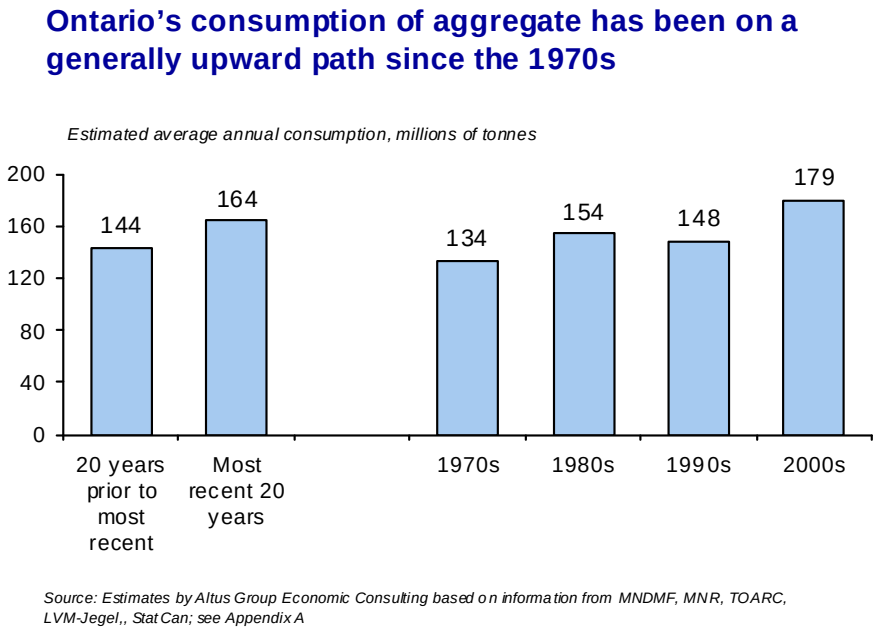
This section examines past consumption patterns for aggregate in Ontario, in order to answer key questions, including:

- How much aggregate is used in Ontario each year?
- Where does Ontario get the aggregate it uses?
- What are the consumption patterns in different areas of the province?

2.1 HOW MUCH AGGREGATE IS USED IN ONTARIO?

- During the decade of the 2000s (i.e. the 10 year period from 2000 through 2009), Ontario consumed an estimated 179 million tonnes of aggregate on average per year (Figure 2- 1)[1].

Figure 2- 1 Average Annual Historical Aggregate Consumption, Ontario



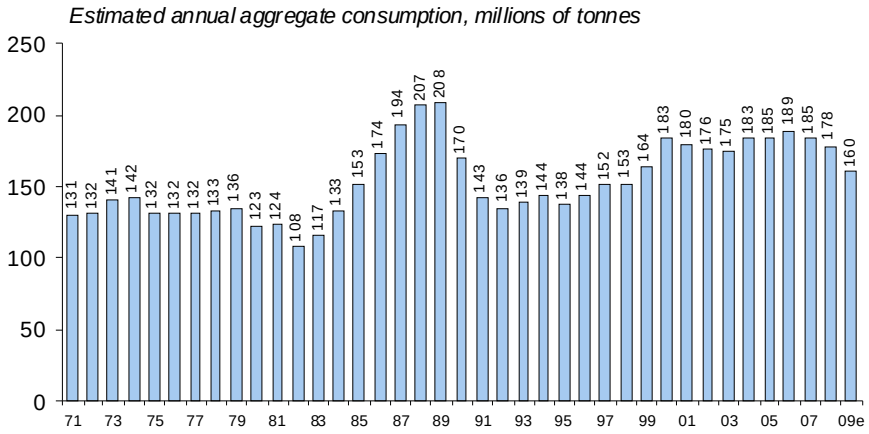
Source: Estimates by Altus Group Economic Consulting based on information from MNDMF, MNR, TOARC, LVM-Jegel,, Stat Can; see Appendix A

[1] These consumption estimates are based on data on primary local aggregate production (as measured by TOARC, and previously MNR and MNDMF, production data), as well as estimates of trade in aggregates (imports and exports) from Statistics Canada data and use of recycled material from estimates prepared by LVM-Jegel

- This is up from the previous decade (the 1990s) and also higher than either the 1970s or 1980s.
- Over the past 20 years in total, Ontario has consumed over 3 billion tonnes of aggregate.
- Consumption of aggregate can fluctuate significantly from year-to-year (Figure 2- 2). Over the past 40 years, aggregate consumption has ranged from an estimated low of just over 100 million tonnes in recession-ravaged 1982, to over 200 million tonnes in the strong building days of the latter 1980s.

Figure 2- 2 Aggregate Consumption by Year, Ontario

Consumption of aggregate in Ontario can fluctuate year-to-year

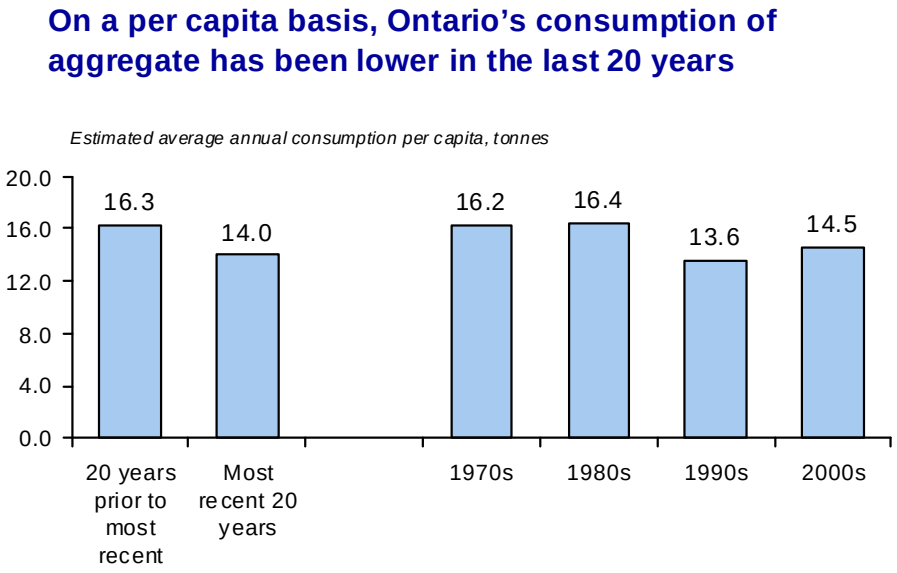


Source: Estimates by Altus Group Economic Consulting based on information from MNDMF, MNR, TOARC, LVM-Jegel,, Stat Can; see Appendix A

- The annual level ramped up in the latter 1980s – almost doubling in the space of only 6 years – before dropping back down in the early 1990s.
- After being on a generally upward path since the early 1990s, aggregate consumption has been negatively impacted by the current recession. Similar short-term declines were experienced during the recessions of the early 1980s and early 1990s, before consumption picked up again.
- Over the past 20 years, the total amount of aggregate consumed in the Province of Ontario is equivalent to about 14

tonnes per capita on average per year (Figure 2- 3) – about 14% lower than during the previous 20 year period.

Figure 2- 3 Average Annual Aggregate Consumption Per Capita, Ontario



Source: Estimates by Altus Group Economic Consulting based on information from MNDMF, MNR, TOARC, LVM-Jegel,, StatCan; see Appendix A

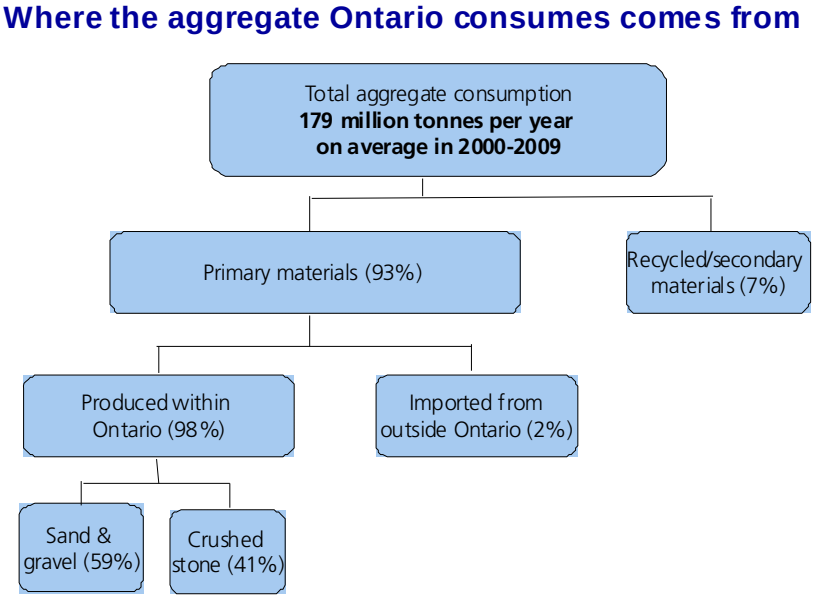
- The per capita pattern, however, has not been consistently downward. During the 1990s, when construction activity had fallen substantially, per capita aggregate consumption fell to below 14 tonnes per year on average, before increasing again during the 2000s.

2.2 WHERE DOES ONTARIO GET THE AGGREGATE IT USES?

- Ontario's aggregate consumption is filled by two general types of material:
  - **Primary aggregate:** Newly produced sand and gravel, and crushed stone, taken directly from pits and quarries (sometimes referred to as "virgin" aggregate); and
  - **Secondary aggregate:** Recycled aggregate and substitute materials.

- Most of the aggregate used in Ontario is primary aggregate (Figure 2- 4). Of the 179 million tonnes of aggregate used each year on average over the past 10 years, it is estimated that about 93% was comprised of primary aggregate.

Figure 2- 4 Sources of Aggregate Used in Ontario



Source: Estimates by Altus Group Economic Consulting based on information from MNDMF, MNR, TOARC, LVM-Jegel,, StatCan; see Appendix A

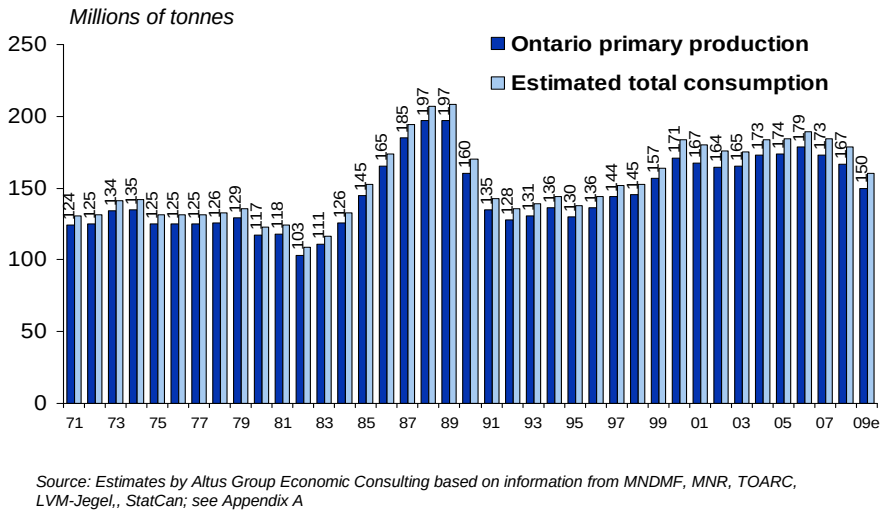
- While still only a modest contributor to Ontario's overall aggregate use, the proportion of demand filled by secondary material (essentially recycled material) has grown, up from about 4% in the early 1990s to the current 7%.[2]
- Primary materials can be either produced locally, or imported from other provinces or countries. However, given the nature of the product, and transportation costs, there is little trade in aggregate between Ontario and other areas.
- Imports to Ontario during the decade of the 2000s accounted for only about 2% of the primary aggregate consumed (or roughly 3

[2] The role of recycled material is discussed more fully in SAROS Paper 4: Recycling and Re-use.

million tonnes per year).[3] The majority of the imports are from the U.S., in particular the states bordering the Great Lakes region (primarily Michigan and Ohio).

- Production from within Ontario accounted for the vast majority of primary aggregate consumed in Ontario (98% in 2000-2009) and of total aggregate supply (over 90%). In the 2000s, that amounted to a contribution of about 163 million tonnes per year on average from Ontario's own pits and quarries.[4] Annual primary production in Ontario of aggregate compared to total consumption is shown on Figure 2- 5. These primary production numbers are as reported by TOARC (and previously MNR and MNDMF).

Figure 2- 5 Annual Primary Production of Aggregate Compared to Total Consumption, Ontario



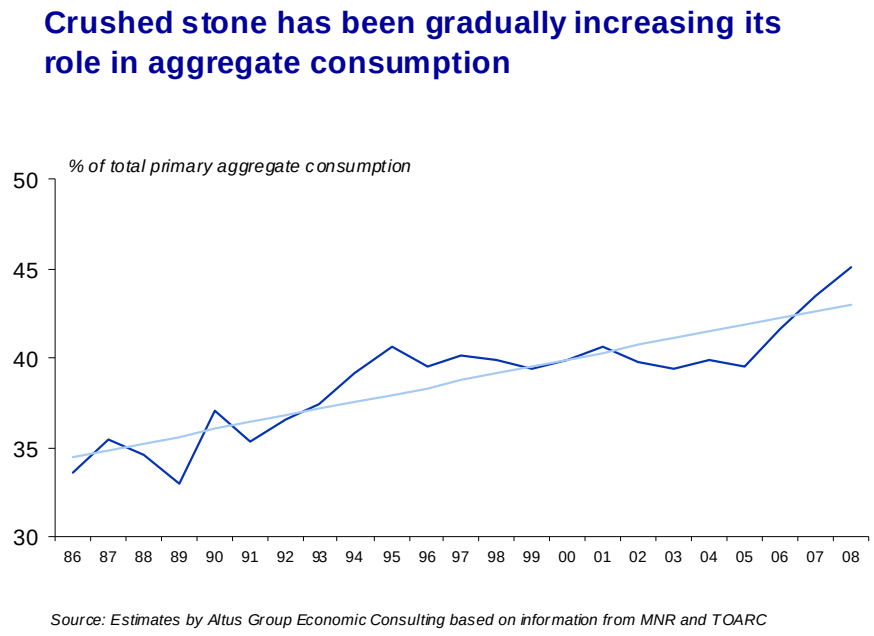
Source: Estimates by Altus Group Economic Consulting based on information from MNDMF, MNR, TOARC, LVM-Jegel,, StatCan; see Appendix A

[3] This is based on international trade statistics. Information on movements of aggregate between Ontario and other provinces is not known, however the quantities are considered to be minimal. Exports of aggregate from Ontario during the 2000s averaged about 4 million tonnes per year, slightly offsetting the imports.

[4] This estimate excludes an estimated 5 million tonnes per year of aggregate produced in Ontario during the 2000s that was exported to other countries, the vast majority to the U.S. Great Lakes region. Total average annual production of primary aggregate in Ontario during the 2000s was therefore about 168 million tonnes.

- Sand, gravel and crushed stone are all consumed in Ontario. During the decade of the 2000s, slightly more than half of the primary aggregate produced in Ontario was sand and gravel, and slightly less than half was crushed stone.[5]
- Crushed stone's relative role in aggregate consumption has been growing over the past 25 years, from a 34% share on average in the latter 1980s to 43% on average per year during the latter 2000s (Figure 2- 6).

Figure 2- 6 Crushed Stone as a % of Total Consumption of Primary Aggregate, Ontario



Source: Estimates by Altus Group Economic Consulting based on information from MNR and TOARC

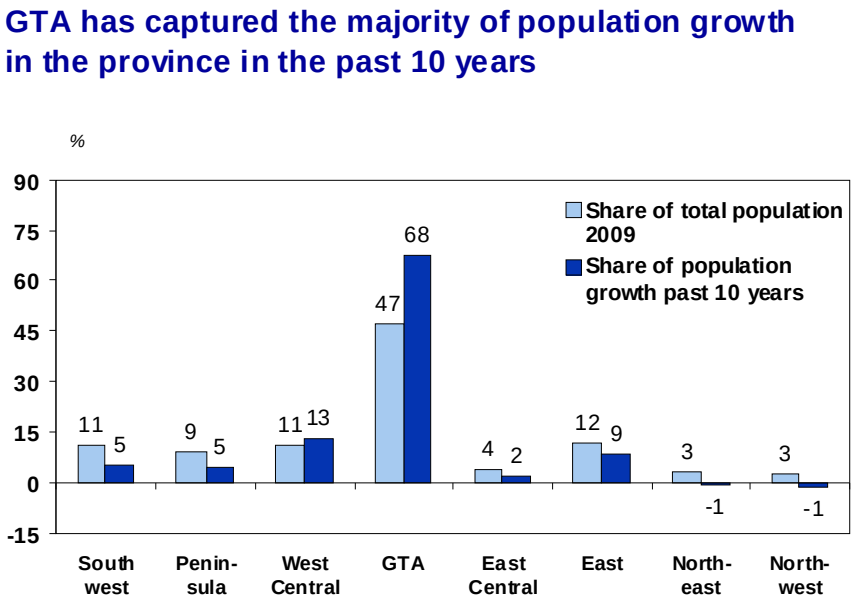
2.3 WHAT ARE THE CONSUMPTION PATTERNS IN DIFFERENT AREAS OF THE PROVINCE?

- As discussed in Section 1.2, there are 8 geographic areas within Ontario that were considered for the analysis in this study. To provide context, it is helpful to look at population patterns for those areas.

[5] The crushed stone estimates throughout this report include "other" types of aggregate (clay/shale, building stone, industrial stone and dimension stone); these account for only about 2% of all primary aggregate production in Ontario.

- The Greater Toronto Area (GTA) – comprised of the City of Toronto, and the Regional Municipalities of Durham, York, Peel and Halton - is the largest of the 8 geographic regions in terms of population, and is currently home to almost half of Ontario's residents (Figure 2- 7).
- The GTA has also been the growth leader both in absolute and relative terms, accounting for about two-thirds of population growth in the province over the decade of the 2000s.

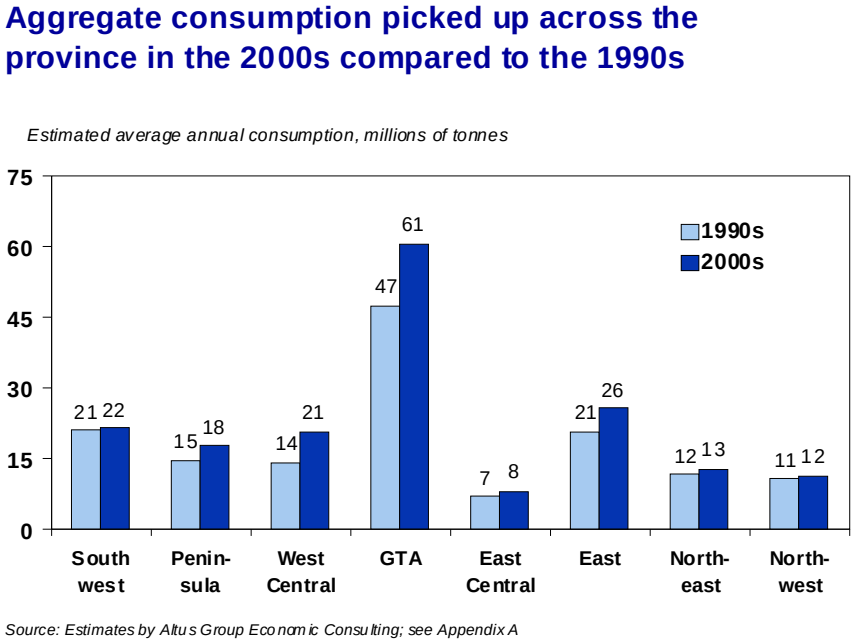
Figure 2- 7 Total Population and Population Growth by Geographic Area



Source: Altus Group Economic Consulting based on StatCan data; see Appendix A

- Given its sizeable and growing population base, it is not surprising therefore that the GTA accounts for the largest share of total Ontario aggregate consumption (Figure 2- 8) – roughly one-third (or about 61 million tonnes per year) of the 179 million tonnes consumed in Ontario per year in the 2000s.

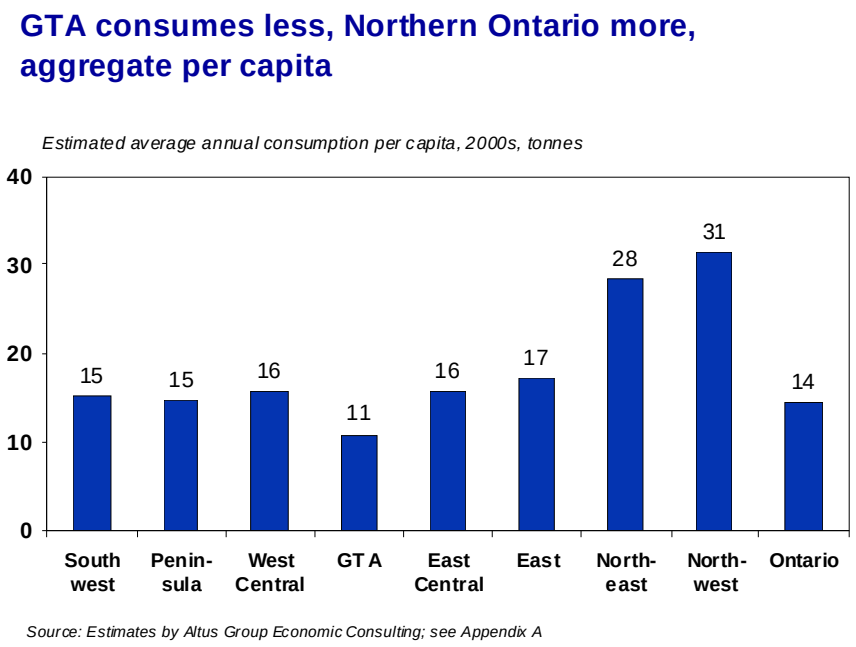
Figure 2- 8 Aggregate Consumption by Geographic Area



Source: Estimates by Altus Group Economic Consulting; see Appendix A

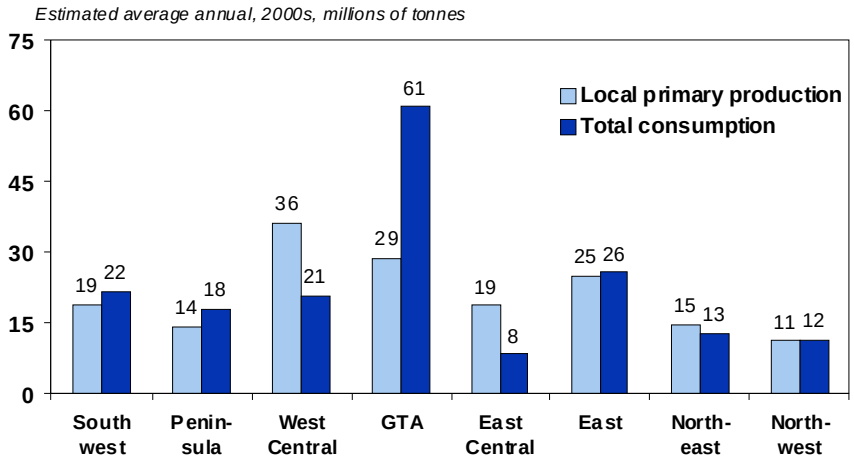
- All parts of the province saw some increase in consumption of aggregate during the 2000s compared to the 1990s – even those where population growth declined, or was negative. This illustrates the point that while growth is an important driver of the use of aggregate, there is also demand generated from within the existing population base.
- The GTA's share of aggregate consumption is below its share of population growth and total population, reflecting lower per capita consumption than the Ontario average (Figure 2- 9).
- The highest per capita consumption of aggregate is in Northern Ontario (the Northeast and Northwest geographic areas). As will be discussed later, this in part reflects more intensive use of aggregate in road building due to more severe climate, as well as generally higher use of aggregate per capita in lower density areas due to need for, but less intensive use of, infrastructure.

Figure 2- 9 Per Capita Consumption of Aggregate by Geographic Area



Source: Estimates by Altus Group Economic Consulting; see Appendix A

Figure 2- 10 Comparison of Total Aggregate Consumption and Local Primary Production, Geographic Areas



Source: Estimates by Altus Group Economic Consulting; see Appendix A

- For most of the 8 geographic areas, the aggregate consumed comes from primary or secondary aggregate produced locally within those areas (Figure 2- 10).
- However that is not the case for the GTA, which relies on "excess production" from neighbouring areas, in particular the West Central and East Central areas, to provide about half of what it uses.

3.0 AGGREGATE CONSUMPTION IN ONTARIO COMPARED TO OTHER AREAS

In this section, Ontario's relative aggregate usage is compared to other areas of the world. Key questions addressed include:

- How does Ontario's per capita consumption of aggregate compare to other provinces, U.S. states and other developed countries?
- What factors help explain variation in per capita aggregate consumption?

3.1 A NOTE ON COMPARABILITY OF DATA

- Comparing aggregate consumption across different jurisdictions is a difficult process for a number of reasons, including:
  - Information on aggregate consumption is not necessarily collected on a consistent basis, and the coverage and quality of the information can vary substantially from one area to another.
  - Information on secondary sources of aggregate are limited and in some jurisdictions even non-existent.
- It was beyond the scope of the analysis here to be able to produce comprehensive information on aggregate consumption in other jurisdictions which is 100% consistent with the relatively high quality of information available for Ontario. Because of data comparability limitations, **the comparisons here should be used with caution, and used to identify broad patterns, rather than pinpoint absolute differences**.[6]
- The 2002-2007 period was chosen for the comparisons in this section, as this is the timeframe over which European data was most readily available. Unless otherwise noted, the analysis is

[6] To illustrate the difficulties in the comparisons, three sources of information on aggregate production examined for the European data (UEPG's producers survey, the UK European Mineral Statistics and the USGS Minerals Yearbook), generally showed a wide variation for most countries. The higher of the estimates for each country was used in the analysis here, as it was reasoned that the likelihood of production being underreported was greater than data overstated actual production.

limited to consumption of primary sources of aggregate, but including both local production and net imports.

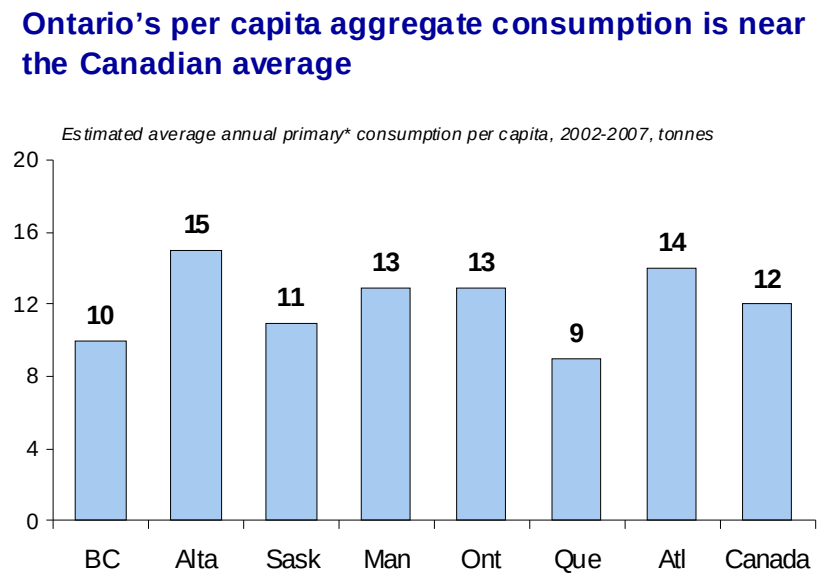
3.2 HOW DOES ONTARIO'S PER CAPITA CONSUMPTION OF AGGREGATE COMPARE TO OTHER AREAS?

This section compares aggregate consumption per capita in Ontario to other areas. An examination of factors which may explain variations in per capita consumption follow in Section 3.3.

3.2.1 Comparison with other Provinces

- Focusing on consumption of primary aggregate only (i.e. excluding recycling and other secondary sources), for the 2002-2007 period, Ontario's 13 tonnes per capita per year on average is slightly above the Canadian average (Figure 3- 1)[7].

Figure 3- 1 Per Capita Consumption of Primary Aggregate in Canada by Region



[7] For consistency for the comparison to other provinces, the Ontario data referred to in this section is based on Statistics Canada estimates, which show lower total aggregate production than the TOARC series (which show primary consumption of closer to 14 tonnes per capita for the same period).

- Per capita consumption ranged from a low of 9 tonnes per year in Quebec to a high of 15 tonnes per year in Alberta.

3.2.2 Comparison with U.S. States

- Due to a lack of readily available information on international trade by state, as well as movements of aggregate between states, the comparison of per capita aggregate usage in Ontario with the U.S. is limited to per capita local production. The information for individual states should therefore be viewed with caution, as the generally smaller geographic size of states compared to Ontario could mean a higher potential for some interstate movements.
- The analysis suggests that per capita primary aggregate production in the U.S. over the 2002-2007 period was lower on average than for Ontario.
- The comparison for individual states however shows a wide variation. For about half of the states, per capita aggregate production appears to be below that of Ontario, with the remainder split roughly equally between states with similar per capita production and higher per capita production.
- Factors contributing to the variation by state and comparisons to Ontario are examined in Section 3.3.

Figure 3- 2 Per Capita Primary Aggregate Production, Ontario Compared to U.S. States

Ontario per capita production of primary aggregate above the U.S. average but similar or lower than half of U.S. states

(tonnes, 2002-2007 annual average)

Ontario	***14***	***U.S. Total***	***10***		
States Higher than Ontario		**States Similar to Ontario**		**States Lower than Ontario**	
Wyoming	40	Kentucky	16	Virginia	11
South Dakota	26	Arkansas	16	New Hampshire	11
Nevada	22	Arizona	15	Ohio	11
Alaska	21	Alabama	15	Pennsylvania	10
North Dakota	20	Wisconsin	14	New Mexico	10
Montana	19	Indiana	14	Michigan	10
Iowa	18	Oregon	13	Georgia	10
Utah	18	Nebraska	12	North Carolina	10
Idaho	17	Colorado	12	Texas	10
Missouri	17	Minnesota	12	South Carolina	10
Vermont	17	Kansas	12	Washington	9
Oklahoma	17	Tennessee	12	Illinois	9
		Maine	12	West Virginia	9
				Florida	8
Averages by U.S. Geographic Divisions				Maryland	8
				Hawaii	7
Northeast:	**6**	**South:**	**10**	Mississippi	6
New England	6	South Atlantic	9	California	6
Middle Atlantic	6	East South Central	13	Connecticut	5
Midwest:	**12**	West South Central	10	New Jersey	5
East North Central	11	**West:**	**10**	Louisiana	5
West North Central	15	Mountain	16	Massachusetts	4
		Pacific	7	New York	4
				Rhode Island	4
U.S. Total	**10**			Delaware	3

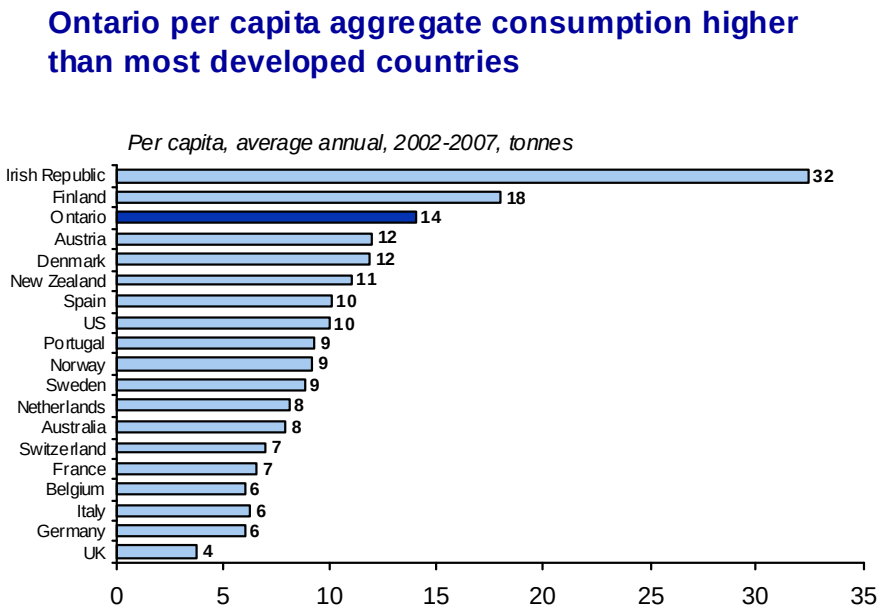
Source: Altus Group Economic Consulting based on data from USGS and U.S. Bureau of the Census

3.2.3 Comparison with Western Europe, U.S, Australia and New Zealand

- Available data suggests that Ontario's per capita consumption of primary aggregate[8] is somewhat higher than western European countries (except for Ireland and Finland), as well as Australia, New Zealand and, as previously noted, the U.S. (Figure 3- 3).
- At the low end of the usage table is the UK.

[8] Data in this section include international trade data in the consumption estimates, but exclude secondary sources of material.

Figure 3- 3 Per Capita Primary Aggregate Consumption, Ontario and Selected Countries



Source: Altus Group Economic Consulting based on data from UK European Mineral Statistics, UEPG, TOARC, StatCan, USGS and OECD

3.3 WHAT FACTORS HELP EXPLAIN VARIATIONS IN PER CAPITA AGGREGATE CONSUMPTION?

- A variety of factors were examined with respect to the extent to which they play a role in variation in per capita consumption of aggregate.
  - **Construction spending per capita** – as the majority of aggregate is used in construction work, higher rates of construction spending would be expected to generate more aggregate demand per capita. Caution needs to be used in interpreting this variable however, as the mix of work (e.g. engineering vs. building) and relative cost structures (e.g. labour costs vs. materials costs, etc.) are not controlled for.
  - **Rate of population growth** – stronger population growth would be expected to generate more construction work per capita and therefore higher aggregate consumption.

- **Rate of economic (GDP) growth** – to the extent that aggregate is also used in non-construction applications, stronger economic growth may contribute to stronger demand for aggregate on a per capita basis. Real GDP growth also embodies construction spending, as it is a component of GDP.
- **Mean annual temperature** – geographies with lower average temperatures may need deeper road bases and more repair spending due to more severe weather, which would require higher amounts of aggregate per capita.
- **Population density** – more densely populated areas may use less aggregate on a per capita basis.
- **Extent of use of secondary aggregate** – as there is no comprehensive data on secondary aggregate consumption for all of the areas covered, this is considered as an explanatory factor (rather than being included in consumption) – greater use of secondary material reduces the use of primary material.

- Information for these factors where available are summarized on the following chart (Figure 3- 4) for the international comparison. Similar charts follow at the end of this section comparing Ontario to U.S. states (Figure 3- 5), other provinces (Figure 3- 6), as well as comparing the Ontario geographic areas (Figure 3- 7).
- Using this information, a correlation analysis was conducted which shows the direction and strength of the relationship between each factor and primary aggregate consumption per capita. Correlation analysis shows whether patterns tend to move in the same or opposite directions and the strength of the relationships of the movements.
- The analysis (see bottom line of Figure 3- 4) confirmed the relationships outlined above in terms of their directional impact (for example, a negative sign for mean temperature indicates that lower mean temperature is associated with higher aggregate consumption per capita although the degree of the relationship is not particularly strong). It should be emphasized

that correlation is not the same as causation; rather it shows if two factors move together but not whether one factor is causing the other to occur.

Figure 3- 4 Comparison of Potential Factors Contributing to Variation in Per Capita Consumption of Primary Aggregate, Ontario and Selected Countries

		Selected characteristics						
	Per capita primary aggregate consumption *tonnes 2002-07*	**Population growth rate** *% 2002-07*	**Real GDP growth rate** *% 2002-07*	**Real GDP per capita** *$000s 2002-07*	**Real construc-tion spendng per capita** *$000s 2002-07*	**Mean temp** *degrees Celsius*	**Density** *pop/sq. km 2005/06*	**Secondary aggregates** *% 2005/06*
Ontario	*14*	*1.2*	*2.4*	*32*	*3.1*	*9*	*13*	*7*
Selected countries								
Irish Republic	32	2.0	5.6	34	5.4	10	59	1
Finland	18	0.3	3.2	29	3.2	5	16	1
Austria	12	0.5	2.4	30	3.5	11	98	6
Denmark	12	0.3	1.8	30	3.0	8	126	na
New Zealand	11	1.4	3.5	23	2.6	14	15	na
Spain	10	1.6	3.4	23	3.5	15	86	0
US	10	0.9	2.6	37	3.3	15	32	na
Portugal	9	0.5	0.9	17	2.1	17	114	na
Norway	9	0.7	2.4	39	2.7	6	14	0
Sweden	9	0.5	3.1	31	1.9	7	20	6
Netherlands	8	0.3	1.9	31	3.3	10	400	21
Australia	8	1.4	3.3	30	4.1	13	3	na
Switzerland	7	0.7	2.1	33	2.5	10	180	9
France	7	0.7	1.8	27	3.1	12	111	5
Belgium	6	0.5	2.2	29	2.8	10	342	19
Italy	6	0.4	1.0	26	2.7	16	193	2
Germany	6	0.0	1.2	27	2.6	10	231	14
UK	4	0.5	2.6	29	2.5	11	245	25
Correlation with primary aggregate consumption		***0.6***	***0.7***	***0.2***	***0.7***	***-0.3***	***-0.4***	***-0.5***

Source: Altus Group Economic Consulting based on data from UK European Mineral Statistics, UEPG, TOARC, StatCan, USGS and OECD

- Some broad conclusions can be drawn from the analysis.
- Those countries towards the bottom of the usage chart (under 9 tonnes per capita) tend to have characteristics that help explain lower per capita primary aggregate consumption than Ontario, including:
  - Being more densely populated than Ontario (except for Australia), even if the Northern area of Ontario is excluded;[9]
  - Having slower rates of population growth (except for Australia)
  - Have slightly lower rates of GDP growth over the period (except UK and Australia), and slightly lower GDP per capita (except for Switzerland)
  - Having somewhat higher mean temperatures
  - Having higher rates of use of secondary aggregate (except for France and Italy).
- However a key factor that does not appear to be consistent is the comparison of the per capita construction spending estimates. In general, per capita construction spending is only slightly lower in the countries with substantially lower aggregate consumption per capita than Ontario. This is puzzling if construction spending is a key driver of aggregate usage. It may be due to differences in the mix (i.e. a relatively higher share of the Ontario construction spending in more aggregate intensive uses), as well as the fact that these numbers include only new work (i.e. repair work is not included). But it might also suggest that there is understatement in the European numbers/coverage relative to the Ontario production data series.
- Ireland stands out as having much higher aggregate consumption per capita than any other country. This in large part however likely reflects the timeframe for the analysis. The period of 2002-2007 was a period of exceptionally strong population and economic growth and strong construction spending (refer to

[9] Excluding the Northeast and Northwest areas increases Ontario density to about 108 persons per sq. km.

Figure 3- 4). With weaker economic conditions post 2007, it is likely that Ireland's per capita aggregate consumption has moderated from this level.

- What has not been built into the quantitative analysis here however is potential policy impacts. For example, the U.K. has the lowest per capita primary aggregate consumption, but also unlike other countries examined, has a very sizeable aggregate levy (currently 2 pounds sterling per tonne, or roughly $3.50 Canadian[10] – this compares to the $0.11 per tonne licence fee in Ontario). To what extent this may have altered aggregate consumption patterns – and/or encouraged underreporting of primary production – is unclear. It is even unclear whether the relatively high use of secondary material is a function of the levy, as trends to higher recycling appear to have been occurring prior to the introduction of the levy.

[10] Based on an exchange rate of $1.73 Canadian dollars per UK pounds sterling (as of December 18, 2009)

Figure 3- 5 Comparison of Potential Factors Contributing to Variation in Per Capita Production of Primary Aggregate, Ontario and U.S. States

	Per capita primary aggregate production *tonnes 2002-07*	Selected Characteristics: Population growth rate *% 2002-07*	Real GDP growth rate *% 2002-07*	Mean temp *degrees Celsius*	Density *pop/sq. km 2005/06*
Ontario	*14*	*1.2*	*2.4*	*9*	*13*
State					
Wyoming	40	1.0	2.6	7	2
South Dakota	26	0.8	3.3	8	4
Nevada	22	3.4	5.4	20	7
Alaska	21	1.2	2.9	5	0
North Dakota	20	0.0	3.6	5	4
Montana	19	0.9	3.7	7	2
Iowa	18	0.3	3.1	10	20
Utah	18	2.6	4.1	11	10
Idaho	17	2.1	4.1	11	6
Missouri	17	0.7	1.3	12	31
Vermont	17	0.2	2.3	7	25
Oklahoma	17	0.7	2.5	16	19
Kentucky	16	0.7	2.3	13	39
Arkansas	16	0.9	2.7	16	20
Arizona	15	3.1	4.5	23	17
Alabama	15	0.6	2.9	18	34
Wisconsin	14	0.6	1.6	7	38
Indiana	14	0.6	1.5	11	65
Oregon	13	1.2	4.5	11	14
Nebraska	12	0.5	2.8	10	9
Colorado	12	1.5	2.1	10	16
Minnesota	12	0.7	2.4	7	24
Kansas	12	0.5	2.4	12	13
Tennessee	12	1.1	2.8	15	53
Maine	12	0.4	1.6	7	16
Virginia	11	1.2	2.9	14	69
New Hampshire	11	0.7	2.0	7	53
Ohio	11	0.1	1.1	11	107
Pennsylvania	10	0.2	1.7	12	106
New Mexico	10	1.2	3.0	13	6
Michigan	10	0.1	0.2	9	68
Georgia	10	2.1	2.3	16	55
North Carolina	10	1.6	3.2	15	64
Texas	10	1.9	3.3	20	31
South Carolina	10	1.4	1.9	17	51
Washington	9	1.2	2.9	11	34
Illinois	9	0.4	1.5	11	86
West Virginia	9	0.1	1.3	13	29
Florida	8	1.8	3.9	20	114
Maryland	8	0.7	2.9	13	209
Hawaii	7	0.8	3.5	25	73
Mississippi	6	0.4	1.9	18	23
California	6	0.9	3.2	16	84
Connecticut	5	0.3	2.0	11	271
New Jersey	5	0.3	1.6	13	438
Louisiana	5	-0.3	2.6	20	40
Massachusetts	4	0.2	1.7	11	313
New York	4	0.3	3.0	9	155
Rhode Island	4	-0.1	2.1	10	387
Delaware	3	1.4	2.2	13	155
Correlation with primary aggregate production		***0.3***	***0.3***	***-0.3***	***-0.6***

Source: Altus Group Economic Consulting based on data from USGS and U.S. Bureau of the Census

Figure 3- 6 Comparison of Potential Factors Contributing to Variation in Per Capita Consumption of Primary Aggregate, Ontario and Other Canadian Regions

		Selected characteristics			
	Per capita primary aggregate consumption *tonnes* *2002-07*	**Population growth rate** *%* *2002-07*	**Real GDP growth rate** *%* *2002-07*	**Mean temp** *degrees celsius*	**Density** *pop/sq. km* *2005/06*
Ontario	*14*	*1.2*	*2.4*	*9*	*13*
Other regions					
Atlantic	14	0.6	2.9	5	5
Quebec	9	0.6	2.1	4	6
Manitoba	13	1.6	2.4	3	2
Saskatchewan	11	1.8	2.5	3	2
Alberta	15	0.8	3.9	2	5
B.C.	10	0.7	3.6	10	4

Note: mean temperatures are based on provincial capitals

Source: Altus Group Economic Consulting based on data from TOARC and StatCan

Figure 3- 7 Comparison of Potential Factors Contributing to Variation in Per Capita Consumption of Primary Aggregate, Ontario Geographic Areas

		Selected characteristics	
	Per capita primary aggregate consumption *tonnes* *2002-07*	**Population growth rate** *%* *2002-07*	**Density** *pop/sq. km* *2005/06*
Ontario	*14*	*1.2*	*13*
By Geographic Subarea			
Area 1: Southwest	14	0.6	68
Area 2: Peninsula	14	0.6	167
Area 3: West Central	15	1.6	69
Area 4: GTA	10	1.8	780
Area 5: East Central	15	0.8	22
Area 6: East	17	0.7	51
Area 7: Northeast	27	-0.1	2
Area 8: Northwest	31	-0.3	1
Ontario excluding North	13	1.3	108

Source: Altus Group Economic Consulting based on data from TOARC and StatCan

4.0 THE WAYS IN WHICH AGGREGATE IS USED IN ONTARIO

The preceding section examined the extent to which Ontario uses aggregate each year. This section examines the ways in which aggregate is being used. Key questions to be answered in this section include:

- What are some of the uses of aggregate?
- Which uses are more important in relative terms?
- How much aggregate is used per dollar of construction work?
- How much aggregate does it take for specific construction applications?

4.1 WHAT ARE SOME OF THE USES OF AGGREGATE?

- Aggregate can be used in a variety of applications, including various types of construction work and manufactured products.
- Some of the uses of aggregate are outlined in Figure 4- 1.

4.2 WHICH USES ARE MORE IMPORTANT IN RELATIVE TERMS?

- Unfortunately, data is not available to quantify the amounts of aggregate that go into each of the specific uses identified on Figure 4- 1. However, we can look at their relative roles on a higher, more aggregated level using information from Statistics Canada's Input-Output model of the Canadian economy.
- Construction work accounts for the majority of aggregate consumed in Ontario. During the 2000s, an estimated 81% of the total aggregate consumed in Ontario was used in various construction applications (Figure 4- 2).
- Some of this was aggregate that went directly into construction work (about two-thirds of total construction related aggregate); the remainder was indirectly used in construction, through building products such as ready-mix concrete, manufactured concrete products, and other building materials such as roofing tiles (Figure 4- 3).

Figure 4- 1 Examples of Uses of Aggregate

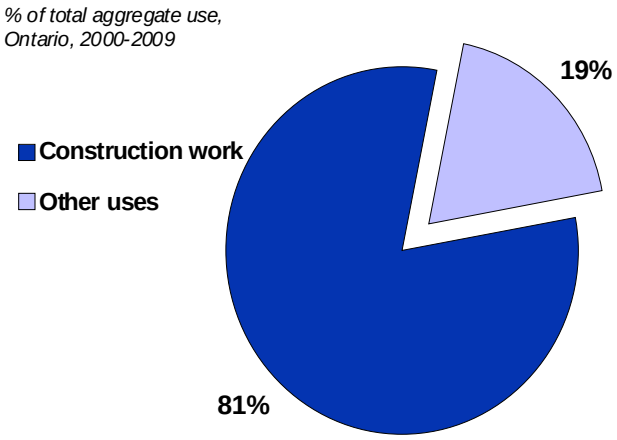
Aggregate is used in many different applications

- abrasive cleanser
- agricultural purposes and fertilizer plants
- agricultural soil supplements
- asphalt aggregate
- automotive frames
- automobiles and aircraft parts
- automotive & vehicular glass & glazing
- backfill for mines
- bake & culinary ware
- bridges
- buildings (office, hospital, schools)
- carpet
- catalytic converters
- concrete aggregate
- container packaging
- cosmetics
- crushed glass (for water filtration)
- emergency flood retention
- fibre glass
- flat glass
- flux in iron and steel plants
- housing
- ice control (road sand)
- industrial flue scrubbers
- landfill cover
- landscaping
- light bulbs
- lime kilns
- medical research instruments
- metal cast moulding
- metal casting
- mild abrasive
- military field fortification
- mirrors
- monumental and ornamental
- mortar sand
- parking lots
- pharmaceuticals
- photovoltaics
- piers & wharfs
- pipes (main and sewers)
- power plants
- pulp and paper mills
- railway ballast
- railway bedding
- recreational sand
- glass tile
- retention walls
- riverbed lining
- road metal
- roads & highways
- roads: Ice control
- roads: road bed, surface
- roofing granules
- rubble and riprap
- runways
- Sandblasting
- septic system/beds
- shoreline protection
- sidewalks
- soil remediation
- streetcar & tram brake systems
- stucco dash
- subway tunnels
- sugar refineries
- surgery instruments
- tableware
- toothpaste
- tunnels
- TV & computer screens
- washing detergent
- water filtration
- wind turbines

Source: Compiled by Altus Group Economic Consulting based on synthesis of many documents (see Reference list)

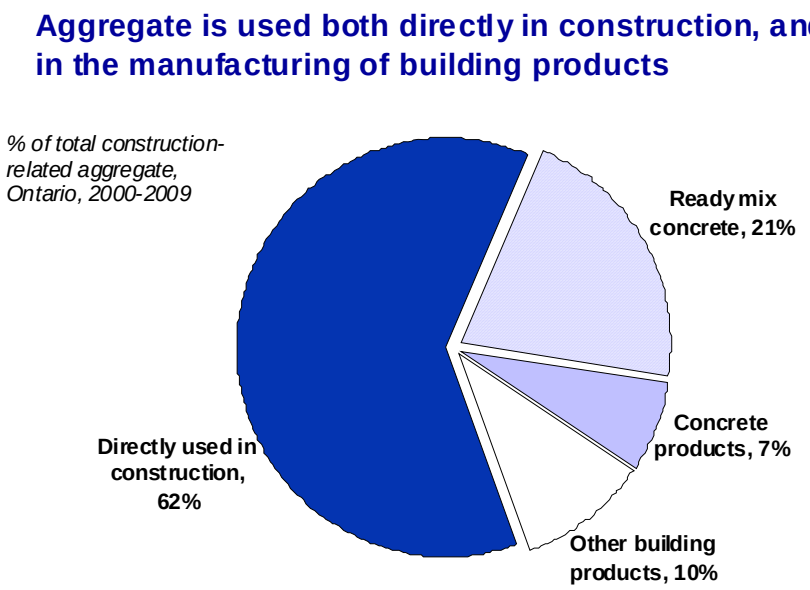
Figure 4- 2 Use of Aggregate in Construction vs. Other Uses, Ontario

Construction work is the major use for aggregate



Source: Estimates by Altus Group Economic Consulting based on StatCan 2005 National Input-Output model

Figure 4- 3 Aggregate Used in Construction Work, Direct vs. Building Products



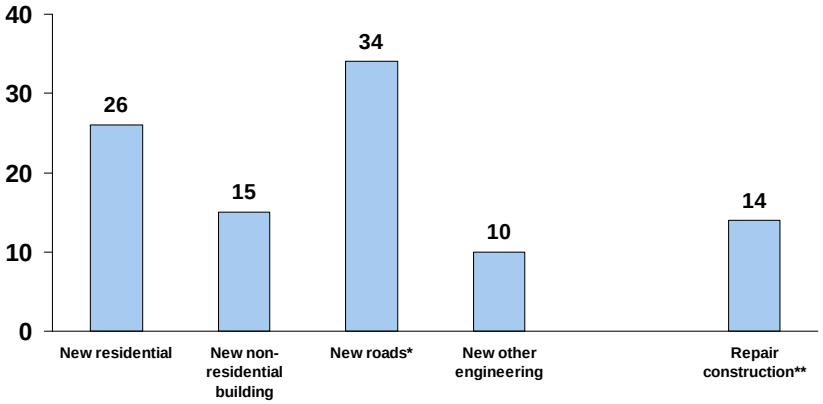
Source: Estimates by Altus Group Economic Consulting based on StatCan 2005 National Input-Output model

- The use of aggregate in construction work can be further disaggregated by type of construction work.
- During the 2000s, new road construction in Ontario accounted for an estimated one-third of construction-related aggregate use (Figure 4- 4). Construction repair work accounted for another 14%. As roads are estimated to account for most of the aggregate use related to repair work, this suggests that, combined, new and repair/maintenance road work account for close to half of aggregate used in construction work.
- It is important to note that the public sector plays a key role in aggregate consumption through its roadbuilding and other infrastructure related programs (most of which is included in "new other engineering").

Figure 4- 4 Use of Aggregate in Construction Work by Type of Construction, Ontario

Roads consume the largest share of aggregate used in construction work

Estimated share of construction-related aggregate by type of construction 2000-2009

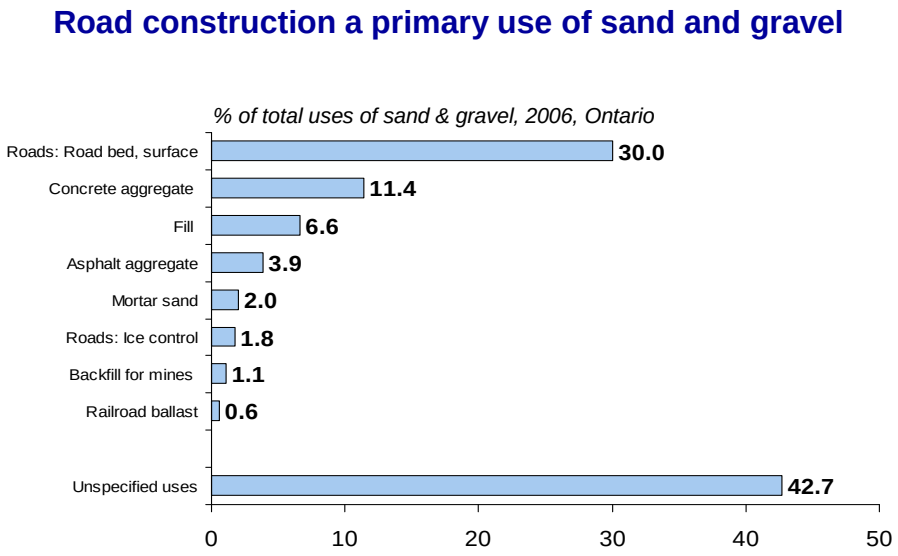


* *Includes municipal, provincial and private sector road spending*
***While a breakdown is not available in the input-output model, the majority of aggregate used in repair work is estimated to be for road repairs*

Source: Estimates by Altus Group Economic Consulting based on StatCan 2005 National Input-Output model

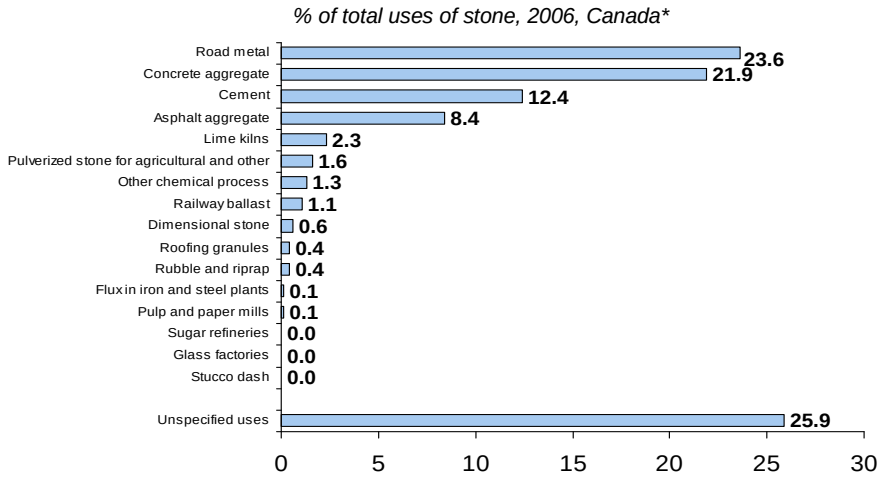
- The information available from the analysis of the National Input-Output model can be supplemented with StatCan survey information to gain some additional insight into the relative importance of specific uses of aggregate.
- Information is collected from producers on known uses of aggregate (Figure 4- 5 and Figure 4- 6).
- While not as comprehensive as one might like (in particular, there are substantial portions of "unspecified" uses, in part as the producers often would not have the information on the end use by the purchasers), it does confirm that road construction and concrete are key uses of aggregate.

Figure 4- 5 Uses of Sand and Gravel, Ontario



Source: Altus Group Economic Consulting based on StatCan, Non-Metallic Mineral Mining and Quarrying (Catalogue 26-226)

Figure 4- 6 Uses of Stone



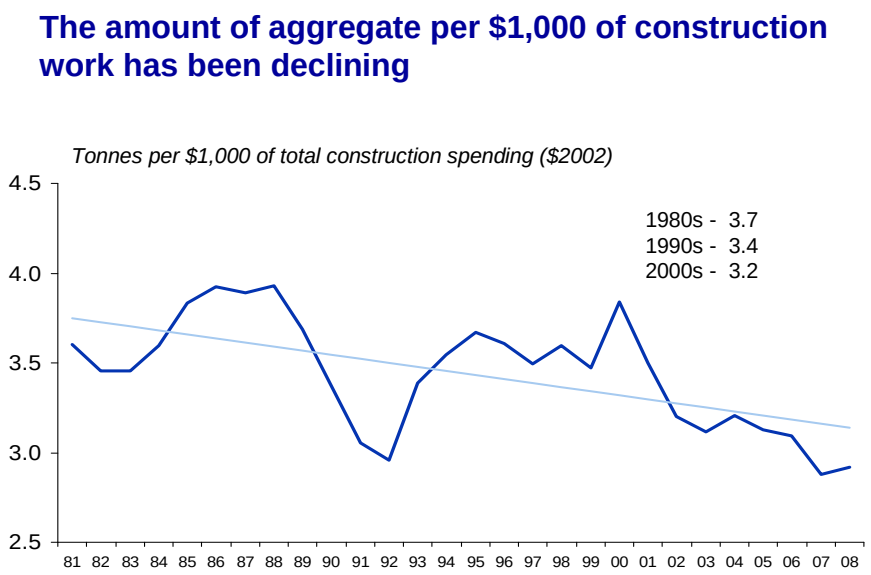
** Note: data on this chart are for Canada, as comparable information is not published specifically for Ontario*

Source: Altus Group Economic Consulting based on StatCan, Non-Metallic Mineral Mining and Quarrying (Catalogue 26-226)

4.3 HOW MUCH AGGREGATE IS USED PER DOLLAR OF CONSTRUCTION WORK?

- For every $1,000 spent on construction work during the 2000s, there was a corresponding use of about 3.2 tonnes of aggregate (primary and secondary combined) on average per year (Figure 4- 7).[11]

Figure 4- 7 Trend in Amount of Aggregate Used Per $1,000 of Construction Spending, Ontario



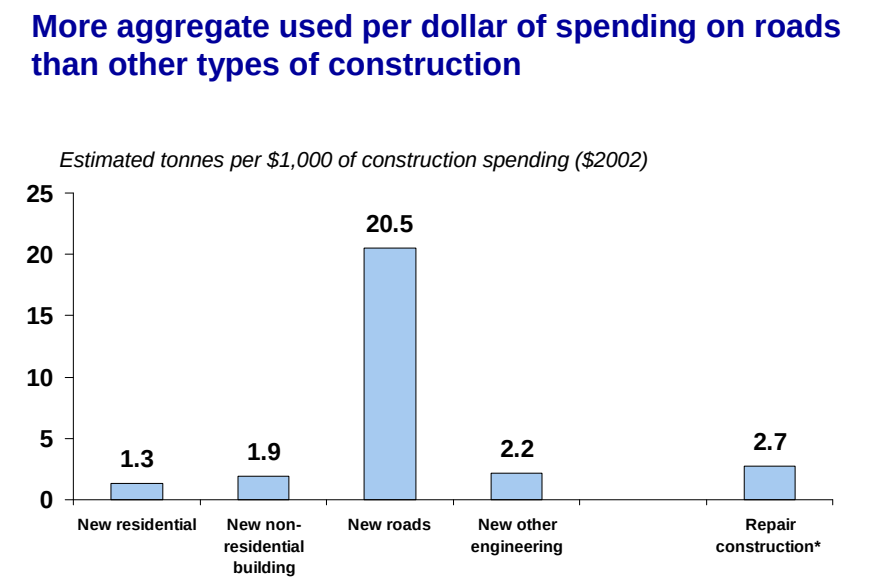
Source: Estimates by Altus Group Economic Consulting based on information from MNR,TOARC and StatCan

- The tonnes of aggregate used per $1,000 of total construction spending however has been on a generally downward trend since the early 1980s.[12]
- The amount of aggregate used per $1,000 of spending varies by type of construction work, with significantly more aggregate being used per dollar spent on road construction than other types of construction work (Figure 4- 8).

[11] Note that no adjustment has been made here to exclude aggregate used in non-construction activity, due to lack of comprehensive information on annual trends in that component.

[12] The pronounced lower intensity levels in the early 1990s reflected that construction spending during that period was primarily work that lingered from the non-residential overbuilding in the latter 1980s; much of the initial stages of work on these buildings (aggregate is typically used in the earlier stages of this type of work) would have been completed by the early 1990s.

Figure 4- 8 Amount of Aggregate Used Per $1,000 of Construction Spending by Type of Construction, Ontario



** While a breakdown is not available in the input-output model, the majority of aggregate used in repair work is estimated to be for road repairs*

Source: Estimates by Altus Group Economic Consulting based on StatCan 2005 National Input-Output model

4.4 HOW MUCH AGGREGATE DOES IT TAKE FOR SPECIFIC CONSTRUCTION APPLICATIONS?

- As part of the work for this project, estimates of the amounts of aggregate required for specific applications were prepared.[13]
- Unlike the dollar spending basis approach used in the previous section, the analysis in this section focuses on aggregate needed for a particular physical "quantity" of construction work.
- The results are summarized on Figure 4- 9. Highlights include:
  - 18,000 tonnes of aggregate per kilometre of a 2 lane highway in Southern Ontario
  - 250 tonnes for a 185 m^2 (2,000 sq. ft.) house
  - 114,000 tonnes per kilometre of a subway line

[13] This analysis was conducted primarily by LVM-Jegel, based on construction projects undertaken by the firm and its affiliated companies. The specific assumptions underlying the construction of the factors are provided in Appendix B.

Figure 4- 9 Tonnes of Aggregate Used in Specific Construction Applications

Roads (per km)	Tonnes
2 lane highway	18,000
4 lane highway	30,000
4 lane freeway	44,000
Major arterial road:	
Southern Ontario	18,000
Northern Ontario - typical	13,500
Northern Ontario - high volume	24,000
Minor arterial road:	
Southern Ontario	7,500
Northern Ontario - typical	13,500
Northern Ontario - high volume	22,000
Collector:	
Southern Ontario	14,000
Northern Ontario - typical	12,500
Northern Ontario - high volume	22,000
Local:	
Southern Ontario	6,500
Northern Ontario - typical	12,000
Northern Ontario - high volume	21,000
Laneway	6,500
Buildings and parking	**Tonnes**
House (185 m^2)	250
Office, school, hospital space (1,000 m^2)	730
Parking (per space)	
Underground parking garage	9
Above ground suspended slab	7
At grade	15
Underground water pipe and sewer line (per km)	**Tonnes**
Underground water pipe - under a boulevard	
Southern Ontario	1,000
Northern Ontario	1,000
Underground water pipe - under a road	
Southern Ontario	3,000
Northern Ontario	4,500
Underground sewer line - under a boulevard	2,500
Underground sewer line - under a road	14,500
Miscellaneous infrastructure	**Tonnes**
4 lane concrete bridge over 6 lane highway (83 meters)	7,500
Railway bed (per km)	6,000
Rural septic/filter bed	85
Wind turbine	4,000
Subway line (per km)	114,000
Nuclear power plant	136,000

Source: LVM-Jegel (see Appendix B) and AECOM Canada (see subway case study in SAROS Paper 3 - The Value of Aggregates)

5.0 THE FUTURE CONSUMPTION OF AGGREGATE IN ONTARIO

This section examines the prospects for future consumption of aggregate in Ontario as a whole, and for each of the 8 geographic areas. Key questions addressed include:

- How well have past analyses of the future use of aggregate in Ontario performed?
- How is future aggregate consumption modelled in other jurisdictions?
- What is the recommended projection methodology?
- What key factors might impact the underlying trend in per capita consumption of aggregate over the next 20 years?
- What is the economic and population growth outlook for the province?
- What is the projected trend in per capita aggregate consumption?
- What is the projected consumption of aggregate in Ontario over the next 20 years?
- What sources are likely to provide the aggregate used in Ontario over the next 20 years?
- What alternate scenarios should be considered?

5.1 HOW WELL HAVE PAST ANALYSES OF THE FUTURE USE OF AGGREGATE IN ONTARIO PERFORMED?

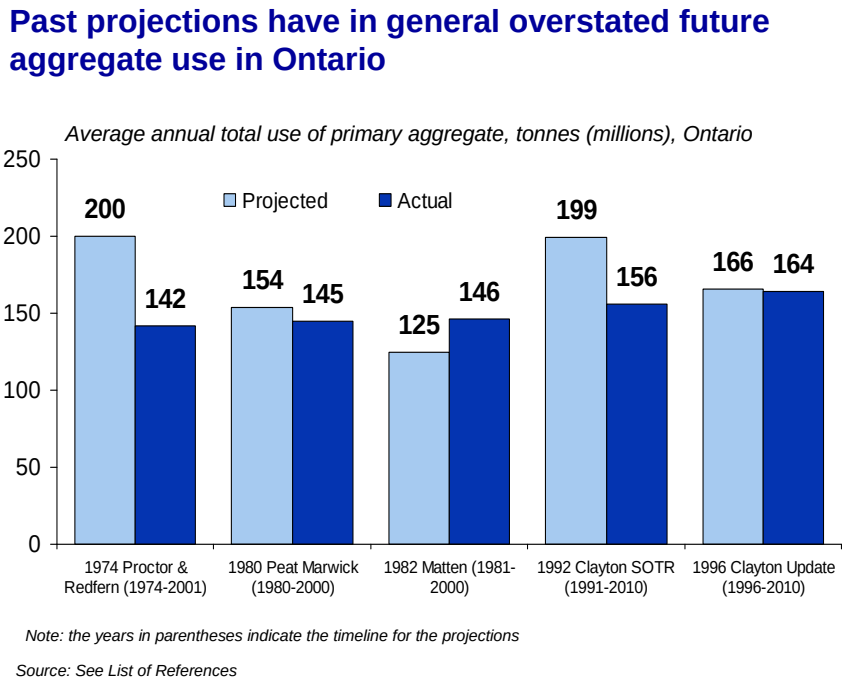
- Projections of the future consumption of aggregate are not a new situation in the Province of Ontario. Several past exercises have been undertaken for the Ministry of Natural Resources that have tried to "predict" what the future holds.[14]
- For the most part, these projections have tended to overstate future use (Figure 5- 1). Some factors behind the poor track record include:
  - In some cases the models themselves were not the best choice. The most recent of these past projections for

[14] A summary of these past studies is provided in Appendix A.

MNR was almost 20 years ago. The historical series available at that time to help in the modelling exercise was more limited – that is, shorter term information by necessity had to be used to project longer-term trends.

– Like the situation for projections in general, the world does not always unfold as expected – that is, while the model may have been reasonable, the inputs/assumptions used to derive the outputs were not what actually occurred. For example, when the last exercise was conducted for MNR in 1992 (the State of the Resource Study, or SOTR), the general view was that Ontario would quickly recover from the recession of the early 1990s; this did not however occur, and construction levels remained constrained through the rest of the decade.

Figure 5- 1 Comparison of Past Ontario Projections of Aggregate Use



Note: the years in parentheses indicate the timeline for the projections

Source: See List of References

- Given the poor track record in general on projecting future aggregate consumption for the province, one might well ask "Why do it?". The answer is that a view of the future is necessary in order to plan for what might unfold. The key in

projections, however, is to keep them dynamic – easily and readily updateable if and when the real world starts to veer from the projected world.

- Moreover, as already indicated, there is more information available today to help in the projection exercises than was the case when previous projections were prepared. The additional years of historical information provide a sounder basis on which to assess past trends, and how they might apply to the future.

5.2 HOW IS FUTURE AGGREGATE CONSUMPTION MODELLED IN OTHER JURISDICTIONS?

- Ontario has been among the frontrunners in the world in terms of commissioning work to model the future consumption of aggregate.
- Many other jurisdictions do not even attempt to do so. Among those that do, methods generally fall under 3 main categories:[15]
  - **Historical trend**: using such simple assumptions as recent per capita consumption or recent average annual levels (the California model uses this approach)
  - **Regression models:** using either macroeconomic indicators (such as GDP, population, unemployment rate, etc.) or based on construction spending (this was the previous UK methodology; it was also used in the 1992 State of the Resource Study as a short-term projection method as this method tends to identify turning points better than other methods)
  - **Construction input factors**: these may be either **space-based** (i.e. tonnes per sq. ft. of different types of construction; previous work for the Lower Mainland in B.C. took this approach) or **dollar-based** factors (i.e. tonnes per dollar spending), for different types of construction (the approach used in the 1992 State of the Resource Study).

[15] A concise summary of various models used in past Ontario studies as well as more recent ones for other jurisdictions, is provided in Appendix A.

5.3 WHAT IS THE RECOMMENDED PROJECTION METHODOLOGY?

5.3.1 The Per Capita Approach

- The following key principles were considered in terms of choosing the appropriate modelling methodology for this exercise:
  - The model should not be overly complicated - the methodology should be relatively easy to understand, and not a "black box".
  - Any data required to operationalize and update the model should be readily available, with external updates of key inputs available preferably on an annual basis, or at least every few years.
  - The methodology should lend itself to sensitivity testing and formulation of alternate scenarios.
- With these principles in mind, it was recognized that a methodology that was built on assumptions about per capita use of aggregate might best fit these criteria:
  - Applying a per capita aggregate consumption assumption to total population is a relatively simple process.
  - The key data require for the exercise is readily available, as long-term projections of total population are prepared on a regular basis by the Ontario Ministry of Finance, for Ontario as a whole as well as for each census division, which can then be compiled into projections for each of the 8 geographic areas.[16]
  - Sensitivity testing can be easily done on alternate population scenarios as the Province's projections include base case, low and high scenarios. Alternate assumptions about the per capita level can also be easily applied.

[16] While previously these projections were prepared only every few years, in the latest population projections document (Ontario Population Projections, 2008-2036) it is stated that "The new projections will be updated every year in future to provide planners and researchers with a demographic outlook reflecting the most up-to-date trends and historical data" (pg. 3)

- It was also recognized however that a constant per capita assumption would not be reasonable. As shown previously, over the longer-term, per capita usage has been gradually declining. However, it also tends to be above trend in periods of stronger economic activity, and below trend in periods of weaker economic activity.
- It was felt that regression analysis could prove useful in helping to determine the future trends in per capita aggregate consumption. Regression analysis statistically identifies the relationship between an independent variable (in this case, per capita consumption of aggregates in Ontario) and a set of independent variables. The potential independent variables considered for the analysis here included total population, population growth, housing starts, real GDP growth (%) and the unemployment rate. These variables were the focus, as they are all variables contained in typical long-term Ministry of Finance economic projections.
- To begin, a correlation analysis was done for these variables for the 1980-2008 period (Figure 5- 2).

Figure 5- 2 Correlation Analysis, Per Capita Aggregate Consumption and Various Factors, Ontario, 1980-2008

	Total population (000s)	Total population growth (000s)	Unemployment rate %	Housing starts (000s)	Real GDP growth (%)	Per capita total aggregate consumption (tonnes)
Total population (000s)	1.00					
Total population growth (000s)	0.22	1.00				
Unemployment rate %	-0.28	-0.51	1.00			
Housing starts (000s)	0.30	0.70	-0.71	1.00		
Real GDP growth (%)	-0.13	0.03	-0.25	0.16	1.00	
Per capita total aggregate consumption (tonnes)	-0.19	0.69	-0.68	0.79	0.26	1.00

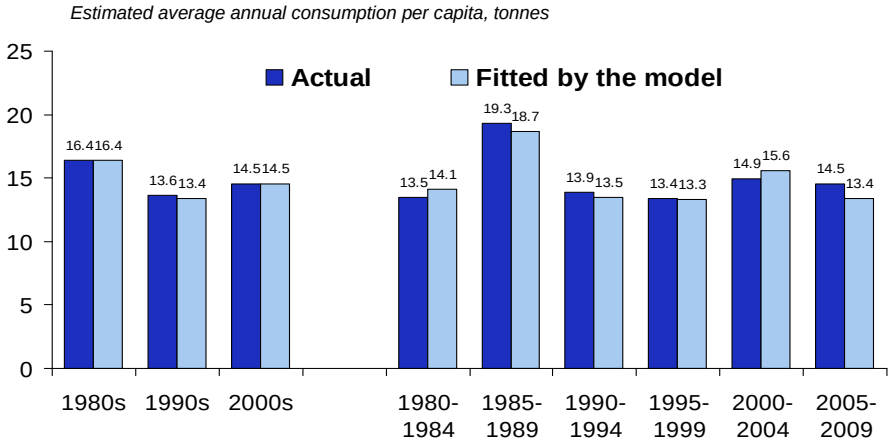
Source: Altus Group Economic Consulting based on data from MNR, TOARC and StatCan

- The analysis confirmed that these factors are all correlated with per capita aggregate consumption to some degree and have the expected positive or negative signs:
  - **Total population** has a moderate, negative correlation, meaning that as total population increases, the per capita amount of aggregate used declines.
  - **Population growth** (number of persons) has a higher correlation with per capital aggregate consumption than total population, and the sign is positive, as expected.
  - The **unemployment rate** is highly correlated with per capita aggregate consumption, and the sign is negative (i.e. an increase in the unemployment rate would be expected, all other things being equal to be associated with a decline in per capita aggregate consumption).
  - **Housing starts** are highly correlated with per capita aggregate consumption, and the sign is positive – the higher the level of housing starts, the higher the level of per capita aggregate consumption.
  - **The rate of real GDP growth** is moderately correlated with per capita aggregate consumption, and the sign is positive (i.e. stronger economic growth is associated with higher per capital consumption).
- Based on this correlation analysis, all of the independent variables identified above were included in the regression analysis conducted for the 1980-2008 period.[17]
- The overall fit of the model was very good, with an adjusted R^2 of 89%. All of the independent variables were shown to be statistically significant, with the exception of real GDP growth (the latter variable however was kept in the model as removing it reduced the overall model fit).
- The resulting model was used to "project" historical consumption, to see how well it did for the longer term (10 year), medium term (5 year) and short-term (annual).

[17] The key model statistics, as well as the annual data used to conduct the regression analysis, are provided in Appendix A.

Figure 5- 3 Per Capita Aggregate Consumption, Actual vs. Regression Model, Ontario, Average Annual

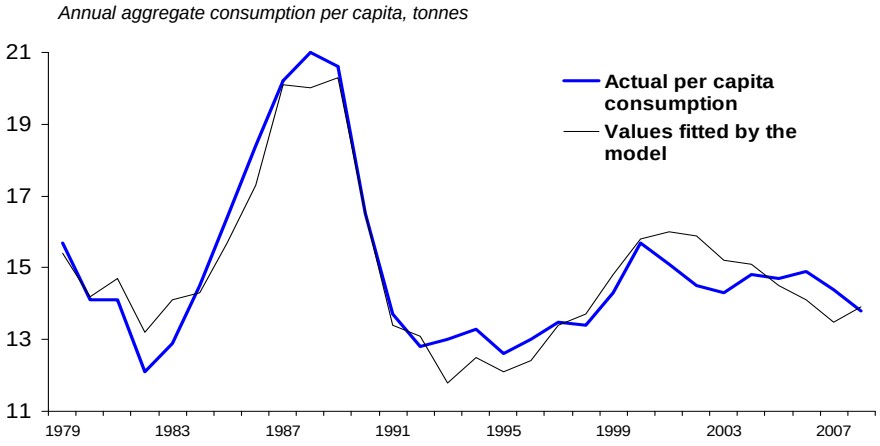
The model performed well on 10 year historical periods, less well on recent 5 year periods



Source: Altus Group Economic Consulting based on information from MNR, TOARC and StatCan

Figure 5- 4 Per Capita Aggregate Consumption, Actual vs. Regression Model, Ontario, Annual

The model generally able to "predict" broad turning points



Source: Altus Group Economic Consulting based on information from MNR, TOARC and StatCan

- The fit for the longer-term 10 year basis was quite good, with results closely matching the actual per capita consumption (Figure 5- 3). The medium-term 5 year basis was also fairly close, although the model tended to "overpredict" per capita aggregate consumption in the early 2000s, and "underpredict" the latter 2000s. This pattern for early vs. latter 2000s was also exhibited in the annual results (Figure 5- 4). It is likely that spending under the government stimulus program, which is not directly captured in the model, is playing a role in the short-term.
- Given the above, it was decided that the per capita approach would be adopted for this study. The regression model was used to do initial runs of per capita usage, however consideration was also given to potential factors outside the model variables that might impact future trends in per capital aggregate usage. An analysis of those factors is conducted in Section 5.4.

5.3.2 Why a construction spending approach not adopted for use in this study

- Since construction spending is the primary user of aggregate, serious consideration was given to using a projection approach which first projects construction spending by type of construction, and then applies factors showing the amount of aggregate used per dollar of various types of construction spending. This was the approach used in the 1992 **State of the Resource Study**.
- This methodology, however, does not meet one of the key criteria, which is that the data needed to operationalize the model should be readily available. Indeed, it falls short in several areas in this respect:
  - The methodology requires generating factors on the amount of aggregate used per dollar spending of various types of construction activity. These factors are generally obtained from Statistics Canada's Input-Output model. However, the level of detail required by type of construction work, and for the actual aggregate products (sand & gravel and crushed stone) are only available at the national level, not specific to Ontario. Therefore

several assumptions and adjustments are required to operationalize the model for Ontario.

  - The model requires a good series on historical Ontario construction spending by type of construction, and for new and repair/maintenance work, in order to determine what the historical usage factors are (i.e. the amount of aggregate per dollar of various types of construction spending). While the provincial economic accounts provide information on new construction spending, total non-residential construction is not broken down into building, road engineering and other engineering (which is needed, since as shown in Section 4.3, the amount of aggregate per dollar of spending varies by type of construction). Similarly, projections of construction spending at the level required for the methodology are not readily available, and would need to be independently generated as part of the projection exercise.
  - As the amount of aggregate used per dollar of construction spending has been declining over time (as shown in Section 4.3), adjustments would need to be made to the factors over time.
  - Adjustments/assumptions need to be made for non-construction uses as well, based on limited historical information.

- Also, while construction spending is a good predictor of aggregate usage over longer period, it performs less well in identifying short-term turning points. That is because construction spending series are based on “work put in place” through the life of the project, but for many types of construction aggregates are mainly used in the earlier stages of the work.
- While it was decided that the construction/usage factors approach would not be the prime methodology used in this study because of the data limitations for operationalizing the model, this method was used as a “backup” to test the reasonableness of the projections generated using the per capita aggregate usage approach.

5.4 WHAT KEY FACTORS MIGHT IMPACT THE UNDERLYING TREND IN PER CAPITA CONSUMPTION OF AGGREGATE OVER THE NEXT 20 YEARS?

Before using the per capita aggregate consumption approach to determine the future total levels of aggregate consumption, the next section assesses whether there are other factors, not captured in the regression model, which might be expected to have an additional impact on future per capita trends.

5.4.1 Major infrastructure spending

- In the 2009 Ontario budget, $32.5 billion was announced for infrastructure investment over a 2 year period, as part of the economic stimulus program.
- Major investments in public transportation are in various stages of planning and/or construction in the Greater Golden Horseshoe, mostly within the GTA. These public transit investments include major expansions to existing networks, as well as new services which include an expanded regional rail network, the extension of subway lines, the creation of light rail transit (LRT) and bus rapid transit (BRT) corridors, as well as incremental expansions to local bus networks. The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Region prepared by Metrolinx provides a summary of projected major transit expansion plans (totalling about $50 billion) for the next 25 years including the following:
  - Subway expansions to Vaughan and Richmond Hill and new east-west subway line through Downtown Toronto;
  - Improved express regional rail service between Toronto and Hamilton, Mississauga, Brampton, Richmond Hill, and Oshawa;
  - Regional Rail expansions and improvements to urban centres such as Barrie, Guelph, Kitchener-Waterloo, Peterborough and Niagara; and
  - Extensive construction of new LRT and BRT routes throughout the GTA and Hamilton region including service to Pearson International Airport, service along the

waterfront, and several corridors which will connect the various urban growth centres.

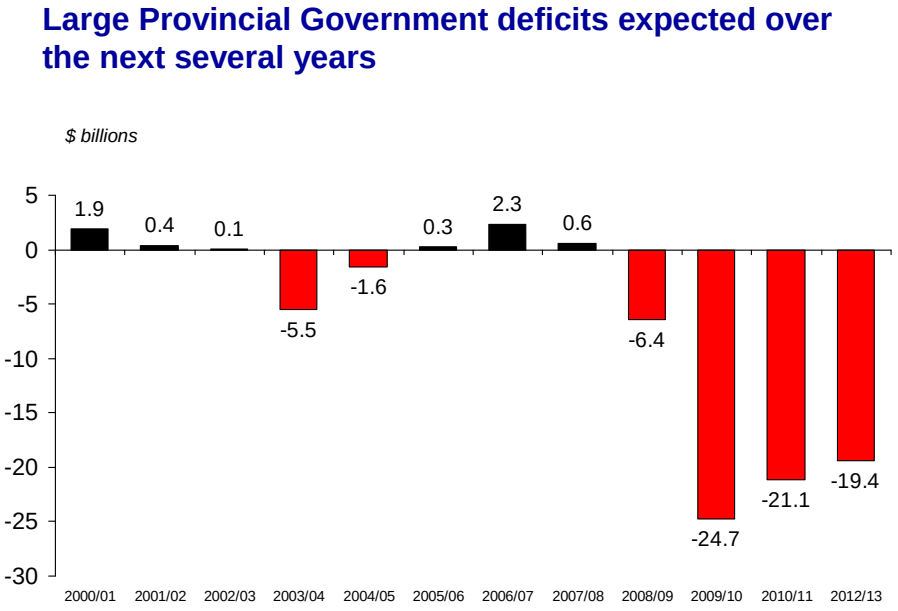
- In addition to planned major transit expansions, several other infrastructure investments are also at various stages of planning and potential development within Ontario. Most of these projects relate to the construction of new highways or extensions to the current network. Among these proposed highway developments are the following major initiatives:
  - New Niagara-GTA corridor proposed along the top of the escarpment passing to the west of Hamilton (80-90km);
  - New east-west corridor from Vaughan to Kitchener, north of Highway 401 (75-85 km);
  - Extending Highway 427 northward to Highway 89/400 (50 km);
  - Extending Highway 404 northward from Newmarket to Highway 7/12 (55 km);
  - Cambridge Bypass linking Highway 401 and Highway 403 (20-30 km);
  - Extending Highway 407 eastward to Highway 35/115 (40 km)
  - A new bridge border crossing at Windsor and associated improvement to Highway 401 and
  - The widening of several portions of 400-series highways to accommodate HOV lanes.

- Considerable ongoing annual maintenance will also be required including occasional repairs and resurfacing of thousands of kilometres of Provincial Highway and extensive municipal road networks. While some of this repair work would be “typical”, some would be from deferred work.
- In addition to planned highway expansions, there is a push to address an infrastructure deficit. Much of the investment in public infrastructure occurred in the 1950s and 1960s. The need to repair and/or replace roads and bridges represents an

increasing challenge as this infrastructure continues to age. There will be a continued need to invest in the on-going rehabilitation of Ontario's highway network and extensive municipal street systems through repair, replacement and/or resurfacing. The question however will be whether the funds are available to finance this investment.

- While it is expected the infrastructure investments already committed to by the Provincial Government will proceed, current stimulus investments, combined with lower tax revenues, are having a detrimental impact on the financial situation of the province, as outlined in the Fall 2009 Economic Update (Figure 5-5). This may lead to more constrained infrastructure spending in future years as increasing debt levels start to be dealt with.

Figure 5- 5 Province of Ontario Annual Surpluses/Deficits



Source: Altus Group Economic Consultign based on Ontario Economic Outlook and Fiscal Review 2009

5.4.2 Growth Plan for the Greater Golden Horseshoe

- The Province of Ontario approved the June 2006 **Growth Plan for the Greater Golden Horseshoe** (also known as **Places to Grow**) under the Places to Grow Act of 2005. The Growth Plan

provides a framework for implementing the province's vision for building stronger, more prosperous communities, by better managing growth and promoting the creation of healthy, balanced communities. Through the Plan, the Province seeks to manage growth in a manner that contributes to the creation of more compact, complete communities that make efficient use of infrastructure and land resources.

- The Growth Plan acknowledges that the Greater Golden Horseshoe area (the GTA, Hamilton and selected surrounding municipalities) will experience significant population growth pressures through a 2031 planning horizon and presents a strategy for better managing new development and infrastructure in the Region. Highlights of the Growth Plan include the following:
  - **Greenbelt**: the Growth Plan recognises the 7,300 km^2 Greenbelt Area as identified in the Province's Greenbelt Plan (2005) which also includes the Niagara Escarpment and Oak Ridges Moraine. The Greenbelt Plan identifies where the urbanization should not occur in order to provide permanent protection to the agricultural land base and the ecological features and functions occurring on this landscape.
  - **Identification of Urban Growth Centres**: a hierarchy of urban growth centres are identified throughout the GGH and should serve to accommodate major transit infrastructure, major institutional uses, regional public services and major employment centres, as well commercial, cultural and intensive residential uses. The Plan provides minimum gross density targets for these centres and they will be planned to achieve densities ranging from 150 to 400 persons and jobs per hectare by 2031.
  - **General Intensification Targets**: Due to growth boundaries such as the greenbelt area and a need to more efficiently utilize land resources and existing infrastructure, significant targeted intensification of existing urban areas is expected. The Plan requires that

by the year 2015, and each year thereafter, at least 40% of annual residential development in each GGH municipality will be within the built-up area.

- **Minimum Density Targets for Greenfield Areas**: greenfield development at the urban fringe will continue in many areas of the GGH for residential and limited employment uses. This greenfield area will however be developed more compactly, with a generally increased presence of public transit, higher density forms and increased mixing of land uses. A minimum density target of 50 residents and jobs combined per hectare will be achieved within these greenfield areas.
- **Creating Complete Communities**: new development in greenfield areas will be planned and designed in a manner that contributes to creating complete communities. This means creating neighbourhoods that can meet people's needs for daily living throughout a lifetime by providing convenient access to an appropriate mix of jobs, services, full range of housing, recreation and community infrastructure.
- **Multi-modal Transportation**: increased investment and reliance on public transportation is anticipated and encouraged. The transportation system in the GGH will be planned and managed to offer multi-modal access to jobs, housing, recreation and services. Public transit will be the first priority for transportation infrastructure planning and major transportation investments and will be utilized as a means to shape growth.
- **Investment in Infrastructure**: the Growth Plan recognises the existing infrastructure deficit in the province and the need for significant investment to provide balance. The strategic staging of infrastructure investments will help to mitigate sprawl and is critical to implementing the Plan.
- **Protecting what is Valuable & Mineral Aggregate Resources**: a balanced approach to the wise use and management of aggregate resources will be implemented

and the Province will work with municipalities and producers to develop a long-term strategy for ensuring the wise use, conservation, availability and management of the resource in the GGH. This acknowledgement recognises that mineral aggregates are a key component to supporting growth and infrastructure objectives.

5.4.3 Trends in development patterns and urban form

5.4.3.1 General trends

- As part of the analysis for this study, MHBC Planning undertook a "thought piece" on the impact of general development patterns and urban form on the potential consumption of aggregates. Highlights of that analysis and key trends include:[18]
  - There is a shift in the construction of residential neighbourhoods towards a more compact grid pattern. Modified-grid pattern neighbourhoods tend to have much more intricate and extensive street patterns, resulting in more roads per square kilometre and per dwelling unit, despite typical increased densities. These neighbourhoods do however tend to consume less land.
  - More compact development suggests a larger share of new residential units will be smaller dwellings/multiple housing forms. However, high-rise apartment units consume more aggregate per given area.
  - The Greenbelt and municipal growth boundaries are serving to constrain the outward expansion of cities, creating an impetus to develop remaining land more efficiently.
  - Infilling will represent an increasing share of annual residential development. While many projects can piggy-back on existing urban infrastructure, large-scale initiatives can demand all new roads and servicing to increase access and capacity.

[18] A background document which assesses each trend is provided as Appendix C.

- Minimum density standards for targeted intensification areas will increase the rate of construction for mid and high-rise buildings which will increasingly feature underground parking facilities.
- With transit improvements, the per capita provision of parking spaces is expected to decline slightly, but more of this parking will be accommodated in underground structures that consume more aggregate per unit.
- The adaptation and re-use of historic building stock is increasing, particularly for old industrial buildings through office or loft conversions. This extends the active life of these buildings and intensifies their use, thereby decreasing demand for new aggregates.
- The mixing of land uses within neighbourhoods is increasing, including the incorporation of retail development. This provides popular destinations closer to home and could slightly reduce personal travel patterns, and possibly “wear and tear” on the road systems.
- Advances in sustainable development practices and the construction of “green buildings” may increase the use of recycled aggregate and alternative construction materials.
- Major expansions to local and regional rapid transit systems are planned which would result in a threefold increase of the existing network. This investment may increase transit ridership and reduce demand for highway infrastructure.
- The creation of major transit station areas tends to spur redevelopment in the surrounding area, creating more intensive neighbourhoods.
- The proportion of commuters and average commute times has increased in Ontario, placing pressure on inter-regional travel networks.
- Investment in public transit and the construction of more compact, mixed-use communities should reduce average

auto usage, but there will still be a net increase in vehicle trips as a result of significant population growth.

- The movement of goods by truck will continue to be the dominant shipping method and will continue to demand highway and border crossing improvements.
- Ontario's street and highway network is extensive and aging. Much of this infrastructure has deteriorated and is in need of widespread investment in maintenance and rehabilitation.
- The use of high quality crushed stone in road construction is increasing, particularly in urban settings where high volumes and heavy loads are encountered. This trend is expected to continue for both ongoing maintenance and new construction. This trends to use of more high quality stone may result in reduced repair/maintenance in future, although any impact on per capita aggregate consumption would not likely be felt until later in the projection period.

- A summary of the various trends discussed above that are actively influencing both the per capita volume of aggregates consumed and requirements for high quality crushed stone material is provided on Figure 5- 6. Upward and downward arrows are shown to indicate when the trend is working to increase or decrease use of aggregates on a per capita basis. For some factors, the shorter term impact is expected to be increased per capita consumption of aggregates, as new infrastructure is built, however there is potential for longer-term lower per capita usage once new systems are in place (e.g. HOV lanes, more compact urban forms, etc.).
- The analysis is not meant to be exhaustive. However, it does emphasize that there are a wide range of factors that could potentially impact future per capita consumption of aggregate, some suggesting an increase, others a decrease - and the net impact of the factors is unclear.
- As such, for the purposes of this exercise, there is no strong basis for assuming any additional movements in per capita use of aggregates over and above what has already been shown by

the regression model exercise for at least the next 5-10 years. However later in the projection period some additional downward impact may be felt as less future maintenance is required on infrastructure built with higher quality stone.

- With respect to the need for higher quality aggregate however, the patterns do suggest there will be some additional shift in consumption to the use of crushed stone throughout the projection period.

Figure 5- 6 Assessment of Directional Impact of Selected Emerging Trends on Per Capita Aggregate Consumption and Use of Higher Quality Aggregate

Theme	Trend	Directional impact on per capita aggregate consumption	Directional impact on use of higher quality crushed stone
Neighbourhood Development Patterns	Adoption of grid street pattern which may also include rear laneways	↑	–
	Smaller residential lot sizes	↓	–
	Decreased proportion of single-family homes with more semi-detached, townhomes and apartments	↓	↑
	Increased provision of neighbourhood open space including stormwater management facilities	↑	–
	More mixed use neighbourhood development	↓	–
	Reduced average household size (i.e. fewer persons per household)	↑	–
	Increasing work-at-home and live-work development	↓	–
	Minimum neighbourhood density standards	↓	–
Intensification and Infilling	Increased small-scale infilling and minor intensification	↓	–
	Increased major urban redevelopment/revitalization schemes requiring new infrastructure	↑	–
	Reduced parking standards	↓	–
	Increasing provision of structured parking including above-grade and underground	↑	↑
	Replacement of old and/or insufficient infrastructure including underground servicing	↑	–
	Proportionally more high-rise development	↑	↑
	Increasing adaptive reuse and renovation of historic building stock	↓	–
	Increased urban densities within targeted intensification areas	↓	–
Transportation Systems and Demand	Provincial highway expansion plans	↑	↑
	Maintenance of ageing infrastructure	↑	–
	Road design standards & crushed stone requirements	–	↑
	Addition of HOV lanes to major highways	↑ ↓	–
	Expansions to rapid transit systems including subway, LRT and BRT	↑ ↓	↑
	Expansions to regional rail networks including GO transit and possible high speed rail corridor	↑ ↓	–
	Increased transit use as proportion of modal share	↓	–
	Investment in cycling and pedestrian facilities	↓	–
	Adoption of Transportation Demand Management (TDM) measures	↓	–
	International trade and goods movement	↑	↑

5.4.3.2 Case studies

- To supplement the analysis, two case studies were undertaken in order to assess the cumulative net impact of the various factors that affect consumption patterns for aggregate resources. These case studies are intended as measurable examples of the previously described trends by quantifying changes to the urban landscape in terms of per capita aggregate resource consumption for streets and buildings. Each case study presents two development scenarios, one based on conventional development patterns, and the second reflecting new development trends and policy models.[19]
- **North Milton**
  - This case study compares two adjacent, predominantly residential neighbourhoods, one developed on the conventional low-density loops and cul-de-sacs model (Dorset Park) and the second more recently on a modified grid pattern (Dempsey). Both sites have very similar locational characteristics in terms of access to transit, employment, shopping and major transportation routes. Both sites also represent “superblock” neighbourhoods with the larger structure of the Town of Milton, with central park/school concepts and apartment blocks at the fringe.
  - Key comparative measures for the two neighbourhoods are provided on Figure 5- 7. The key conclusion is that while the new neighbourhood pattern is more dense (67.4 residents per hectare vs 40.4 for the conventional neighbourhood), this higher density is offset by a more elaborate street network (such that roads on a per resident basis are similar under both development concepts). Overall, therefore, the new neighbourhood may be no more efficient in terms of per capita aggregate consumption. However, through increased densities, the new neighbourhood consumes less land and better centralizes the population, creating some regional infrastructure savings.

[19] More details on the case studies are provided in Appendix C.

Figure 5- 7 North Milton Case Study: Key Comparative Indicators

Development Efficiency Calculations

Efficiency Measure	*Dorset Park*	*Dempsey*	*Proportional Difference*
Gross Density : units per hectare	13	17.2	32%
Gross Density: residents per hectare	35.9	47.8	33%
Road Length: metres of road per km^2	10,410	13,753	24%
Road Length: metres of road per resident	2.9	2.9	0%
Road Length: metres of road per dwelling unit	8	8	0%
Travel Patterns: walking, cycling and transit use	9.70%	7.40%	-31%

Open Space Network & Net Residential Densities

	Dorset Park (149.6 ha)		*Dempsey (100.8 ha)*	
Land Use	Size (ha)	% of total area	Size (ha)	% of total area
Parks	11.23	7.5%	4.67	4.6%
Storm water management / drainage	0.59	0.4%	10.31	10.2%
Environmental / woodlot	0	0.0%	9.17	9.1%
School	3.65	2.4%	5.13	5.1%
Commercial Uses	1.1	0.7%	0	0.0%
Total Non-Developable	16.57	11.1%	29.28	29.0%
Net Developable Area	133.0 ha		71.5 ha	
Net Density: units per hectare	14.6		24.3 (66% increase)	
Net Density: residents per hectare	40.4		67.4 (67% increase)	

Source: MHBC Planning

- **Regent Park**
  - This case study assesses changes in how lands are developed or redeveloped in a dense urban setting by comparing two large-scale development plans for the Regent Park area of Toronto that were established under contrasting design ideologies. This serves as a good example for how urban centres continue to evolve through the process of urban intensification and redevelopment. Further, an assessment of these contrasting plans will shed light on how approaches to planning and land management in dense urban settings has changed and what these changes mean for aggregate consumption.
  - The first was built in the post-war era and reflects development patterns for higher density uses most prevalent throughout the GGH until the 1990s. This form is based on the concept of segregating land uses and creating a tower-in-the-park atmosphere that seeks to maximize access to greenspace. This form of high-density development can still be found in a more limited capacity in suburban settings, but has largely fallen out of favour.
  - The second plan was developed only recently and is now being implemented. The new development plan reintroduces a traditional urban street grid, provides a greater mix of uses and centralizes park space. This plan will almost completely replace the previous development and serves as a good example of how development projects are designed today within these mixed-use, higher density urban settings.
  - Key comparative measures for the two Old and New Regent Park development concepts are provided on Figure 5- 8.

Figure 5- 8 Regent Park Case Study: Key Comparative Indicators

Development Efficiency Calculations

Efficiency Measure	*Old Regent Park*	*New Regent Park*	*Proportional Difference*
Gross Density : units per hectare	74.4	160.7	116%
Gross Density: residents per hectare	267.9	446.4	67%
Road Length: metres of road per km^2	10,640	28,930	172%
Road Length: metres of road per resident	0.4	0.65	63%
Road Length: metres of road per dwelling unit	1.43	1.8	26%

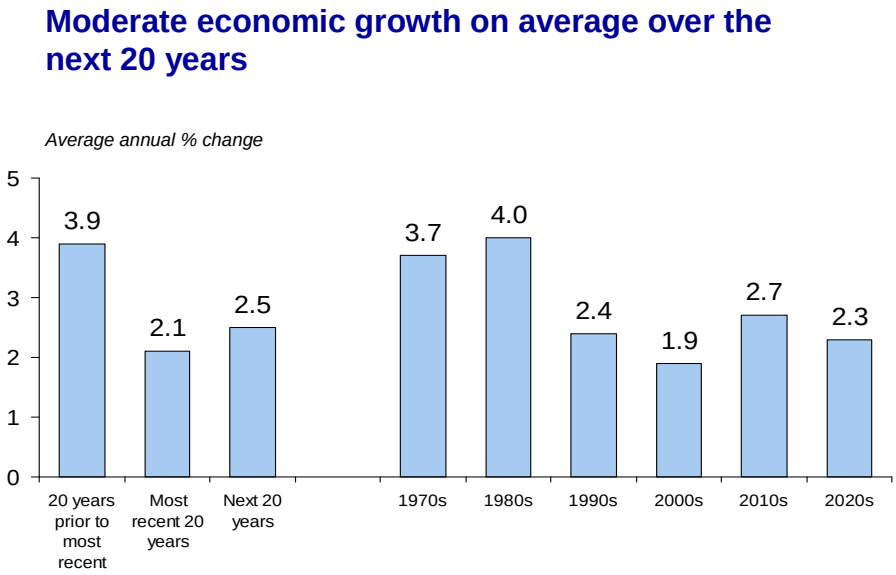
Source: MHBC Planning

- While the population of Regent Park is expected to double once the project is completed, the length of new roads will nearly triple, meaning more roads per capita (and more road-related aggregate per capita).
- The significant increase to density has also necessitated the replacement of water and wastewater services to increase capacity. The construction of new roads, buildings and servicing mitigates many of the efficiencies typically associated with infilling and more closely resembles a dense greenfield development.
- The creation of proportionally more high-rise units will also necessitate large volumes of high quality aggregate which includes the construction of underground parking facilities.
- The more intensive clustering residential populations will reduce outward expansion pressures at the edge of the city and produce some net infrastructure savings as this form typically consumes less infrastructure per capita than suburban development.

5.5 WHAT IS THE ECONOMIC AND POPULATION GROWTH OUTLOOK FOR THE PROVINCE?

- The future economic and population outlook are key inputs into the model of future aggregate consumption, so they are examined here.
- In terms of the economic outlook for Ontario, projections prepared by the Ministry of Finance[20] suggest that while the short-term outlook through 2010 is for a challenged economy, over the next 20 years as a whole, the province can be expected to record moderate average annual real GDP growth of about 2.5% - slightly above the average of the last 20 years (Figure 5- 9).

Figure 5- 9 Projected Average Annual Real GDP Growth, Ontario



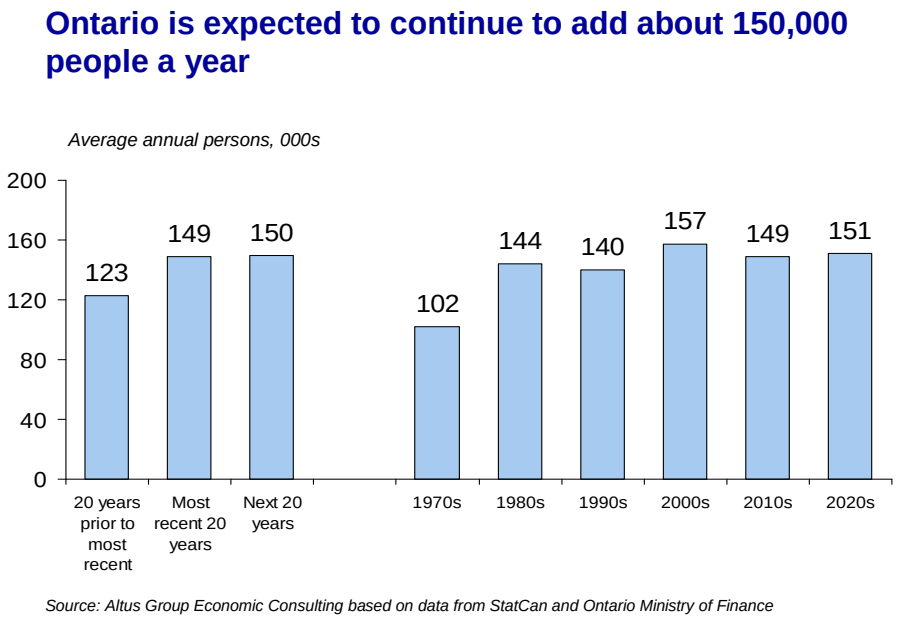
Source: Altus Group Economic Consulting based on data from StatCan and Ontario Ministry of Finance

- The population of Ontario is projected to grow strongly over the next 20 years.

[20] The Ministry of Finance economic outlook through 2012 is from Ontario Economic Outlook and Fiscal Review 2009. The longer-term projections are based on the base case projections in Toward 2025: Assessing Ontario's Long-Term Outlook

- Projections prepared by the Province[21] suggest that Ontario's population will grow by about 150,000 persons per year on average over the next 20 years – similar to the past 20 years (Figure 5- 10) – for total growth for the period of about 3 million persons.

Figure 5- 10 Projected Average Annual Total Population Growth, Ontario



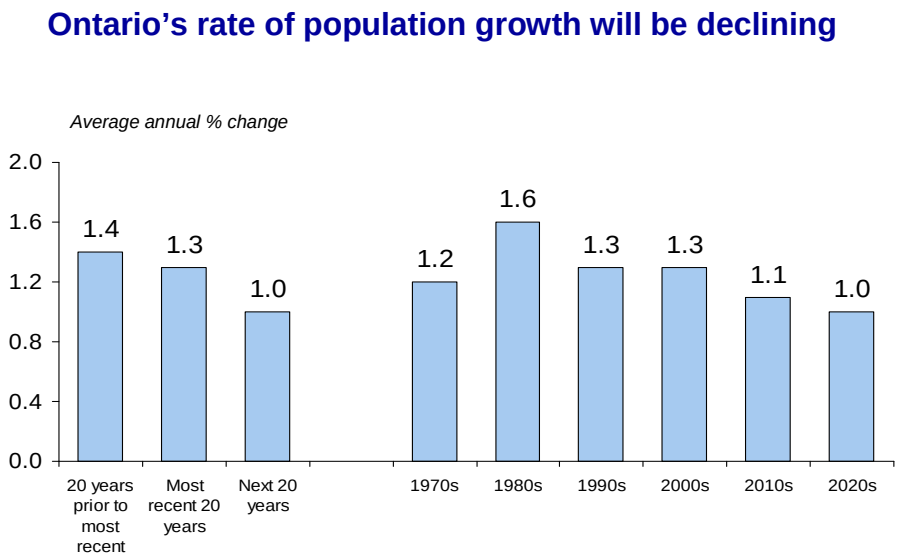
Source: Altus Group Economic Consulting based on data from StatCan and Ontario Ministry of Finance

- The rate of population growth however – which measures absolute growth against the size of the existing population base – will be gradually declining over the projection period (Figure 5-11).
- In terms of the number of people, growth will continue to be focused in the GTA (Figure 5- 12).[22]

[21] For the disaggregation by geographic area, the projections from the Growth Plan for the Greater Golden Horseshoe have been adopted (which are based on the compact growth scenario); for other areas of the province, the 2009 Ministry of Finance projections are used. The province totals are the sum of the projections for the GGH and other areas.

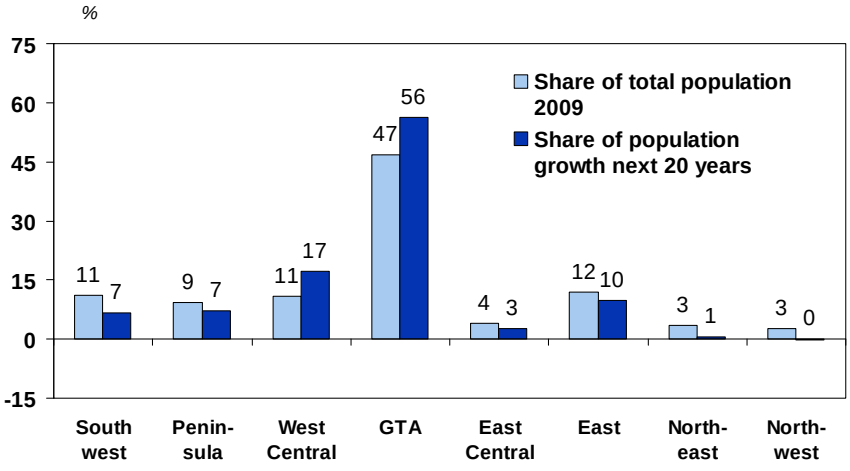
[22] Projections of total population for Ontario and by geographic area are provided in Appendix A.

Figure 5- 11 Projected Average Annual Population Growth Rate, Ontario



Source: Altus Group Economic Consulting based on data from StatCan and Ontario Ministry of Finance

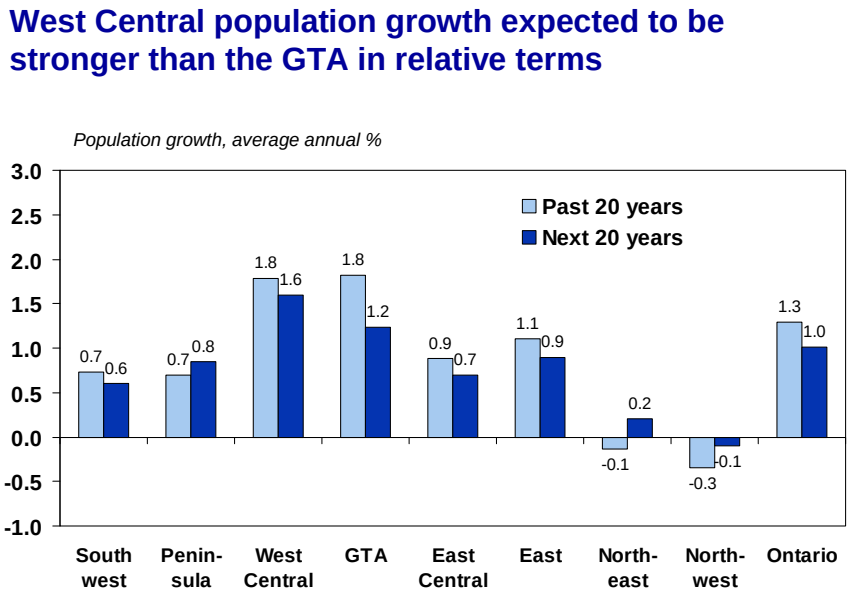
Figure 5- 12 Share of Future Population Growth by Geographic Area



Source: Altus Group Economic Consulting based on data from StatCan and Ontario Ministry of Finance

- However the West Central area is expected to grow faster in relative terms than the GTA, and the other geographic areas (Figure 5- 13).

Figure 5- 13 Projected Population Growth Rate, Geographic Areas



Source: Altus Group Economic Consulting based on data from Statistics Canada and Ontario Ministry of Finance

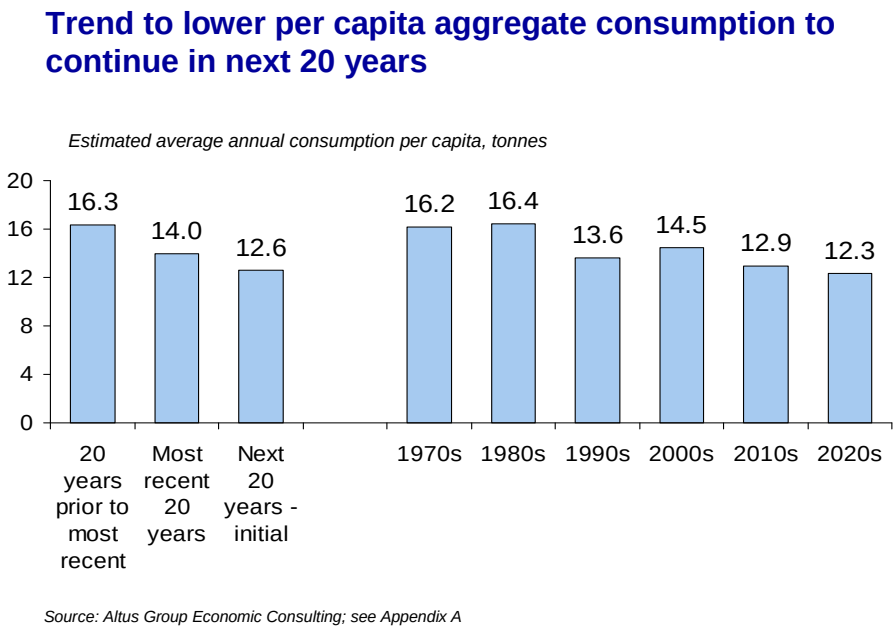
5.6 WHAT IS THE PROJECTED TREND IN PER CAPITA AGGREGATE CONSUMPTION?

- Based on the economic and population growth scenario outlined it the previous section, as well as assumptions on future housing starts and the unemployment rate,[23] an initial projection of per capita aggregate consumption was derived using the regression model outlined earlier.
- This initial projections (Figure 5- 14) showed lower average per capita consumption of aggregate in the next 20 years (12.6 tonnes per capita) compared to the most recent 20 years (which was 14.0 tonnes per capita).

[23] While not shown here, the other required inputs for the regression model are housing starts and the unemployment rate; these inputs are provided in Appendix A.

- However, it was felt that there would likely be some moderate additional downward trend in per capita aggregate consumption due to the need for less repair and maintenance work as the role of higher quality stone increases. This impact would likely however not be felt until later in the projection period (i.e. primarily impacting the latter 10 years of the forecast period).[24]
- The projections of per capita aggregate consumption is shown on Figure 5- 14.

Figure 5- 14 Projections of Future Per Capita Aggregate Consumption, Ontario



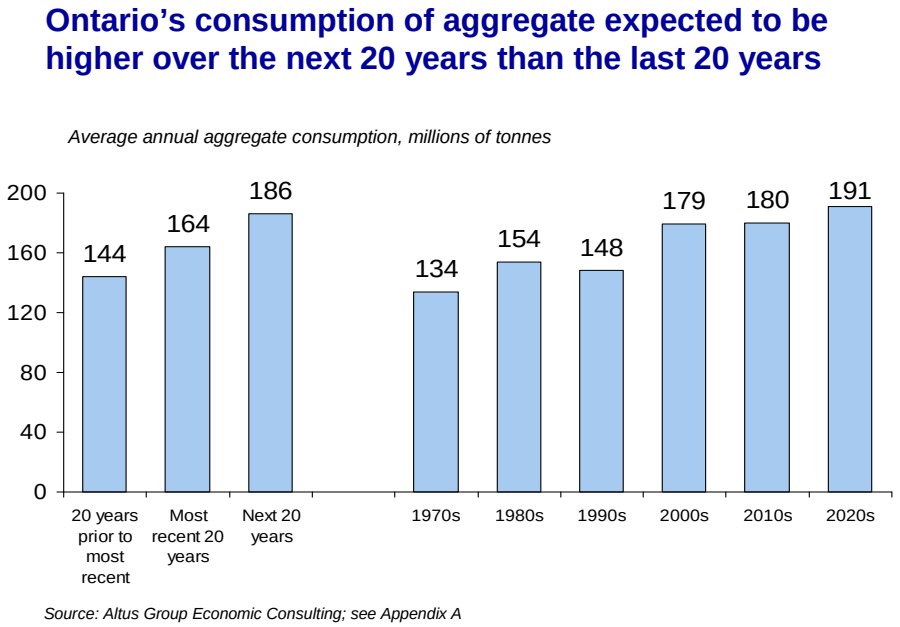
Source: Altus Group Economic Consulting; see Appendix A

[24] The initial per capita aggregate consumptions factors derived from the model, as well as the adjusted factors used, are shown in Appendix A.

5.7 WHAT IS THE PROJECTED CONSUMPTION OF AGGREGATE IN ONTARIO OVER THE NEXT 20 YEARS?

- The projections of per capita aggregate consumption were applied to the projections of total population outlined in Section 5.5 to derive the projections of total aggregate consumption over the next 20 years.[25]
- Ontario can be expected to consume in the order of 186 million tonnes of aggregate per year on average over the next 20 years, both primary and secondary combined (Figure 5- 15).[26] This is above the average level of the last 20 years as a whole.

Figure 5- 15 Average Annual Projected Total Aggregate Consumption, Ontario



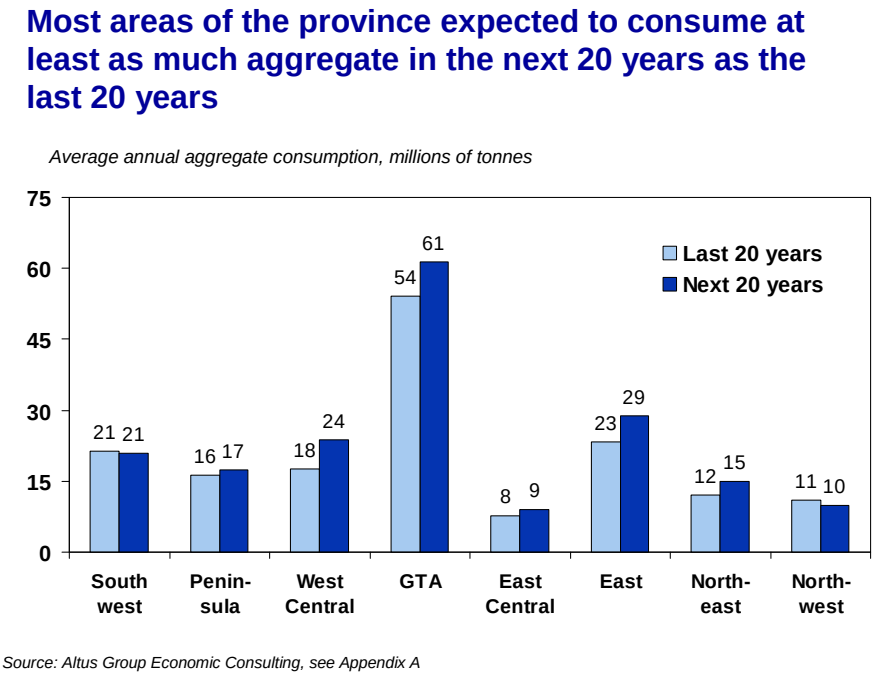
Source: Altus Group Economic Consulting; see Appendix A

[25] More detail on the projection inputs and outputs, as well as 5 year intervals, are provided in Appendix A.

[26] As indicated earlier, a construction expenditures/input factors approach (similar to that used in the 1992 State of the Resources Study) was used to confirm the reasonableness of the projections generated through the per capita methodology adopted for the current study. The alternate approach generated total aggregate consumption of between 180 and 190 million tonnes per year on average over the next 20 years (compared to the 186 million tonnes average using the per capita methodology).

- Note that the projections of future aggregate use should be viewed as being an “unconstrained” scenario. In particular, the projections assume that:
  - Increases in the future price of aggregate are more or less in line with general price increases in the economy (i.e. that aggregate prices do not experience any more substantial upward “shocks” that could impact underlying consumption patterns)
  - Sufficient aggregate is available to meet the expected underlying consumption patterns
- Consumption of aggregate in the GTA is expected to be moderately higher in the next 20 years compared to the most recent 20 years, and will continue to account for roughly one-third of the province’s total aggregate use (Figure 5- 16).

Figure 5- 16 Projected Total Aggregate Consumption by Geographic Area



Source: Altus Group Economic Consulting, see Appendix A

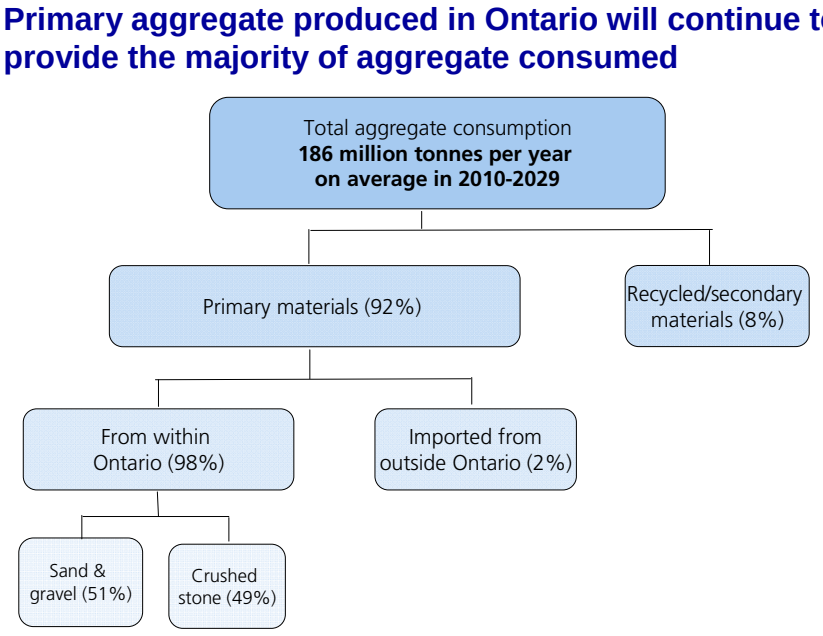
- Most other areas of the province also will have higher average aggregate consumption levels than in the past 20 years, except for the Southwest and the Northwest.

- Note that the consumption figures here, both for the province and the 8 geographic areas, include both primary aggregate (locally produced and imported), as well as secondary sources. The next section reviews what sources are likely to provide the aggregate used in Ontario over the next 20 years.

5.8 WHAT SOURCES ARE LIKELY TO PROVIDE THE AGGREGATE USED IN ONTARIO OVER THE NEXT 20 YEARS?

- The likely sources of aggregate used in Ontario over the next 20 years are outlined on Figure 5- 17.
- For the 20 year period, primary sources of aggregate are expected to continue to fill the vast majority of demand, at roughly 92%.

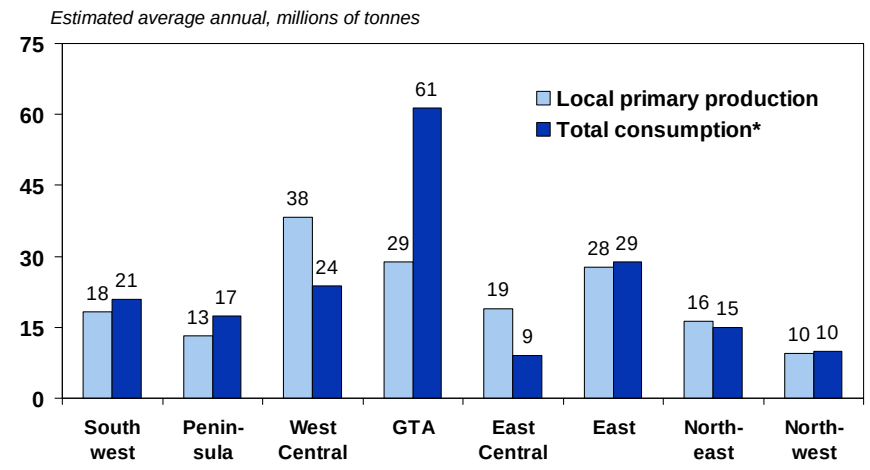
Figure 5- 17 Sources of Aggregate Over the Next 20 Years, Ontario



- The vast majority of primary aggregate (98%) is expected to continue to be supplied from Ontario operations – suggesting Ontario's primary production will be about 171 million tonnes a year, up from an average of 154 millions tonnes per year in the most recent 20 years.
- Secondary products (primarily recycling) are expected to be an increasing source of supply, averaging about 8% of the total aggregate consumed for the next 20 years as a whole (but increasing to about 9% in the 2020s).[27]
- For the geographic areas, estimates of regional exchanges of aggregate based on trends in the 2000s were used to determine what the likely level of locally produced primary aggregate would be. Note that these estimates are based on recent trends – assuming the "status quo" in terms of no additional supply side constraints.
- The estimates suggest that the GTA is likely to continue to be a net importer of aggregate, with the main source the neighbouring geographic areas (Figure 5- 18).
- As discussed earlier, there is expected to be a continued gradual shift in Ontario towards the use of higher quality crushed stone.
- The contribution of crushed stone to the supply of total primary aggregate consumed in each geographic area over the next 20 years is shown on Figure 5- 19.

[27] Discussions with LVM-Jegel suggest that the additional penetration based on existing capabilities would likely not exceed 10% of total aggregate consumed.

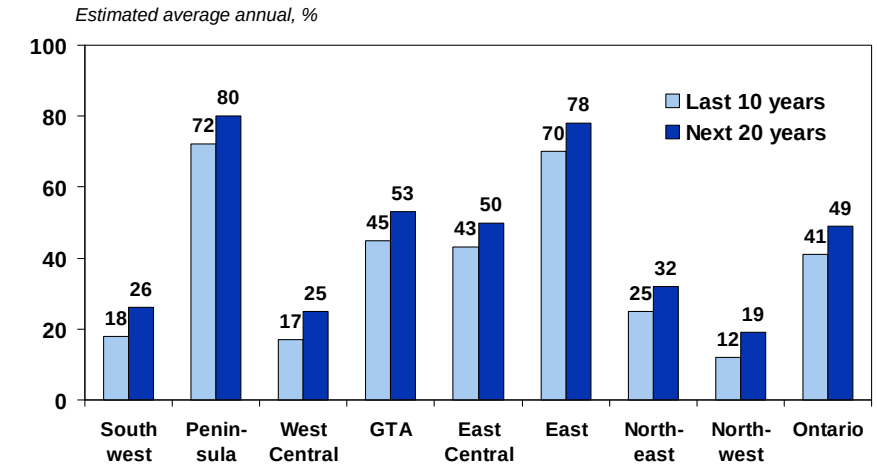
Figure 5- 18 Local Primary Production of Aggregate Compared to Total Consumption of Aggregate, Geographic Areas



** As filled by all sources – local primary production, international and interregional imports and secondary sources*

Source: Altus Group Economic Consulting, see Appendix A

Figure 5- 19 Crushed Stone as % of Total Consumption of Primary Aggregate, Geographic Areas

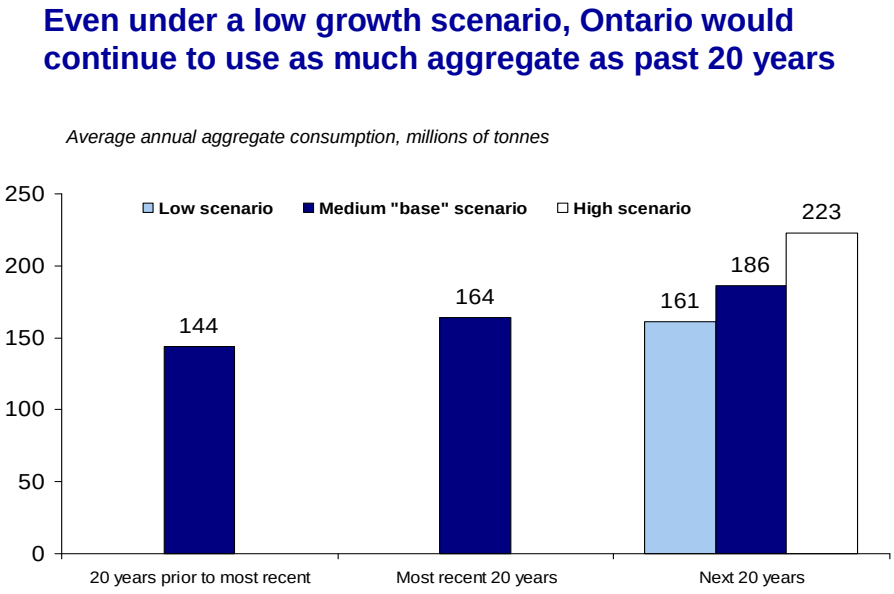


Source: Altus Group Economic Consulting, see Appendix A

5.9 WHAT ALTERNATE SCENARIOS SHOULD BE CONSIDERED?

- The projections presented in the previous section are based on the Province's most recent "base case" economic and population scenarios, which are consistent with a medium growth scenario.
- At the Ontario level only, alternate projections that represent low and high growth scenarios were also formulated.[28]
- The resulting projections show a range of potential aggregate consumption over the next 20 years, from a low of about 161 million tonnes per year on average to a high of about 223 million tonnes per year (Figure 5- 20).[29] It can be noted, however, that even under the low scenario, future aggregate consumption would not be lower than in the most recent 20 years.

Figure 5- 20 Alternate Scenarios of Future Aggregate Consumption, Ontario



Source: Altus Group Economic Consulting; see Appendix A

[28] The alternate scenarios were not produced for the geographic areas, as low and high population projections are not prepared below the Ontario-wide level.

[29] More details for the alternate projection scenarios are provided in Appendix A.

6.0 KEY FINDINGS AND SUGGESTIONS FOR FUTURE WORK

This section summarizes some of the key findings of the analysis, and outlines areas of the analysis that could benefit from additional work.

6.1 KEY FINDINGS

This section summarizes the key findings of the paper.

6.1.1 Ontario's aggregate consumption patterns

- Over the past 20 years, Ontario has consumed over 3 billion tonnes of aggregate - or about 164 million tonnes per year on average.
- On a per capita basis, about 14 tonnes of aggregate were consumed each year in the past 20 years – down from about 16 tonnes per capita in the previous 20 years. The highest per capita consumption of aggregate is in Northern Ontario, the lowest in the GTA.
- The aggregate that Ontario uses comes mainly from primary sources of material extracted from Ontario pits and quarries. Imports from other countries play only a small role. Secondary sources of material (primarily recycled materials) have played an increasing role, at about 7% of consumption in the past 10 years (up from about 4% in the early 1990s).
- Most parts of the province saw some increase in consumption of aggregate during the 2000s compared to the 1990s – even those where population growth declined, or was negative. This illustrates the point that while growth is an important driver of the use of aggregate, there is also demand generated from within the existing population base.
- For most of the 8 geographic areas of the province considered in this study, the aggregate consumed mainly comes from primary and secondary aggregate produced locally within those areas. However, that is not the case for the GTA, which imports about half of the aggregate it uses from neighbouring areas
- Both sand and gravel, and crushed stone, are used. Crushed stone currently accounts for less than half of the primary aggregate consumed, but its share has been increasing.

6.1.2 Aggregate consumption in Ontario compared to other areas

- Available data suggests that Ontario's per capita consumption of aggregate is broadly similar to other provinces but somewhat higher than western European countries (except for Ireland and Finland), Australia, New Zealand and the U.S, although the degree of the difference is not conclusive given data comparability issues.
- Factors which likely contribute to lower per capita aggregate consumption in European countries compared to Ontario include:
  - Being more densely populated than Ontario
  - Having slower rates of population growth than Ontario
  - Have slightly lower rates of GDP growth than Ontario over the period examined and slightly lower GDP per capita
  - Having somewhat higher mean temperatures than Ontario
  - Having higher rates of use of secondary aggregate than Ontario.

6.1.3 The ways in which aggregate is used in Ontario

- Aggregate is used for a wide range of applications, however the primary use is in construction work - either directly, or through concrete and other building products.
- Roads (provincial highways, as well as municipal and private roads) account for the largest share of construction-related aggregate, at about one-half.
- The amount of aggregate used per dollar of construction spending has been on a generally downward trend since the early 1980s.
- Some examples of typical amounts of aggregate used in various applications include:
  - 18,000 tonnes per kilometre of 2 lane highway

- 250 tonnes for a 185 m^2 house
- 114,000 tonnes per kilometre of a subway line

6.1.4 The future consumption of aggregate in Ontario

- Based on provincial government projections, Ontario is expected to continue to experience substantial economic and population growth over the next 20 years.
- This growth will generate the need for aggregate for construction work and other applications - on average, about 186 million tonnes per year (or roughly 3.7 billion tonnes in total), above the levels of the past 20 years.
- While some moderate increase is expected in the share of aggregate consumption filled by recycled materials, the main source is expected to continue to be primary aggregate from Ontario pits and quarries (an average of roughly 171 million tonnes per year compared to 154 million tonnes per year over the past 20 years).
- The GTA, and broader Greater Golden Horseshoe, are expected to use more aggregate over the next 20 years than in the past 20 years.

6.2 SUGGESTIONS FOR FUTURE WORK

- The estimates of sources of aggregate supply for the geographic areas prepared for this study required the formulation of assumptions about the extent of movements of aggregate within the province. The internal “trade” estimates for this study were derived based on a combination of methods, including examination of construction activity over the past 10 years, an analysis of local production patterns relative to growth patterns to see what “excesses” are being generated and then potentially exported to other areas, as well as discussions with key industry participants. The analysis however is not definitive, and could benefit from a formal survey process undertaken on a periodic basis (similar to that conducted in the UK), to establish movements of aggregate within the province. Such an

undertaking would require the buy-in and support of the provincial government, as well as the aggregates industry and also major purchasers of aggregate to determine where these consumers obtain their supplies (since producers do not necessarily know the end destination for their products).

- In addition, research by LVM-Jegel suggests that recycled material currently fills roughly 7% of aggregate supply on a province-wide basis, and that the proportion is likely higher in the GTA and major urban areas, and lower in smaller centres. Additional research to better understand the variation in use of recycled material by geographic area in the province would be beneficial to the projection exercise.
- An initial thought piece on the potential impact of various development patterns and trends was undertaken for this study by MHBC Planning, which showed that there are a myriad of factors which could potentially impact future aggregate consumption per capita – some increasing and some decreasing. Further work in this area to quantify some of these impacts would be beneficial in the projection exercise, in particular to differentiate between short-term and long-term impacts, and between per capita needs for new development versus on-going maintenance and repair.
- It is recommended that the projections of aggregate consumption be monitored on a periodic basis (such as every other year) to see how they are tracking, as well as to incorporate relevant updated projections of economic and population growth.

List of References

British Geological Survey, 2008, European Mineral Statistics 2002-06, Keyworth, Nottingham; British Geological Survey.

British Geological Survey, 2008, United Kingdom Minerals Yearbook 2007, Keyworth, Nottingham; British Geological Survey.

British Geological Survey, 2009, European Mineral Statistics 2003-07, Keyworth, Nottingham; British Geological Survey,).

British Geological Survey, 2008, Managing Aggregates Supply in England, Keyworth, Nottingham; British Geological Survey.

Canada Mortgage and Housing Corporation, Housing Time Series database.

Canadian Urban Institute, Between Rock and a Hard Place: Understanding the Foundations of Ontario's Built Future.

Chang, I-Cheng & Hsiao, Teng-Yuan (2004), Short-Term Model of the Production of Construction Aggregates in Taiwan Based on Artificial Neural Networks.

Clayton Research Associates Limited, The Demand for Aggregate in Ontario: The Outlook Through 2010, January 1996.

Coriolis Consulting Group (1996), Development of a Model for Forecasting the Consumption of Aggregates in the Lower Mainland, Ministry of Energy, Mines and Petroleum Resources, October 1996.

Coulter, Terence (2003), Changes in Aggregate Production and Use in Victoria B.C.

Hemson Consulting Ltd., The Growth Outlook for the Greater Golden Horseshoe, January 2005.

Johansson, Kurt et al (2008), Industrial Minerals and Rocks, Aggregates and Natural Stones in the Nordic Countries.

Karakas, Ahmet & Turner, Keith (2004), Aggregate Supply and Demand Modeling Using GIS Methods for the Front Range Urban Corridor, Colorado.

Kohler, Susan (2006), Aggregate Availability in California, California Department of Conservation, California Geological Survey.

Koziol, Wieslaw et al (2008), Production of Aggregates in European Union.

Matten, E. E. (1982), A Simplified Procedure for Forecasting Demand for Mineral Aggregate in Ontario - Industrial Mineral Background Paper 4, Ontario Ministry of Natural Resources, March 1982.

Metrolinx (2008), The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area, Greater Toronto Transportation Authority.

Minister of Finance (2009), 2009 Ontario Budget: Budget Papers, Queen's Printer for Ontario.

Minister of Finance (2009), 2009 Ontario Economic Outlook and Fiscal Review, Background Papers, Queen's Printer for Ontario.

Nasser, Khalil (1987), Supply/Demand Analysis of Aggregates in the Denver Metro Area, Jefferson County, Colorado Planning & Zoning Department.

NZIER (2008), Economic Analysis of the Quarrying and Aggregate Production Industry, Aggregate & Quarry Association of New Zealand.

O'Brien, J. (2006), Planning for Growth? The Determinants of Aggregates Demand in New Zealand.

Ontario Ministry of Finance (2005), Toward 2025: Assessing Ontario's Long-Term Outlook, Queen's Printer for Ontario.

Ontario Ministry of Finance, Fall 2009, Ontario Population Projections, 2008-2036, Queen's Park Printer for Ontario 2009.

Ontario Ministry of Municipal Affairs and Housing, Greenbelt Plan 2005, Queen's Printer for Ontario, February 28, 2005.

Ontario Ministry of Northern Development and Mines, Ontario Mineral Score, Government of Ontario.

Ontario Ministry of Public Infrastructure Renewal, Places to Grow; Growth Plan for the Greater Golden Horseshoe, 2006, Queen's Printer for Ontario, 2006.

Ontario Ministry of Transportation, Transportation Fact Sheet (Various), July 28, 2008.

Organization for Economic Co-operation and Development, OECD Database (2008), Gross domestic product (expenditure approach), US $, current prices, 22 July 2009, OECD.

Peat, Marwick and Partners & M. M. Dillon Limited (1980), Mineral Aggregate Transportation Study – Industrial Mineral Background Paper 1, Ministry of Natural Resources, December 1980.

Planning Initiatives Ltd. and Associates, Aggregate Resources of Southern Ontario: A State of the Resource Study, November 1992.

Proctor & Redfern Limited (1974), Mineral Aggregate Study of the Central Ontario Planning Region, Ministry of Natural Resources, March 1974.

Robinson, Gilpin & Brown, William, Sociocultural Dimensions of Supply and Demand for Natural Aggregate – Examples from the Mid-Atlantic Region, United States, United States Geological Survey.

Statistics Canada, 2005 Input-Output Model Simulations (National Model), Statistics Canada Catalogue no. 15F0004XDB.

Statistics Canada, 2008, Implicit Price Indexes, Gross Domestic Product (table), Provincial and Territorial Economic Accounts Review, 2008, Statistics Canada Catalogue no. 13-016-X.

Statistics Canada, 2008, Real Gross Domestic Product, Expenditure-based (table), Provincial and Territorial Economic Accounts Review, 2008, Statistics Canada Catalogue no. 13-016-X.

Statistics Canada, 2009, Cd1T30an Labour Force Estimates by Provinces, Territories and Economic Regions, annual average (table), Labour Force Historical Review, 2008, Statistics Canada Catalogue no. 71F0004XCB.

Statistics Canada, Annual Population Estimates for July 1, 1971 to 2008, Canada, Provinces and Territories (table), Annual Demographic Statistics, 2008, Statistics Canada Catalogue no. 91-213-XIB.

Statistics Canada, Non-metallic Mineral Mining and Quarrying NAICS 2123, 2006, Statistics Canada Catalogue no. 26-226-X.

Statistics Canada, Table 026-0013 Residential values, by type of investment, quarterly (dollars), CANSIM (database).

Statistics Canada, Table 026-0016 Investment in non-residential building construction, by type of building, province and census metropolitan area (CMA), quarterly (dollars), CANSIM (database).

Statistics Canada, Table 026-009 Maintenance and repair expenditures in housing, annual (dollars), CANSIM (database).

Statistics Canada, Table 029-0002 Capital expenditures on construction, by type of asset, annual (dollars). CANSIM (database).

Statistics Canada, Table 029-0040 Capital expenditures on construction, by type of asset, annual (dollars), CANSIM (database).

Statistics Canada, Table 031-0002 Flows and stocks of fixed non-residential capital, by North American Industry Classification System (NAICS) and asset, Canada, provinces and territories, annual (dollars), CANSIM (database).

Statistics Canada, Table 032-0002 Public and private investment, summary by province and territory, annual (dollars), CANSIM (database).

Statistics Canada, “Value of Non-Residential Building Permits by Municipality, Greater Toronto Area & Kitchener CMA” (table), Building Permits, Statistics Canada Catalogue no. 64-001-XWF.

The Australian Quarrying Industry – Industry Analysis, www.quarry.com.

The Ontario Aggregate Resources Corporation (1998 - 2008), Mineral Aggregates in Ontario, Production Statistics.

U.S. Bureau of Economic Analysis, Gross Domestic Product by State in Current and Real (2000) Dollars by State, Table 649, June 2008.

U.S. Bureau of Economic Analysis, Survey of Current Business, July 2008.

U.S. Census Bureau, 2008 Population Estimates by State, Table 3, Population Estimates Program.

U.S. Geological Survey, Department of the Interior/USGC, Minerals Yearbook, Sand and Gravel (1994-2007).

U.S. Geological Survey, Department of the Interior/USGC, Minerals Yearbook, Silica (1994-2007).

U.S. Geological Survey, Department of the Interior/USGC, Minerals Yearbook, Stone, Crushed (1994-2006).

U.S. Geological Survey, Department of the Interior/USGC, Minerals Yearbook, Stone, Dimension (1994-2007).