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State of the Aggregate Resource in Ontario Study

Consolidated Report

February 2010





The State of the Aggregate Resource in Ontario Study

Consolidated Report

**Ontario Ministry of Natural Resources
February 2010**

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Future Aggregate Availability and Alternatives Analysis

- MHBC Planning



Rehabilitation

- Skelton Brumwell & Associates Inc.



1.0 Introduction

This consolidated report is a summary of information from a series of six papers that make up the State of the Aggregate Resource in Ontario Study. Not all of the information and findings contained within the papers is presented. For more detailed information, explanation and analysis refer to the relevant paper.

1.1 2010 -The State of the Aggregate Resource in Ontario Study (SAROS)

There have been many changes to the planning landscape over the past 20 years since the previous study of aggregate resources in Ontario was undertaken (such as the Oak Ridges Moraine Conservation Plan, Greenbelt Plan, Growth Plan, and Source Water Protection Planning). There is growing concern from stakeholders that a new strategic direction for aggregate management in Ontario is required. For a new strategic direction to be developed, information on various aspects of aggregate management had to be gathered.

In 2007, the Premier announced that the government, working with multiple ministries and stakeholders, would undertake a study to bring information on aggregate resources in the province up to date. It would include updating key parts of the first study on aggregates in the Province completed in 1992 titled: Aggregate Resources of Southern Ontario — A State of the Resource Study.

This study's purpose is to gain a better understanding of aggregate resources by gathering the most recent information and current science on:

- the value of aggregates to the province;
- consumption;
- demand;
- recycling/reuse;
- current reserves;
- availability;
- alternatives;
- transportation;
- rehabilitation.

1.2 Objectives of the State of the Aggregate Resource in Ontario Study

The objectives of the study are as follows:

- provide updated information about aggregate resources in Ontario;
- provide information to support provincial, regional and municipal strategic planning for aggregate supply to meet long term demand;
- provide a more definitive understanding of the current supply and future aggregate resource constraints that may affect long term supply;

- develop a methodology to track recycling activities to account for present use and enable more recycling and reuse of aggregates;
- provide an analysis of alternative sources of aggregates including an assessment of transportation issues;
- develop a methodology to forecast future aggregate demand;
- provide an overview of the social, economic and environmental value of aggregates to Ontario;
- provide insight into the status of rehabilitation in Ontario and global applications of science and technology to enhance rehabilitation;
- provide a credible source of information on aggregate resources available to the general public online.

1.3 Scope of the Study

This study has expanded the scope of the 1992 study to include all of Ontario where applicable and has gathered up-to-date information on aggregate resources and their management.

1.3.1 Geographic Scope

To allow for geographic comparability of results between this and the 1992 study, a similar geographic breakdown of the province was required. As a result, the Canadian Portland Cement Association (now the Cement Association of Canada) Geographic Areas (Figure 1) were chosen as the geographic area units.

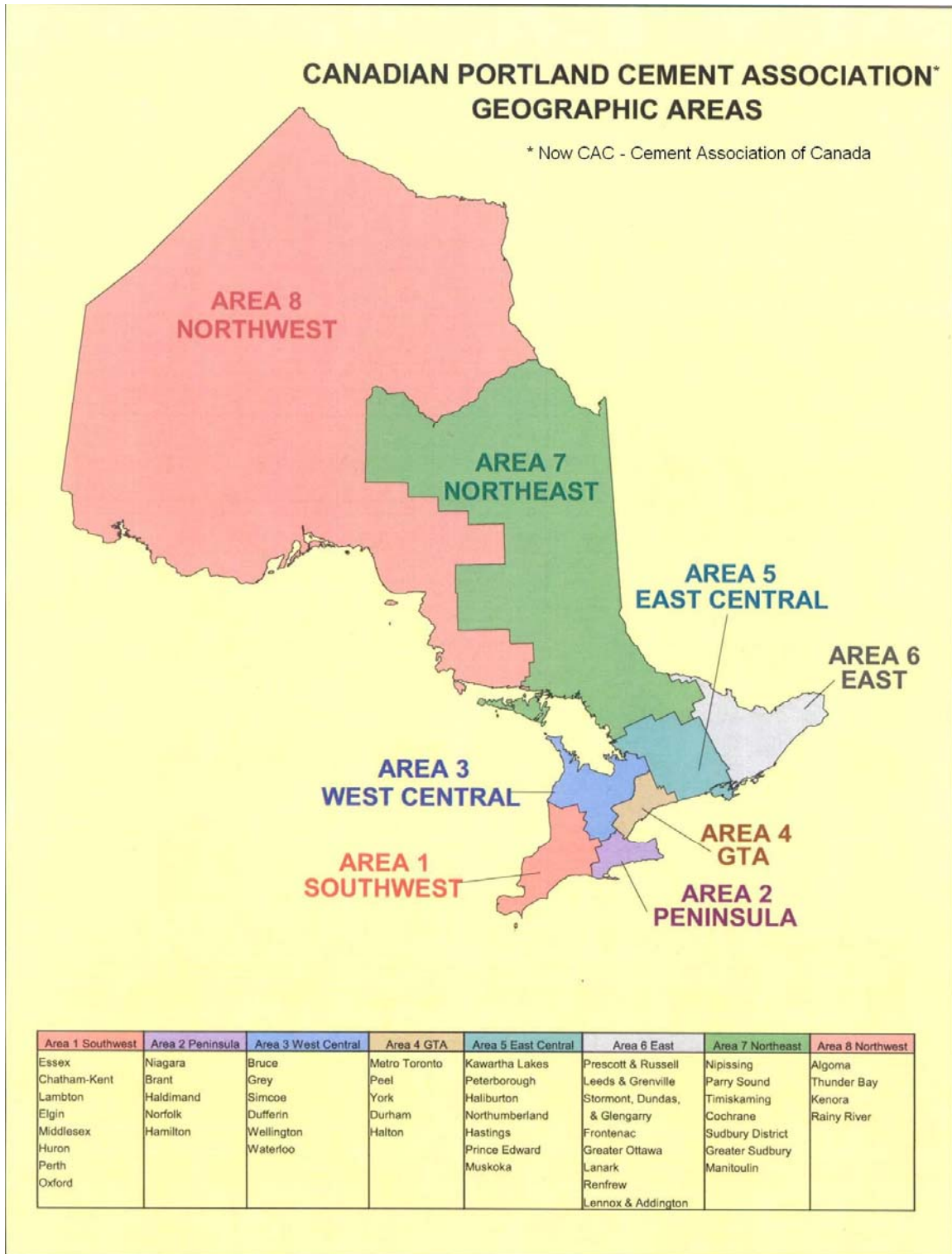


Figure 1: Canadian Portland Cement Association Geographic Areas (now the Cement Association of Canada)

1.4 Methodology

The State of the Aggregate Resource in Ontario Study was divided into six major sections and undertaken as separate papers by six different consulting teams. This approach ensured the most qualified specialists were involved in each aspect of the study and significantly reduced the time required to complete all the required reports. The six papers are:

- The Value of Aggregates;
- Aggregate Consumption and Demand;
- Reuse and Recycling;
- Aggregate Reserves in Existing Operations;
- Future Aggregate Availability and Alternatives Analysis;
- Rehabilitation.

An Aggregate Resource Advisory Committee became the governance structure (see Figure 2) comprising leaders of stakeholder organizations able to speak for their organizations and membership. Their role was to monitor the study's progress and provide advice and recommendations to the Minister of Natural Resources based on the study findings.

The SAROS governance structure also included a Technical Expert Panel made up of experts from various ministries, aggregate industry associations, academics, environmental stakeholders and municipal and professional planning associations. Their role was to provide technical advice and information.

Throughout the project the Ministry of Natural Resources secretariat provided direction and ongoing guidance to the consulting teams and oversight for the entire project.

SAROS Study Structure

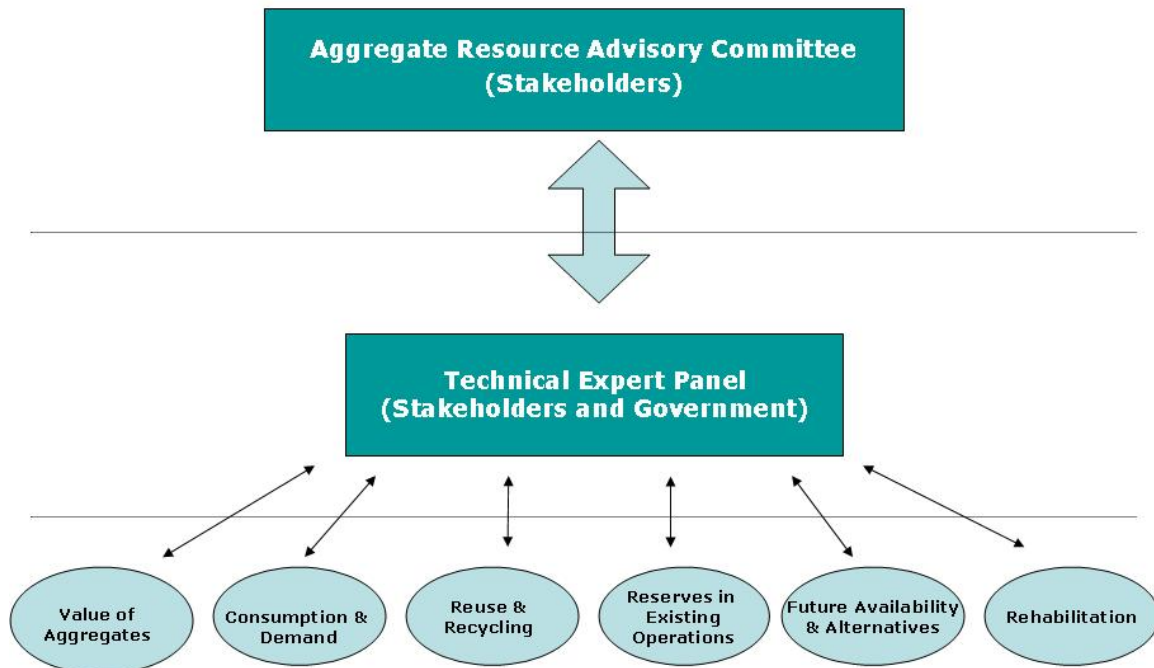


Figure 2: SAROS Study Structure

1.5 Introduction to Aggregate Resources

Aggregate is defined in Ontario's Aggregate Resources Act as gravel, sand, clay, earth, shale, stone, limestone, dolostone, sandstone, marble, granite, rock or other prescribed material. Alternatively, it is described as any combination of sand, gravel, or crushed stone in a natural or processed state. Aggregates are characterized as non-renewable resources found in certain fixed locations with few viable substitutes.

Aggregates are used in the construction of highways, water mains, dams and airports, as well as residential, industrial and institutional buildings. The primary use is in construction projects, with roads (provincial highways, municipal and private roads) accounting for the largest share. Some examples of the amounts of aggregate used in various construction applications include:

- 18,000 tonnes per kilometre of a two-lane highway in Southern Ontario;
- 250 tonnes for a 185 m² (2,000 sq. ft.) house;
- 114,000 tonnes per kilometre of a subway line; and
- 1,000-4,500 tonnes per kilometre of water main.

Aggregates are a component of a number of manufacturing processes including the processing of iron, steel, aluminum and plastic. They are critical ingredients

in a number of manufactured products such as glass (silica sand), coated paper, paint and pharmaceuticals (calcium carbonate). They are also found in fertilizer, floor coverings and even toothpaste.

1.6 Aggregate Production and Consumption in Ontario

The following figure clarifies the use of production and consumption numbers as reported in this study. Total aggregate consumption for 2007 was 184 million tonnes, which includes both primary and secondary (recycled) aggregate consumption. Primary aggregate consumption in Ontario totalled 171 million tonnes and is made up of primary production, plus imported materials, minus exported materials.

Aggregate Resources Production and Consumption in Ontario

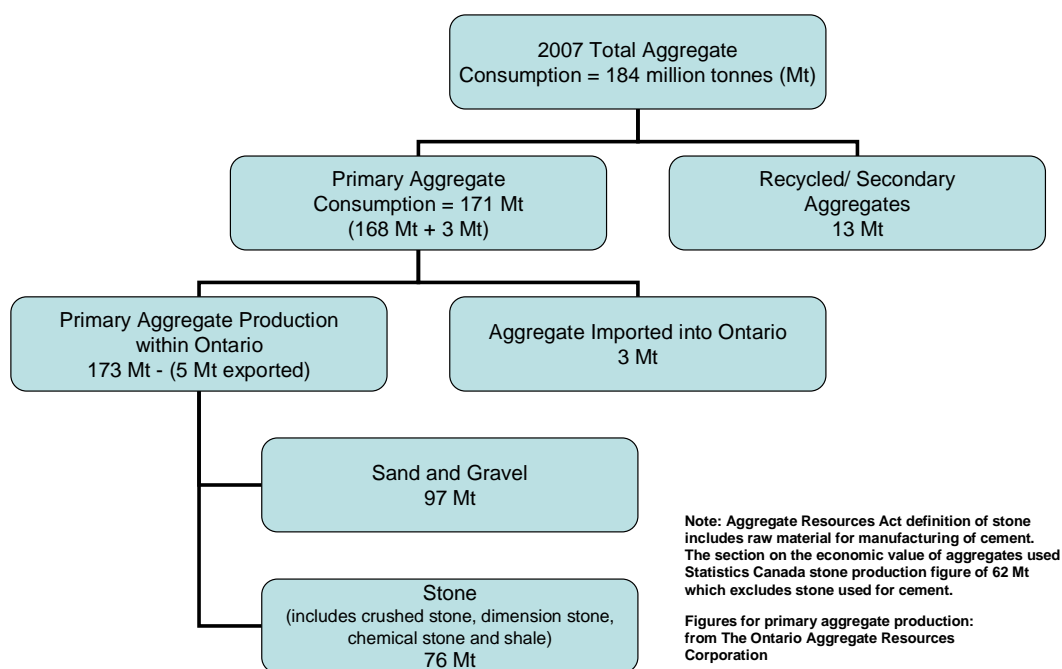


Figure 3: 2007 Aggregate Resources Production and Consumption in Ontario.

The following sections summarize each of the six paper's findings.

2.0 The Value of Aggregates

The focus of this paper was to determine the value of aggregates in Ontario. The three aspects of value investigated are: economic, social and environmental value.

2.1 Economic Value

In 2007, primary aggregate production in Ontario, excluding the stone used in the manufacturing of cement, totalled almost 164 million tonnes¹. The economic value of this production was approximately \$1.3 billion.

The aggregate industry generates economic effects on both the primary industries (upstream, i.e. initial extraction, processing and transportation sectors) and secondary industries (downstream, i.e. industries that use aggregates to produce goods such as concrete). These effects on primary industries (upstream) include spending by the aggregate industry on its industry supply chain and the industry itself. In 2007, taking into account direct, indirect and induced effects this sector generated approximately:

- \$2.9 billion of gross output
- \$827 million of labour income
- \$1.6 billion of GDP
- 16,600 full time jobs

The 2007 aggregate production volumes were tracked to 16 end-use sectors which subsequently were grouped into three categories: cement and concrete, other products and construction.

Approximately 21 per cent of the provincial aggregate production, by value, flows to industries in the cement and concrete category and 57 per cent to various forms of construction. The remaining 22 per cent is destined for a variety of industry sectors in the other products category. The economic output attributable to aggregate production in the secondary (downstream) sectors is:

- \$3.2 billion of gross output
- \$940 million of labour income
- \$1.6 billion of GDP
- 18,300 full time jobs

In terms of all the industry categories, 59 per cent of the value added (GDP) falls to construction. The cement and concrete category accounts for 22 per cent and the other products category 19 per cent. The secondary (downstream) industry categories and sectors referred to in this study generate the following economic yields:

- \$44.7 billion of gross production
- \$13 billion of labour income
- \$22 billion of GDP
- 245,000 full time jobs

¹ Note: The production figures quoted in this section originate from Natural Resources Canada and relate only to stone, sand and gravel production for construction purposes but do not include other aggregates used for secondary industries such as cement. In 2007, approximately 10 million tonnes of stone was used for cement production. As a result these numbers are generally lower than those used in the other papers resulting in a conservative estimate of economic value.

The paper concluded that aggregate plays an important role in the Ontario economy. Although it is a low-priced commodity, it is used in very high volumes. It is an essential ingredient for the end-use industry categories which play a large role in the provincial economy. Although it is not the dominant resource or product in most sectors in terms of value, it is nevertheless essential and one for which there is no obvious substitute at the present time.

2.1.1 Case Studies

To further examine the economic impacts of aggregates, case studies were identified by examining 25 infrastructure projects in Ontario with the largest cost or value between 2005 and 2009. Of the 25 largest, the vast majority were energy and hospital/healthcare projects.

Five projects were selected for closer study and project information was gathered through interviews with relevant project contacts. The studies were selected to find projects that would use a great deal of aggregate and aggregate products, represent a wide range in project sizes, project types and cover a wide geographic area.

Through assessing the value of aggregates in the five selected case studies it was concluded that the value of aggregates in infrastructure projects is a relatively small component of the total project. For each of the case studies, all of the projects had a readily available local source of aggregate. Although the value of aggregates is a relatively small component of a project's value, aggregates do not have many readily available substitutes and without them these major projects could not proceed.

2.2 Social Value

The social value associated with aggregates and aggregate extraction was examined to get a better understanding of its role in society in terms of the level of importance, costs and benefits. Two approaches were used to understand how Ontarians value the “built” (constructed) environment and the social costs and benefits associated with aggregate extraction.

The first approach was through public attitude research – a telephone survey of 1,420 Ontario residents. The second approach was a content analysis of recorded public comments related to aggregate extraction from Ontario Municipal Board (OMB) hearings and from 31 MNR licence applications. These applications were the most recent licence applications and were also used in the environmental value section of this paper.

From the perspective of community well-being, respondents to the telephone survey, in general, did not rank development and infrastructure projects highly among other things that they value about their community. However, when respondents were asked to rate the importance of various development and infrastructure projects, many were ranked highly. This leads to the conclusion

that respondents seemed unwilling to trade the most important things they value about their community for development and infrastructure projects.

Respondents living near a pit or quarry were more likely to name nuisance effects as a social cost of aggregate extraction. However, respondents that live near an aggregate truck transportation route were more likely to see the economic aspects of aggregate extraction as a social benefit. Based on the findings from the geographical variation study, the conclusion is that respondents who live in an urban area (such as Area 4 – Greater Toronto Area (GTA)) ranked parks and trails as an important aspect of their community. Also, respondents from the GTA highlighted new institutional buildings as important. Respondents living further away from the GTA were more likely to name development and infrastructure projects as a benefit of aggregate extraction.

As a result of the content analyses from a combination of the MNR (31 licences) and OMB (76 cases) data, it is clear that the three most frequently reported public complaints were truck traffic, noise and air pollution (dust). The content analysis represents public concerns from a specific group of people who are directly affected by aggregate activities. However, when surveying a more statistically significant representation of the Ontario population, environmental effects emerge as the main costs to aggregate extraction.

Finally, the base knowledge among the general public of the aggregate industry seems to be varied, with many respondents being unfamiliar with the industry. This lack of familiarity indicates that the aggregate industry is not “top of mind” for a statistically significant portion of the Ontario population and that opportunity exists to build public awareness and education.

2.3 Environmental Value

The importance of aggregates in achieving environmental objectives is often overlooked when extraction is associated with the removal of natural features. A careful analysis of the less visible, but equally important, environmental uses of aggregate is important to balance the scale and intensity of environmental effects. This analysis also helps determine the net environmental value of the resource in the context of other landscape resources.

The paper presents a list of the ecosystem services provided by the use of aggregates. A wide range of aggregates are used in processes that provide an environmental benefit and include:

- landscape restoration and/or rehabilitation;
- water quality treatment;
- removal of anthropogenic pollutants;
- uses in mines, landfills and waste disposals;
- maintenance of biodiversity.

The majority of the ecosystem services provided by the extraction of aggregate itself were cultural. The reason is two-fold: the use of aggregate is the main source of building materials and the rehabilitation of sites for culturally important functions provides secondary benefits.

The bulk of aggregates' harmful effects on ecosystem services are either regulating services (due to the bi-products of aggregate processing) or preserving services (due to the permanent impact that such things as buildings, roads and dams have on the developed landscape).

An examination of 31 MNR licences found that environmental features were almost entirely preserved indicating that legislation with respect to the natural environment is having a positive effect on the end results. A small amount of good quality habitat is affected due to extraction. However, if habitat is affected, on balance it will be replaced through rehabilitation.

Across the sample of licences, the most significant losses were agricultural land, balanced between prime agricultural lands (Classes 1, 2 and 3 soils) and other agricultural lands. The net shift in land use within the sample, because of extraction processes, was from terrestrial to lake habitats, with a 50 per cent net reduction in agricultural lands.

3.0 Aggregate Consumption and Demand

The focus of this report is the nature and extent of aggregate consumption in Ontario as a whole and as divided into eight geographic areas (see Figure 1).

3.1 Trends in Aggregate Consumption

Over the past 20 years, Ontario has consumed over three billion tonnes of aggregate, or an average of 164 million tonnes (including recycling) per year. Given projected levels of economic and population growth, future consumption projections average about 186 million tonnes (including recycling) per year over the next 20 years, or 13 per cent higher than in the past 20 years. Most of the eight areas considered in this study are expected to consume more aggregate over the next 20 years than the previous 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 slightly declined over the last 20 years (presently at 14 tonnes per person per year). This trend is expected to continue as Ontario's population density increases.

Available data suggests that Ontario's per capita consumption of aggregate is broadly similar to other provinces but somewhat higher than Western Europe (except for Ireland and Finland), Australia, New Zealand and the United States.

Factors which may contribute to higher per capita aggregate consumption in Ontario compared to Europe include:

- being less densely populated
- having higher rates of population growth
- having slightly higher rates of economic growth over the period examined
- having somewhat lower mean temperatures
- having somewhat lower use of recycled and other secondary sources of aggregate.

The aggregate that Ontario uses comes mainly from primary sources of material, while imported material makes up only a small portion of the aggregates supply. Recycled materials have played an increasing role, at about seven per cent of supply in the past 10 years (up from about four per cent in the early 1990s). Their use is expected to continue to gradually increase over the next 20 years.

For most of the eight areas considered in the study, the aggregate consumed mainly comes from new and recycled aggregates produced locally. 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. 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 the movement of construction standards towards the use of specified higher-quality material.

4.0 Reuse and Recycling

The purpose of this paper was to update existing information on recycling of aggregates in the province and to recommend a strategy to track the movement of recycled materials effectively.

4.1 Benefits of Reuse and Recycling

Aggregate reuse and recycling:

- Reduces land use pressures – most pits and quarries are located near urban centres to minimize the cost of shipping aggregates to construction projects, which brings them into competition and conflict with housing, commercial and industrial development and recreational land.
- Reduces energy consumption – it takes energy to produce primary aggregate and even more energy to transport it to where it is used. Reuse and recycling conserves energy and reduces greenhouse gases.
- Reduces waste – reusing aggregates and recycling other waste products as aggregate substitutes reduces the amount of waste.

- Reduces costs – in some cases, recycled aggregates may cost less than primary aggregates depending on the distance of transportation and the cost of energy.

4.2 Aggregate Reuse and Recycling in Ontario

Ontario uses about 184 million tonnes of aggregate (2007) a year, of which about 13 million tonnes comes from recycled sources. Approximately three-quarters of the aggregate consumed in Ontario is used in road construction, building construction, and installing water mains and sewer pipes. Enhanced recycling and reuse of excess materials and by-products in bulk applications can be a key contributor to the sustainability for aggregate resources.

Over the past 15 years, there has been an increasing awareness of the need for sustainable development and preservation of non-renewable aggregate resources. This awareness, coupled with rising costs of energy, has contributed to a number of changes in the reuse and recycling of aggregates that has significantly increased the amount of reuse and recycling being undertaken in the road construction sector.

The use of recycled material in road building grew substantially between 1991 and 2006 from six million tonnes per year to approximately 13 million tonnes. It has gradually increased to the point that primary recyclable materials are now entirely consumed. Now the focus of the industry has shifted to ensuring the most appropriate use of those materials. At the same time, effort has to be made to develop technology and processes which will make available secondary and tertiary materials and other wastes such as mine waste rock that have suitable engineering properties but no potentially harmful environmental effects.

A review was also completed of provincial policies and initiatives along with official municipal plans from representative municipalities across southern Ontario to identify the general policy framework for aggregate recycling and reuse. Based on this review, recycled aggregate is not contemplated in most municipal official plans in terms of permitted uses or specific policies. This prevents additional recycling activities from taking place within municipalities. Furthermore, many municipalities avoid using recycled materials due to lack of experience, an unfavourable past experience, or due the movement towards the use of high-performance materials which do not allow the use of recycled materials.

4.3 Wastes and By-Products

There are two sources of recycled aggregates: aggregate that has already been used in concrete and asphalt, and other wastes and by-products that can be used as substitutes for primary aggregate. In either case, wastes and by-products must be technically appropriate and demonstrate economic,

environmental and social benefits in order to be considered for reuse and recycling.

Used asphalt and concrete products are the largest source of recycled aggregate. Low volume wastes and by-products such as waste glass, roofing shingles, spent foundry sands and municipal solid waste bottom ash have some promise as alternative sources of aggregates but will have limited impact in reducing primary aggregate demand.

Currently almost all steel slag, blast furnace slag and spent foundry sand, which accounted for about one million tonnes of recycled aggregates prior to 1991, are now used for other purposes. Therefore the reuse and recycling of conventional by-product aggregates such as used asphalt and concrete has increased substantially.

4.4 Methodology to Track Recycled Aggregate

One of the main deficiencies for successful reporting on the levels of aggregate reuse and recycling is the lack of a system to track recycled material use effectively across the province.

Based on the results of a survey of public agencies and a review of similar international systems, the following is the recommended method for tracking recycled aggregate in Ontario:

1. Guidelines on how and what materials to be tracked should be developed in order to standardize the data being put into the system from across the province.
2. An online computer database should be developed to provide a means for the public agencies to record their information about the use of recycled aggregate.
3. In order for public agencies to be able to do this additional work, they will require more funding for staff and training.
4. In order to hold public agencies accountable for this additional work, the additional funding should be tied to proper recording of the data.
5. In order to promote the social benefits of recycling, annual report cards should be created outlining the successes and opportunities for improvement in the use of recycled aggregate across the province.

5.0 Aggregate Reserves in Existing Operations

The aggregate demand and resulting consumption in the Greater Toronto Area has remained relatively consistent since 1991. However, the licensing of replacement reserves has not kept pace with this consumption. This has resulted in a 2.5 to one consumption to replacement ratio between the years 1991 and

2009. In addition over two-thirds of the licenced reserves supplying the GTA are more than 35 years old and their supply is being rapidly depleted.

While the Aggregate Resources Act offers some level of protection to licenced reserves, it is important to understand the relative amounts of those protected reserves in relation to the overall supply and demand. This section of the report examines the availability of limestone/dolostone reserves, determines areas of relative abundance and scarcity of reserves and presents opportunities to make the best use of the resource within existing licenced properties in the central portion of southern Ontario.

Ninety-seven licenced aggregate quarries were evaluated with respect to their remaining reserves as of the end of 2008. They included all quarries within Areas 2, 3, 4 and a portion of Area 5 that have a licenced area of 20 hectares or greater (see Figure 1).

5.1 Estimated Licenced Reserves

The calculated licenced reserves of stone in these 97 quarries total about 3.44 billion tonnes of limestone and dolostone of variable quality. This total includes the full volume of rock found on these properties, both high and lower quality stone. It does not account for unusable by-products (silt sized fines) generated through the process, which can be as much as 10 per cent of the total. Also, the majority of these reserves are located further away from the markets that demand them. Only 902 million tonnes exist within 75 km of the Vaughan Corporate City Center (Vaughan) (see Figure 4).

The volume and tonnage calculations are based on dimensions, distances and elevations provided on the site plan. These calculations assume that all material is extracted, is viable for aggregate production and that no reserves are used for construction of internal haul roads, ramps or left in place as benches for rehabilitation.

High quality stone that meets strict specifications is required for concrete and asphalt applications, making it particularly important. Of the 97 quarries, only 30 had site-specific geological information in varying degrees of detail, available for review. These 30 quarries represent 818 million tonnes of stone. Of this total, 505 million tonnes was estimated to be high enough quality for concrete and/or asphalt. The remaining 313 million tonnes is considered to be acceptable (road base), low or unknown quality.

Subject to a number of limitations with the remaining 67 quarries for which site-specific geological information is not available, 968 million tonnes was estimated as high quality with the remaining 1.65 billion tonnes considered acceptable, low or unknown quality.

The total estimated amount of high quality reserves is approximately 1.47 billion tonnes. Of this total only about two-thirds (987 million tonnes) would be available for inclusion in concrete and asphalt grade products in the form of crushed stone and manufactured sand. The remaining 483 million tonnes of reserves would, through the process of generating concrete and asphalt grade stone, create a by-product such as granular road base.

Of this total about 476 million tonnes are located within 75 km of Vaughan. Since only about two-thirds of the total high quality reserves is available for production of concrete and asphalt grade stone and manufactured sand, about 317 million tonnes is available within 75 km of Vaughan (see Figure 4).



Figure 4: Aggregate Reserves located within 75km of the GTA (Vaughan)

5.2 Areas of Relative Abundance and Scarcity of Reserves

An assessment was carried out in relation to each of the areas covered in this study and in relation to a major market demand area of the GTA, Vaughan. Vaughan was selected as a reference point for the GTA because it has been identified as a growth centre in the province's Place to Grow Plan. The assessment determined that 2.41 billion tonnes of the 3.44 billion tonnes of total aggregate is abundant and located within quarries where the reserve base is greater than 55 million tonnes. The following table summarizes these findings.

Area	Reserve totals (million tonnes)											
	Abundant				Moderate				Scarce			
	H*	A	L	U	H	A	L	U	H	A	L	U
2	206.9	55.6	0.0	0.0	117.1	108.4	69.1	62.6	55.9	19.9	5.9	4.4
3	191.8	286.3	237.0	77.8	141.4	25.8	25.6	0.0	62.7	14.3	10.8	1.2
4	65.0	0.0	0.0	0.0	37.6	4.9	0.0	0.6	10.1	1.0	0.0	0.0
5	447.1	427.0	348.5	65.7	104.1	34.4	0.0	35.6	33.5	27.2	10.6	6.1
Total	910.9	768.9	585.5	143.4	400.2	173.5	94.7	98.8	162.2	62.4	27.3	11.8

*H – high quality, A – acceptable quality, L – low quality, U – unknown quality

Abundant - licenced properties with greater than 55 million tonnes of reserves

Moderate – licenced properties with between 14 million tonnes and 55 million tonnes of reserves

Scarce - licenced properties with less than 14 million tonnes of reserves

These abundant reserves are found in only 15 quarries, 12 of which are further than 75 km from Vaughan. This indicates that approximately 70 per cent of the reserve base that is considered abundant is found in only 15 per cent of the total number of quarries evaluated. The remaining 85 per cent have either a scarce or moderate reserve base. It is clear that the majority of the reserves supplying the GTA market are coming either from moderate or scarce reserves.

5.3 Maximizing Resource Use within Existing Licences

The existing reserve base is being depleted at a greater rate than new licences are being granted, so how can the reserves that are currently licenced be used to get the most out of them? To answer this, an evaluation of various options was carried out as part of this paper.

The four options considered are:

1. Reduce or eliminate regulatory setbacks;
2. Remove road allowances where possible;
3. Extract to a greater depth;
4. Import most of the material required for rehabilitation of the properties rather than using on-site reserves.

While not the answer to the demand/supply question, taking full advantage of the reserves on an existing licenced property is a responsible method for resource management, to the extent that the surrounding natural environment and social receptors are affected as little as possible.

6.0 Future Aggregate Availability and Alternatives Analysis

The purpose of this paper was to analyze current bedrock constraints, examine the feasibility of alternative sources of aggregate and modes of transportation, and assess the effectiveness of the practice of “close to market supply.”

6.1 Aggregate Resource Management and Supply

The province is mandated to ensure that aggregate resources are protected for long-term use. Ontario has declared a provincial interest in maintaining the “close to market supply” policy, as per the Provincial Policy Statement (2005), in order to minimize transportation costs and effects including air quality, greenhouse gas emissions and fossil fuel consumption.

Over the past 40 years and following numerous background studies and policy reviews, the provincial interest in aggregate resource management has remained strong, which underlines the importance of aggregate resources to Ontario’s economic well-being.

Local concern regarding environmental effects and opposition to proposals for new and expanded pits and quarries remains strong. There has been increasing pressure to evaluate alternative sources of aggregate and the need for extraction of resources as close as possible to where they will be ultimately used.

There are environmental policies that protect some of the more significant environmental areas in southern Ontario. For example, 70 per cent of the Niagara Escarpment Plan Area and over 50 per cent of the high potential

aggregate areas in the Oak Ridges Moraine Conservation Plan Area do not allow consideration for new or expanded mineral aggregate operations.

Aggregates are required in large quantities in economically active regions and growth centres. Their high bulk and low per unit value places constraints on the distances they are transported. Extracting the resource close to where it is being used avoids unnecessarily transferring the effects of extraction to other jurisdictions.

6.2 “Close to Market” Research

A literature review was conducted to evaluate policies for mineral aggregate planning in other international jurisdictions and to identify areas that use a “close to market” approach. Fifteen jurisdictions were identified for further review based on the availability of information and studies. Five of these jurisdictions were selected for an in-depth review of their aggregate resource policies.

Historically, the most common reason for incorporating “close to market” policies has been to ensure aggregate materials were available to the areas of need as economically as possible. Several jurisdictions were identified that support this approach and are similar to Ontario in terms of policy and rationale.

Where jurisdictions did not have general policies to guide the location of aggregate extraction, market forces prevailed. Despite the lack of a consistent policy framework, traditional industry practices and market forces cause operators to locate as close to their buyers as possible and where such deposits exist. Some jurisdictions support long distance transportation when local availability/supply is limited or does not exist or where other factors affect supply (i.e. tourism or the preservation of natural features).

6.3 Planning, Environmental and Agricultural Constraints Analysis

Mineral aggregate deposits by their very nature are found in river valleys, outwash plains, limestone plains, glacial deposits and other geologic rock formations. These landforms also contain wetlands, woodlands, agriculture and water features.

An analysis of planning, environmental and agricultural constraints was completed for all of southern Ontario (areas 1-6, Figure 1) assessing overlapping effects of constraints on selected bedrock resource areas. In total, 20 constraints were applied such as Provincially Significant Wetlands and Prime Agricultural Lands. Ninety-three per cent of the selected bedrock resource had overlapping constraints. Of the remaining seven per cent that did not have overlapping constraints, 91 per cent of this area is located within Areas 5 and 6 (eastern Ontario). Overall, based on the constraints analysis, the conclusion is that there is a large overlap of prime agricultural land, wetlands, and significant woodlands with selected bedrock resource areas.

In addition to the 20 constraints, there are numerous other factors that must be considered to determine whether the deposit area can be assembled and made available to supply mineral aggregate needs. Without an integrated and balanced approach, it is unlikely that an aggregate deposit could be licenced since there is a high probability of on-site and adjacent natural features, agriculture, water resources and social factors to consider.

The constraints analysis also identified that the majority of other rural resources are located outside of the selected bedrock resource area. For example, 95 per cent of Areas of Natural and Scientific Interest, 91 per cent of significant woodlands, 94 per cent of all wetlands and 96 per cent of prime agricultural lands are located outside of selected bedrock resource areas within the study area.

6.4 Alternative Sources of Aggregates

The five alternative sources to surface pits and quarries examined were mine tailings, river or lake dredged sand/gravel, manufactured sands, underground bedrock mining and mega-quarries. Of these, underground mining and mega-quarries were found to have a stronger feasibility than dredging, mine tailings and manufactured sands. These sources would only supplement the supply of crushed stone aggregates and not completely replace supply from traditional pits and quarries.

Environmental concerns and questions of quality and quantity have historically limited dredging production to a small percentage of total aggregate production in the province. There have been no active dredging operations in Ontario for several years.

Mine tailings tend to be located in remote areas well outside economically feasible distances from urban areas. It is unlikely that mine tailings will be significantly used until transportation costs to southern Ontario are lower. The use of mine tailings could also pose problems if they are contaminated.

Manufactured sand from bedrock quarries is a possible alternative source of aggregate in areas where natural sands do not exist. In areas where natural sands exist, manufactured sand is not an economically feasible alternative due to high production costs.

Underground mining of limestone aggregates has been explored for over 30 years in Ontario. While investigations to assess its feasibility have occurred, no underground mining operations have been developed in the province. However, there are 86 active underground mines in the United States (2007). Underground mining appears feasible, but the cost of aggregate may be two or three times higher than that extracted from a surface pit or quarry. Underground mining reduces surface disruption but will not eliminate social and environmental concerns since processing and shipping still occur at the surface and draining

where necessary can influence water wells and surface water features such as ponds, lakes, rivers and streams.

A mega-quarry, which is defined as having 150 million tonnes of reserves and an annual production capacity of at least 10 million tonnes, appears to be a workable alternative. Mega-quarries are similar to Ontario's existing surface quarries but are much larger. There would be a much greater level of activity on site, which would affect a larger area around it and require greater mitigation of social and environmental impacts.

6.5 Feasibility of Alternative Transportation Systems

Three alternative transportation modes were considered - marine, rail and long distance trucking, to supply the GTA from distant/remote sources.

The transportation analysis concluded that there would be significant economic, environmental and social implications by shifting from the "close to market" policy to importing aggregate from distant/remote sources. The delivery cost would more than double compared to the existing cost. Delivery from pits and quarries that are near their market is the most efficient economic method because of the shorter travel distances and direct delivery. Replacing nearby supply with imports from remote sources would also increase greenhouse gas emissions significantly. For example, rail, marine and long distance trucking all create more than double the greenhouse gas emissions compared to transportation from close to market sources.

Previous studies assessing transportation alternatives have not found any identifiable environmental benefit of extracting from pits and quarries located further from their markets. However there are additional harmful effects such as increased greenhouse gases as well as the effects from the production and maintenance of transport vehicles, facilities and infrastructure.

Though there might be fewer people that could be affected near remote extraction sites, there would be a greater social impact to use these sources because of the larger number of people that would be affected over the longer transportation distance. Also the redistribution terminals that would be required for long-distance transportation could affect local populations.

Significant government intervention would be required to change from using close to market sources of aggregate, including market interventions and compensation including incentives, expropriation and overriding municipal land use controls. It would also require significant capital investment and construction for new infrastructure, vehicles and facilities and would take years to achieve. Close to market sources would still be needed during the interim and phase-in periods.

The results of this assessment should not be taken as a conclusion that some long distance transport by rail or ship is not feasible, appropriate, cost-effective or

environmentally inappropriate. Smaller quantities and/or using rail from closer sources may prove to be viable and are currently occurring or are under consideration. However, it is reasonable to conclude that there are strong economic, environmental and social reasons why the alternatives will not replace using close to market sources of aggregate that is transported over short distances.

7.0 Rehabilitation

This report addresses rehabilitation and provides insight into the status of rehabilitation in Ontario, including field assessments from surrendered and active sites, a review of public expectations, an examination of current and emerging techniques and technologies around rehabilitation and a review of its global applications.

7.1 Legislative and Industry Context

The scope of policies, legislation, and programs that directly or indirectly influence the rehabilitation of pits and quarries in Ontario is substantial. Legislation and policies that apply to aggregate extraction and rehabilitation are in effect to ensure that aggregate extraction is an interim land use and rehabilitation is carried out to return the lands to the previous use, or one that is compatible with adjacent land uses.

They provide an important framework to guide the rehabilitation of pits and quarries. The results of the research suggest that there is less of a need to modify existing legislation, policies, and guidelines than to work with them and use additional supporting tools to help realize the full potential of rehabilitation programs. For example, it is clear that implementation of the Aggregate Resources Act would benefit from the development of comprehensive best practices guides and forums tailored to respond to the information needs of producers and Ministry of Natural Resources Aggregate Resource Officers.

7.2 General Expectations of Rehabilitation by Stakeholders

Common sentiments from those contacted regarding the site rehabilitation focussed on:

- lack of visible progress towards rehabilitated sites;
- delays in rehabilitation and a lack of provincial enforcement and a shortage of staff resources;
- limited evidence of successful rehabilitation beyond a few commonly referred-to showcase examples;
- lack of information about rehabilitation reaching operators to help them understand and implement rehabilitation on their sites;
- lack of information about rehabilitation reaching the public.

Comments were provided on the potential need to revisit existing legislative and policy tools. Others suggested that providing incentives and recognition would achieve more significant advances in rehabilitation.

Additional feedback indicated that additional policies are needed to establish time limits for permitting, maximum disturbed areas and strengthening rehabilitation requirements. A review of these comments in the context of this paper suggests that some of the opinions can be substantiated while others are largely a result of limited outreach and education. Some of the recommendations, such as improved documentation of surrendered licences and targeted research that responds to identified knowledge gaps, will help address these criticisms.

7.3 Review of Progressive Rehabilitation on Licenced Pits and Quarries

An assessment of 50 licenced sites found that 58 per cent of them had begun some progressive rehabilitation and 40 per cent had not yet started. However, where rehabilitation has started the requirements of the site plans are being fulfilled. In making qualitative observations and reviewing collected data a further pattern suggests that more advanced and complex rehabilitation is being performed by mid- to large-size producers rather than the smaller site operators/owners. Within these sites there are opportunities to improve some of the techniques and approaches to better achieve certain end landuse objectives and to rehabilitate the sites to a level that they contribute to healthy communities and healthy ecosystems.

7.4 Review of Surrendered Licences

It was determined that surrendered sites included a wide range of land uses, with the majority being either agriculture, open space, or recreation and that they were generally well integrated into the surrounding landscape. The existing land uses are not necessarily the same as the proposed end uses identified on the site plans since the proposed end uses were identified when sites were originally licenced. In general, the land uses on the surrendered sites are compatible with the surrounding area and the public would not easily identify them as former pits or quarries. It was noted that the Ministry of Natural Resources documentation of surrendered licences is inconsistent and in many instances incomplete.

7.5 Opportunities for Rehabilitated Sites to Achieve Broader Healthy Community Objectives

Comprehensive planning and decision-making in a healthy communities context will lead to enhanced potential and realized opportunities for rehabilitated aggregate sites to achieve a range of socio-economic and ecological objectives that will benefit the landscape and its inhabitants.

7.6 Comprehensive Rehabilitation Plans

The concept of comprehensive site plans was explored, drawing from three case studies with the conclusion that both incentives and a clear planning process are critical to ensuring success. Additionally there is a need for agencies to ensure a streamlined and consistent review process and also to provide as many varied opportunities as possible for public engagement. These will contribute to stakeholders' greater willingness to overlook higher temporal and financial costs in favour of longer-term benefits associated with these types of innovative projects.

7.7 Rehabilitation Technologies and Applications: A Global Scan

Comprehensive discussions with municipal and environmental stakeholders about rehabilitation goals are needed early in the process. Some rehabilitation techniques yield acceptable and predictable results, while others may require more research to ensure that they do not result in unforeseen and/or undesirable side effects. Conditions resulting from extraction activities may necessitate the creation of new ecosystems by virtue of their biological and physical characteristics. Key to the consideration and success of any final land use will be tailoring it to site-specific and landscape level socio-economic and ecological characteristics.

7.8 Alternative After Uses of Pits and Quarries: A Global Scan

Rehabilitation efforts in the United Kingdom are viewed as excellent examples and can be at least partly attributed to:

- widespread promotion and acknowledgment of high quality efforts;
- innovative partnerships between industries, non-government organizations, and in some cases research institutions;
- recognition of complementary relationships between human needs and nature conservation.

This leadership and research may be due partly to the significantly higher per tonne fee collected through their Aggregates Levy. Rehabilitation efforts in Ontario will meet with more success if the full range of possible land uses is considered and if networks of sites are considered simultaneously at the landscape level.

8.0 Major Study Findings

8.1 New Research and Approaches

The State of the Aggregate Resource in Ontario Study has not only updated the information base of the 1992 study, but has researched new areas of aggregates that have never been studied before in Ontario. For instance,

- The Value of Aggregates paper investigated the economic, social and environmental values of the resource in Ontario. The report found that there is a substantial positive economic impact from both the extraction and secondary industry use of aggregates. The research into social value concluded that the public is concerned about social and environmental costs of extraction and transportation, but also appreciates the positive effects of infrastructure development. When the 31 most recently issued licences were reviewed it was found that the existing aggregate legislation is working to protect natural environment features.
- The Recycling and Reuse paper focused on approaches to account for the vast amount of recycled aggregates that are used by various private and government contractors. The use of recycled material has increased to 13 million tonnes per year with the potential for additional increases being realized by using a provincial reporting system.
- The Aggregate Availability and Alternatives paper examined the transportation of aggregates from a systems approach. This was undertaken to better understand the full impact and infrastructure requirements of various methods of transporting aggregates from the pit or quarry to the job site. The paper also investigated the efficiency of various transportation methods in terms of greenhouse gas emissions and found that rail, marine and long distance trucking all contributed more than double the greenhouse gas emissions compared to using nearby sources.

8.2 Key Findings

The following summarizes some of the key findings from all of the papers:

1. Upstream value of aggregates:
 - \$2.9 billion of gross output
 - \$827 million of labour income
 - \$1.6 billion of GDP
 - 16,600 full time jobs
2. Downstream value of aggregates:
 - \$3.2 billion of gross output
 - \$940 million of labour income
 - \$1.6 billion of GDP
 - 18,300 full time jobs
3. The public is concerned about social and environmental costs of extraction and transportation, but they also appreciate the positive effects of infrastructure development.
4. Existing legislation is working to protect natural environment features.

5. There is concern for loss of agricultural lands that are being replaced by natural features.
6. Ontario is expected to continue to experience strong growth over the next 20 years.
7. There will be a substantial need for aggregate, estimated at an average of 186 million tonnes per year for the next 20 years.
8. Expect demand to continue for primary aggregate.
9. The use of recycled material has increased to 13 million tonnes per year.
10. Used asphalt and concrete are the largest sources of recycled aggregate.
11. Improved recycling technology enables almost complete use of available recyclable material.
12. There is a lack of municipal awareness and acceptance of recycling technologies.
13. There is a movement towards the use of high-performance materials, which generally precludes the use of recycled material.
14. Current licenced reserves total 3.44 billion tonnes of limestone/dolostone within selected quarries in the study area. This is a total of all material not taking into consideration quality, distance to market, and applicability of the resource in high-specification applications such as high rises, condominiums, overpasses and major highways.
15. There are approximately 317 million tonnes of high quality limestone/dolostone reserves close to the GTA market.
16. The majority of reserves are located at greater distances from the market areas as close to market sources continue to be depleted.
17. Relatively few existing aggregate operations contain reserves that are considered to be abundant.
18. Techniques to maximize aggregate reserves will provide some increases in existing supply.
19. Ontario has abundant and high quality aggregate deposits close to high demand areas. However, ninety-three per cent of unlicensed bedrock resources have overlapping environmental, planning and agricultural constraints.
20. Mega-quarries and underground mining are the most feasible alternative sources of aggregate.
21. There are significant economic, environmental, and social implications from shifting away from the "close to market" policy.
22. Shifting away from close to market policy would require significant government intervention, including market interventions, capital

investment, new infrastructure, and overriding municipal land use controls.

23. Rehabilitation, both progressive and final, is occurring on the majority of sites in Ontario. However, progressive rehabilitation can be slow to occur.
24. Final rehabilitation on sites includes a wide range of land uses (i.e. agriculture, open space, natural heritage).
25. Excellent examples of rehabilitation can be attained by partnerships between industry, NGOs, and research institutions
26. Existing policies and legislation, including the Aggregate Resources Act, are generally well suited to guiding the rehabilitation of pits and quarries in Ontario.

9.0 Moving Forward

This study has provided the province with several findings and recommendations to guide future aggregate resource management. The information gathered will help inform the policy debate and could influence the land use planning process. The findings and recommendations could assist with the development of policy and legislative amendments in the future. Furthermore, opportunities for future research have been identified which would add to the body of work already completed and positively contribute to aggregate resource management in Ontario.

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