REGIONAL DISTRICT

AGGREGATE SUPPLY AND DEMAND UPDATE AND ANALYSIS

A TETRA TECH COMPANY

NOVEMBER 2013
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EBA FILE: K23103029-01

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EXECUTIVE SUMMARY

> "Sand and gravel are finite, non-renewable resources that are essential in the construction of roads, railways, schools, etc., as well as for more specialized industrial uses such as sewage filtration, agriculture, erosion prevention, etc. In British Columbia there are about 2,600 active aggregate pit operations producing approximately 50 million tonnes of sand and gravel per year. This output is valued at over $170 million annually and directly employs 4,000 to 5,000 people. However, many communities and municipalities are currently, or will shortly, experience aggregate shortages as local reserves are depleted or sterilized. Effective management of the aggregate resource represents a considerable challenge to both planners and the industry." (BC Ministry of Energy and Mines)[i]

The *Local Government Act* says the Regional Growth Strategy (RGS) should work towards maintaining the integrity of a secure and productive resource base and ensuring adequate inventories of suitable resources for future settlement[ii]. The intent of this study is to contribute to the planning and maintenance of a secure and productive aggregate resource, balanced with environmental and community considerations.

Aggregate in the Community

The development and maintenance of our communities as we know them are dependent upon aggregate, and its extraction, processing, and transportation. Approximately two thirds of aggregate produced is used simply to maintain our current infrastructure[iii]. We need its products, such as concrete and asphalt, to build communities that have a greater population density, which in turn reduces the pressure on our natural landscape, road systems and greenhouse gas emissions.

However, there can be neighbourhood and environmental concerns with aggregate pits and quarries. Issues of dust, noise, visual impacts and safety have been putting pressure on pits close to market. However, when operations are pushed further from market, the result is increased costs, road impacts and greenhouse gases. In addition, natural sand and gravel is the result of tens of thousands of years of geological activity. As such, it is essentially a non-renewable resource, existing only where nature put it. We run the risk of sterilizing the resource by not using deposits that are close to market first.

Neighbourhood concerns have resulted in conflicts. Citizens and local governments are seeking active involvement in the permitting process. In consultation with local governments, we have developed a Site Suitability Assessment (SSA) process that addresses environmental and neighbourhood issues. The intent is a process that:

- Provides consistency within the Regional District of the Central Okanagan (RDCO) for each *Mines Act* application referral;
- Addresses truck routes, land use, environmental and adjacency factors;
- Provides recommendations based on existing provincial Best Management Practices (BMPs); and
- Facilitates communication processes between the Ministry of Energy and Mines (MEM) and local governments.

To provide the basis for this approach, we set out to find the answers to:

- Where are aggregate sources in the RDCO?
- How much natural sand and gravel is available within the RDCO boundaries.
- How much aggregate will communities within the RDCO need over the next 20, 50 and 100 years?
- What are potential impacts to the environment and groundwater from extraction, and how can these be mitigated?
- What are the impacts of dust, noise and visual quality, and how can these be mitigated?
- What are the resulting greenhouse gases, and how do these change based on pit location?
- What are the road impacts, and how do these change based on pit location?

Report Structure

This report is tiered, with each tier having increasing amounts of detail. The executive summary provides an overview of results and recommendations. The report body includes background, methods, supply and demand results, and analysis of environmental and groundwater factors, infrastructure impacts, greenhouse gas emissions, noise, health (dust and radon), and visual quality. Detailed recommendations are included at the end of the report. Mapping results follow in the figures. Background information and the Site Suitability Assessment are included in the appendices.

Supply

Aggregate comes to us through three main supply channels:

- Natural sand and gravel
- Bedrock
- Recycled aggregate

Each of these sources has been reviewed for this study. Mapping of natural sand and gravel deposits, as well as bedrock, has been prepared for the District. Figures 2 through 6 shows: sand and gravel deposits, overburden, bedrock potential for aggregate, and bedrock potential with overburden, respectively. Figure 7 has the current generalized land use in the RDCO. Figure 8 illustrates sand and gravel deposits *outside of* existing residential, institutional and commercial land use areas.

Through our survey, local producers have provided a snapshot of current supply under permit, as well as aggregate composition, use, transportation routes and cost. Recycled concrete and asphalt provide yet another source of aggregate. Each component is assessed for potential supply.

Table 1 outlines potential sand and gravel volumes based on surficial geology mapping and borehole data. Areas along creeks and lakeshores are included in this estimate.

Table 1: Sand and Gravel Quantities Based on Borehole Data

Aggregate Potential	Area (km^2)	Volume Estimated (m^3)		Tonnage (tonne)*	
		Min	Max	Min	Max
High	111.84	309,860,000	950,830,000	526,760,000	1,616,420,000
Moderate	128.52	110,270,000	308,190,000	187,450,000	523,930,000
Low	154.52	10,830,000	200,890,000	18,420,000	341,520,000
Totals	**394.87**	**430,960,000**	**1,459,920,000**	**732,630,000**	**2,481,870,000**

*Based on unit weight conversion of 1.7 tonnes / m^3

Evaluating Bedrock Aggregate Potential

The classification of hard rock aggregate potential for this study was based on two key parameters, rock type and overburden thickness. Overburden thickness provides an idea of how economical the rock will be to mine. That is, a thin overburden will be more economical, with less waste, than areas of thick overburden. The results are shown in Figure 5 – Aggregate Potential Bedrock Polygons with Overburden, attached.

Producer's Survey

Table 2 shows details of supply currently under permit, based on the local producer's survey.

Table 2: Annual Production and Supply Under Permit

	Sand & Gravel	Quarried Rock	Recycled Asphalt	Recycled Concrete
Average Annual Production (2012)	1,500,000	165,000	63,300	49,300
Supply Under Permit	59,000,000	9,500,000	N/A	N/A

*Based on 2013 Producer's survey, in metric tonnes

Table 3 illustrates typical hauling distances and costs, based on the local producer's survey.

Table 3: Trucking Hauling Distances and Costs

Aggregate Product	Hauling Distance
Range of Typical Area of Service	Site to 70 km
Average Hauling Distance for road fill, structural fill, concrete and asphalt	17 km
Extent of Hauling Distances for specialty products (e.g. landscape rock & masonry sand)	Site to 2500 km
Average Cost – Truck per hour	$94
Average Cost – Truck and Trailer per hour	$115

*Based on 2013 Producer's survey

Recycled Aggregates

Recycled concrete and asphalt present an additional source of aggregate for the RDCO. Asphalt and concrete waste comes from the demolition of roads, sidewalks, bridges and buildings. Other materials that can be incorporated into aggregate materials include asphalt shingles, crushed glass, brick, fly ash, and blast furnace slag.

The utilization of recycled aggregate varies between jurisdictions, as does the demand per capita of aggregate in general. Below is a selection of recycling rates relative to total consumption of aggregate per year:

- RDCO - 7.8% (2012, based on producer's surveys, not including MOTI figures)
- Ontario MOT – 18-19%[iv] (for highways in 2006)
- England (UK) – 28%[v]

The Master Municipal Construction Documents (MMCD) indicates that recycled concrete may be used for road base and sub-base material, with the approval of the Contract Administrator. The MMCD states that hot-mix asphalt concrete paving may contain up to 20% of recycled asphalt in a new asphalt mix, without a special mix design. The Ministry of Transportation and Infrastructure (MOTI) has a specification for hot-in-place asphalt recycling, but no reference specifically to recycled concrete use.

Demand

"The only substance people consume more of than concrete is water; every year one ton of concrete is produced for each person on earth."[vi]

Demand figures were used based on Canada Census and BC Stats data, using consumption figures based on published literature and projected growth rates. The population in the Central Okanagan is expected to grow at a rate of 1.52% to 2036, according to BC Stats Data[vii]. While BC Stats projects a gradually decreasing growth rate to 2036, we assessed a range of growth rates, including 1%, 1.5% and 2%, to arrive at the 100 year projections, due to the uncertainty in predicting beyond 2036.

Table 4 illustrates projected consumption over 20, 50 and 100 years for individual demand areas, and the RDCO as a whole, at an average consumption rate of 12 tonnes per capita, and an average growth rate of 1.5%.

Table 4: Consumption by Area over 100 Years at 1.5% Growth Rate and 12 Tonnes per Capita

Area	0-20 Years	21-50 Years	51-100 Years	0-100 Years Total
Kelowna	34,658,200	75,779,000	232,496,900	342,934,100
West Kelowna	9,126,600	19,955,000	61,223,900	90,305,500
Lake Country	3,459,000	7,562,900	23,203,700	34,225,600
Peachland	1,536,300	3,359,000	10,305,700	15,201,000
Electoral Areas	1,696,400	3,709,100	11,379,900	16,785,400
First Nations	2,654,500	5,804,000	17,807,100	26,265,600
RDCO (Total)	**53,131,000**	**116,169,000**	**356,417,200**	**525,717,200**

Figure A, below, illustrates the demand by area, based on existing population and a consistent growth rate of 1.5% through the RDCO over the next 20, 50 and 100 years.

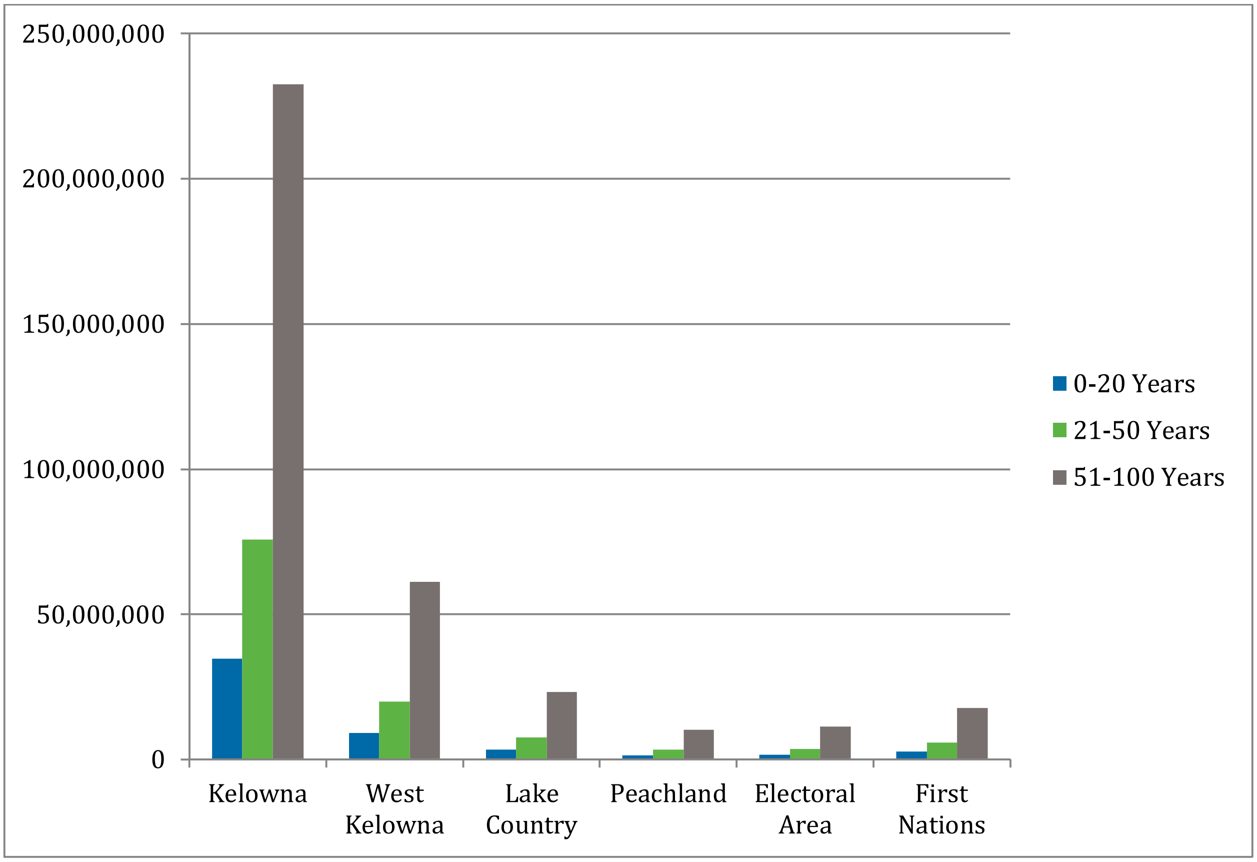

Figure A. Consumption at 1.5% Growth Rate and 12 Tonnes per Capita by Demand Area

Permitting – *Mines Act*

Sand and gravel operations and rock quarries must be permitted by the MEM under the requirements outlined in the *Mines Act*[viii]. A mine permit is required for both sand and gravel operations and rock quarries whether on private or Crown Land. Applications are subjected to a 30 day, inter-agency review process as well as a public review/comment period, which may include a public information meeting(s). Proposals deemed to be sensitive maybe referred to the local Regional Mine Development Review Committee (RMDRC). The RMDRC is comprised of representatives of both federal and provincial government agencies whose interests may be affected by the proposed mine. Local government and First Nations may also be invited to participate as members of the RMDRC. Usually, draft copies of the *Mines Act* permit are circulated to the RMDRC members as an opportunity for final comments subsequent to the Committee's review. Generally, First Nations are consulted on where First Nation interests may be impacted.

Legislation

Federal and provincial legislation protecting species at risk, migratory birds, and fish and fish habitat, has the potential to affect aggregate extraction. In addition, provincial legislation with respect to land tenure, the Agricultural Land Reserve, soil conservation and forest practices may need to be addressed as part of the application.

Soil Removal and Deposit Bylaws

To date, the City of Kelowna, District of Lake Country, District of Peachland, and District of West Kelowna have bylaws for soil removal and deposit. The fees, conditions and permit requirements vary between jurisdictions. Regional Districts are not allowed to implement volume based deposit or removal fees, because road maintenance is done by the Ministry of Transportation and Infrastructure (MOTI). As such, the RDCO has not pursued a Soil Removal and Deposit Bylaw to date.

Analysis

Within the framework of the environmental and groundwater conditions, community concerns, greenhouse gas impacts and road and traffic impacts, there are many considerations with respect to aggregate operations. The following sections outline considerations regarding environment, groundwater, greenhouse gas generation, land use, noise, dust, visual impacts and road and traffic.

Environment

Environmental sensitivities have the potential to constrain aggregate production, and in turn, aggregate production has potential to impact the environment. Federal, provincial and local legislation and guidelines are in place to safeguard the environment. According to the Aggregate Operator's Best Management Practices (BMP) Handbook[ix]:

"All aggregate production must be carried out in an environmentally sensitive manner. This can be accomplished through careful planning and BMP use on the property, and through coordinating on-property activities with the environmental activities of the immediate neighbouring area[x]."

Aggregate extraction has the potential to impact the environment in a number of ways, including terrestrial and aquatic habitat loss through vegetation removal, sedimentation of water-bodies, dust, changes to surface hydrology and groundwater through water pattern changes and/or water use, and potential acid rock drainage.

Groundwater

Groundwater resources can potentially be impacted due to aggregate operations. While gravel and its removal is inert, ground water impacts are possible due to the removal of vegetation, topsoil, overburden, due to the handling of fuel on-site, or through the use of groundwater, if required by the operation. Issues of consideration with respect to groundwater include:

- Location and final excavation depth with respect to vulnerable groundwater aquifers (MEM's standard is that the final depth of excavation be 1 metre above groundwater);

- Proximity to water wells;
- Metal leaching and acid rock drainage from site;
- Fuel storage siting and design;
- Septic system siting and design (if applicable);
- Water demand for operations (if applicable); and

Removing/stockpiling overburden or aggregate. The groundwater analysis included a review of existing mapping and data, and pertinent guidelines and literature. It also included preparing the criteria for base information selection.

EBA has chosen to incorporate the MOE system of aquifer classification for the purposes of this study. The MOE system defines aquifers at scales down to tens of meters, which is an appropriate scale for evaluating site-specific aggregate operations. For areas in the RDCO that fall outside of mapped MOE aquifers, proponents will be directed to BMP studies, including site-specific hydrogeological and aquifer vulnerability assessments by third-party qualified professionals, to provide information on expected effects of an aggregate operation on groundwater quantity and quality.

The City of Kelowna also delineates vulnerable groundwater aquifers in Map 5.6 Natural Environment DP Areas of their Official Community Plan. These aquifers, and all the environmental and hazardous DP areas within the City of Kelowna and the remainder of the RDCO, have been captured in the Regional Growth Strategy's Preliminary Constraints Areas Map, which in turn have been captured in this study on Figure 10 – Natural Environment and Hazardous Conditions DP Areas.

Greenhouse Gas Emissions

EBA developed an emissions calculator that can be used by prospective proponents to approximate the greenhouse gases of their proposed operations. The greenhouse gas (GHG) calculator was prepared specifically for aggregate production, which could be used for any operation, with a variety of processing activities. The calculator also includes transportation inputs. However, assuming the same trucks are used, transportation emissions of the aggregate material are generally going to vary only by the distance travelled. The calculator also allows the user to select different fuel types, to demonstrate the different emission associate with fuel choice. It may or may not be possible to utilize some trucks with different fuel choices. Transportation emissions are equally as important to overall emissions as processing emissions, and obviously the less the distance travelled from aggregate extraction place to mixing area, the lower will be the emissions. Note that the calculator assesses GHG resulting from the extraction, processing and transportation to site, but not those GHG that result from the product end use, such as the curing of concrete.

For processing emissions, natural sand and gravel has the lowest associated emissions (1912.81 CO2e kg CO2e / t) followed by recycled concrete (2885.40 kg CO2e / t). Recycled asphalt is more intensive (5418.6 kg CO2e / t) with quarried rock being the most emissions intensive aggregate to process (8,129.72 kg CO2e / t), due to the blasting process required.

Infrastructure Impacts

As part of this study, the potential impact of aggregate hauling on existing roads was also undertaken. For this assessment, the exact location of the aggregate sources, volumes of aggregates, duration of aggregate hauling and the haul routes were not available. The analysis, therefore, was completed based on hypothetical scenarios to illustrate the potential impacts resulting from the hauling of the aggregate.

The aggregate hauling operation would result in increased traffic volumes on the roads included in the haul route. Typically, pavement structures are designed for specific traffic volumes and an increase in the traffic volume or truck size would result in the consumption of the pavement service life. This may result in premature failure of the pavement structure and required earlier rehabilitation interventions or reconstruction.

The results of the infrastructure assessment indicate that road impacts are directly related to existing road condition. While a Type A pavement structure, such as that on main arterials and highways, results in a small impact of service life under a similar trucking impact, Type B (collector roads, typically) has an additional impact and the service life of Type C roads (local roads) is significantly impacted under the same loads.

Figure B illustrates the relative impact of having 1,000,000 tonnes of aggregate over a Type A, Type B and Type C pavement structure.

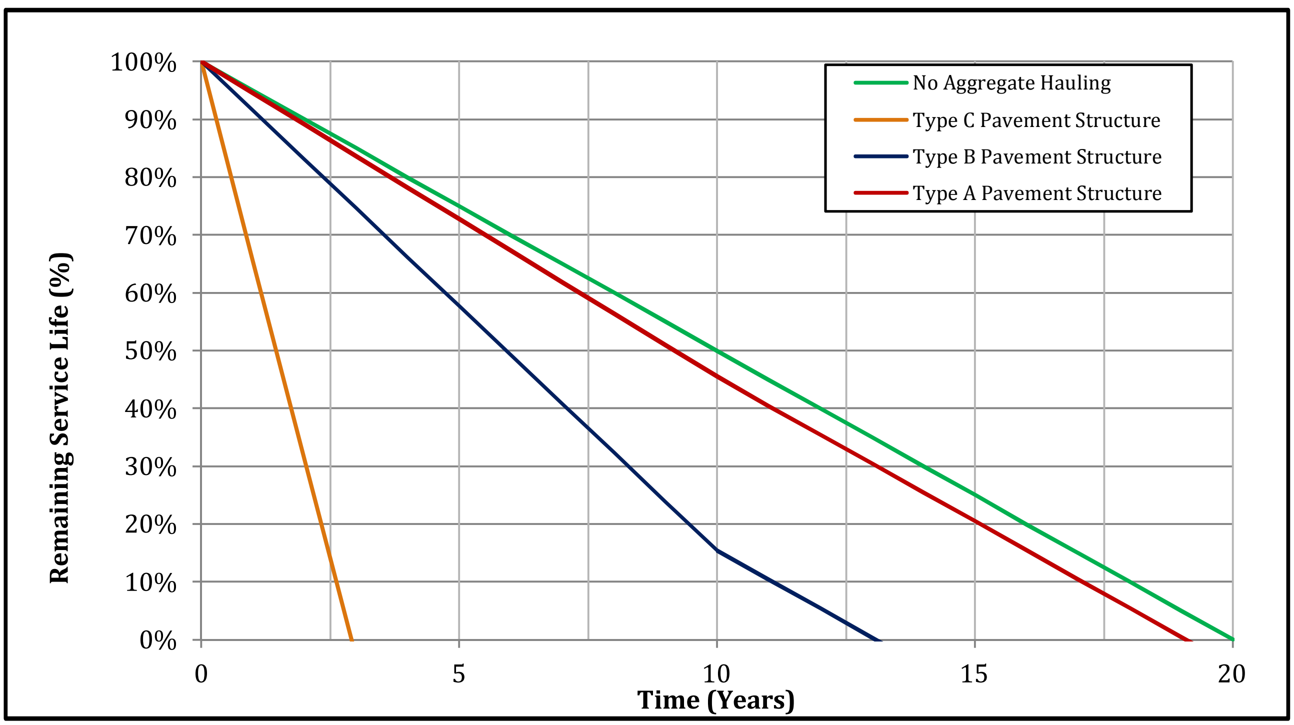

Figure B. Impact of 1,000,000 MT of Aggregate Hauling on Pavements

Traffic

An aggregate operation necessarily comes with increased truck activity for hauling. In addition to infrastructure impacts, there are impacts due to increased traffic, and concerns such as pedestrian safety and congestion, fumes and dust, and associated noise. These vary with the operation, number of trucks per day, route, and distance to a truck route.

According to the AO Handbook[xi], off-site traffic concerns can include:

- Noise;
- Driver behaviour;
- Truck visibility;
- Vibration;
- Traffic volume;
- Dust;
- Visual impacts;
- Landscape character;
- Detachment;
- Fear and intimidation;
- Highway safety; and
- Road degradation.

Noise

A key community concern of aggregate operations is noise. Noise can be caused by a number of sources, including crushers, screeners, trucks, generators, loaders, scrapers, and for quarry operations, hydraulic hammers and blasting. Noise levels depend on distance from the source, direction, and the amount of reflection, absorption or deflection present.

The *Health, Safety and Reclamation Code*[xii] (the *Code*) recommends mufflers be installed on machinery and sets maximum permissible noise exposure limits of Lex = 85 dBA average for 8 hours or equivalent, plus additional peak noise impulse restrictions. In addition, each local government has a noise control bylaw that regulates hours of construction.

Health – Dust

The dust created by an aggregate operation will vary, depending on site conditions, weather, nature of the material and operations. Dust becomes airborne through a number of activities, including surface stripping, handling, crushing or screening, loading, and blasting of materials, if present. Dust can also be released by truck traffic over unpaved surfaces, and wind over stockpiles.

Dust is defined as any particle up to 75 microns (μm) in size[xiii]. Dust can come from a variety of sources including vehicle exhaust, agriculture, domestic and forest fires, and tire wear. Small particles of dust travel farther than larger particles. Particulate matter, less than or equal to 10μm, are referred to as PM_{10} present a greater health risk than larger particles. The dust indices typically described in the news and air quality reports usually refer to dust smaller than 10 μm[xiv]. Particulate matter less than 10 microns are divided up into two categories. The Environmental Protection Agency (EPA) uses the following definitions:

- 'Inhalable coarse particles' – are from 2.5 to 10 microns in size, and can be found near roadways and dusty industries.
- 'Fine particles' - are less than 2.5 microns in size, such as those found in smoke and haze. Typical sources include forest fires, or when gases from power plants, industries and automobiles react in the air.[xv]

Inhalable coarse particles are typically filtered out by the respiratory system prior to entering the lungs. $PM_{2.5}$ is considered the most significant health concern, as they are most apt to be trapped in the lungs[xvi], and according to BC Air Quality, can cause respiratory and cardiac problems[xvii]. It is for $PM_{2.5}$ that standards for air quality are established in Canada and the United States.

Table 5: Dust Concerns and Typical Travel Distances by Physical Particle Size[xviii]

Dust Categories	Size μm	Concerns	Distance Traveled	Typical Percentage from Aggregate Pits
Large Dust (a)	30 – 75 μm	Nuisance	100 m	94%
Large Dust (b)	10 – 30 μm	Nuisance	200 – 500 m	
(2.5 to 10 μ)	2.5 – 10 μm	Health (inhalable coarse particles)	1000 m	3%
(less than 2.5μ)	< 2.5 -μm	Health (inhalable / respirable fine particles)	> 1000 m	3%

Larger particles will fall out more quickly than small ones, which travel farther. Most aggregate dust is over 30 μm, which will fall out within 100 m of its source. Intermediate particles will fall out between 200-500 m of its source. Particles under 2.5 μm can travel over 1000 m[xix]. Particles under 10 μm are considered a health concern, as these are not removed by normal respiration. Approximately 94% of the dust created by aggregate operations is dust with particle size over 10 μm. This component is not typically inhalable or respiratory, and as such, is not considered a health concern.

Health – Radon

Radon is a naturally occurring radioactive gas that is produced by the decay of radium isotopes (primarily ^{226}Ra), which results from the decay of uranium and thorium[xx]. Uranium and thorium are present in variable concentrations in most soils and rocks. Radon gas has a half-life of 3.8 days and upon decay releases an alpha particle (radiation); the solid particle (progeny) left behind undergoes various stages of further decay during an approximate 24 year half-life. These progeny can either be retained in the lung or directly inhaled. Fortunately their electrical charge renders them to attach to larger particles and plate out in the environment. Radon gas is a health concern as it can accumulate in enclosed areas, particularly in confined areas such as the basement of a house. Long-term exposure to high concentrations of radon increases a person's risk of developing lung cancer[xxi]. According to the Federal Provincial

Territorial Radiation Protection Committee (FPTRPC), there is scientific evidence of a measurable risk of lung cancer with radon levels as low as 100 Bq/m^3[xxii].

There may be potential, through product end uses such as concrete or construction sub-base made with aggregates with a high concentration of uranium, to result in elevated rates of radon within built environments. (Refer to the Health Canada Review of Existing Guidelines and Regulations Surrounding the Radioactive Content of Construction Aggregate: Production and Use, Appendix F). In response to the concern over radon potential in houses, the BC Building Code was amended in December, 2012, to include provisions of installing the rough-in works for radon gas ventilation in new construction, where elevated levels of radon are a potential risk, including the geographic area of the RDCO. The current guideline value for acceptable levels of radon gas in a house is 200 Bq/m^3 (Becquerels per cubic meter). This guideline value was established by the FRTRPC. By comparison, this Canadian guideline value is less protective than the USA EPA Action Level of 4 pCi/l (148 Bq/m^3). There are no guidelines for radon gas in an open space although dilution is considered to render the resulting outdoor exposure much lower than that of any indoor guideline

For this study, we identified testing protocols to identify uranium concentrations and radon potential in the resource. Testing rock through a whole elemental rock analysis, as well as a leaching test, will provide information on the concentration of uranium and thorium in the rock and its long term potential to release radon gas.

Visual Impact Analysis

Visual impacts from an aggregate operation may vary from one operation to another and may be caused by the landform or excavation themselves, mobile equipment, buildings and structures, or alteration of landforms and vegetation. The *AO BMP Handbook*[xxiii] suggests that operations close to urban areas undertake a visual landscape evaluation to assess potential visual impacts and affected areas, using a 'key viewpoint approach'. The Handbook outlines a four step approach to assessing visual impacts and modifying the design of the operation to reduce these impacts.

Other standards within British Columbia for visual impact assessments include the *Visual Impact Assessment Guidebook*[xxiv] used for forestry projects and the *Manual of Aesthetic Design Practice*[xxv] used for highway projects. While not all the design techniques for forestry and highways apply to aggregate operations, there are some procedures and mitigation measures that can be borrowed from these references. The *Visual Impact Assessment Guidebook* outlines procedures on how to assess significant viewpoints and prepare assessment visuals. Mitigation measures for visual impact are outlined in the AO BMP Handbook.

Costs

Costs of delivered aggregate include the product, processing, permitting, operation, reclamation, and transportation. Aggregate, by nature, is heavy. As such, the cost of transportation adds significantly to its overall cost. It is also the cost, which varies the greatest, depending how far the pit is to the project site. In 2000, the average haul distance within the RDCO was 12 km. In 2012, the average haul distance has increased to 17 km, representing a 41 percent increase in average haul distance. Over time, tonnes and kilometers, this has an impact on overall cost to projects. It reflects ultimately on all of us through the costs of new development and through taxes, as the various levels of government consumes 60 percent of the aggregate produced in BC and funds the increased infrastructure life-cycle maintenance costs of roads, bridges, government buildings, hospitals and schools[xxvi].

Recommendations - Site Suitability Assessment

A template for a Site Suitability Assessment (SSA) was prepared in order to achieve consistency with the referral process that takes into consideration potential impacts to the local community and environment. A review of local bylaws and guidelines was undertaken to ensure the assessment was consistent with existing policy. The SSA is intended to be used as a checklist by local governments to assess aggregate proposals that are referred to them by the MEM. The SSA will provide a predictable and consistent approach to project referrals throughout the RDCO and from proposal to proposal.

The SSA was prepared based on the integration of current standards, inventories and regional land use and permitting areas. It incorporated considerations of:

- Roads and traffic, including road safety;
- Land use;
- Environmentally Sensitive Development Permit (EDP) Areas;
- Environmentally Hazardous Development Permit (EHDP) Areas;
- Provincial Aquifer Mapping;
- Visual Sensitivity;
- Adjacency for dust and noise;
- Health, including radon gas exposure;
- Greenhouse gas; and
- Mitigation and reclamation plans.

The SSA works through each component to assess potential suitability and impacts. If a potential concern or impact is noted, a corresponding assessment, with mitigation and/or compensation where appropriate, is recommended. If there are impacts that cannot be mitigated or compensated for, then a recommendation for non-support is proposed.

Recommendations - Communications and Aggregate Advisory Committee

The circulation of referral requests, results of assessments and mitigation measures, and the resulting permit conditions is an important part of the process. When assessments and/ or mitigation measures are recommended through the review and the use of the SSA by local governments, this request will go back to the MEM as part of the referral process. It is important that the local government have an opportunity to review the results of any assessments and mitigation plans prepared, prior to the issuance of a *Mines Act* or *Mineral Tenure Act* permit. The flow of information back to local government will help them understand the mitigation measures operators are responsible for. This information flow is outlined in the SSA process.

We recommend that a regional Aggregate Advisory Committee (AAC) be established. The study has demonstrated the need for a coordinated approach to aggregate planning. Transportation is critical to the successful and economical delivery of aggregate, and the impacts are significant with respect to road structure. Given these potential impacts to roads, it is advantageous to have pits located as close to major arterial roads as possible. Coincidentally, the transportation of aggregate can also result in community concerns. A coordinated planning approach to aggregate, together with regional transportation planning and land use considerations, would benefit the process of securing and delivering aggregate within the RDCO over the long term. A committee, with representatives from local government, agencies and producers, to collectively and cooperatively plan for aggregate extraction, processing and delivery, is a key element in the implementation of the results of this study and innovations and changes going forward. The committee could address elements including the following:

- Transportation planning with respect to aggregate
- Coordination of a regional approach to aggregate permit referrals
- Assessment of construction specifications (e.g. road base etc.) with respect to recycled aggregate content and similar use of recycled products and technologies in other jurisdictions

Regional cooperation on regional aggregate issues (e.g. GHG target objectives and visual quality)
Recommendations - Planning

A number of planning principles have become evident through the course of the study. These are described below.

- **Plan for Near Market Extraction first**
  - Use close to market resource first
  - Use resource prior to sterilization by other land use
  - Plan for recycling facilities near market in perpetuity
- **Plan for Extraction Near Highways and Arterials**
- It is recommended to plan for aggregate extraction as close to main roadways as possible, to reduce impacts. The closer the supply is to market, it will:
  - Reduce infrastructure impacts
  - Reduce neighbourhood impacts
  - Reduce greenhouse gases
  - Reduce relative noise impacts
  - Reduce costs (both in terms of transportation costs for the product and resulting infrastructure impact costs over the long term)

Recommendations – Bedrock Sources of Aggregate

The investigation of bedrock aggregate potential for this study is preliminary. Additional information will be required to support the classifications and to confirm aggregate potential in any one location. Any additional investigation should follow a step wise process of delineating the potential resource.

Recommendations - Recycled Aggregates

While the system of concrete and asphalt recycling in the RDCO is functioning, much can be done to improve on the efficiency and its resulting value within the District. Recommendations to improve the recycling of aggregate in the District are included below.

- Identify and zone aggregate recycling sites in perpetuity (possibly through covenant or purchase);
- Review and revise specifications;
- Establish a technical group, including representatives from local government infrastructure personnel, producers, engineers, manufacturers and agencies and to establish workable processes, guidelines, and specifications for local and provincial governments to improve the options for reusing recycled aggregates;
- Tender policies and construction techniques that encourage recycling; and
- Public education.

Recommendations – Environment

The framework for environmental recommendations is based on provincial BMPs and federal, provincial and local legislation, guidelines and permit requirements. The MEM will refer an application to federal or provincial agencies if it determines there is an environmental risk under their legislation, such as the *Fisheries Act* or the *Water Act*. Through the Site Suitability Assessment process, we propose that each potential site has an overview level environmental assessment conducted by a Qualified Environmental Professional (QEP), to identify any potential issues at a high level. This will ensure that environmental issues are being considered at the beginning of the process, and it corresponds with the Ministry of Environment's (MOE; formerly Ministry of Water, Land and Air Protection's (MWLAP)) recommended BMPs for site inventory information[xxvii]. The MEM and MOE have detailed BMPs for the protection of habitat, aquatic areas and the environment. These should be followed through all stages of the operation.

Recommendations – Groundwater Assessment

As part of the Site Suitability Assessment, an overview groundwater assessment is recommended to be submitted with a Notice of Work (NoW) application.

The assessment should include depth to aquifer, soil permeability, and the following:

- Adjacent groundwater resources including adjacent wells upstream or downstream);
- Metal leaching and acid rock drainage (ML-ARD) for hard rock applications;
- Fuel management plan and spill response plan;

- Septic system design plan (if applicable); and
- Water demand assessment (if a well is proposed).

Recommendations – Infrastructure

The review of the data indicates that the roads with thinner pavement structures (Type C, local roads) would likely fail prematurely and not likely be able to meet their intended design life under aggregate hauling conditions.

It has been concluded that it would be economically beneficial to limit the hauling operation primarily to roads with thicker pavement structures (similar to Type A, arterial roads). It would also be better to evaluate the condition of the pavement for the road segments included in the haul route and complete any upgrading / rehabilitation prior to the start of the aggregate hauling operation. The proper selection of aggregate haul routes and road upgrading prior to the beginning of hauling, will present efficiencies with respect to time of travel, maintenance of vehicles and pavement performance.

Recommendations - Traffic

As noted in the *AO BMP Handbook - Volume I,* there are established best management practices that the producer can implement, including receiving and attending to complaints, avoiding overloading, covering loads, refusing to load non-compliant drivers, wheel washing, and loading trucks with chutes to avoid spillage.[xxviii] The trucking company can cover lads, reduce speed, implement driver training, time trips to avoid rush hours and / or school start and finish times.

Recommendations – Noise Attenuation

As noted in the *AO BMP Handbook - Volume I*[xxix] there are a number of options and best management practices for noise control possible during site layout, operations and interception. Noise attenuation can be achieved by interceptors, site layout modifications, protecting the equipment, driving trucks slower and a number of mitigation measures. Mitigation starts at the planning stage, and continues through site layout, interceptors, and operating practices. The first step should be a Noise Attenuation Plan to be submitted with a Notice of Work (NoW) application, to the MEM. The plan should include locations of noise generating activities, noise reflectors and absorption barriers, and an operational plan including speed control, mufflers, reducing drop height, keeping tailgates closed, and other noise reduction techniques. The plan should be circulated to the local government for review and comment.

Recommendations – Dust Control

As outlined in the *AO BMP Handbook*[xxx], dust control planning includes both site layout and operational procedures. Applicants should prepare a plan for dust control, and document it on a Site Layout Map. From the Handbook, the plan would best include:

- Dust generating activities;
- Off-site facilities that are sensitive to dust;
- Prevailing wind direction(s) and onsite wind patterns;

- Placement of berms, stockpiles and tree buffers to create or enhance wind shadows;
- Possible locations of dust-generating activities and haul roads in calm locations and far from dust sensitive facilities; and
- Location of existing trees and shrubs to create wind breaks.

The plan should also include dust reduction measures during operation.

Recommendations – Radon

The level of uranium in the ore body could be determined as a factor for potential radon release once the material is imported into a closed site setting such as a building envelope. Note that this ore body evaluation should not alleviate homeowners from testing the radon gas levels in their houses, as there are other site-specific factors that can influence radon levels within a building.

There are numerous analytical methods available to determine the total uranium concentration in various physical media (rock, soil, water, vegetation, biota). When evaluating a potential bedrock material for aggregate use, it will be important to first determine the total uranium concentration present in the rock by way of whole rock elemental analysis, and secondly to determine the potential for uranium present in the rock to leach into water and soil, and ultimately influence biota and vegetation.

In order to determine the whole rock elemental concentration, various mass spectrometer applications, such as inductively coupled plasma mass-spectroscopy (ICP-MS), may be applied. Shake flask extraction analyses, or similar leaching tests, could be run to determine the potential for uranium leaching into the water column. These analyses are also required to characterize metal leaching and acid rock drainage potential of the bedrock sources, and would be run concurrently as part of the geochemical characterization program. When running these analyses, the proponent may select which elements they would like to test for to ensure that all potential contaminants of concern are evaluated.

Recommendations – Visual Impact Mitigation (VIM)

Visual impact planning and mitigation measures have been adapted from the *Visual Impact Assessment Guidebook*[xxxi]. Recommendations are based on the *AO BMP Handbook, Volume II*[xxxii] and the *Manual of Aesthetic Design Practice*[xxxiii].

VIM Planning

As outlined in the *AO BMP Handbook*[xxxiv], visual impact mitigation planning includes both site layout and operational procedures. Applicants should prepare a plan for visual impact mitigation, and document it on a Site Layout Map. From the *Handbook*, the plan would best include:

- Key viewpoints and viewscapes;
- Potential visual impacts (e.g., structures and equipment);
- Topography;
- Conditions pre-development and anticipated conditions post-development;

- Local landscape character.

VIM Site Layout

The VIM site layout needs to assess the position(s) of the viewer(s) with respect to distance and topography. Large cuts against steep slopes are more difficult to screen, so various mitigation options may need to be combined to achieve results. The *Manual of Aesthetic Design Practice*[1] includes visual impact mitigation techniques that could be applied to aggregate operations for:

- earthworks;
- berm design;
- uphill and downhill slopes;
- blast cut surface treatment;
- integration with adjacent topography;
- near road screening;
- response and integration to adjacent natural vegetation;
- varying the vegetation edge; and
- bioengineering for erosion control on permanent slopes.

Conclusion

While the RDCO has a relative abundance of natural sand and gravel, with additional potential from crushed rock, there remain significant constraints to accessing and delivering this product to market. For example, the resource may be in an environmentally sensitive area, within the ALR or above a vulnerable aquifer. There may be neighbourhood concerns of dust and noise. The transport route may lack a designated truck route designed to accommodate aggregate transport. The transport route may run through a residential area or school zone, causing concern for pedestrian safety. In addition, while aggregate operations are pushed further from market in order to avoid neighbourhood conflicts, the costs of delivery rise, as along with the greenhouse gases associated with transportation.

However, aggregate forms the very foundation of our transportation network and built environment. We need and use the resource to continue to build sustainable communities. The results of this study suggest that a proactive planning approach, where significant aggregate deposits are identified as future extraction areas, complete with an effective transportation network, with environmental and neighbourhood buffers and concerns addressed, points to a smoother process of permitting and operations for the delivery of aggregate. In addition, a cooperative approach between municipalities, producers and agencies to establish state of the art recycling processing and specifications in the RDCO, will enable greater efficiency of the resource and reduce the requirement of new material.

[1] MOTI, 1994. Manual of Aesthetic Design Practice. http://www.th.gov.bc.ca/publications/eng_publications/environment/design_practice.htm