



AGGREGATE SUPPLY AND DEMAND UPDATE AND ANALYSIS



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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 settlementⁱⁱ. 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 infrastructureⁱⁱⁱ. 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 / m³

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.

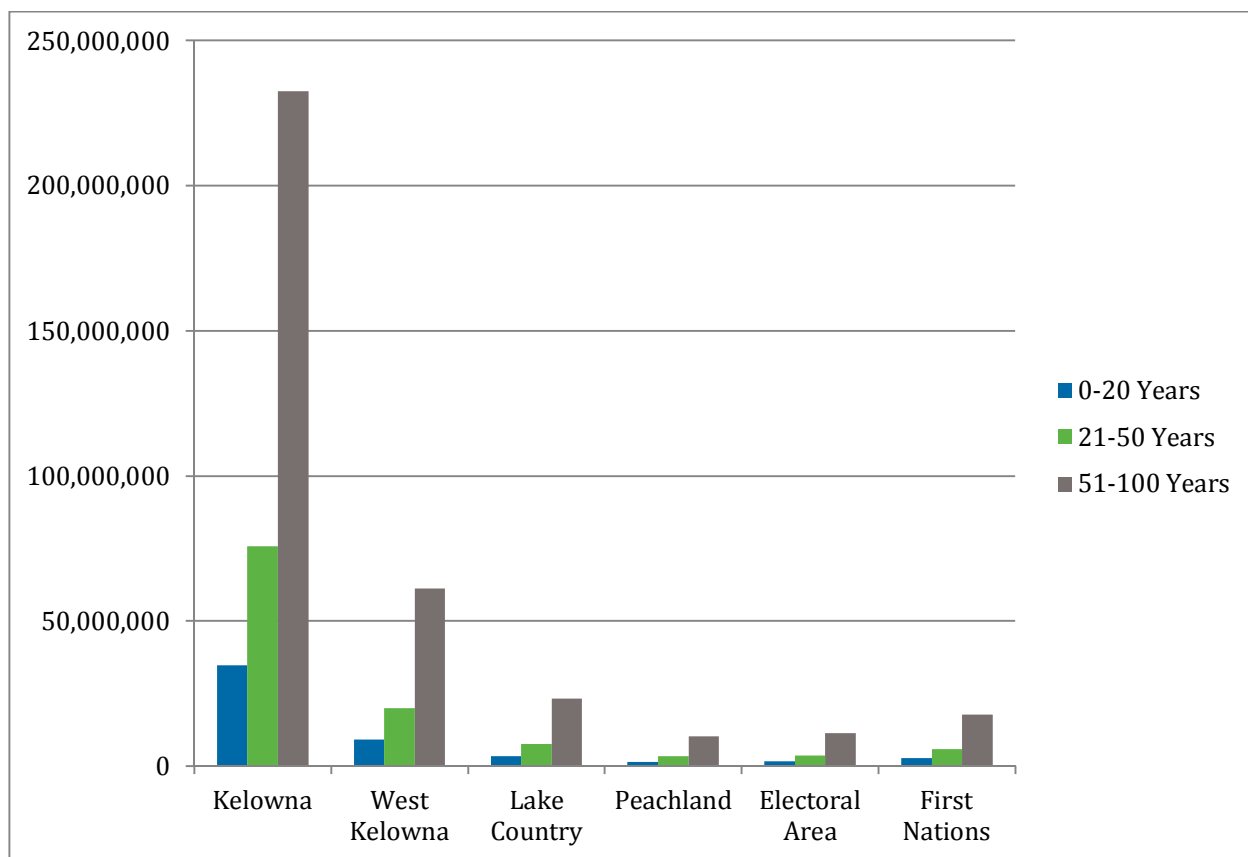


Figure A. Consumption at 1.5% Growth Rate and 12 Tonnes per Capita by Demand Area

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.

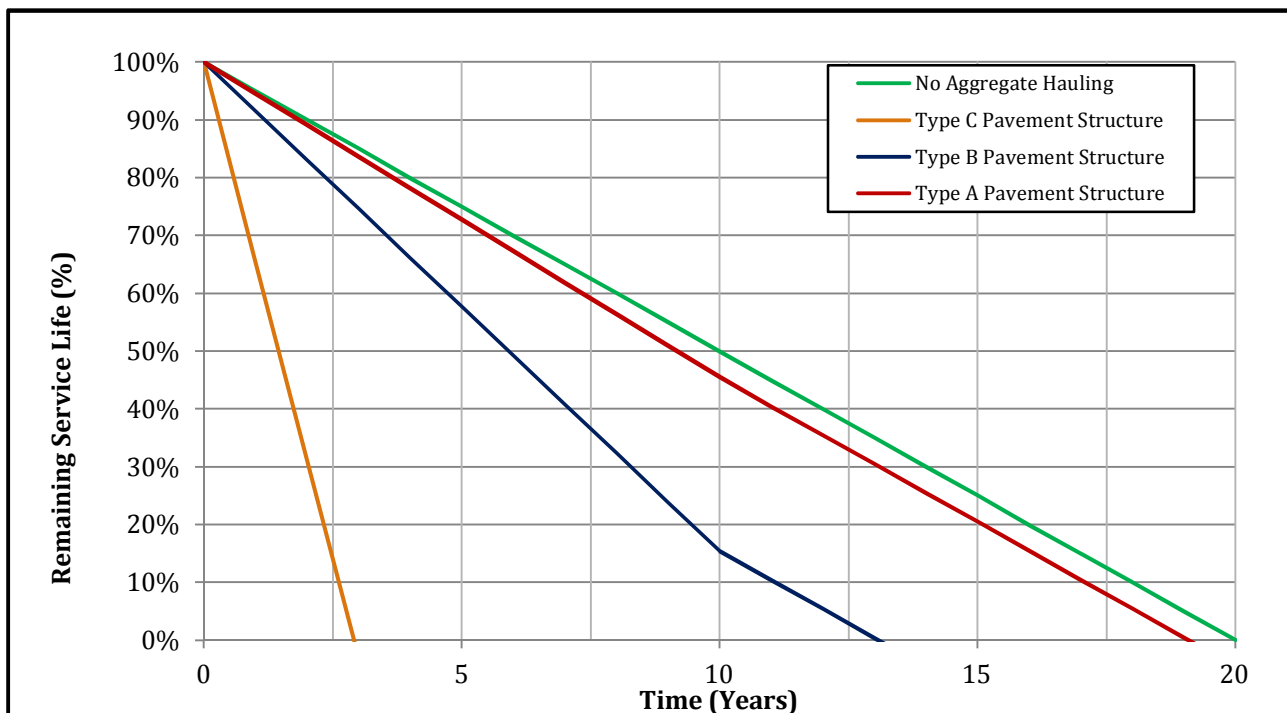


Figure B. Impact of 1,000,000 MT of Aggregate Hauling on Pavements

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 $L_{eq} = 85$ 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 $10\mu\text{m}$, 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 $10\mu\text{m}$ ^{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. $\text{PM}_{2.5}$ 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 $\text{PM}_{2.5}$ 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 2.5 μ)	< 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/m³^{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/m³ (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/m³). 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*^{xxxix}. Recommendations are based on the *AO BMP Handbook, Volume II*^{xxxix} and the *Manual of Aesthetic Design Practice*^{xxxix}.

VIM Planning

As outlined in the *AO BMP Handbook*^{xxxix}, 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 viewscales;
- 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

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ACRONYMS & ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AAC	Aggregate Advisory Committee
ALR	Agricultural Land Reserve
AO BMP	Aggregate Operator's BMP Handbook – Volumes I and II
BEC	Biogeoclimatic Ecosystem Classification
BMP	Best Management Practice
CCME	Canadian Council of Ministers of the Environment
CDC	Conservation Data Centre
CoK	City of Kelowna
CWS	Canada-wide Standard
EDP	Environmental Development Permit
EHDP	Environmentally Hazardous Development Permit
EPA	Environmental Protection Agency of the United States
DLC	District of Lake Country
DoP	District of Peachland
DP	Development Permit
DWK	District of West Kelowna
EBA	EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company
ESAL	Equivalent Single Axle Loads
FRTRPC	Federal Provincial Territorial Radiation Protection Committee
ICP-MS	Inductively coupled plasma mass-spectroscopy
IHSC	Interior Heart and Surgical Centre
ILMB	Integrated Land Management Bureau
GIS	Geographic Information System
km	kilometre
LEED®	Leadership in Energy and Environmental Design
MAC	Maximum Allowable Concentration
MEM	Ministry of Energy and Mines

MEMPR	Ministry of Energy Mines and Petroleum Resources (currently the MEM)
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MINFILE	MOENMGH database for geological data and mapping information
ML-ARD	Metal Leaching / Acid Rock Drainage
MMCD	Master Municipal Construction Documents
MMCDA	Master Municipal Construction Documents Association
MOE	Ministry of Environment (currently the MFLNRO)
MWLAP	Ministry of Water, Land and Air Protection (currently the MFLNRO)
MOT	Ministry of Transportation (Ontario)
MOTI	Ministry of Transportation and Infrastructure
NoW	Notice of Work
OBWB	Okanagan Basin Water Board
OEL	Occupational Exposure Limits
PEM	Predictive Ecosystem Mapping
PM	Particulate Matter
PM2.5	Particulate Matter less than or equal to 2.5 microns in diameter
PM10	Particulate Matter less than or equal to 10 microns in diameter
ppb	parts per billion
QA	Quality Assurance
QC	Quality Control
QEP	Qualified Environmental Professional
RAP	Reclaimed asphalt pavement
RAR	Riparian Areas Regulation
RCA	Recycled concrete aggregate
RDCO	Regional District of the RDCO
RGS	Regional Growth Strategy
RMDRC	Regional Mine Development Review Committee
RSBC	Royal Statutes of BC
SARA	Species at Risk Act
SAROS	State of the Aggregate Resource in Ontario Study

SEI	Sensitive Ecosystem Inventory
SHIM	Sensitive Habitat Inventory Mapping
SRDB	Soil Removal and Deposit Bylaw
TBT	Bioterrain Mapping
TSM	Terrain Stability Mapping
TEI	Terrestrial Ecosystem Information
TEM	Terrestrial Ecosystem Mapping
TEMSEI	Terrestrial Ecosystem Mapping / Sensitive Ecosystem Mapping
µg	microgram
µg/m ³	microgram per cubic metre
UK	United Kingdom
WSI	Wildlife Species Inventory

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Regional District of the Central Okanagan and their agents. EBA Engineering Consultants Ltd. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the Regional District of the Central Okanagan, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Services Agreement. EBA's General Conditions are provided in Appendix H of this report.

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1.0 INTRODUCTION

“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)^{xxxv}

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^{xxxvi}. 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.

1.1 Project Objectives

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) is pleased to submit the Aggregate Supply and Demand Update and Analysis Study for the Regional District of the RDCO (RDCO).

The deliverables for the aggregate study include providing:

- an aggregate supply and demand update for a time horizons of 20, 50 and 100 years;
- an analysis of potential constraints to production based on other land uses / elements; and
- a site suitability assessment checklist, with which individual sites may be evaluated, to help mitigate community concerns regarding aggregate production.

This report includes the project background, methods, supply and demand results, an analysis of potential impacts and constraints including land use, environment, groundwater, greenhouse gas emissions, road and traffic, greenhouse gases, noise and health (dust and radon), as well as visual sensitivity. A site suitability assessment checklist has been developed to provide a systematic framework to assess sites for extraction suitability. The study area is shown in Figure 1.

1.2 Background

In 2000, the RDCO, together with the City of Kelowna (CoK), District of Peachland (DoP), and the District of Lake Country (DLC) conducted an Aggregate Supply and Demand Study of the RDCO. This study assessed potential supply based on surficial geology, undertook a producer survey to estimate supply under permit, and projected demand to 2020. The project also developed a generic template for a Soil Removal and

Deposit Bylaw (SRDB). To date, the City of Kelowna, District of Lake Country, District of Peachland, and District of West Kelowna (DWK) have SRDBs.

Since 2000, a there has been a significant number of terrain mapping projects in the RDCO, establishing a detailed terrain database. In addition, updated geological mapping has been completed in Lake Country. New legislation exists that has potential to have an impact on extraction, as well as land use changes over the past 13 years. This study includes an update of mapping data, supply and demand projections, legislation, and land use changes.

1.3 Consultation

The study included a consultation process that involved local government staff, agencies, aggregate producers and the public. The Technical Advisory Committee (TAC) included representatives from each member municipality, Interior Health and the Ministry of Transportation and Highways (MOTH). Westbank First Nation were invited but unable able to attend the meetings. The consultation process included the following:

- Technical Advisory Committee #1 and Producer's Meeting February 2013
- Distribute Preliminary Maps and Presentation to Producers February 2013
- Producer's Survey Distributed to Producers via e-mail and phone March 2013
- Technical Advisory Committee Meeting #2 – Supply and Demand April 2013
- Two local aggregate pit tours by EBA April 2013
- Technical Advisory Committee Meeting #3 – Site Suitability Assessment May 2013
- Governance and Services Committee / Regional Board Meeting June 2013
- Public Open House – West Kelowna June 2013
- Public Open House – Regional Growth Strategy – Kelowna June 2013
- Referral to Agencies, Utilities, Local Governments June 2013
- Referral of Issued for Review Report directly to Producers on list via e-mail June 2013
- Comments Received from Referral Process August 2013
- Technical Advisory Committee Meeting #4 September 2013
- Revisions based on Technical Advisory Committee Meeting September 2013
- Governance and Services Committee / Regional Board Meeting October 2013
- Revisions based on Governance and Services Committee Meeting October 2013

In June 2013, the report was issued for review and comment to the following:

- Local aggregate producers
- Ministry of Energy and Mines
- Ministry of Transportation and Infrastructure
- Ministry of Agriculture
- Ministry of Forests, Lands and Natural Resource Operations
- Ministry of Environment
- Ministry of Community, Sport and Cultural Development
- Ministry of Jobs, Tourism and Skills Training
- Interior Health Authority
- Agricultural Land Commission
- Integrated Land Management Bureau
- Westbank First Nation
- Okanagan Indian Band
- Okanagan Nation Alliance
- Regional District of North Okanagan
- Regional District of Okanagan Similkameen
- Regional District of Kootenay Boundary
- Regional District of Thompson Nicola
- City of Kelowna
- District of Lake Country
- District of West Kelowna
- District of Peachland
- RDCO APC (Central Okanagan East)
- RDCO Environmental Advisory Commission
- RDCO Agricultural Advisory Commission
- Fortis BC
- BC Hydro
- School District 23
- Telus
- Shaw Cable
- Black Mountain Irrigation District
- Southeast Kelowna Irrigation District
- Glenmore Ellison Improvement District
- Okanagan Basin Water Board
- Economic Development Commission

2.0 AGGREGATE DEFINED

This section describes aggregate as a commodity, sources, and how and where it occurs in the landscape.

2.1 Aggregate Use in the Community

Aggregate is the term used to describe sand, gravel and crushed rock that builds the structure and transportation networks of our communities. It is the primary component of concrete and asphalt. It is also used for structural fill under buildings, drain rock, sub-base material for roads and sidewalks, along with a multitude of other residential and commercial uses. Natural sand and gravel deposits are our primary sources of aggregate. Bedrock is also quarried and crushed for use as aggregate, as well as for large

dimension stone used for such applications as riprap and rock walls. Each use has particular specifications with regard to grain size, particle shape and physical properties, to ensure quality requirements are met. To meet these specifications, gravel deposits and quarried rock can be screened, crushed and/or washed, in order to achieve the desired physical properties. The location where these materials have been deposited, and/or the characteristics of the bedrock, dictates where they can be mined. Like oil, natural aggregate is non-renewable and only occurs in specific locations based on geological processes.

“Because sand, gravel and stone deposits are created over very long periods of time by geological and other natural forces, they are considered a non-renewable resource. Like other non-renewable resources, it is important that they be managed wisely.”^{xxxvii}

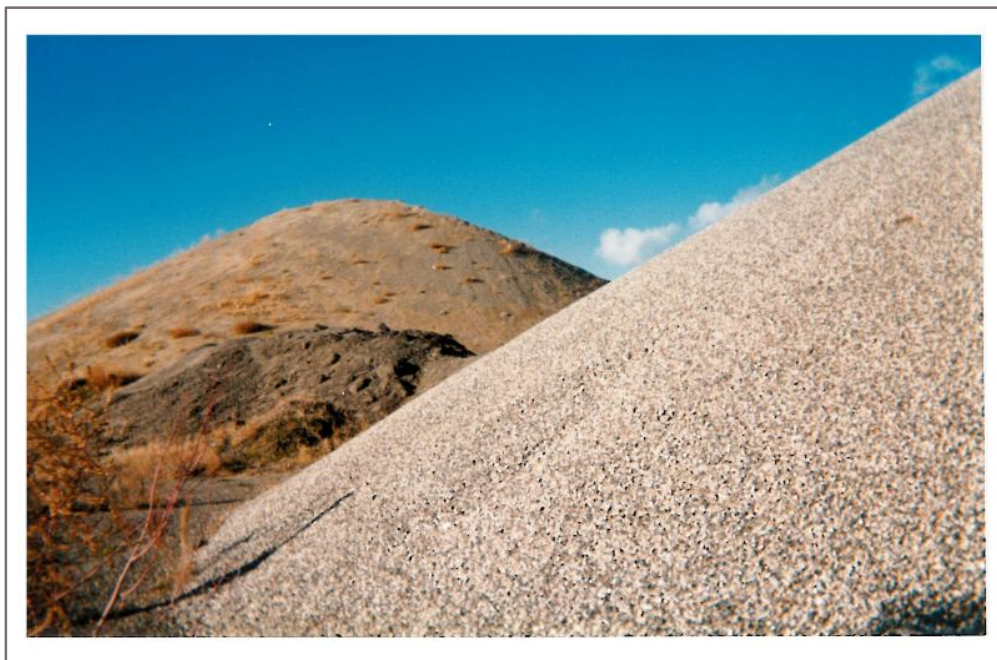


Photo 1 Aggregate in the Community

3.0 METHODS

This section outlines the methods undertaken to complete each component of the study.

3.1 Sand and Gravel Mapping

Since 2000, there have been many terrain and ecosystem mapping projects completed in the RDCO. The projects have varied in scope, scale, coverage and purpose. The projects included Sensitive Ecosystem Inventory (SEI), Terrain Stability Mapping (TSM), and Terrestrial Ecosystem Mapping (TEM).

The task for this project was to synthesize the various terrain projects and assess the data specifically with respect to its potential for identifying natural sand and gravel deposits. Terrain components included:

- Surficial material (e.g. modern or glacial river beds);
- Surficial expression (provides depth information, e.g. a veneer or blanket);
- Percentage of sand and gravel within a polygon;
- Percentage of fines (silts and clay) within a polygon; and
- Drainage (e.g. approximate depth to groundwater).

Based on these characteristics, the potential for sand and gravel deposits were given ratings of high, low, moderate or nil. Thick glacial till deposits have been mapped separately. While till deposits have potential for sand and gravel, they are typically embedded in a matrix of fine-grained silt and clay. This reduces its value for aggregate production. The fine-grained component would need to be screened or washed out for many applications, reducing its value for sand and gravel production.

An overburden map was created based on surficial expression. This provided an estimate of the depth of the deposit over bedrock. The overburden depth provided information to both the sand and gravel maps, and bedrock maps. For the sand and gravel maps, it helps estimate the depth of the sand and gravel resource. For the bedrock maps, it is the depth of overburden on top of the bedrock. In this case, thinner overburden would result in a higher value where quality bedrock for aggregate is present. This would require less material to be removed prior to rock extraction.

In 2000, the aggregate potential maps were based on mapping by P. Bobrowsky in 1998^{xxxviii}. Supply data under permit was gathered through a producer’s survey. The more recent projects have been mapped at a more refined scale than 2000 with a higher percentage of field checking.

A list of the mapping data available in 2000 compared to the mapping data available today is shown in Table 1.

Table 1 Comparison of Previous and Current Terrain Mapping Available

Item	2000 Aggregate Supply and Demand Study	2013 - Base for Mapping Update
Aggregate Mapping	P.T. Bobrowsky –(1:50,000) Level III - 308 field checks from Salmon Arm to Osoyoos	Sensitive Ecosystem Inventory (SEI) -RDCO Study (1:20,000) - 450 field checks SEI – Kelowna – (1:20,000) - 343 field checks SEI Lake Country – (1:20,000) - 282 field checks SEI – Joe Rich – 142 field checks (1:20,000) PEM – Dry Belt Okanagan TSA (1:20,000) ^{xxxix} Surficial Geology – Kelowna (1:50,000) ^{xl} Terrestrial Ecosystem Information (TEI) – compilation of the above data and others
Ministry of Energy and Mines – formerly Ministry of Energy Mines and Petroleum Resources (MEMPR) Mapping – Pits and Quarries	MEMPR - 1999	MEM – Current

Terrestrial Ecosystem Information

The Terrestrial Ecosystem Information (TEI) is an online warehouse of terrain, soils, ecosystem, wildlife habitat mapping and standards for BC. For this project, the TEI contained over 150,000 polygons within 10 project types and 49 separate projects (many of which overlapped each other).

Our geomorphologist reviewed the 49 projects, and selected 19 based on our mapping criteria. From these, a single layer of the TEI database was created covering the RDCO boundary. Our criteria for project selection included the following attributes:

- Scale (1:20,000 over most of District);
- Highest percent of field checking;
- Best coverage;
- Consistency of mapping methodology;
- Percentage of silt and clay; and
- Data with surface expression mapped (surficial material over bedrock).

The resulting projects chosen for the final database included the following:

- TEMSEI (4484, 4498, 4810, 4833, 4834, 247);
- TEM (50264);
- TSMDET (4559, 4563, 4564, 4567, 4570, 4572, 4575, 4688, 4692, 4694, 4695,=); and
- TBT (4741).

Once the base information was prepared, a set of rules were established to determine potential for natural sand and gravel deposits. The criteria included surficial material, thickness of deposit, permeability and drainage, and percentage of the material within the polygon (Appendix A1 and A2). The rules captured polygons with varying degrees of gravel and overburden potential and filtered the final database to create our potential mapping.

Sand and Gravel Volume Estimate – Borehole Data

To prepare the estimate based on borehole data, the Natural Sand and Gravel Potential with Constraints Map was cross-referenced with EBA Kelowna's database of geotechnical boreholes, as well as, the RDCO's water well database. Approximately 100 boreholes from each of the high, moderate, and low natural sand and gravel potential areas were analyzed to determine the average thickness of gravel and natural sand in each of the zones. The thickness of sand and gravel in each borehole analyzed was recorded and then the mean and standard deviation for the high, moderate, and low potential zones was determined. In order to provide a reasonable and conservative estimate of the gravel potential, the maximum thickness calculated is the mean value of the gravel thickness of the zone and the minimum estimated thickness is one standard deviation from the mean. The percentage was derived from the component of sand and gravel within each polygon assessed.

The variability in the overall minimum and maximum estimated volumes is a function of the potential variability in triangulation due to averaging potential thickness between the borehole points. We consider the values to be conservative in nature, but are confident in the results due to the accuracy of data and number of the boreholes used.

3.2 Bedrock

The evaluation of hard rock aggregate potential in the RDCO was completed as a desktop study that included a review of the bedrock geology of the area, overburden thickness, and assessment of the key parameters of high quality aggregate material for its intended purpose.

The investigation of bedrock aggregate potential described herein is preliminary due to the general nature of the base geological mapping, and the inherent variability of rock types with respect to their characteristics that make them suitable or unsuitable as an aggregate resource. The results presented in this study provide a base point for future investigation and collection of additional information, which will be required to support the classifications and to confirm aggregate potential.

Geologic Maps

Geology information of the RDCO was compiled utilizing the following digital map sources as noted in Table 2.

Table 2 Comparison of Previous and Current Bedrock Mapping

Item	2000 Aggregate Supply and Demand Study	Base for Mapping Update
Bedrock Mapping	D.J. Templeton – Kluit (1989) – 1:250,000 scale	Map 2005-4 Digital Geology Map of British Columbia: Title NM11 Southeast B.C. ^{xii} Map 2005-3 Digital Geology Map of British Columbia: Title NM10 Southwest B.C. ^{xiii}

Bedrock polygon data from the digital databases included information on rock type, formation name, tectonic unit, rock class, age information, and polygon area. In addition to bedrock polygons, regional scale faults and stratigraphic basins were also identified on the map.

The RDCO boundary encloses a cumulative area of 3,137 km² that is host to 22 distinct stratigraphic units. The units range in size from 0.1 km² to 100 km² and are variably distributed across the area. Bedrock geology for the RDCO is shown in Figure 4.

The stratigraphic unit code indicates the age, group suite, and rock code/rock type. For example the stratigraphic code MiPiCvb, can be broken into its individual components as 1) “MiPi” – Miocene to Pliocene age, 2) “C” – Chilcotin Group rocks defined as 3) “vb” – volcanic rocks.

The depth of surficial material from the TEI database was superimposed over the bedrock geology map to produce an Overburden Thickness Map (Figure 3). An analysis of overburden thickness is important when evaluating the associated stripping costs with sourcing a bedrock material.

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. In the absence of a field reconnaissance and sampling program, the interpretation of the rock types and their associated physical characteristics was based on a review of the available literature, survey responses, and government database information.

In order to interpret and assess the rock type, a summary of the Ministry of Mines Database File (MINFILE) database was completed on the eight dominant stratigraphic units encountered within the study area. The MINFILE database compiles information on geological showings, producers, and past producers for various types of commodities, including aggregate. The database was reviewed to determine typical rock types encountered within each mapped polygon, and relate that back to the stratigraphic unit as a whole.

This study also relied on discussions with local aggregate producers to characterize the aggregate currently being extracted for use in the RDCO. The discussions with local producers were primarily completed by way of a survey that was distributed to producers in the area.

Bedrock - Limitations and Assumptions

The information presented herein is based on a desktop study and is limited by the absence of field based classifications of rock type and quality. Conclusions presented have not been validated or verified against actual site conditions within the RDCO. The following limitations of the study have been identified:

- **Mapping Scale:** The bedrock geology information is based primarily on 1:250,000 scale mapping (with the exception of 1:50,000 mapping in the Lake Country Mapping Sheet). At this scale the bedrock geology polygons are expected to broadly represent discrete geologic units, but individual unit boundaries may vary significantly.
- **Rock Type:** Aggregate potential has been assigned based on the expected physical parameters of a given rock type. Local variations in mineralogy, structure, weathering, and alteration may all impact the suitability of a given rock type.
- **Unknown physical parameters:** The sulphide content, clay and mica mineralogy, and weathering were not evaluated in detail.
- **External Factors:** This section presents only the findings of the evaluation of bedrock geology and overburden thickness. Additional factors that will influence the suitability of a bedrock source are discussed elsewhere in this report. Specific factors have not been tied directly to the bedrock polygons.
- **Bedrock Thickness:** The physical thickness of bedrock material is unknown. Volumes of potential aggregate material have not been identified.

These limitations support the recommendations at the end of the document, which indicate the need for additional data collection and investigation.

It is noted that existing producers have located bedrock material suitable for aggregate use in areas that have not been defined as high potential herein. BURSCO Rock Products Ltd., for example, have identified granite and gneiss material for excavation in an area that is mapped as unit CPH (volcaniclastic rocks –

described here as low-moderate potential). This speaks to the limitations of mapping and basing classifications on findings of a strictly desktop based study.

3.3 Producer's Survey

A survey was prepared and circulated to producers with extraction permits within the RDCO. A list of producers was obtained from the MEM. The survey assessed current levels of production and supply under permit. A copy of the survey is included in Appendix B. Information was gathered on the following:

- Aggregate market use;
- Annual volume of sand and gravel;
- Annual volume of quarried rock;
- Annual volume of recycled aggregate;
- Aggregate composition;
- Percentage waste;
- Estimated reserve;
- Depth to and use of groundwater;
- Estimated remaining life of pit;
- Transportation routes; and
- Reclamation plans and future use of pit.

3.4 Recycled Aggregates

The methods for the recycled aggregates review was based on:

- Results from the producer's survey for recycled aggregate volumes and uses;
- Discussions with local producers regarding recycled aggregates;
- Discussions with local infrastructure personnel regarding recycled aggregate processes and use; and
- Literature review from other jurisdictions.

3.5 Demand

Demand figures were based on population information from Canada Census and BC Stats data, using consumption figures based on published literature and projected growth rates. The population growth rate in the Central Okanagan is expected to be 1.52% from now until 2036, according to BC Stats Data^{xliii}. 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 100 year projections, due to the uncertainty in predicting beyond 2036.

Consumption figures were based on published literature^{xliv} and RGS projected growth rates.

3.6 Permitting

The permitting review involved preparing a summary of the *Mines Act* permitting requirements and guidelines review. In addition, since 2000, legislation and regulations have been enacted that have the potential to impact aggregate extraction in some areas, and / or affect regional policy. This includes the Riparian Areas Regulation (RAR), which would apply to aggregate processing such as asphalt and concrete production, but not extraction, the *Species at Risk Act* (SARA), and the provincial *Greenhouse Gas Reduction Targets Act*. These may pose additional consideration with respect to aggregate production.

3.7 Land Use

From the RGS database, generalized land use data from each municipality and electoral area were superimposed over the natural sand and gravel potential maps. For the calculation of net potential area, the following land uses were assumed to be *not* available for a standard aggregate operation, and the aggregate potential in these locations was removed to create the Net Sand and Gravel Potential Map.

- Residential (Low, medium and high density, as applied by the RGS);
- Commercial;
- Institutional;
- Parks and Open Space; and
- First Nations.

Note that the removal of the above land uses from the net potential map does not necessarily preclude aggregate extraction. For example, where land has not been fully developed to its designated land use, removing aggregate prior to development may be an option. However, the mapping was a generalized exercise to assess lands that, in general were either not available for extraction or that had some restrictions relative to extraction based on land use.

The following land uses areas were maintained as potential aggregate sources within the Net Sand and Gravel Potential Map. Note that further limitations or additional permitting requirements may be required on these areas, depending on the current land use (e.g. within the ALR). The land uses remaining in the net potential map included:

- Agricultural;
- Industrial;
- Resort;
- Rural;
- Future Urban Reserve; and
- Rural Reserve.

A comparison of the previous land use data available in 2000 compared to what is available today is included in Table 3.

Table 3 Comparison of Previous and Current Land Use and ALR Mapping Available

Item	2000 Aggregate Supply and Demand Study	2013 – Base for Mapping Update
Land Use Mapping	Member Municipalities - 1999	Regional Growth Strategy (RGS) Generalized Land Use – Current
Agricultural Land Reserve Mapping	ALR mapping - 1999	ALR mapping – Current

3.8 Environmental

The environmental analysis involved a review of pertinent legislation, regulations, bylaws and permits that have potential to affect aggregate extraction. **Error! Reference source not found.** outlines current legislation and regulation, compared to what was in place in 2000. The analysis also involved a review of provincial Best Management Practices (BMPs), specific to aggregate planning, operations, and reclamation. The analysis was conducted within the context of federal guidelines, such as the *Land Development Guidelines for the Protection of Aquatic Habitat*^{xlv} and DFO's *Riparian Areas and Revegetation Operational Statement*.^{xlvi}

Table 4 New Environmental Legislation and Best Management Practices Since 2000

Legislation	Year 2000	Year 2011
Federal <i>Fisheries Act</i>	Yes	Yes
Provincial <i>Fish Protection Act</i>	Yes	Yes
Provincial Riparian Areas Regulation (RAR) (under the <i>Fish Protection Act</i>)	No	Yes (2004)
Federal <i>Species at Risk Act (SARA)</i>	No	Yes (2002)
<i>Drinking Water Protection Act</i> and Regulation	No	Yes (2001)
Ground Water Protection Regulation (under the <i>Water Act</i>)	No	Yes (2004)
Provincial <i>Wildlife Act</i>	Yes	Yes
Provincial <i>Water Act</i>	Yes	Yes
Provincial <i>Weed Control Act</i>	Yes	Yes
Best Management Practices		
Provincial Standards and Best Management Practices for Instream Works ^{xlvii}	No	Yes
Develop with Care 2012: Environmental Guidelines for Urban and Rural Land Development in British Columbia ^{xlviii}	No	Yes

Mapping involved producing a rare species map based on current Conservation Data Centre (CDC) occurrence records. The environmentally sensitive and hazardous areas map was prepared based on the RGS – Preliminary Constraint Areas, which has combined the environmentally sensitive and hazardous areas from each of the local governments and electoral areas in the RDCO. Table 5 outlines currently available rare species and environmental and hazardous areas mapping information, compared to what was in place in 2000.

Table 5 Comparison of Previous and Current Environmental Data Available

Item	2000 Aggregate Supply and Demand Study	2013 - Base for Mapping Update
Conservation Data Centre (CDC)	CDC – Occurrence Records – 2000	CDC – Occurrence Records – 2013
Development Permit (DP) Area Maps	DP Areas – Member Municipalities – 1999	RGS Preliminary Constraint Areas – incorporating environmentally sensitive and hazardous development permit areas from each local government and RDCO - Current

3.9 Groundwater

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. Documents reviewed include the following:

- An Aquifer Classification System for Ground Water Management in British Columbia^{xlix}
- BC Ground Water Protection Regulation (under the *Water Act*)^l
- BCGWA Ground Water Protection Handbook^{li}
- WLAP Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater^{lii}
- Regional Growth Strategy: Water Resources, Lakes and Streams Discussion Paper^{liii}
- UK Department of the Environment - Controlling the Environmental Effects of Recycled and Secondary Production Good Practice Guidance^{liv}
- OBWB – Groundwater Objectives 2 and 3 Basin Study^{lv}
- MOH – Sewerage System Standard Practice Manual, Version 2^{lvi}
- MEM – Guidelines for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia^{lvii}

The methods including assessing the applicability of the MOE classification system versus the Okanagan Basin Water Board (OBWB) classification system.

The two aquifer classification systems in the RDCO are:

- MOE system – established by the BC MOE to map and classify aquifers across BC based on a wide range of use, vulnerability, yield, physical and water quality parameters,^{lviii} and,
- OBWB system – developed for purposes of catchment-scale groundwater budgeting as part of a basin-scale water balance model incorporated in the Phase 2 Water Supply and Demand Study of the Okanagan Basin Water Board^{lix}.

The MOE system was developed in the 1990s; and currently includes hundreds of mapped aquifers in its inventory around the province (including all of the productive aquifers within the RDCO). This system classifies aquifers on the basis of their level of development (i.e., groundwater demand relative to aquifer productivity) and vulnerability (to contamination from surface sources), and provides ranking values for

aquifers using hydrogeologic and water use criteria. Rankings are used to show relative aquifer importance, based on a range of factors such as, productivity, size, vulnerability, demand, type of use, quality concerns (that have health risk implications), and quantity concerns.

The MOE system, as compared to the OBWB system, defines aquifers at scales down to tens of meters, which is an appropriate scale for evaluating site-specific aggregate operations. Given the scale advantages and systematic ranking system, we have adopted the existing BC MOE system of aquifer mapping and classification for this study (Figure 9). 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.

3.10 Greenhouse Gas

To complete the greenhouse gas (GHG) assessment, the GHGs of four types of aggregate were evaluated. They are:

- Natural sand and gravel;
- Quarried rock;
- Recycled asphalt; and
- Recycled concrete.

In addition, we developed a simple emissions calculator that can be used by prospective proponents to approximate the potential greenhouse gas emission from their proposed operation. The calculator uses published emission factors for the various processes and efficiencies of transport trucks. The user inputs are mass of aggregate in tonnes, and distance from aggregate source to mixing area. One or more combination of aggregates can be entered and calculated together. References and assumptions are made on the truck type, load mass per truck and vehicle fuel efficiency and references are provided.

3.11 Infrastructure Impacts

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

The performance of the asphalt pavement infrastructure is dependent upon:

- Quality of initial construction and surface drainage;

- Climatic conditions;
- Adequacy of the supporting embankment;
- Adequacy of the pavement structure;
- Type of vehicles; and
- Volume of traffic.

On the premise that the original pavements were initially designed and constructed to account for the factors listed above, increased traffic is the only variable attributed to the hauling of additional materials. Any significant increases in future traffic volumes may reduce the design life of the existing pavement structure. For this analysis, it has been assumed that the normal pavement maintenance practices were followed in the past and would continue to be followed throughout the service life of the pavement.

Considering that the variables needed to complete a detailed evaluation on a specific segment of road (existing structure, subgrade, traffic type, traffic volume, etc.) are unknown at this time, a generalised evaluation has been completed to evaluate the potential impact of additional traffic likely to be imposed as a result of aggregate hauling on different pavement structures.

3.12 Noise

The noise analysis involved a review of current regulations, standards, bylaws and literature. Recommendations are based on the *AO BMP Handbook, Volume II^x*, for noise reduction. The review and recommendations included:

- current occupational health and safety regulations and standards;
- the nature of noise and noise receptors;
- typical noise levels in the community;
- typical noise associated with aggregate operations;
- local noise bylaws; and
- recommendations for noise attenuation.

3.13 Dust

The dust analysis involved a review of current regulations, standards and literature. Recommendations are based on the *AO BMP Handbook, Volume II^{xi}*, for dust reduction. The review and recommendations included:

- the nature and content of dust;
- health concerns of dust;
- applicable standards and guidelines;
- impacts in the environment;

- crystalline silica;
- dust typical of aggregate operations;
- relative efficiency of various dust controls in aggregate operations; and
- recommendations for dust control.

3.14 Radon

The radon analysis involved a review of current regulations, impacts on health, and literature, and recommendations for testing. The review and recommendations included:

- applicable standards and guidelines;
- impacts on health; and
- Recommendations for testing.

3.15 Visual Impacts

The visual impact analysis involved a review of current provincial standards for analysis, impact reduction standards, and recommendations. We reviewed provincial standards for visual impact assessments, including those used by the *Visual Impact Assessment Guidebook*^{lxii}. Recommendations are based on the *AO BMP Handbook, Volume II*^{lxiii} and the *Manual of Aesthetic Design Practice*^{lxiv}. The review and recommendations included:

- Provincial standards for visual impact assessments;
- Visual impact mitigation techniques; and
- Recommendations for visual impact assessments and mitigation.

3.16 Site Suitability Assessment

The Site Suitability Assessment was prepared based on the integration of current standards, inventories and regional land use and permitting areas. A review of local government policy was conducted to ensure consistency. The policies reviewed are shown in Table 6, below.

Table 6 Local Policy Review

Jurisdiction	Policy
City of Kelowna	Official Community Plan 2030, Bylaw 10500
	Zoning Bylaw 8000
	Development Application Procedures Bylaw 10564
	Soil Removal and Deposit Regulation Bylaw No. 9612
District of West Kelowna	District of Westside Official Community Plan, Bylaw No. 0100
	Soil Removal and Deposit Bylaw 2011 No. 0127
District of Lake Country	Official Community Plan (2010-2030) Bylaw 750
	Zoning Bylaw

Table 6 Local Policy Review

Jurisdiction	Policy
	Development Application Procedures Bylaw 99-240
	District of Lake Country Soil Removal and Deposit Bylaw 95-015 includes Bylaw 335
District of Peachland	Official Community Plan
	District of Peachland Earthwork Control Bylaw Number 832, 1982
Regional District of the Central Okanagan	Development Application Procedures Bylaw 944
	Zoning Bylaw # 871
	Brent Road & Trepanier Official Community Plan, Bylaw No. 1303
	Ellison Official Community Plan, Bylaw 1124
	Rural Westside Official Community Plan Bylaw No. 1274
	South Slopes Official Community Plan bylaw No. 1304, 2012
	Joe Rich Rural Land Use Bylaw No. 1195
	Regional Growth Strategy Economic Development Discussion Paper

The SSA incorporated considerations of:

- Land use;
- Environmentally Sensitive Development Permit Areas;
- Hazardous Development Permit Areas;
- Provincial Aquifer Mapping;
- Visual Sensitivity, using provincial standards and BMPs;
- Adjacency for dust and noise;
- Roads and traffic;
- Greenhouse gas; and
- Mitigation and reclamation plans.

4.0 SUPPLY

In general, aggregate used in our local community is derived from three main supply sources:

- Natural sand and gravel – deposited by glacial or modern rivers and streams;
- Bedrock – typically blasted and crushed to a usable size;
- Recycled aggregate – from concrete, asphalt paving, and asphalt shingles.

Each of these sources has been reviewed for this study. We have prepared aggregate potential mapping for sand and gravel, as well as bedrock, for the RDCO. In addition, local producers have provided information on 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.

5.0 NATURAL SAND AND GRAVEL

5.1 Sand and Gravel Origins

The term 'natural aggregate' is used for those sand and gravel deposits that were deposited by geologic processes and occur in the landscape. Sand and gravel is deposited through the process of water erosion and, to a lesser extent, deposition by gravity. This process takes tens of thousands of years. Most of the gravel in the valley is a result of glacial outwash from the last ice age.

The force of modern and glacial rivers move boulders, gravels, sands and silts from the hills into the valleys below. Rocks that are carried by water into streams are split and rounded as they move down the channel, producing particles of different shape and size. The particles are laid down based on the slope. Therefore, the velocity of the stream determines what size of particle is deposited. Boulders and cobbles are deposited higher in the watershed, where the stream has great velocity and power. Sands and gravels are deposited further down in the watershed where the stream has a moderate velocity. Silts and fine sands are deposited even lower in the watershed, at the delta, where the stream is slow and meandering. Clays are waterborne until the water is very still. Therefore, clay deposits occur at the bottom of modern lakes, or in locations where glacial lakes once stood.

Sand and gravel deposits that are suitable for aggregate are found in specific locations in the landscape. These include terraces and fans that have been laid down by glacial rivers, terraces of modern (post-glacial) rivers, the riverbeds of modern rivers or streams, and deltas of modern streams that reach out into lakes. The understanding of how water moves rock and sand has provided the basis of the terrain mapping used in this project. Appendix C contains an overview of surficial materials in the landscape.

5.2 Sand and Gravel Mapping

The integration of 49 terrain databases resulted in over 29,000 polygons throughout the District that were assessed for sand and gravel quantity and quality. The assessment looked at landform, surficial material, drainage, depth of deposit, and percentage of silt and clay. Thick glacial till deposits were also considered a potential source of aggregate, as these deposits also have sand and gravel. The resulting criteria for high, moderate, low, till and nil potential areas is outlined below and Figure 2.

High Potential Areas

- Thick (>5 m), clean, well-drained glacial or modern river deposits.

Moderate Potential Areas

- Glacial or modern river deposits that may be thin have high silt content and/or be moderately drained.

Low Potential Areas

- Imperfectly drained glacial and modern river deposits.

Till

- Thick (>5 m) glacial till deposits.

Nil

- All remaining areas (glacial lake sediments (silt / clay), organic, bedrock).

Net Sand and Gravel Potential

While the area of the various aggregate potential polygons tell us how much the gross area is, it does not tell us how much has been sterilized to date through existing development. To calculate potential areas net of existing development, using the RGS Generalized Land Use database, we removed the following land uses:

- Residential (High, Medium and Low Density);
- Commercial;
- Institutional;
- Parks and Open Spaces; and
- First Nations Lands.

The resulting overall areas for sand and gravel, and those net of those sterilized by development or in parks, is shown in Figure 8 and Table 7.

Table 7 Sand and Gravel Potential Areas

Sand and Gravel Potential	Gross Area* in RDCO	Net Area* in RDCO
High	140	112
Moderate	197	129
Low	202	155
Till	85	73
No Potential	2386	1994

*Area in square kilometres

The sand and gravel potential gross area, by jurisdiction in the RDCO, is shown in Table 8 and in Figure A.

Table 8 Gross Sand and Gravel Aggregate Potential Areas – within the RDCO Area

RDCO Jurisdiction	High	Moderate	Low	Till
Kelowna	30.8	64.3	31.4	6.3
Lake Country	12.1	15.1	10.2	8.4
Peachland	6.3	0.9	2.1	0.1
RDCO East	37.3	44.6	51.2	54.3
RDCO West	42.8	40.7	95.9	7.9
West Kelowna	8.8	25.1	9.5	6.4

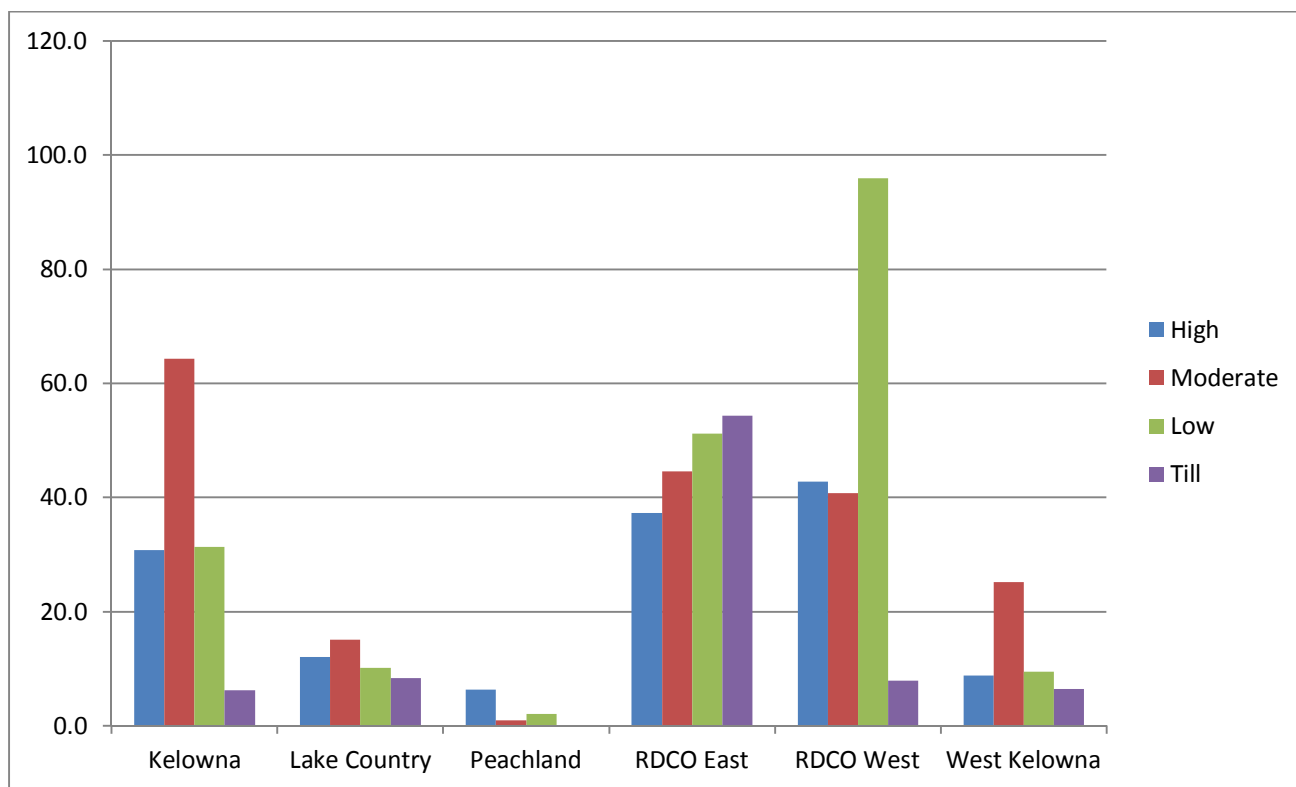


Figure A Gross Potential of Sand and Gravel in RDCO by Area

The sand and gravel potential area, net of constraints, by jurisdiction, is shown in Table 9 and in Figure B.

Table 9 Sand and Gravel Aggregate Potential Areas Net of Constraints – within the RDCO Area

RDCO Jurisdiction	High	Moderate	Low	Till
Kelowna	23.8	28.2	11.1	4.7
Lake Country	8.5	9.4	7.4	7.7
Peachland	2.4	0.6	0.6	0.1
RDCO East Electoral Areas	34.9	38.7	45.3	48.8
RDCO West Electoral Areas	36.1	31.6	88.2	6.8
West Kelowna	6.1	15.7	6.6	5.1

* Area in square kilometres

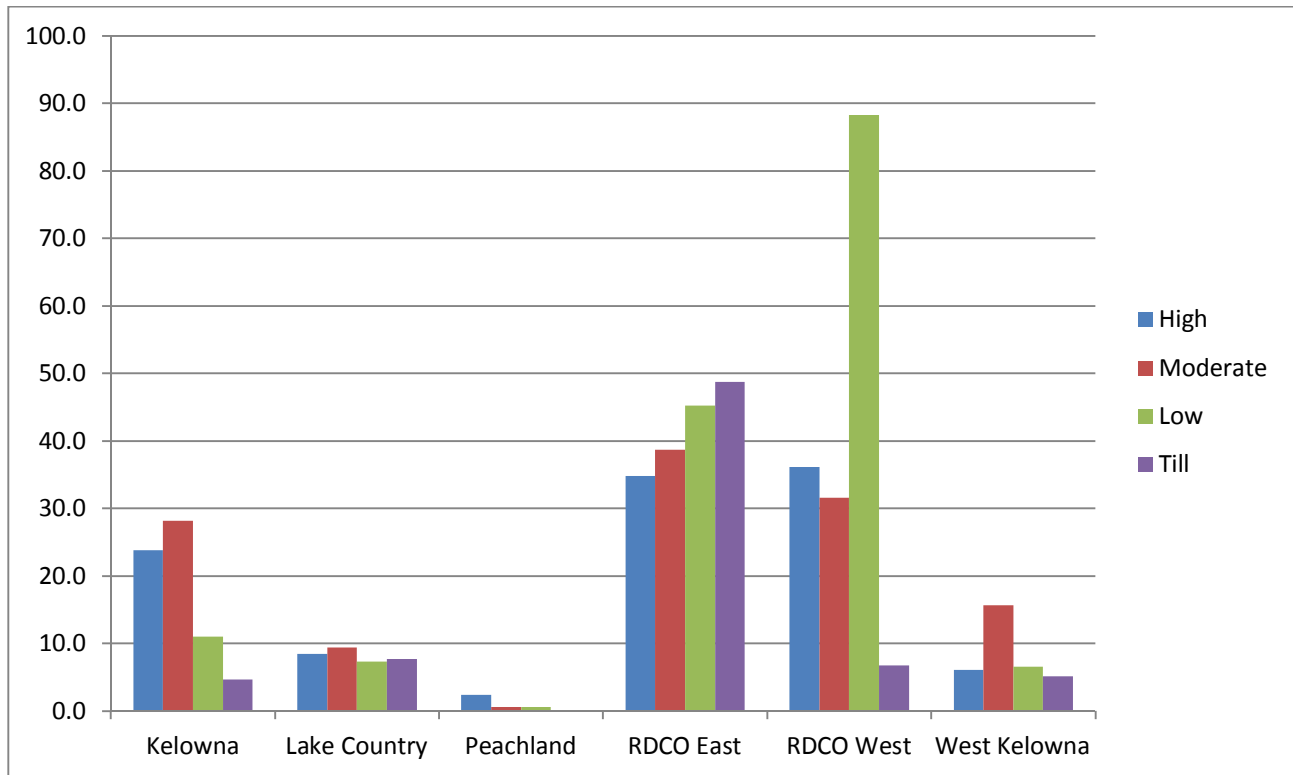


Figure B Sand and Gravel Aggregate Potential Areas Net of Constraints

5.3 Sand and Gravel – Volumes by Borehole and Water Well Data

Using provincial well data and borehole data from internal files, we assessed the depth of sand and gravel at over 100 sites throughout the District. Using this approach, we found the gravel supply in the District ranges from a minimum of 732,629,489 metric tonnes to 2,481,866,081 metric tonnes. This is including the estimated sum of all high, moderate and low supplies of natural sand and gravel outside residential, commercial, institutional land uses, as well as parks and First Nations Lands. Many of the thickest deposits are located in the southwest quadrant of the RDCO. Table 10 outlines the results.

Table 10 Sand & Gravel Quantities based on Borehole Data

Gravel Rule #	Area (km ²)	Volume Estimated (m ³)		Tonnage (tonne)*	
		Min	Max	Min	Max
High	111	309,860,000	950,830,000	526,760,000	1,616,420,000
Moderate	129	110,270,000	308,200,000	187,450,000	523,930,000
Low	155	10,830,000	200,890,000	18,420,000	341,520,000
Totals	395	430,960,000	1,459,920,000	732,630,000	2,481,870,000

*Based on unit weight conversion of 1.7 tonnes / m³

6.0 BEDROCK

Bedrock sources represent an important component of the overall supply balance of aggregate material available in the RDCO. As surficial deposits are exhausted or become more difficult to locate, the importance of identifying suitable bedrock sources will become more apparent.

The feasibility of sourcing aggregate material from bedrock sources depends on many factors, including the physical characteristics of the rock, ease of access, transport distance, and environmental impacts. Although some of these factors are also of importance in sourcing aggregate from surficial sand and gravel deposits, there are unique differences between the two.

The classification of hard rock aggregate potential for this study was based on two key parameters, rock type and overburden thickness. The evaluation of rock type also includes a consideration for estimated degree of fracturing, weathering, porosity, alteration and mineralization based on known rock type and geologic setting. Additional factors influencing the development of aggregate sources are discussed in other sections of this report.

6.1 Physical Characteristics of Bedrock Sources of Aggregate

Aggregate material has a multitude of end uses, including road construction, concrete and asphalt production, structural fill, and landscaping stone. The physical characteristics that define a suitable aggregate source will vary greatly with the end use of the product. The generalized criteria considered for this study include the following:

- Massive to thickly bedded with low porosity and permeability:
 - Contributes to mechanical rock strength. A rock with high porosity and permeability is subject to water infiltration that leads to freeze-thaw cycles that expand cracks in the rock and perpetuate fracturing.
- Grain size:
 - Grain size can be correlated to mechanical strength of an aggregate material. The important factor is the amount of surface area available for bonding between grains.
- High intact rock strength and resistant to fracturing.
- Low sulphide content (<1%):
 - Sulphides, if present, can react with water to produce sulphuric acid, a phenomenon commonly referred to as acid rock drainage (ARD). This is considered an environmental issue.
- Fresh – lacks significant weathering and alteration:
 - Pervasive alteration and weathering may lead to mechanical weakening of the aggregate, and affect the visual characteristics of the material. Alteration may introduce unwanted mineralization or rock texture.
- Undeformed – lacks structure, shearing, micro fracturing, cleavage, etc.

- Deformed rock units may contain planes of weakness in the aggregate clasts, reducing the compressional strength of the material, and making them more susceptible to mechanical failure. Additionally, fractures may act as conduits for water infiltration that lead to freeze-thaw cycles that expand and perpetuate fracturing.
- Low amounts of platy minerals (i.e. clays and micas):
 - Platy minerals may contribute to planes of weakness. Soft clays and micas may also influence the abrasion resistance of the material.
- Low alkali-aggregate reactivity (in concrete applications):
 - Exposure of concrete to moisture causes reaction rims to form around the reactive aggregate particles, creating pressure and cracking the concrete.
- This is not a definitive list, as individual product end uses will inform specific physical requirements of the material. Material specifications must suit the end use for the product. Construction applications will typically have the most stringent material quality specifications.

6.2 Bedrock Mapping – Results

A summary of the geologic units identified in the RDCO, and estimated overburden thickness in the area, is presented below.

Bedrock described as intrusive rocks, unsubdivided volcanic rocks and high grade metamorphic units were classified as high potential. They are thought to exhibit the favourable physical characteristics for aggregate use as described above. The moderate potential category includes volcanoclastic and low to medium grade metamorphic rocks. The low potential category was reserved for unsubdivided sedimentary rocks, including shale, mudstone, and siltstone. The aggregate potential based on rock type is presented Figure 5.

Bedrock material classified in the moderate or low potential category would be expected to have less favourable physical characteristics, including lower intact rock strength, higher porosity and permeability, and a greater propensity for well-developed structure.

6.3 Distribution of Stratigraphic Units

The 22 stratigraphic units identified within the RDCO boundary represent a range of bedrock types with various ages, metamorphic histories and rock types. The distribution of lithologies can roughly be divided into four quadrants, separated by a dominant fault system that runs through the center of the area parallel to Okanagan Lake (Figure 4).

The southeast quadrant area is dominated by the stratigraphic unit PrPzShm, defined as unsubdivided metamorphic rocks of the Shuswap Assemblage, which is dominantly composed of schists and orthogneiss.

The northeast quadrant is dominated by two stratigraphic units, PrPzog, defined as unnamed orthogneiss metamorphic rocks and MiViCvb described as Chilcotin group non-marine plateau basalts.

The southwest quadrant is defined by overlapping sedimentary and volcanic sequences intermixed with igneous intrusions. The dominant stratigraphic units here are EPeMK, described as alkalic and calc-alkalic volcanics, and LTrJgd, defined as unnamed granodioritic intrusive rocks.

The northwest quadrant is dominated by two stratigraphic units, MJgd, defined as unnamed granodioritic intrusive rocks and EPev, defined as undivided volcanic rocks of the Penticton Group.

Refer to Appendix D-1 for a description of stratigraphic units and Appendix D-2 for corresponding aggregate potential.

6.4 Favourable Rock Types for Aggregate Use

The following seven rock types were identified as having the greatest potential for aggregate use based on estimated and assumed physical characteristics that fit the criteria established for this study.

Unit MJgd This unit is concentrated in the northwest quadrant of the RDCO. It is described as unnamed granodioritic intrusive rocks (granodiorite quartz diorite, diorite, and quartz monzonite). In some areas, the MINFILE database notes that the intrusive rocks are cut by Tertiary dikes related to an overlying section of Eocene Penticton Group volcanic rocks. The volcanic dikes are of lower potential.

Unit LTrJgd This unit is concentrated in the southwestern most corner of the RDCO boundary. It is described similarly as unnamed granodioritic intrusive rocks (granodiorite, quartz diorite, quartz monzonite, diorite and gabbro).

Unit MJOgd This unit occurs along fault boundaries in the southwestern quadrant, and is described as granodiorite intrusive rocks associated with the Mesozoic aged Okanagan Batholith.

Unit MJgr This unit occurs as in three polygons through the south-central portion of the RDCO boundary. It is described as unnamed granite and alkali feldspar granite intrusive rocks.

Unit KOL This unit occurs as discrete intrusions, including the Ladybird and Valhalla interiors composed of granite and granodiorite rock types.

Unit Egr This unit occurs in the north central portion of the RDCO boundary and is partially overlain by Lake Okanagan. It is described as unnamed granite and alkali feldspar granite intrusive rocks.

Unit ECsy This unit occurs as three small discrete intrusions in the southwestern quadrant. It is described as the Coryell plutonic suite of syenitic to monzonitic intrusive rocks.

These units, as granitic intrusive rocks, are expected to exhibit a massive texture, with medium-coarse grain size, and high mechanical rock strength. It is assumed that they are thickly bedded, with low permeability and porosity. Bedrock types are shown in Figure 4.

6.5 Overburden Thickness

The surficial geology information was overlain by the following five overburden thickness categories: 1 - Bedrock (No Overburden); 2 - Thin Overburden (0-1 m); 3 - Blanket Overburden over Bedrock or Talus Slopes (1 – 4 m); 4 – Talus Slope; and 5 – Thick Overburden (>4 m).

For the purpose of this study, bedrock sources were deemed as having high potential where the overburden cover is less than 1 m thick. Depending on the quantity and quality of bedrock material, a deposit could potentially be a viable target with a thicker overburden cover.

A thick overburden cover is noted through the central zone to the east of the Okanagan Lake. Bedrock exposures are rare in these areas and typically concentrated to the west of Okanagan Lake. The area along the eastern edge of the lake is dominated by a thick Quaternary alluvium and cover.

The eastern extent of the RDCO boundary is dominated by thin overburden or talus slopes with a thickness of between 1-4 m. Overburden is thickest along river and stream channels that branch away eastward from Okanagan Lake. Note that there was no surficial depth data available for the northwest quadrant of the study area (TFL 49). The overburden thickness is shown in Figure 3.

6.6 Bedrock Sources

Based on the two criteria, rock type and overburden thickness, established for this study, multiple bedrock sources have been identified for further investigation and consideration as aggregate material. The greatest potential has been identified to the west of Okanagan Lake, in the area identified as the southwestern quadrant. The combination of predominant intrusive rocks and thin overburden, including sporadic bedrock outcrops, make this the highest potential area. The best starting point in this area would be adjacent to existing producers and in the areas of existing infrastructure. For the Bedrock Potential Map, see Figure 5.

7.0 PRODUCER'S SURVEYS

The local producers were surveyed, and provided a snapshot of current supply under permit, as well as aggregate composition, end use, transportation routes and cost. Refer to Appendix B for a copy of the survey sent to producers.

7.1 Producer's Survey – Results

There are 59 gravel pits and quarries on the current MEM list for the District. We contacted as many producers that could be reached through the phone numbers provided by the MEM. An information meeting for producers was held in February 2013. Information on the study was sent by e-mail to those who provided e-mail addresses. Of 59 aggregate and rock quarry operations in the RDCO, 28 operations submitted survey responses. In addition, it was found that 7 operations were either exhausted and/or had transitioned into other uses. The producer response rate is outlined in Table 11.

Table 11 Producer Survey Response

Response	# Operations
Survey Responses Received	28
Permits with exhausted pits and/or have transitioned to other uses	7
Surveys sent but not received	10
No response and / or not able to contact	10
Chose not to respond	4

Table 11 Producer Survey Response

Response	# Operations
Total	59

It is estimated that, in terms of volume, the survey respondents represent approximately 75 percent of typical annual production in the RDCO.

Based on the survey, the annual average production of sand and gravel, quarried rock and recycling sources is noted in Table 12.

Table 12 Annual Production and Supply under Permit*

	Sand & Gravel	Quarried Rock	Recycled Asphalt	Recycled Concrete
Average Annual Production (based on 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

The majority of sand and gravel is used for roads and infrastructure, which includes both new road construction and asphalt production. A portion of the concrete production would be included in roads and infrastructure as well, for curbing, sidewalks, and medians. Based on the surveys, the estimated percentages of different uses for sand and gravel are shown in Table 13.

Table 13 Sand and Gravel – Estimated Ratio of Use

Item	%
Roads (Construction and Maintenance)	30%
Concrete (incl. mortar sand)	25%
Asphalt	17%
Structural Fill	16%
Landscaping	6%
Other Uses	6%

The majority of quarried rock is also used for roads and infrastructure. A portion of the concrete production would be included in roads and infrastructure as well, for curbing, sidewalks, and medians. Dimension stone, rip-rap and decorator rock together account for approximately 23% of quarried rock. The estimated ratio of different products for quarried rock is shown in Table 14.

Table 14 Quarried Rock – Estimated Ratio of Use

Item	%
Road Fill Aggregate	20%
Decorator Rock** (e.g. shale, granite)	12%
Rip Rap	6%
Dimension Stone**	5%
Other (primarily concrete and asphalt production)	54%
Waste	2%

*Based on 2013 Producer's survey

** Decorator rock and dimension stone are not considered 'construction materials' and require a permit under the *Mineral Tenure Act*

Based on the surveys, the existing sand and gravel operations are located within “clean” deposits, with very little silt component. In fact, most operators do not operate a wash plant. Their product only needs to be screened, and sometimes crushed, to meet specification. There is also generally very little overburden, typically less than 2 metres, with most operators reporting less than 1 metre of overburden. This results in low rates of waste or unusable material. There were no reports of acid rock drainage issues in any of the responses.

The producers reported on typical hauling distance and area of service. For road aggregate, concrete and asphalt production, the hauling typically ranged from 0 to 70 km. The farthest destination for these products was Penticton, from Westside producers. From Lake Country and Kelowna producers, Vernon was the typical limit of area of service for road aggregate, concrete and asphalt. The distance was farther for specialty products such as decorator rock and masonry sand. These are being hauled to points in BC Interior and as far as Northern Alberta. Hauling distances and extents are noted in Table 15. One producer noted that they were trucking in specific products from other areas for specialty products. For example, pea gravel is being brought in from the Lumby area, for use in exposed aggregate concrete driveways.

Table 15 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

Reclamation plans for the pits varied based on future land use. Some sites will be zoned industrial, others agricultural, residential or returned to forest use. Some sites had progressive reclamation and hydro-seeding as a condition to their reclamation plans.

Producers Concerns

From the producer’s surveys, some of their suggestions include:

- Promote recycling through local or MMCD specifications changes, allowing more in road base and structural fill.
- Educate the public in CO2 emissions related to haul distances.
- Focus on monitoring unlicensed gravel operations.
- Focus on gravel supplies closest. The costs rise sharply with a longer haul and the more wear and tear on the road.

From the producer’s surveys, some of their concerns include:

- Pits are not allowed due to a vocal minority, even though potential impacts can be mitigated.
- Competition with municipalities for aggregate sales.

- Bureaucracy makes it difficult to operate.

8.0 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. In fact, recycled pozzulanic materials including fly ash and silica fume are added into concrete to improve its structural and chemical properties. Here, however, we will focus on recycled asphalt and concrete, as these are the predominant sources of recycled aggregate in the RDCO. This section outlines various uses of these products, sources, specifications, and policies. It is concluded with a review of the use of recycled aggregates in other parts of Canada and abroad.

8.1 Utilization of Recycled Aggregate

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%^{lxv} (for highways in 2006)
- England (UK) – 28%^{lxvi}

While this appears to be a significant variation in recovery rates, the recycling rates need to be reviewed in context. For example, the average annual consumption rate for England is 4 tonnes per capita. Therefore, approximately 1 tonne per capita comes from a recycled source. In addition, the UK growth rate was 0.5% over this time period, whereas the RDCO growth rate was approximately 1.8%^{lxvii}. For the RDCO, as a growing community, we have a consumption rate between 10 and 12 tonnes per capita. Our recovery rate per capita is therefore between 0.78 and 0.94 tonnes per capita, based on a 7.8% recovery rate.

Other factors also come into play regarding recycling rates. Highways work undertakes more kilometres of paving per year than a municipality. For this reason, the project scale for hot-in-place asphalt recycling is more economically viable for MOTI than the roads work in municipalities. These are considerations in an overall review of aggregate recycling and recovery.

8.2 Recycled Aggregate Concrete

This section outlines uses of recycled concrete aggregate (RCA). RCA is produced by the re-processing of waste concrete. Typically waste concrete is broken up into pieces that can be managed by the crushing equipment. Large magnets remove metal (e.g. rebar) from the concrete. The concrete is then put through a jaw crusher and then a cone crusher to break it down into a usable size. Recycled concrete typically has a higher percentage of fines than natural aggregate. These can be screened out and used as fillers for other applications. Uses of RCA include granular base course and sub-base course for roads, non-structural embankment fill, as a surfacing for unpaved roads or parking lots, and non-structural Portland cement

concrete. The RCA used for Portland cement concrete must meet chemical composition, strength and durability requirements. This can be difficult to assess if the parent material (i.e. source of demolished concrete) is unknown. Therefore, this discussion focuses on fill applications for which RCA is better suited.



Photo 2 Recycled Concrete Aggregate (RCA)

8.3 Non-Structural Portland Cement Concrete

RCA may be used for non-structural Portland cement concrete where strength and durability specifications are less stringent than for structural applications. Examples include controlled low strength materials for trench back fill, lean concrete mud slabs, concrete anchor blocks and no-post barriers.

8.4 Granular Base and Sub-Base Course for Roadways

Recycled aggregates, both RCA and reclaimed asphalt concrete (RAP) are both well suited to use as granular base and sub-base course for roadways. Due to the high angularity and interlock (particularly RCA), they tend to be very stable and have qualities that can outperform natural aggregate in certain applications. They are, in some applications, superior to natural aggregate^{lxviii}. Where the sub-grade soils are very soft, for example, recycled aggregates are used to add stability. RCA and RAP can be used together in base and sub-base course layers. It is typically not used in areas of high groundwater because of potential sulphate attack.

The City of Edmonton (which requires 100% recycling of concrete and asphalt removed from roadways during maintenance or rehabilitation) has used a mix of RCA and RAP as a base course with success^{lxix}. The

RAP (typically asphalt millings) is added to improve the grading of the recycled aggregate for improved compatibility.

8.5 Subgrade Fill

Recycled aggregates have potential to be used for fill where subgrades need replacement, such as in soft soils. This is being done in the RDCO when specified as acceptable by the project engineer.

8.6 Non-structural Embankment Fill

RCA can be used where non-structural embankment fill is required. Typically, regular fill is less expensive and therefore used. However, in some cases where greater stability is required, RCA may be used for this quality and it is easier to compact than natural fill.

8.7 Topping for Unpaved Roads, Parking Lots and Road Shoulders

Both RCA and RAP can be used as a topping for unpaved roads and parking lots. The fines within the RCA tend to compact with pressure and moisture over time, to create a surface that is less dust prone than gravel surfacing alone.

Similarly, RAP can be used as an unpaved road and parking lot topping. With hot weather compaction and traffic, the bitumen softens and tends to bind the product, producing a less expensive topping solution than asphalt. This can be a cost-effective solution for low volume roads, driveways or parking lots that would not otherwise have a topping. RAP is used locally in the RDCO for topping on road shoulders and back lanes.

8.8 Recycled Asphalt

Recycled asphalt results in millings or reclaimed asphalt concrete pavement (RAP). Millings are produced when only the top of the asphalt layer (25 – 50 mm)^{lxx} are removed from the roadway. RAP is produced by removing the entire bound asphalt layer, which results in a portion of the loose granular base course included in the product. Millings have a high bitumen content, and RAP is more granular.

As discussed above, RAP is well suited for use in base and sub-base course applications. Both RAP and millings can be used as topping for unpaved roads, parking lots, lanes and road shoulders. In addition, both RAP and millings can be recycled immediately in Hot In-Place recycling operations, or mixed into a new asphalt mix in the plant. These products and applications are discussed in greater detail below.



Photo 3 Recycled Asphalt Pavement (RAP)

8.9 Reclaimed Asphalt Pavement (RAP)

RAP is the removal of the entire asphalt paving course. Typically, some of the gravel sub-base attaches to it as it are removed from the road, resulting in a more granular product than millings. Potential uses for RAP include:

- Re-crush into a 1 1/8" minus for base screening;
- Place as a topping for shoulders, driveways and lanes;
- Add in a rejuvenating chemical to use recycled asphalt in older asphalt plants; and
- Reintegrate the RAP into new asphalt mixes.

The benefit of using RAP in new asphalt mixes is that both the binder (bitumen) and the aggregate can be recycled efficiently^{lxxi}. The MMCD specifies that 20% of the asphalt mix may be RAP without a special mix design. Acceptance varies between jurisdictions, with some allowing 50% RAP or more. In Europe, there is a higher acceptance and utilization of RAP. A Swiss double drum hot mix plant is being used in the Netherlands, which enables a portion of 70% RAP to be used in the asphalt mix.^{lxxii}

Current uses of RAP in the District include as a topping for road shoulders, lanes, driveways and parking lots that would otherwise not have a topping surface.

8.10 Asphalt – Millings

The term ‘millings’ is typically referred to the pieces of asphalt that are recovered when only the top surface of the asphalt pavement is ground, such that the base sand and gravel are not caught up in the product. Millings therefore, have a higher bitumen content than RAP, and they are more consistent in particle size, making them a valuable addition to a new asphalt mix. The bitumen content is approximately 5%, which helps offset the cost of bitumen in the new asphalt mix.^{lxxiii}

8.11 Asphalt – Hot-in-Place

Hot-in-Place asphalt placement involves stripping the top layer of existing asphalt, adding additional bitumen and rejuvenators, and then replacing the new hot asphalt mix in situ, all in one process. It requires a series of specialized equipment. It is more commonly done on highways, which can achieve an economy of scale due to the volume of kilometers done on a project.

8.12 Asphalt – Shingles

Asphalt shingles can be added to an asphalt paving mix. They are typically about 18% oil, which makes them a valuable addition to the mix. Oil is the most expensive component in asphalt, currently at \$740 per tonne^{lxxiv}. Considering this, the value of the oil in shingles, if added into a new asphalt mix, is approximately \$150/tonne.

8.13 Winter Sand Recycling

Sand used on the roads in winter presents another possible aggregate for recycling. The City of Edmonton and the Edmonton Waste Management Centre of Excellence conducted a two year trial project to assess the potential of recycling this sand. During the trial, the City was able to recover and recycle almost 90,000 tonnes of the 140,000 tonnes of sand used in the City over the two year period.^{lxxv}

8.14 Local Asphalt and Concrete Recycling

Currently within the RDCO, concrete and asphalt are subject to mandatory recycling^{lxxvi}. There is currently a tipping limit for both concrete and asphalt at the City of Kelowna Landfill of 1 tonne, with a \$25/tonne fee. It can also be delivered, or picked up, for recycling, at several aggregate pits, where it will be recycled into a number of different products for reuse. The tipping fee for asphalt is approximately \$40 per truck. For concrete, it is approximately \$100 per tandem truck.

8.15 Specifications for Recycled Asphalt and Concrete

Specifications for recycled asphalt and concrete products vary between jurisdictions and agencies. In BC, most municipal projects use the Master Municipal Construction Documents (MMCD). MOTI follow the Standard Specifications for Highway Construction^{lxxvii}. These specifications as they relate to recycled aggregates are outlined below.

8.16 Master Municipal Construction Documents

Master Municipal Contract Documents is a set of Master Municipal Specifications typically used in municipal contracts within British Columbia, and is published by the Master Municipal Contract Documents Association (MMCD).

MMCD – Recycled Concrete Aggregate

The MMCD states that recycled aggregate material may be used if it meets all the conditions of the specification, and if approved by the Contract Administrator. Specifications are noted below.

- Clean recycled concrete may be used as pipe bedding sand.^{lxxviii}
- Recycled crushed Portland concrete may be used as aggregate, (for example in base and sub-base applications) if approved by the Contract Administrator. Other recycled materials including asphaltic pavements are identified as *not* acceptable.^{lxxix}

The MMCD does not have specifications for the inclusion of RCA in Portland concrete mixes.

MMCD – Asphalt

The MMCD states that hot-mix asphalt concrete paving may contain up to 20% of RAP without a special mix design. Higher percentages must be approved by the Contract Administrator if the mix is demonstrated to meet the specification requirements.^{lxxx} For Superpave hot-mix asphalt, the MMCD specifies asphalt binders based on the percentage of RAP used in the mix.

The MMCD does not allow RAP in a granular aggregate (e.g., for use in base or sub-base).

MMCD – Full Depth Reclamation

The MMCD has specifications for full depth reclamation of an existing road structure. This process involves removing and crushing the full depth of flexible pavement portion of a road and a pre-determined depth of base material. The resulting aggregate is then incorporated into a base or sub-base course. Liquid additives may be added for stabilization.^{lxxxii}

8.17 Ministry of Transportation and Infrastructure

The MOTI has a specification for Hot-in-Place recycled asphalt pavement. Hot-in-Place asphalt recycling is the process by which the existing asphalt structure is pulled up, reprocessed, remixed with additional aggregate and rejuvenating additives as required, and laid back down in place, all in one process. The specification is a performance based specification, where the contractor is responsible for attaining the quality control of the product and the Ministry undertakes quality assurance.

The MOTI has currently has no specifications regarding the use of recycled concrete for sub-base and base course aggregates.^{lxxxii}

8.18 Recycled Aggregates and Sustainability

Recycling aggregate products can significantly contribute to the environmental sustainability of any one project, or the region in general. It offsets landfill requirements, reduces the environmental impacts of taking natural material from the landscape, and reduces the carbon emissions resulting from the production of concrete and asphalt and their additives, including cement and bitumen.

8.19 Recycled Aggregates and LEED

Leadership in Energy and Environmental Design (LEED®) is a green building certification program that uses a rating system based on environmentally sustainable building techniques. Recycling waste contributes to LEED® credits. Recycling concrete in the demolition process, due to its weight, is an efficient way to gain LEED® points. Credits are achieved also by using recycled products in the project. This is also measured by a weight calculation. The use of recycled concrete in a parking lot sub-base, for example, would result in LEED® credits. Similarly, the use of millings or RAP in the asphalt paving would result in LEED® credits. Additives such as fly ash or silica fume in concrete are considered pre-consumer waste and qualify as well.

Recycling and recycled aggregates have been used locally to achieve LEED® benchmarks. For example, Interior Health aims to achieve LEED® Gold status for the Interior Heart and Surgical Centre (IHSC). The project involves the demolition of the Pandosy Building, which is being carefully deconstructed such that many materials, including concrete, can be recycled. Concrete and rebar were sorted on site and removed for recycling. Approximately 8900 tonnes of concrete were recycled from the demolition. The concrete will be recycled into aggregate to produce new concrete. Reduction in carbon emissions are realized by the reduction of cement, virgin aggregate, and the resulting emissions from their mining, production and transportation.^{lxxxiii}

8.20 Recycled Aggregates in other Jurisdictions and Abroad

The use, policies and specifications of recycled aggregate products vary widely between jurisdictions and countries. In locations where natural aggregate sources are scarce, costs are higher. This is motivation for the development of policies and standards, which encourage the use of recycled products. The following section is a review of other jurisdictions, their specifications, standards, and quality controls for recycled aggregates.

The City of Saskatoon

The City of Saskatoon is faced with a shortage of natural aggregate close to the city. The average haul is over 100 km, resulting in a cost of approximately \$32/tonne to market^{lxxxiv}.

In response, the City of Saskatoon has conducted a trial using recycled asphalt and road base in situ under their 'Green Streets' program, and looked at the performance results, as well as sustainability standards economically, socially and environmentally. The existing road base was recycled in situ to create two courses, the lower of 230 mm using recycled aggregates, and the upper 200 integrating a cement / emulsion rejuvenator to strengthen the recycled base. A hot mix asphalt layer of 100 mm was placed on top. The trial resulted in a cost savings of approximately 43% over conventional methods. Technically, the

road outperformed over the conventional road standard in deflection tests, and the mechanical properties were found to be equal or superior to those of conventional construction^{lxxxv}. The 'Green Streets' program has conducted trials to improve the quality of recycled aggregate through processing techniques as well as in situ road reconstruction projects.

The City of Edmonton

The City of Edmonton has used a blended mix of recycled concrete and asphalt and found it has functioned well as a base material for road pavements^{lxxxvi}. They have produced up to 400,000 tonnes of recycled aggregate (1997, 1998)^{lxxxvii}. The steel from the concrete, up to 100 tonnes, is also recycled.

The Town of Caledon, Ontario

The Town of Caledon, and two other Ontario municipalities surveyed in the *State of the Aggregate Resource in Ontario Study* (SAROS) report, have policy statements, which describe encouraging recycling aggregates in order to make best use of the resource, promote procurement policies for recycled aggregates, or both^{lxxxviii}.

United Kingdom

The United Kingdom has a centralized system for specifying recycling aggregates, with an established quality control and assurance protocol to give assurance over their use. Recycled aggregates represent 28% of all aggregates sold in the UK^{lxxxix}, of which, approximately 90% are used under their Specification for Highway Works. Specific details are below.

- They use recycled aggregates in sub-base, capping, pipe bedding and drainage applications.
- They have established specifications for different applications and mix types. For example, Type 1 for unbound sub-base can contain up to 50% asphalt and 25% glass, but no more than 1% of other materials.

The Netherlands

The Netherlands have initiated an integrated approach to aggregate recycling, combining policies, economic tools, research efforts and including the consumers and industry on the development of guidelines and specifications. Their approach includes:

- Phased bans on the disposal of concrete and asphalt waste in landfills;
- High tipping fees, up to \$352/tonne (2001)^{xc};
- Research programs for technique development using recycled aggregates; and
- Involvement of consumers and industry representatives in policy and specifications.

Denmark

In Denmark, the government has taken the lead in promoting recycling of post-consumer aggregate. They have a multiple faceted approach, which includes:

- The development of specifications using a consensus approach among producers, environmental agencies, owners and contractors;
- Field testing and trials, including long term evaluation;
- Land fill restrictions and disposal taxes; and
- The routine use of 30% of RAP in asphalt pavement mixes and 50% in road base course.

9.0 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.” H. Goldstein (1995)^{xcii}

Demand figures for this report are based on Canada Census and BC Stats data^{xcii}, using consumption figures based on published literature and projected growth rates. The rate of growth in the Central Okanagan to 2036 is expected to be 1.52%, according to BC Stats Data^{xciii}. 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 100 year projections, due to the uncertainty in predicting beyond 2036.

Consumption figures are based on published literature^{xciv} and RGS projected growth rates. A range of growth and consumption rates were used to accommodate potential differences in growth patterns.

9.1 Projected Population Growth

The growth projections for the RDCO portray a slowly declining growth rate. From a 2010 growth rate of 2.1%, the rate drops steadily to 0.9% in 2036. This growth is expected to come primarily from migration, as fertility rates in the RDCO^{xcv}, and British Columbia in general, have continued to witness a steady decline^{xcvi}. The population will rise over this period from 188,306 in 2010 to 267,717 in 2036.

We have assessed a range of rates to accommodate fluctuations in projected growth, with 1% as a conservative projection, 1.5%, and 2.0% as an aggressive projection in growth rate. Using the BC Stats population data, and Census Canada ratios for population per jurisdiction, the projected population growth is illustrated in Table 16.

Table 16 Population at 1.0%, 1.5% and 2.0% Growth Rates

Time Horizon	1.0%	1.5%	2.0%
20 Years	230,182	254,076	280,315
50 Years	310,250	397,141	507,752
100 Years	510,247	836,079	1,366,659

Note: Due to the uncertainty of long term population projections, the variability in range is great. These numbers are not intended as a statistical population projection, but simply as a range of possible outcomes.

9.2 Projected Demand of Aggregate

Consumption rates of aggregate range in Canada from 9 to 15 metric tonnes per person per year^{xcvii}. BC has an average consumption rate of 10 tonnes per person. Consumption per capita tends to be lower in urban

areas than suburban or rural, as the infrastructure is shared by more people. Also, areas with growing road systems and infrastructure will have higher consumption rates than established communities. It is likely that the RDCO’s consumption rate is higher than the BC average, compared to the urban centres of Vancouver and Victoria, because we have less density in our communities.

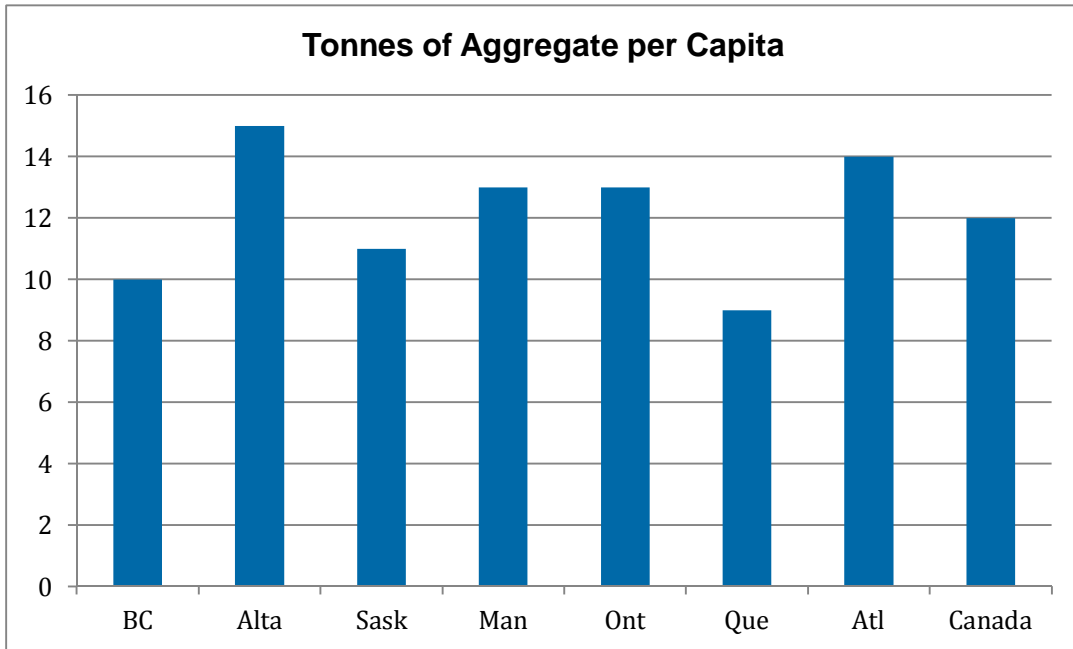


Figure C Tonnes of Aggregate per capita in Canada^{xviii}



Photo 4 Where does it go? Aggregate in our Community

Figure D illustrates the range of consumption over the next 20 years, projecting a range of growth and consumption rates. At a 1.0% growth rate and 10 tonnes per capita consumption rate, the projected cumulative demand for the district is approximately 42 million tonnes. At a 2.0% growth rate and higher consumption rate of 14 tonnes per person, the cumulative consumption over 20 years is over 65 million tonnes.

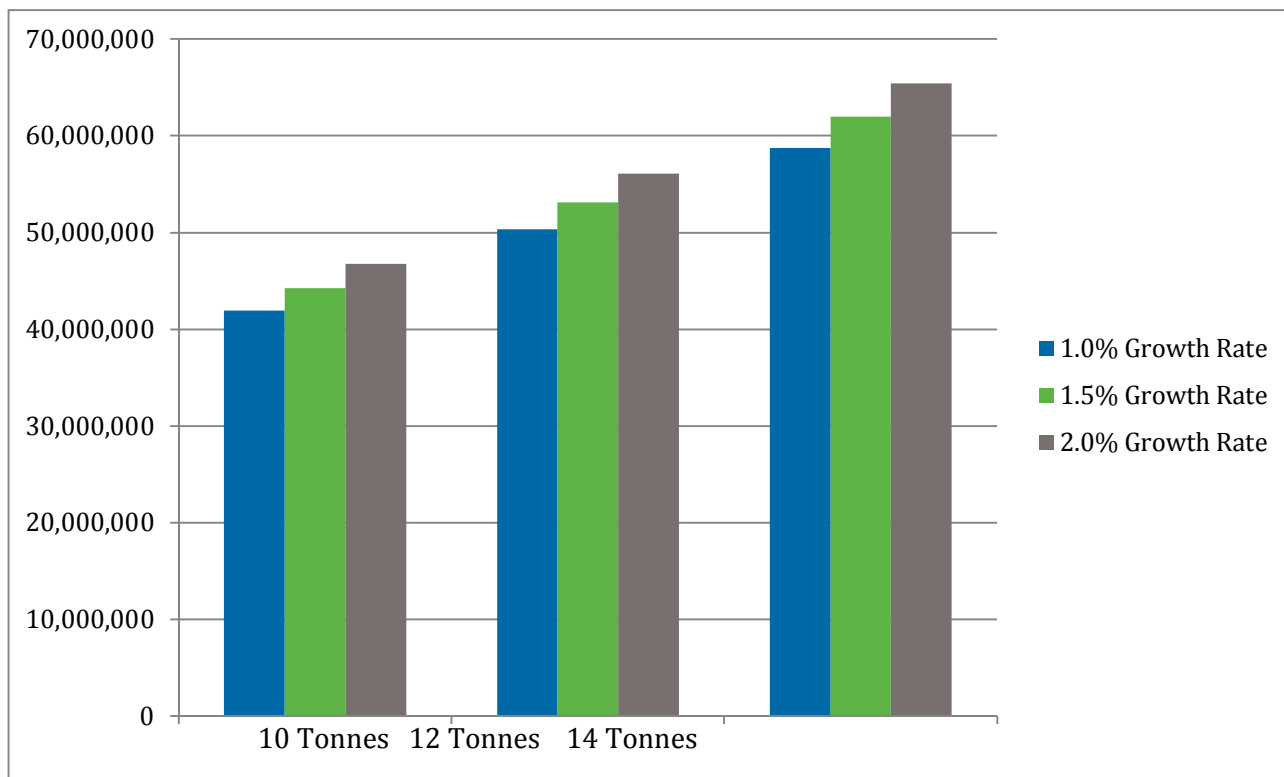


Figure D Consumption over 20 Years at Varying Growth and Consumption Rates

9.3 Demand Areas

A key element in aggregate planning is anticipating market centres. Table 17 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 10 tonnes per capita, and an average growth rate of 1.0%.

Table 17 Consumption by Area over 100 Years at 1.0% Growth Rate and 10 Tonnes per Capita

Area	0-20 Years	21-50 Years	51-100 Years	0-100 Years Total
Kelowna	27,366,600	52,752,300	131,766,000	211,884,900
West Kelowna	7,206,500	13,891,400	34,698,200	55,796,100
Lake Country	2,731,200	5,264,800	13,150,500	21,146,500
Peachland	1,213,100	2,338,300	5,840,700	9,392,000
Electoral Areas	1,339,400	2,582,000	6,449,500	10,370,900

Table 17 Consumption by Area over 100 Years at 1.0% Growth Rate and 10 Tonnes per Capita

Area	0-20 Years	21-50 Years	51-100 Years	0-100 Years Total
First Nations	2,096,000	4,040,300	10,092,000	16,228,300
RDCO (Total)	41,952,800	80,869,100	201,997,000	324,819,000

Table 18 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 18 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

Table 19 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 14 tonnes per capita, and an average growth rate of 2.0%.

Table 19 Demand by Area over 100 Years at 2.0% Growth Rate and 14 Tonnes per Capita

Area	0-20 Years	21-50 Years	51-100 Years	0-100 Years Total
Kelowna	42,696,200	105,929,700	400,039,600	548,665,500
West Kelowna	11,243,300	27,894,700	105,343,200	144,481,200
Lake Country	4,261,200	10,572,000	39,924,800	54,758,000
Peachland	1,892,600	4,695,500	17,732,300	24,320,400
Electoral Areas	2,089,800	5,184,900	19,580,500	26,855,200
First Nations	3,270,100	8,113,200	30,639,300	42,022,600
RDCO (Total)	65,453,200	162,390,000	613,259,700	841,102,900

Figure E 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%.

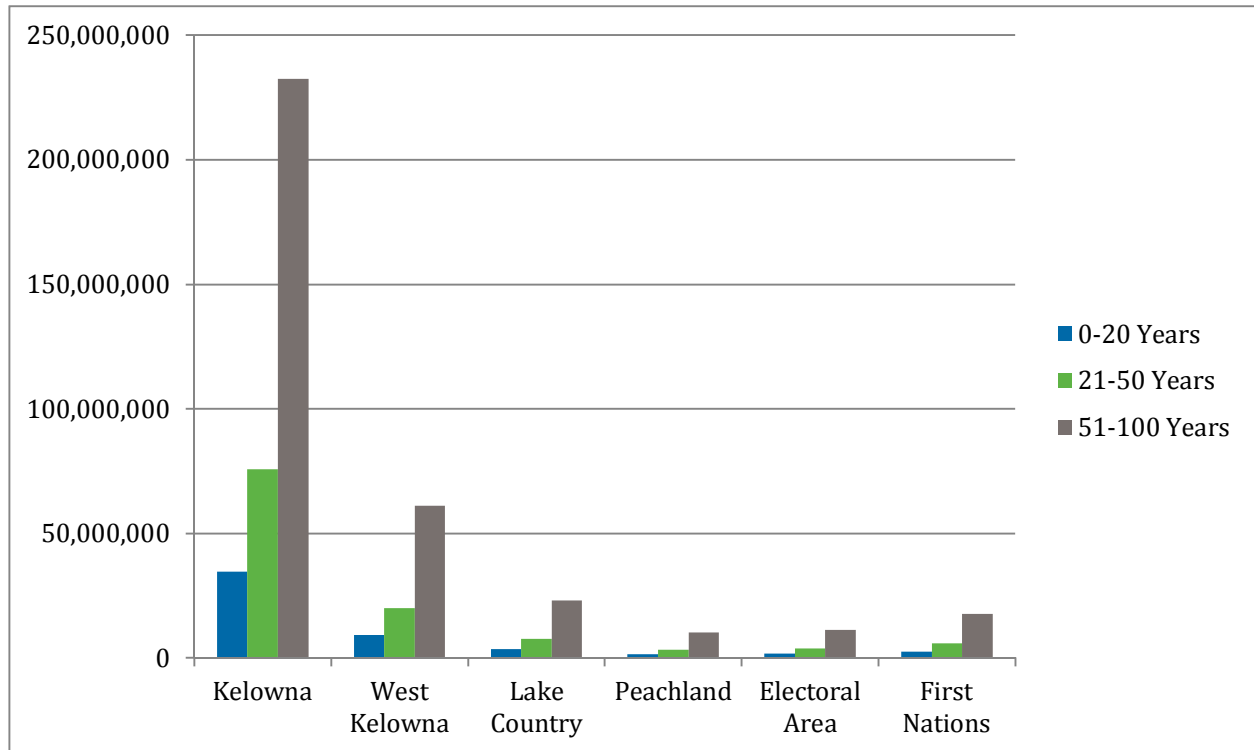


Figure E Consumption at 1.5% Growth Rate and 12 Tonnes per capita by Demand Area

9.4 Residential Demand Centers

Calculations for single family and multifamily residential demand were calculated based on the *City of Kelowna OCP, Chapter 3 Growth Projections^{xcix}*, for projected units in each of the city neighbourhoods. It is estimated that it takes approximately 300 tonnes of aggregate to build an average 150 sq. m. new home.^c This percentage was then combined with an estimated growth rate of 1.5% and a capita consumption of 12 tonnes per capita per year. The results are shown in Figure F.

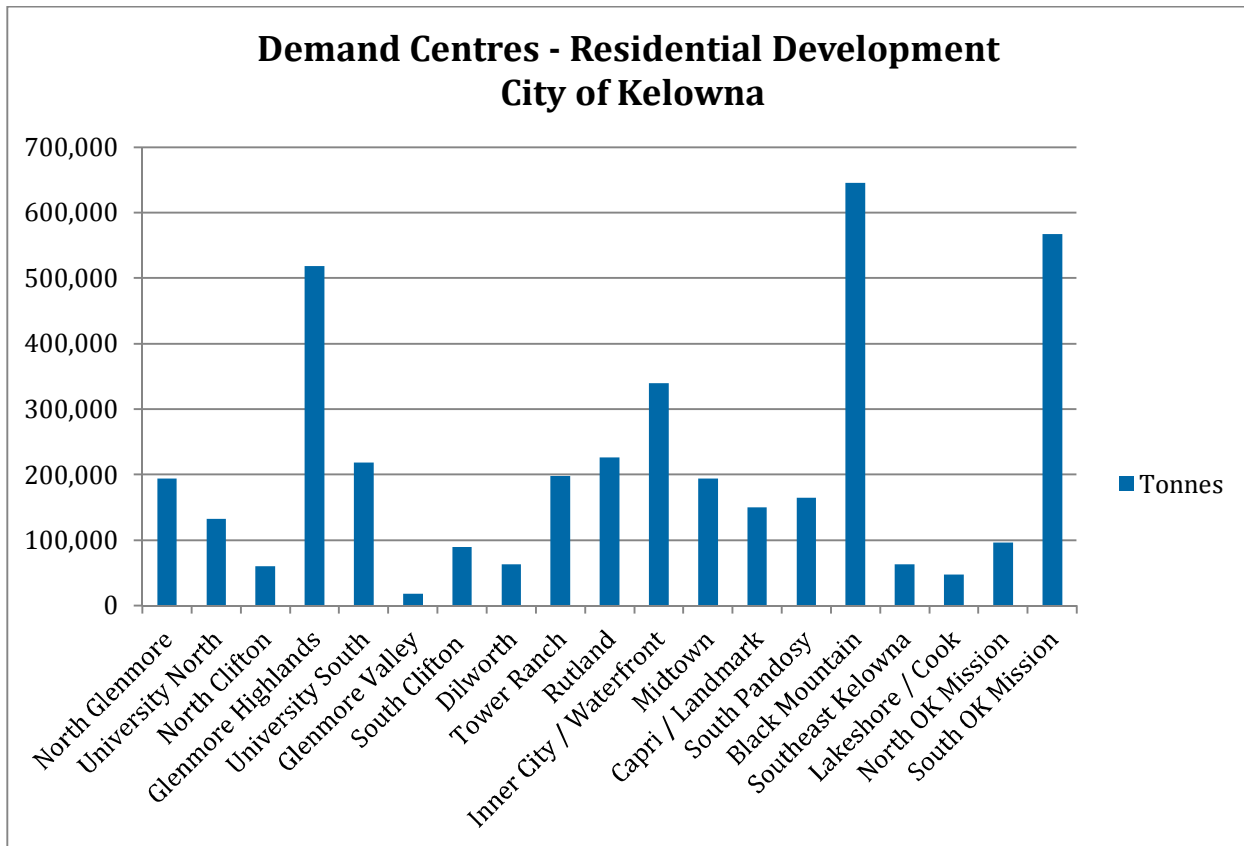


Figure F Demand Centers for Residential Development in the City of Kelowna – 20 Years

For the City of Kelowna, the key demand growth centres projected over the next 20 years are Glenmore Highlands, Black Mountain, South Okanagan Mission, and the Inner City / Waterfront areas. Remaining development is spread over the city. The least residential development is expected in existing neighbourhoods or rural areas including North Clifton, Glenmore Valley, Dilworth, Southeast Kelowna and the Lakeshore/Cook neighbourhood.

Individual neighbourhood projections were not available for the other municipalities.

9.5 Demand and Consumption Abroad

Information on demand and consumption abroad can be helpful for aggregate planning and practices and policies around recycling. Table 20 illustrates the consumption of primary aggregates and secondary (recycled) aggregates in other countries^{ci}. It is interesting to note the percentage of recycled aggregates for those countries, such as the UK and the Netherlands, with government initiated policies such as research and quality control and assurance.

Table 20 Demand and Consumption Abroad

Selected Countries	Primary Aggregate Consumption (tonnes) 2002-07	Population Growth Rate % 2002-07	Real GDP Growth Rate % 2002-07	Real GDP per capita \$000s 2002-07	Construction Spending per capita \$000s 2002-07	Density pop/sq. km 2005-06	Recycled Aggregates %
Irish Republic	32	2.0	5.6	34	5.4	59	1.0
Finland	18	0.3	3.2	29	3.2	16	1.0
Austria	12	0.5	2.4	30	3.5	98	6.0
Denmark	12	0.3	1.8	30	3.0	126	N/A
New Zealand	11	1.4	3.5	23	2.6	15	N/A
Spain	10	1.6	3.4	23	3.5	86	0.0
US	10	0.9	2.6	37	3.3	32	NA
Portugal	9	0.5	0.9	17	2.1	114	N/A
Norway	9	0.7	2.4	39	2.7	14	0.0
Sweden	9	0.5	3.1	31	1.9	20	6.0
Netherlands	8	0.3	1.9	31	3.3	400	21.0

10.0 PERMITTING

Permitting, and legislation that covers aggregate extraction, is summarized below.

10.1 Mines Act Permit

Sand and gravel operations and rock quarries must be permitted by the MEM under the requirements outlined in the *Mines Act*^{cii}. A *Mines Act* 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. Proposals deemed to be sensitive maybe referred to the local Regional Mine Development Review Committee (RMDRC). The RMDRC is comprised of representatives from federal and provincial government agencies and First Nations whose interests may be affected by the proposed mine. Local government 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 comments subsequent to the Committee’s review. Public review and comment is at the discretion of the Inspector reviewing the proposal.

10.2 Sand and Gravel Permitting Process

The following requirements are part of the permit process for sand and gravel operations:

- a Licence of Occupation or Crown Land Lease under the *Lands Act* from BC Assets and Land Corporation for operations on Crown Land;
- a permit application to the Ministry of Energy & Mines (MEM);
- referrals coordinated by MEM (at MEM discretion);

- advertising the proposed operation in the local newspaper and the BC Gazette (at MEM discretion);
- a reclamation and safety plan; and
- inspection by MEM.

10.3 Rock Quarry Permitting Process

A quarry permit is required if the operation supplies non-structural construction materials, for example, rock used for facing stone, rock walls or landscaping. A quarry permit has the following requirements:

- a claim must be staked under the *Mineral Tenure Act*;
- a Free Miner's Certificate must be attained in order to stake a claim;
- taxing of profits under the *BC Mining Tax Act*;
- permit application to the MEM;
- referrals coordinated by MEM (at MEM discretion);
- advertising the proposed operation in the local newspaper and the *BC Gazette* (at MEM discretion);
- a reclamation and safety plan; and
- inspection by MEM.

10.4 Mine Standards

A *Mines Act* permit applicant is required to include detailed projections of mine site reclamation costs, including consideration of long term monitoring, mitigation of environmental impacts and ongoing maintenance. Standards for health, safety and reclamation are established and compliance is required as a condition of every *Mines Act* permit. Site specific conditions may warrant the inclusion of additional permit clauses where appropriate. It is the Ministry's policy to hold security for mine reclamation, which reflects costs to decommission and close the site. Depending on the scale of the project, costs of reclamation may play a key role in determining the economic feasibility of the mining project. In an effort to achieve consistency in the preparation of reclamation cost projections, the Ministry has developed a spreadsheet, which may be utilized by *Mines Act* permit applicants.

10.5 Notice of Application

Mines Act permit applicants may be required to publish a 'notice of filing' in the *B.C. Gazette* and in local newspapers. This requirement is at the discretion of the Inspector and is often required when the application is for a new mine or for a substantive modification to an existing mine plan or reclamation program. When advertising is required, a minimum of two copies of the permit application must be made available for viewing at the local public library for the duration of the application review process.

10.6 Health, Safety and Reclamation Code for Mines in British Columbia

Part 10.1.4 of the Code does not apply to those “mines” as identified in part 10.1.1. That is, the assessments and plans outlined in Part 10.1.4 of the Code are not required for sand and gravel or quarry operations.

However, at the discretion of the Inspector, a technical report(s), to address information gaps or identified concerns such as those listed, including geotechnical assessments, archaeological impact assessments, can be requested, including those noted below:

- Surface water and groundwater flow;
- Fisheries and aquatic resources;
- Air quality;
- Surficial geology and terrain mapping;
- Soil survey and soil characterization;
- Vegetation;
- Wildlife;
- Land capability and present land uses such as agriculture, forestry, fisheries, wildlife, recreation, industrial, commercial and residential; and
- Inhabited places in the vicinity of the mine.

Also, at the discretion of the Chief Inspector, the following may be required:

- A program for the environmental protection of land and watercourses during the construction and operational phases of the mining operation, including plans for:
 - Prediction, and if necessary, prevention, mitigation and management of metal leaching and acid rock drainage;
 - Erosion control and sediment retention;
 - Environmental monitoring designed to demonstrate that monitoring and reclamation work is reported annually; and that
 - Reclamation plans are in place to achieve the proposed use and capability objectives of the land and watercourses.

10.7 Federal Legislation

Federal legislation protecting species at risk, migratory birds, and fish and fish habitat, which have the potential to affect aggregate extraction, summarized in Table 21 below.

Table 21 Federal Legislation

Federal Legislation	
Fisheries and Oceans Canada Federal Fisheries Act	Section 35(1) of the <i>Fisheries Act</i> protects fish and associated fish habitat from Harmful Alteration or Disruption, or the Destruction, of fish habitat (HADD), unless a Section 35(2) Authorization for a HADD is granted
Environment Canada Migratory Birds Convention Act	The <i>Migratory Birds Convention Act</i> prohibits the damage or destruction of migratory birds or their nests without a permit. ^{ciii}
Environment Canada Wildlife Act	The Act facilitates the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and allows the government to enact measures to protect endangered wildlife. ^{civ}
Environment Canada Species at Risk Act (SARA)	SARA protects the critical habitat of species at risk listed by COSEWIC on federal lands, and may be invoked on provincial or territorial lands if provincial or territorial laws do not effectively protect the critical habitat. ^{cv}
Transport Canada Navigable Waters Act	Transport Canada regulates and monitors any changes to a water body, including over or around it that might impact its ability to be navigated.

10.8 Provincial Legislation

A summary of potentially applicable provincial legislation is included in Table 22, below.

Table 22 Provincial Legislation

Ministry of Energy and Mines	
Mines Act	Under the <i>Mines Act</i> and Safety and Reclamation Code for Mines in BC, the MEM regulates sand and gravel and quarried rock operations in BC. A Notice of Work and Reclamation Program for a Sand & Gravel / Quarry Operation (NoW) is required, along with a description of proposed work, environmental protection plan, reclamation plans, maps and cross sections. ^{cvii}
Integrated Land Management Bureau	
Land Act	For operations on crown land, the applicant would be required to apply for a crown lease tenure through the Integrated Land Management Bureau (ILMB), under the <i>Land Act</i> . Operators are also required to submit a volume based royalty on an ongoing basis to the province. ^{cvii}
Agricultural Land Commission	
Agricultural Land Reserve Act^{cviii} Soil Conservation Act	In order to extract aggregate from a property within the ALR, an approval from the ALC under the <i>Agricultural Land Reserve Act</i> and the <i>Soil Conservation Act</i> is required. A <i>Mines Act</i> application typically also goes to the local government for approval under the <i>Soil Conservation Act</i> . ^{cx}
Ministry of Forests, Lands, and Natural Resource Operations	
Fish Protection Act & Riparian Areas Regulation (RAR)	RAR is a regulation enacted under the <i>Fish Protection Act</i> that requires an assessment by a Qualified Environmental Professional (QEP) for any residential, commercial and industrial developments including removing vegetation and the disturbance of soils, within 30 metres of a stream in designated jurisdictions, including the RDCO. ^{cx}
Water Act	Under the <i>Water Act</i> , a permit is required for work below high water mark of any stream in BC.
Wildlife Act	The BC <i>Wildlife Act</i> prevents the damage, disturbance or destruction of any raptors nests at any time of year, including those of owls and herons, and also any disturbance to a bird or eggs in a nest (except sparrows and invasive species).

Table 22 Provincial Legislation

Forest Act Forest and Range Practices Act	Under the BC <i>Forest Act</i> and the <i>Forest and Range Practices Act</i> , for forestry roads and lands, the applicant may be required to apply for a Special Use Permit, Road Permit, Free Use Permit, Licence to Cut Permit, or a burning permit.
Heritage Conservation Act	Under the <i>Heritage Conservation Act</i> , a permit is required to undertake any activities that could affect a heritage object. ^{cxii}
BC Weed Control Act	The <i>BC Weed Control Act</i> requires all registered land owners to control weeds that are listed as noxious weeds in BC on their property. It was formerly administered by the Ministry of Agriculture but is currently administered by the MFLNRO.
Ministry of Environment	
Environmental Assessment Act	Under the BC <i>Environmental Assessment Act</i> , an environmental assessment and project approval certificate is required for those sand and gravel projects over 500,000 tonnes in any one year of operation, or over 1,000,000 tonnes in any 4 years, or an expansion of more than 35% of area previously permitted. For quarried rock, the Act requires an assessment for volumes over 250,000 tonnes per year, or an expansion of 50% more area than previously permitted. ^{cxiii}
Drinking Water Protection Act^{cxiii}	The <i>Drinking Water Protection Act</i> and the Drinking Water Protection Regulation outlines the requirements of water purveyors must undertake to deliver potable water to their users, and sets out permit requirements.
Public Health Act	Connected to the <i>Drinking Water Protection Act</i> .
Greenhouse Gas Reduction Targets Act (GGRTA)^{cxiv}	The GGRTA sets targets for GHG reduction for BC, including the target of a reduction of 33% or more from 2007 levels by 2020. The Act provides authority for the Emission Offsets Regulation and the Carbon Neutral Government Regulation.
Ministry of Transportation and Infrastructure	
Transportation Act	Under the <i>Transportation Act</i> , a permit is required for an entrance onto a controlled access highway.

10.9 Municipal Bylaws and Permits

Local governments receive their ability to create bylaws and require permits from the provincial Local Government Act, including zoning bylaws, development permits and Soil Removal and Deposit Bylaws. A summary of applicable municipal bylaws and permits is included in Table 23, below.

Table 23 Municipal Bylaws and Permits

Local Governments	
	<p>Local governments can enact bylaws and require permits as designated by the <i>Local Government Act</i>, some of which have potential to affect aggregate extraction. These include:</p> <ul style="list-style-type: none"> ▪ Official Community Plans ▪ Zoning regulations – affects permanent structures and their uses ▪ Development Permits – within designated areas permits are required in order to protect the natural environment or protection of development from hazardous conditions^{cxv} ▪ Soil Removal & Deposit Bylaws – Require permits for soil removal and deposit, and municipalities may collect volume based fees ▪ Temporary Use Permits ▪ Runoff Control ▪ Tree Retention ▪ Signs ▪ Burning ▪ Noise

Table 23 Municipal Bylaws and Permits

Local Governments	
	<ul style="list-style-type: none"> ▪ Commercial Vehicle ▪ Business License ▪ Heritage Conservation

10.10 SRDB – City of Kelowna

The *City of Kelowna – Soil Removal and Deposit Regulation Bylaw No. 9612*^{cxvi} outlines conditions under which soil can be removed or deposited within the City of Kelowna. It applies to volumes over 50 cubic metres. It requires a completion plan, with finished grades indicated and vegetation cover. The permit requires a description of noise and dust controls. It requires a performance security deposit to cover the implementation of any monitoring plans and restoration or mitigation measures recommended by a QEP^{cxvii}.

Bylaw No. 9612 was re-deposited with the Minister of Health on November 24, 2009, and adopted by the City of Kelowna Municipal Council on January 11, 2010. Details on the bylaw are shown in Table 24.

Table 24 City of Kelowna Soil Removal and Deposit Bylaw No. 9612

Item	Provisions
Permit Fee	<ul style="list-style-type: none"> ▪ No permit fee unless soil removal and deposit fees have commenced prior to permit ▪ \$250 permit fee if soil removal and deposit fees have commenced prior to permit
Security Deposit	<ul style="list-style-type: none"> ▪ Subdivision Approving Officer may require a deposit to cover 125% of the estimated cost of the of monitoring plans and QEP mitigation recommendations
Volume Based Fee	<ul style="list-style-type: none"> ▪ No volume based fee
Conditions of Permit	<ul style="list-style-type: none"> ▪ Requires: <ul style="list-style-type: none"> – Site plan with vegetation, watercourses and existing structures, and access – Grading Plan at project completion – Erosion control methods and drainage – Proposed noise and dust control methods ▪ Subdivision Officer may require: <ul style="list-style-type: none"> – Environmental / Geotechnical or Hydrological Assessment – Environmental or Geotechnical Monitoring Contract – Drinking water source proximity and third part oversight ▪ Affect volumes over 50 cubic metres per parcel per year ▪ Exemptions for concrete or asphalt plants operating within zoning bylaw and business permit ▪ Subdivision Approving Officer may refuse a permit if the land use does not conform to the OCP or if it adversely affects the air, light or view of adjacent properties ▪ Prohibits the escape of dirt or dust that may constitute a nuisance

10.11 SRDB – District of West Kelowna

The DWK passed the *Soil Removal and Deposit Bylaw 2011 No. 0127*^{cxviii} on December 11, 2012, after the Ministry of Community, Sport and Cultural Development approved it on November 14, 2012. A summary of fees and permit requirements are shown in Table 25.

Table 25 District of West Kelowna Soil Removal and Deposit Bylaw 2011 No. 0127

Item	Provisions
Permit Fee	<ul style="list-style-type: none"> ▪ \$250 for volumes 5K to 25K cubic metres ▪ \$500 for volumes over 25K cubic metres ▪ \$100 per amendment
Security Deposit	<ul style="list-style-type: none"> ▪ 125% of monitoring plans and QP recommendations ▪ Damage deposit of \$500 for street cleaning and repair ▪ Damage deposit for municipal repairs 30% of estimated cost up to \$10,000
Volume Based Fee	<ul style="list-style-type: none"> ▪ Excess volume fee of additional \$0.50/cu m ▪ Volume fee of \$2.20 without a permit
Conditions of Permit	<ul style="list-style-type: none"> ▪ Prohibits volumes removed or deposited > 1,000 cubic metres on any land without a permit ▪ Requires: <ul style="list-style-type: none"> – Erosion & Sediment Control Plan – Environmental Impact Assessment – Environmental or Geotechnical Monitoring Contract – Evaluation of soil for contaminants under the <i>Environmental Management Act</i> ▪ Hours of Operation include 7:00 AM to 8:00 PM ▪ No nuisance – No dust, dirt or noise to escape ▪ Repair of any damage to property or watercourses ▪ No effect on views ▪ Permit term 1 year ▪ No soil processing allowed without zoning in place ▪ Monthly volume manifest required

10.12 SRDB – District of Lake Country

The DLC *Soil Regulation Bylaw 95-015*^{cxix} was adopted on May 22, 1997. It was amended by Bylaw 335 and adopted on April 16, 2002. The bylaw requires existing and proposed grading plans, structures, locations of machinery and proposed processing methods. It requires that all soil loads are tarped, and stipulates permissible hours for crushing and delivery. The bylaw also imposes a volume based fee of \$0.50 / cubic metre payable to the District of Lake Country. A summary of fees and permit requirements are shown in Table 26.

Table 26 District of Lake Country Soil Removal and Deposit Bylaw 95-015 includes Bylaw 335

Item	Provisions
Fees	<ul style="list-style-type: none"> ▪ No permit fee ▪ Penalty fee not exceeding \$10,000 per offence
Security Deposit	<ul style="list-style-type: none"> ▪ None required
Volume Based Fee	<ul style="list-style-type: none"> ▪ \$0.50/ cu m for soil removed from or deposited in the District, payable every 6 months
Conditions of Permit	<ul style="list-style-type: none"> ▪ Delivery of soil is prohibited between 9:00 PM and 7:00 AM ▪ Crushing of soil is prohibited between 6:00 PM and 7:00 AM ▪ Soil loads must be tarped ▪ Requires: <ul style="list-style-type: none"> – Detailed plans of existing contours, buildings, tree cover, roads and watercourses

Table 26 District of Lake Country Soil Removal and Deposit Bylaw 95-015 includes Bylaw 335

Item	Provisions
	<ul style="list-style-type: none"> - Proposed grading plan at completion - Erosion control methods - Access plan and buffer zones - Water table elevations - Proposed location of machinery, structures, scales & other improvements - Proposed processing methods - Proposed routes, trucking hours and frequency of trucks, hours of work - Certification that the Ministry of Environment’s criteria for the intended use is met - Proposed reclamation and land use of site ▪ District Engineer may require: <ul style="list-style-type: none"> - Geotechnical / hydrological assessment relative to slope stability or erosion

10.13 SRDB – District of Peachland

The DoP is currently reworking their *Earthwork Control Bylaw Number 832, 1982*^{cxx}.

11.0 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 emissions, land use, noise, dust, visual impacts and infrastructure impacts.

12.0 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 *AO BMP Handbook*^{cxxi}:

“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”^{cxxii}.

In this section, we will review potential impacts to the environment with respect to aggregate operations, applicable legislation, ecological conditions in the RDCO, and established BMPs specific to aggregate extraction. Procedures and BMPs from provincial guidelines have been drawn upon for this review. These include:

- Aggregate Operators Best Management Practices Handbook for BC – Volume I, Introduction and Planning^{cxxiii}
- Aggregate Operators Best Management Practices Handbook for BC – Volume II, Best Management Practices^{cxxiv}

- Environmental Objectives and Best Management Practices for Aggregate Extraction^{cxxv}
- Reclamation and Environmental Protection Handbook for Sand, Gravel and Quarry Operations in British Columbia.^{cxxvi}

12.1 Environmental Legislation

In Canada, we have federal, provincial, and local environmental legislation, regulations, and policies for environmental protection. Section 10.0 provides a review of legislation with respect to aggregate operations, which may be referred to for a detailed review of each statute. Below is a summary of the legislation and regulations specific to the environment:

- *Federal Fisheries Act*
- *Federal Species at Risk Act (SARA)*
- *Provincial Fish Protection Act & Riparian Areas Regulation (RAR)*
- *Provincial Water Act*
- *Provincial Wildlife Act*
- *Provincial Local Government Act (Development Permits)*

The province of BC enacted the Riparian Areas Regulation (RAR) in 2004. For areas within 30 metres of a stream, RAR requires an assessment by a QEP in specified jurisdictions, including the RDCO, for residential, commercial and industrial zoned developments, of the potential effects of removing vegetation and the disturbance of soils. RAR applies only to the processing of aggregate such as concrete or asphalt manufacturing. These activities are considered industrial activities with respect to zoning. Aggregate extraction, including crushing and screening with mobile equipment, is not considered a land use, not bound by zoning regulation, and therefore is not captured under RAR.

The City of Kelowna adopted the Streamside Protection Regulations (SPR) and declared itself in conformance with the SPR, and therefore applicants that follow the OCP and comply with the Environmental Development Permit (DP) guidelines are deemed to meet or beat RAR. The City of Kelowna has established no-disturb setbacks for the creeks within Kelowna, noted in their Natural Environment DP Guidelines^{cxxvii}.

12.2 Ecosystems and Species at Risk

The Okanagan Valley is home to a disproportionate percentage of rare ecosystems and species in BC and Canada as a whole. Within BC, the biogeoclimatic ecosystem classification (BEC) system is used to classify terrestrial ecosystems. It is also used to determine ecosystem rarity within BC. For example, within the Ponderosa Pine ecosystem in the RDCO, out of 16 ecosystems, 10 are red listed (extirpated, endangered or threatened), 5 are blue listed (special concern) and 1 is yellow listed (not at risk)^{cxxviii}. The Okanagan lies at the north edge of the Great Columbia Basin, which extends into Washington State and Idaho. Research is revealing that populations at the edges of their ranges are more likely to persist when core populations

decline^{cxix}. As such, the Okanagan could prove to be an important south to north corridor for ecosystems and species, as they are required to adapt to climate change^{cxix}.

The Conservation Data Centre (CDC) of BC keeps a database of rare ecosystems and species. This is an important resource for aggregate planning and operations. Figure 11 shows the rare plant and wildlife species records held for the RDCO as of March 2013. It is important to check the current records for any particular site, as the records are continually updated.

In addition to the CDC, the Wildlife Species Inventory (WSI) provides incidental records of species at risk and regionally important wildlife. This is also a resource that is continually updated and should be checked regularly. Other important ecological values include ungulate winter range (especially for California bighorn sheep and mountain goat) and environmentally sensitive ecosystems, such as wetlands, riparian forest, coniferous woodland, and red and blue listed ecosystems.

Environmentally sensitive ecosystems have been mapped in a series of Sensitive Ecosystems Mapping projects throughout the Okanagan^{cxix}.

12.3 Natural Environment Development Permit (DP) Areas and Hazardous Areas

Within this ecological context, local governments established Natural Environment Development Permit (EDP) Areas and Hazardous Areas for the protection of the natural environment, its ecosystems and biological diversity. Within these areas in particular, developments should be cognizant of ecological and visual sensitivities and must therefore follow site specific environmental requirements. Through the RGS, the Natural Environment Development Permit Areas and Hazardous Areas for each local government have been combined into the RGS Preliminary Constraint Areas Map (Figure 10). Creek setbacks, wetlands, foreshore areas, and vulnerable aquifer areas are captured through the EDP areas. As part of the Natural Environment DP process, an applicant is required to either fill out a DP Waiver^{cxix}, indicating there are no environmental concerns, or prepare an environmental assessment and mitigation plan showing how environmental objectives will be met.

12.4 Potential Environmental Impacts

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. This section will focus on potential terrestrial and aquatic habitat, and surface water impacts. Please refer to Section 13 for potential groundwater and acid rock drainage impact, and Section 17 for potential dust impacts.

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. Table 27 includes potential environmental effects resulting from aggregate operations, and sample BMPs.

Table 27 Potential Environmental Effects and Corresponding BMPs^{cxxxiii}

Mining Activity	Activity Details	Potential Effects on the Environment	Sample BMPs
Clearing, Grubbing and Stripping	<ul style="list-style-type: none"> ▪ Timber clearing ▪ Vegetation removal ▪ Topsoil removal ▪ Overburden removal 	<ul style="list-style-type: none"> ▪ Removal of hydrological buffers / filters ▪ Habitat loss or disturbance ▪ Soil exposure ▪ Weed invasion ▪ Direct impacts or mortality to wildlife, including species at risk, and/or habitat loss 	<ul style="list-style-type: none"> ▪ Tillage ▪ Topsoil management ▪ Vegetation cover ▪ Weed control ▪ Rare species assessment ▪ Wildlife management plan
Extraction, Processing and Transport	<ul style="list-style-type: none"> ▪ Blasting ▪ Crushing ▪ Stockpiling ▪ Waste rock management 	<ul style="list-style-type: none"> ▪ Dust generation ▪ Noise generation ▪ Water quality impacts 	<ul style="list-style-type: none"> ▪ Berm ▪ Pollution prevention ▪ Settling pond ▪ Water spray ▪ Work windows
General Operations	<ul style="list-style-type: none"> ▪ Stormwater management ▪ Erosion and sediment control 	<ul style="list-style-type: none"> ▪ Increased runoff ▪ Increased erosion ▪ Increased sediment load ▪ Increased groundwater recharge ▪ Weed invasion 	<ul style="list-style-type: none"> ▪ Buffer zone ▪ Retention basin ▪ Silt fence ▪ Progressive reclamation ▪ Weeding
Reclamation	<ul style="list-style-type: none"> ▪ Staged ▪ Interim ▪ Final 	<ul style="list-style-type: none"> ▪ Re-establishment of habitat ▪ Weed invasion 	<ul style="list-style-type: none"> ▪ Bioengineering ▪ Grading ▪ Vegetation cover ▪ Progressive reclamation ▪ Weed control

12.5 Environmental Best Management Practices

In 2002, the BC Ministry of Environment, Lands and Parks established environmental BMPs for aggregate extraction. From planning to operation and eventual site reclamation, BMPs have been outlined in the Environmental Objectives and Best Management Practices for Aggregate Extraction^{cxxxiv}. A summary of these BMPs are included in Table 28, below.

Table 28 Environmental Objectives and Best Management Practices for Aggregate Extraction^{cxxxv}

Phase of Work	Best Management Practice
Planning Phase and Site Assessment	
Existing Biological Inventory Data	Reference existing biological data and inventories, including: <ul style="list-style-type: none"> ▪ Sensitive Ecosystem Inventories ▪ Conservation Data Centre ▪ Sensitive Habitat Atlases ▪ Sensitive Habitat Inventory Mapping (SHIM) ▪ Other inventories, depending on jurisdiction (e.g. Wetland Inventory, City of Kelowna)
Inventory	For areas with incomplete data, MWLAP (2002) recommends a biological inventory to assess: <ul style="list-style-type: none"> ▪ ecologically sensitive areas ▪ waterbodies ▪ fish and wildlife species

Table 28 Environmental Objectives and Best Management Practices for Aggregate Extraction^{CXXXV}

Phase of Work	Best Management Practice
	<ul style="list-style-type: none"> ▪ red and blue listed ecosystems and species, including plants ▪ nests of bird species identified in Section 34 of the BC <i>Wildlife Act</i>, and / or any active nests prior to removal of vegetation.
Water Resources	
Erosion and Sediment Control	MWLAP (2002) recommends an Erosion & Sediment Control Plan which includes: <ul style="list-style-type: none"> ▪ Locations of all waterbodies, including ephemeral streams and ditches ▪ Site features, roads and grades ▪ Provisions to maintain all surface runoff on site (e.g. detention ponds or swales) ▪ Sediment control structures (e.g. interceptor ditches, French drains etc.) ▪ Routine inspection and maintenance schedule of stormwater elements ▪ Monitoring to ensure any discharge water < 25 mg/L of suspended solids
Surface Water	If water from a surface water body is to be used for the mine site, a professional hydrologist must prepare a report to assess: <ul style="list-style-type: none"> ▪ Volumes relative to downstream flow ▪ Adequate downstream flows for fish habitat ▪ Pump hoses must be screened to prevent the uptake of fish or aquatic species ▪ Encourage recycling of water used in operation ▪ Prepare a <i>Water Act</i> application for surface water use
Ground Water	MWLAP recommends a hydrogeologic impact study be prepared by a professional hydrogeologist to assess: <ul style="list-style-type: none"> ▪ Potential impacts to groundwater quantity or quality ▪ Potential impacts to adjacent wells ▪ (See Section 13 for more on groundwater)
Road Design	
Design	MWLAP (2002) recommends that roads are designed to be consistent with the Erosion and Sediment Control Plan, including: <ul style="list-style-type: none"> ▪ Minimize stream crossings ▪ Minimize length of new roads ▪ Use cross culverts to preserve existing drainage pattern
Stream Crossings	Stream crossings should comply with the <i>Fisheries Act</i> and the <i>Water Act</i> , and: <ul style="list-style-type: none"> ▪ Allow clear fish passage ▪ Be avoided in spawning areas and flood plains ▪ Clear span bridges and open bottom culverts are preferred ▪ Culverts should be designed by a professional engineer
Mine Development	
Fish & Wildlife Protection	MWLAP (2002) recommends establishing No Disturbance Buffers for fish and wildlife. To avoid contravention of Section 34 (b) of the <i>Wildlife Act</i> , specifically: <ul style="list-style-type: none"> ▪ Eagles nests – physical buffer of 60 m; noise buffer during breeding season 100 m ▪ Great Blue Herons – 100 m vegetated buffer from outlying nest in colony, more in nesting season; up to 200 m for colony over 50 nests ▪ Active Nests – Avoid clearing during peak nesting season, from April 1 to August 1, unless the area has been assessed as being active nest free by a QEP

Table 28 Environmental Objectives and Best Management Practices for Aggregate Extraction^{cxxxv}

Phase of Work	Best Management Practice
Sensitive Ecosystems	<p>Delineate sensitive areas with high visibility fencing:</p> <ul style="list-style-type: none"> ▪ Sparsely vegetated bluffs, terrestrial herbaceous and other sensitive ecosystems – 50 m buffer zone ▪ Riparian areas – 50 metres from high water mark of streams, wetlands and lakes
Instream Work	<p>Should Instream work be required, MWLAP (2002) recommends the following:</p> <ul style="list-style-type: none"> ▪ Instream reduced risk work windows (refer to MWLAP for specific streams and lakes) ▪ Maintain natural stream flow ▪ Isolate the work from the stream ▪ Minimize sediment during culvert installation or replacement ▪ Written contingency plan for events of increased sediment discharge, due to events or weather ▪ Spill Protection Plan ▪ Fish Salvage ▪ Habitat mitigation / compensation if required ▪ Guidance from document <i>A User's Guide to Working in and Around Water, Regulations under British Columbia's Water Act</i>^{cxxxvi}
Site Clearing	<p>MWLAP recommends that:</p> <ul style="list-style-type: none"> ▪ Mature vegetation stands in poor areas of the deposit, to provide banks of seeds and microorganisms that will spread and help restoration later; and ▪ Buffer dust, noise and visual impacts
Stripping & Stockpiling	<p>MWLAP recommends that:</p> <ul style="list-style-type: none"> ▪ Topsoil and subsoil are stripped and stockpiled separately, preserving the organics and microorganisms in the topsoil ▪ Strip soil in dry periods to minimize compaction and potential water borne siltation ▪ Seed stockpiles that will be stored for a long period
Fuel Handling & Spill Containment	<p>MWLAP recommends that:</p> <ul style="list-style-type: none"> ▪ Permanent fuel facilities are not constructed on a mine site ▪ Tanks under 600 L be used ▪ Refueling station are 50 m from drainage structures
Site Rehabilitation	
Progressive Rehabilitation	<p>MWLAP recommends progressive rehabilitation, for large operations, which benefits:</p> <ul style="list-style-type: none"> ▪ wildlife habitat, by establishing successive habitats as the vegetation grows ▪ Visual impact mitigation
Planting Standards	<p>MWLAP's restoration planting standards, which emphasize:</p> <ul style="list-style-type: none"> ▪ Using native plants, suited to the site specifically ▪ Maintaining snags, large woody debris, existing topsoil, & mounds if possible ▪ Establishes plant spacing, survival, and watering if required over the first year ▪ Monitoring survival and replanting if necessary

*Summarized from Environmental Objectives and Best Management Practices for Aggregate Extraction^{cxxxvii} (MWLAP, 2002)

In addition to the MWLAP guidelines for planning and operation, the *AO BMP Practices Handbook* has examples and details for best management practices from planning to operation and through to reclamation. A summary of these BMPs are included in Table 29, below.

Table 29 Best Management Practices from the Aggregate Operators Handbook^{cxxxviii}

BMP	Description / Use	Addresses
Stormwater Management		
Buffer Zone	A naturally vegetated or replanted area around the perimeter of the aggregate site or an environmentally sensitive area. Its purpose is to: <ul style="list-style-type: none"> ▪ Minimizes erosion ▪ Improves water quality ▪ Intercepts dust ▪ Reduces noise ▪ Acts as wildlife corridor 	Visual, Dust, Water Quality
Check Dams	A small, temporary dam within a ditch, drainage, swale, or channel. Its purpose is to: <ul style="list-style-type: none"> ▪ Reduce the gradient of the ditch, which slows the water thereby lowering its ability to cause erosion and allowing sediment to settle out. 	Water Quality
Constructed Wetlands	A modified or constructed shallow pond for the treatment of sediment-laden waters by wetland vegetation. The purpose of these wetlands are to: <ul style="list-style-type: none"> ▪ Receive and temporarily hold sediment-laden waters to prevent downstream surface water pollution ▪ Provide biological treatment to help meet acceptable turbidity standards 	Water Quality
Ditches	Open drainage works ranging from shallow, narrow, frequently dry ditches, to wide, deep, permanently wetted ditches. Their purpose is to: <ul style="list-style-type: none"> ▪ Capture and control stormwater runoff and to direct it off site ▪ Divert stormwater runoff around a site 	Water Quality
French Drain	A hole or trench filled with coarse aggregate. Its purpose is to: <ul style="list-style-type: none"> ▪ Hold collected water until it percolates into the ground 	Dust, Water Quality
Retention Basin	A pond to hold stormwater and filter out sediment. Its purpose is to: <ul style="list-style-type: none"> ▪ Retain stormwater runoff and to remove the majority of the sediment within the stormwater, by settling 	Water Quality
Silt Fence	A temporary linear filter barrier of burlap or synthetic filter fabrics and posts. Its purpose is to: <ul style="list-style-type: none"> ▪ Be used below disturbed areas to remove or reduce sediment in stormwater runoff and sheet or rill erosion 	Water Quality
Slope Drain	A flexible tube or conduit extending from the top of a cut or fill slope to the bottom. Its purpose is to: <ul style="list-style-type: none"> ▪ Temporarily conduct concentrated stormwater runoff down the face of a cut or fill slope without causing erosion on or below the slope 	Water Quality
Erosion Control		
Backfilling	Using lifts of overburden or waste rock to restore a face or mined out area to a specified reclamation slope. Its purpose is to: <ul style="list-style-type: none"> ▪ Reduce slope angles to specific or standard reclamation criteria and the hazard if a slope failure 	Visual, Dust
Bioengineering	Erosion and sediment control structures made from stalks of live willow shrubs that continue to grow once placed in soil. Its purpose is to: <ul style="list-style-type: none"> ▪ Prevent erosion with their physical structure until established plants can provide permanent erosion protection ▪ Jump-start the establishment of self-sustaining vegetation on exposed hillsides 	Visual, Dust

Table 29 Best Management Practices from the Aggregate Operators Handbook^{cxxxviii}

BMP	Description / Use	Addresses
Erosion Control Blanket	A temporary protective blanket laid on top of exposed soil vulnerable to erosion. Its purpose is to: <ul style="list-style-type: none"> Prevent washing away of planted seed and erosion of the prepared seedbed until the area becomes established providing permanent erosion control 	Dust
Grading	Reshaping the ground surface to prepare the site for processing equipment, stockpile areas, etc. Its purpose is to: <ul style="list-style-type: none"> Provide suitable topography for post-mining land uses Facilitate equipment operation and stockpiling Control surface runoff Minimize soil erosion and sedimentation 	Water Quality
Outlet Protection	A rock-lined apron and flow area at the outlet of a pipe or culvert, paved flume, lined waterway, or other flow system. Its purpose is to: <ul style="list-style-type: none"> Prevent scour and erosion at water conveyance outlets Minimizes the potential for downstream erosion by reducing stormwater velocity 	Water Quality
Tarps	A piece of woven fabric or plastic sheeting material used to temporarily cover soil, raw materials, or equipment to provide protection from wind and rain	Dust
Tillage	The roughening of exposed soil with horizontal grooves running across the slope. Its purpose is to: <ul style="list-style-type: none"> Shape the surface of the soil and create pockets that prevent runoff, minimize pondage, and catch and retain moisture 	Water Quality
Topsoil Management	Salvaging, storing, and using topsoil for rehabilitation. Its purpose is to: <ul style="list-style-type: none"> Retain site topsoil for rehabilitation and/or permit requirements Preserve topsoil quality during moving and storage 	Water Quality, Environmental Protection
Vegetation Cover	Establish ground cover with via trees, shrubs, or perennial plants. Its purpose is to: <ul style="list-style-type: none"> Minimize or control dust and erosion, enhance water quality, and facilitate reclamation 	Visual, Dust
Noise and Dust		
Berm	An elongated, raised barrier constructed of overburden, topsoil, or aggregate by-product, commonly seeded with grasses and topped with larger vegetation. Its purpose is to: <ul style="list-style-type: none"> Intercept noise, dust, and the views of an operation, as well as act as a storage option for overburden material 	Noise, Dust, Visual
Drop Height	Reducing the distance material is dropped from conveyors and/or loading equipment. Its purpose is to: <ul style="list-style-type: none"> Minimize and control the amount of dust released into the atmosphere and decrease the noise generated by material impacting truck beds 	Dust
Dust Skirt	Rubber skirts around aggregate where it drops onto a stockpile or into a truck from a conveyor or hopper. Its purpose is to: <ul style="list-style-type: none"> Contain falling aggregate and shield it from wind exposure, thereby reducing dust, cleanup costs, and preventing material segregation 	Dust
Equipment Selection	Selecting equipment based on its energy consumption, noise output, exhaust configuration, compatibility with other equipment on site, and compatibility with approved mine plan	Noise, Dust

Table 29 Best Management Practices from the Aggregate Operators Handbook^{cxxxviii}

BMP	Description / Use	Addresses
Haul Roads Planning	A system of roads within an aggregate mining operation. Its purpose is to: <ul style="list-style-type: none"> Facilitate safe and efficient operation of mobile equipment while minimizing environmental impacts 	Noise, Dust, Visual
Material Corrals	Three-sided storage bays made from interlocking pre-cast concrete blocks. Its purpose is to: <ul style="list-style-type: none"> Keep specialized products and material clean and segregated, especially in tight locations 	Dust
Sinking the Plant	Locating noise generating stationary equipment, such as a processing plant, at a low location on the property. Its purpose is to contain noise and dust	Noise, Dust, Visual
Street Cleaning	Sweeping or cleaning the site entrance, the public roadway, and onsite paved roads on a regular or as needed basis. Its purpose is to: <ul style="list-style-type: none"> Reduce dust and stormwater sediment loading and maintain a clean appearance at the site entrance and adjacent public roads 	Dust
Vibration Reduction	The reduction or minor ground movements generated by production blasts, crushers, and haul trucks driving over rough ground. This is achieved by maintaining smooth and even road surfaces	Noise
Water Spray	The use of water sprays, sprinklers, mists, or foams wherever dust is created at the aggregate site	Dust
Wheel Washer	A washing pit or trough that removes rocks and dirt from vehicle wheels and wheel wells as they drive through. Its purpose is to: <ul style="list-style-type: none"> Reduce the amount of dirt and rock carried by aggregate vehicles onto public roads, this lessening the need for street sweeping and preventing windshield damage 	Dust
Wind Protection	Any structure or method to block or reduce wind flow. This reduces the exposure of dust-generating material to wind, which maintains air quality	Dust
Risk Management		
Environmental Timing Windows	A work schedule that does not conflict with critical life stages for fish and wildlife. These work windows are established by federal or provincial regulatory agencies and vary depending on the proposed activities, location, and habitat type	Environmental Protection
Fences	A man-made or natural barrier than can reduce the amount of noise and dust leaving the site, create a visual barrier, and prevent trespassing thereby minimizing liability to the proponent	Risk Management, Dust, Visual
Lighting Management	The planning and installation of a lighting system that facilitates safe and secure operations, while minimizing offsite visual nuisance. This provides a safe working environment, extended hours of operation, and security to the site after hours	Risk Management
Signage	Information and warning signs for the public and site visitors. This ensures that visitors are aware of potential hazards and deters unauthorized persons from entry	Risk Management
Pollution		
Oil / Water Separator	A pond or tank that separates petroleum products from water using the different in liquid density. This removes any petroleum products that are present prior to the release or reuse of water	Water Quality

Table 29 Best Management Practices from the Aggregate Operators Handbook^{cxxxviii}

BMP	Description / Use	Addresses
Pollution Prevention	Any structure, practice, or method used to manage potential pollutants that are used or stored at an aggregate operation. This prevents or minimizes contamination of stormwater and groundwater by protecting and containing chemicals and petroleum products	Environmental Protection
Scheduled Maintenance	The regular program of maintenance for vehicles and equipment on site. This reduces the number of equipment breakdowns, amount of down time, and frequency of spills or fuel leaks	Risk Management, Water Quality
Settling Pond	Settling ponds remove silt and suspended clays from water used for washing aggregate, and/or from dirty stormwater	Water Quality

*Summarized from AO BMP Handbook – Volume II – Best Management Practices^{cxxxix}

13.0 GROUNDWATER

The groundwater analysis provides a framework for the Site Suitability Assessment, assesses potential impacts to groundwater due to aggregate operations, and reviews existing regulations, guidelines and BMPs.

13.1 Groundwater Overview

The objective of this section is to assess factors relating to groundwater, which affect the siting and acceptable management of future aggregate extraction operations within the RDCO area. These factors and the key issues associated with them are presented in Table 30 below.

Table 30 Key Factors and Issues Relating to Groundwater

Factor	Issues
Site	
Location and final excavation depth with respect to vulnerable groundwater aquifers	Reduced filtering capacity from removed overburden; altered groundwater recharge rates; altering groundwater table and local flow directions; groundwater contamination; vulnerability increased on-site by removing overburden (less depth to groundwater)
Proximity to water wells	Degrading groundwater quality (contamination) or quantity (well interference or mounding) for nearby water wells
Material	
Metal leaching and acid rock drainage from site	Metal leaching and acidic drainage from disturbed/stockpiled soil or crushed rock to off-site water bodies; toxicity for ecological or human receptors
Site Layout	
Fuel storage siting and design	Potential spills to surface, groundwater contamination, runoff to surface water bodies; maintaining acceptable setback from water supplies
Septic system siting and design	Maintaining acceptable setback from water supplies; potential groundwater contamination
Water demand for operations	Matching demand with available supply via installed infrastructure (municipal water mains) or new on-site supply (water well)
Removing/stockpiling overburden or aggregate	Degrading/removing topsoil and surface vegetation; changes in surface runoff characteristics; altered groundwater recharge rates; possible ML-ARD issues (depending on material)

These factors can be grouped into those that use avoidance criteria to constrain the *siting* of a new operation, that which is inherent to the aggregate or overburden *material*, and those, which depend on the *site layout* of a proposed operation (e.g., process requirements, site layout and management. Siting factors are readily mapped and are presented here graphically (via the GIS product), while the material and site layout factors are presented in terms of best management practices (BMP; meaning the best currently available practices according to local or BC provincial industry standards).

Some factors are not easily quantified without site-specific information, and are addressed through recommended BMPs on the checklist (or its associated supporting documents).

13.2 Vulnerable Groundwater Aquifers

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. The methods including assessing the applicability of the MOE classification system versus the Okanagan Basin Water Board (OBWB) classification system.

The two aquifer classification systems in the RDCO are:

- MOE system – established by the BC MOE to map and classify aquifers across BC based on a wide range of use, vulnerability, yield, physical and water quality parameters,^{cxl} and,
- OBWB system – developed for purposes of catchment-scale groundwater budgeting as part of a basin-scale water balance model incorporated in the Phase 2 Water Supply and Demand Study of the Okanagan Basin Water Board^{cxli}.

EBA has chosen to incorporate the MOE system 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. (See Section 3.9 for further information). Given the scale advantages and systematic ranking system, we have adopted the existing BC MOE system of aquifer mapping and classification for this study (Figure 9). 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.

13.3 Greenhouse Gas

In terms of using the BC MOE aquifer system, these mapped aquifers are coded, for example, as follows:

118, IIA (14)

Where,

- 118 = Aquifer identification number
- II = Development classification (I – heavy, II – moderate, III – light)
- A = Vulnerability classification (A – high, B – moderate, C – low)
- (14) = Aquifer ranking value (cumulative sum of individual parameter scores; range: 5-21)

Aquifer development is determined based on water well density, water use, aquifer productivity and sources of recharge. Aquifer productivity is based on aquifer material type, water well yield and specific capacity, and aquifer transmissivity. Vulnerability is a qualitative intrinsic aquifer characteristic, developed using professional judgement based on the type, thickness and extent of materials overlying an aquifer, depth to water, and the material type and porosity of an aquifer. In general, vulnerability is increased with

- less depth to groundwater;
- porous soils; and
- high permeability.

Aquifer ranking values are used to compare the relative importance of two aquifers (the higher the ranking score, the more valuable the aquifer). All of these classification criteria could bear on the siting and acceptability of an aggregate operation. Full details of how the MOE aquifers are mapped and evaluated are presented by Berardinucci and Ronneseth (2002). The BC MOE Aquifer System is shown in Figure 9.

13.4 Adjacent Groundwater Resources

Potential impacts to adjacent groundwater resources may due to an aggregate operation, depending on the depth of the lowest part of the excavation to groundwater, on-site water use, and fuel management and storage.

Proximity to Water Wells

The principal issues for this factor are physical groundwater quality (e.g., turbidity, colour) and well interference (excessive drawdown) or mounding (induced raising of the water table) affecting on-site or nearby water wells. Issues related to chemical groundwater quality (e.g., fuel or septic effluent contaminants) are dealt with in other factors.

Adjacent Well Sedimentation

Physical effects on groundwater quality can be attributed to ground vibrations from operational activities (excavation, screening or loading/unloading) or infiltration into coarse, porous surficial materials from dusty or dirty stockpiled soils or aggregates on site, which can be worsened by removal of the filtering

effects of pre-existing overburden. If affected groundwater travels to nearby water wells without normal filtering effects of soils and the well water may degrade. While these are mainly aesthetic effects, they still are causes for concern for well users.

Adjacent Well Drawdown

Well interference occurs if a new well is installed on an aggregate site and pumped so that its drawdown cone expands and further draws down water levels in nearby water wells. This effect can be calculated based on distance between wells, the nature of the subsurface materials, depth to groundwater and pumping rates. In general, the closer together that wells are, the more likely they will interfere with each other. By the same thinking, if excessive infiltration is induced (e.g., by drainage from washing operations infiltrating through a reduced cover thickness of soil to the groundwater table), a groundwater mound can develop, raising water levels off-site. This can affect water quality in nearby water wells, or the draining characteristics of septic fields designed for a normally-lower groundwater table.

These issues are distance- and rate-dependent, and the severity and nature of the effects will be site-specific. In addition, all else being equal, effects on a municipal well (which serves many users) are assumed to have more severe consequences than those on a domestic water well. Also the effects on clusters of nearby domestic wells are assumed to have more severe consequences than for individual domestic wells.

13.5 Metal Leaching and Acid Rock Drainage

Acid rock drainage occurs when rock or soil fragments containing elemental sulphide minerals are exposed to oxygen and water to form sulfuric acid, and the hydrolysis of ferric iron, which is entrained in runoff or infiltration. Toxicity is related to a suite of metals (e.g., iron, aluminum, copper, lead, silver, zinc, selenium, zinc, molybdenum, nickel, arsenic or antimony) which can leach from the rock into acidic water and affect aquatic systems or human health by direct contact or ingestion. Acidic (low pH) water itself can also have health effects. Metals typically begin to leach from rocks at pH levels of 6 or less, and acidic springs and seeps are typically marked by rusty reddish-yellow colour. Leaching of arsenic, antimony, selenium, zinc and molybdenum may also occur under neutral (pH = 7) or even alkaline (pH > 7) drainage conditions if these metal concentrations in the rock are sufficiently high (MEM, 2002).

The principal issues with this factor are metal leaching and acid rock drainage (ML-ARD) from disturbed/stockpiled soil or crushed rock (or exposed bedrock) to off-site water bodies, and resulting toxicity for ecological or human receptors. ML-ARD is a complex dynamic process involving the mineralogy of excavated material (soil or rock), the exposed bedrock lithological and structural characteristics, weathering, operational procedures (stockpiling and handling) procedures, and chemical geochemical reactions with oxygen and water.

There is a wide range of literature and reference materials relating to ML-ARD. The MEM provides comprehensive guidance for predicting and preventing ML-ARD; storing, mitigating and treating earth materials prone to ML-ARD; as well as permitting and regulatory information (Price and Errington, 1998). Further guidance relating to ML-ARD and more recent additional references is provided in the Aggregate Operators Best Management Practices Hand Book for British Columbia (MEM, 2002).

ML-ARD It is highly site-specific, and typically highly localized in specific areas (on a scale of metres) within a site. However, it is most commonly associated with bedrock containing sulphide minerals (especially blasted or crushed bedrock), more so than with weathered and transported alluvial material (such as sand and gravel).

Indicators of the presence of ML-ARD include:

- Visible sulphide mineralization;
- Visible sulphide oxidization;
- Hydrothermal alteration (rusty or bleached rocks); and
- Proximity to a known metallic mineral deposit^{cxlii}

13.6 Storm Runoff from Site

The principal issues with this factor are increased soil erosion on- and near-site, and siltation of receiving surface water bodies. This is a design factor, and all sites should adhere to the same level of standard best practices of management, control and mitigation (e.g., as described in the *AO BMP Handbook*^{cxliii}.)

13.7 Fuel Storage Siting and Design

The principal issues with this factor are potential spills of fuel products, contamination of groundwater and surface water bodies, and the need to maintain acceptable setback from water supplies. This is a design factor, and all sites should adhere to the same level of standard best practices of management, control and mitigation, as described in the *AO BMP Handbook*^{cxliv}.

13.8 Septic System Siting and Design

The principal issues with this factor are maintaining acceptable setback from water supplies and establish proper septic system design and operation to avoid potential groundwater contamination. This is a design factor, and all sites with septic systems should adhere to standard best practices for the siting, design and operation of the septic system, as described in the *BC Ministry of Health Sewerage System Standard Practice Manual, Version II*.^{cxlv}

13.9 Water Demand

The principal issues with this factor are matching operational water demand (process water and potable water) with available supply via installed infrastructure (municipal water mains) or a new on-site supply (water well). Water demands will vary greatly depending on the purpose, size and design of the aggregate operation, the material involved (e.g., whether washed aggregate is to be produced), the number of employees on site and related facilities, and if there are other planned uses of water (e.g., vehicle washing, landscaping irrigation).

Water demand is highly project-specific. A proponent would need to determine their water demand based on the planned scale and scope of the operation, then approach approving authorities and water suppliers

to discuss and negotiate the supply of adequate water. If only some or none of the demand can be met by installed infrastructure, the proponent would need to evaluate alternative processes requiring less water, or alternative water supplies (typically an on-site water well).

13.10 Stockpiling Overburden or Aggregate

The principal issues with this factor are removing topsoil and surface vegetation, changes in surface runoff characteristics and altered groundwater recharge rates. This is a design factor and will vary greatly depending on the purpose, size and design of the aggregate operation, the location and thickness of unwanted overburden, available space onsite for stockpiling, the aggregate material involved and other site layout features.

For all sites, the proponent must develop their plan and design according to the same level of best practices of management and control as described in the *AO BMP Handbook*^{cxlvi}.

14.0 GREENHOUSE GAS REDUCTION

Sustainable resource management should evaluate the climate impacts of the decisions made. Municipalities should assess the different options for aggregate production (extraction vs. recycle, etc.), from a greenhouse gas (GHG) life cycle approach.

14.1 Greenhouse Gas Emissions

For processing emissions, the processing of various aggregate source materials is:

- natural sand and gravel (1912.81 CO₂e kg CO₂e / t)
- recycled concrete (2885.40 kg CO₂e / t)
- recycled asphalt (5418.6 kg CO₂e / t)
- quarried rock (8,129.72 kg CO₂e / t).

For the various source materials, sand and gravel has the lowest emissions, followed by recycled concrete. Recycled asphalt is more intensive, with quarried rock being the most emissions intensive aggregate to process due to the blasting process required.

Assuming the same trucks are used, transportation emissions of the aggregate material are generally the 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 access 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. A default assumption was made on a typical truck type (Volvo A25E) used and thus the load capacity (24 tonnes). The tonnes per load in the model can easily be changed. The range of trucks typically has load capacities between 12- 32 tonnes per load. The fuel efficiency used is for heavy diesel trucks published by Natural Resources Canada. Specific truck fuel

efficiencies are generally not available but may be published by manufacturers, and other values can be entered into the model. The model also excludes emissions for trucks to drive to sites to pick up materials.

Note that there are other upstream and downstream impacts that have not been taken into consideration through this assessment. For example the broader environmental impacts of pits and quarries and alternative cases for disposed asphalt and concrete.

14.2 Greenhouse Gas Calculator

The greenhouse gas calculator was developed (Appendix E) that may be used to compare the relative greenhouse gases of one site location to another. In addition, it can be used to assess the difference in greenhouse gases using different fuel sources for machinery.

15.0 INFRASTRUCTURE IMPACT ANALYSIS

15.1 Traffic

An 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 a change in the type of traffic or traffic volumes would result in impacts to the pavement service life. An increase in vehicle size or trips may result in premature failure of the pavement structure and required earlier rehabilitation interventions or reconstruction.

Design traffic is calculated in terms of equivalent single axle loads (ESAL) as a means of standardizing different truck and tractor-trailer combinations on the highway systems. By definition, one ESAL is equivalent to 8,167 kg (18,000 lbs) on a single axle with dual tires, or 14,500 kg (32,000 lbs) on a tandem-dual configured axle.

For this analysis, it was assumed that the trucks would be loaded to maximum allowable legal load limits. The passenger cars, light duty pick-up trucks and vans cause negligible distress to the competent pavement structures. Heavy trucks and buses have more significant influence on the performance of the pavement infrastructure. As an example, a dump truck loaded to legal load limits in British Columbia would have approximately 3.5 ESAL's per truck and a typical passenger car / pickup truck would have 0.0004 ESAL's per car. This indicates that each truck would cause damage equivalent to that caused by approximately 8,750 cars. This figure was determined from calculations as indicated by the Load Equivalency Factors for different vehicle types.

For the purpose of this study, the impact of aggregate hauling of 250,000 metric tonnes (t), 500,000 t and 1,000,000 t on different classifications of pavements (pavement structures) were considered. A conversion factor of 1.7 tonnes = 1 cubic meter for aggregates was used to calculate the additional truck trips for the three hypothetical potential aggregate hauling scenarios. The number of truck trips calculated for each scenario is presented in Table 31 below:

Table 31 Additional Truck Trips Owing to Aggregate Hauling

Aggregate Potential (t)	No. of Truck Trips	Corresponding ESAL's
250,000	21,000	73,500
500,000	42,000	147,000
1,000,000	84,000	294,100

15.2 Pavement Structure

The existing pavement structure of the haul routes selected during the aggregate hauling would have a significant impact on the rate of deterioration of the pavement. Three general pavement structures were considered during this analysis as discussed in Table 32.

Table 32 Pavement Structures

Pavement Structure Type	Corresponding Design ESAL's	Typical Pavement Structure Thicknesses (mm)		
		Asphalt	Base	Sub-base
Thick Structure (Arterial Streets) (Type A)	6,500,000	150	300	300
Intermediate Structure (Collector Streets) (Type B)	850,000	100	200	300
Thin Structure (Local Streets) (Type C)	100,000	50	200	200

A moderate to weak subgrade (40 MPa) has been considered when calculating the pavement structures. This is considered typical of subgrade soils found in the Okanagan. The pavement structures considered in Table 32 are assumed pavement structures for different classifications of roadways in municipal settings.

The design ESAL's corresponding to the pavement structures as assumed in Table 32 above, were calculated using the American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavement Structures 1993*. Other inputs needed for the analysis of the pavement structure / design ESAL's were obtained from the *BC Ministry of Transportation's Pavement Structure Design Guidelines* as contained in *Technical Circular T-01/04*.

Many of the rural roads / local roads could originally have been gravel roads that were paved to accommodate passenger vehicles and to eliminate dust. As such, these pavements were constructed with minimal structure and may require significant upgrades to support hauling operations of any kind.

15.3 Impact Analysis

For the purpose of this study, it was assumed that all of the roads to be included in the aggregate haul route were designed for a design life of 20 years (i.e. before any planned rehabilitation treatment). Assuming an average pit life of 10 years, the additional trips resulting from the aggregate hauling operation were added on the design ESAL's for each year to evaluate the impact of aggregate hauling on the various pavement structures.

Figure G to J below indicate the cumulative ESAL's for the various aggregate hauling scenarios for Type A, Type B and Type C pavement structures respectively.

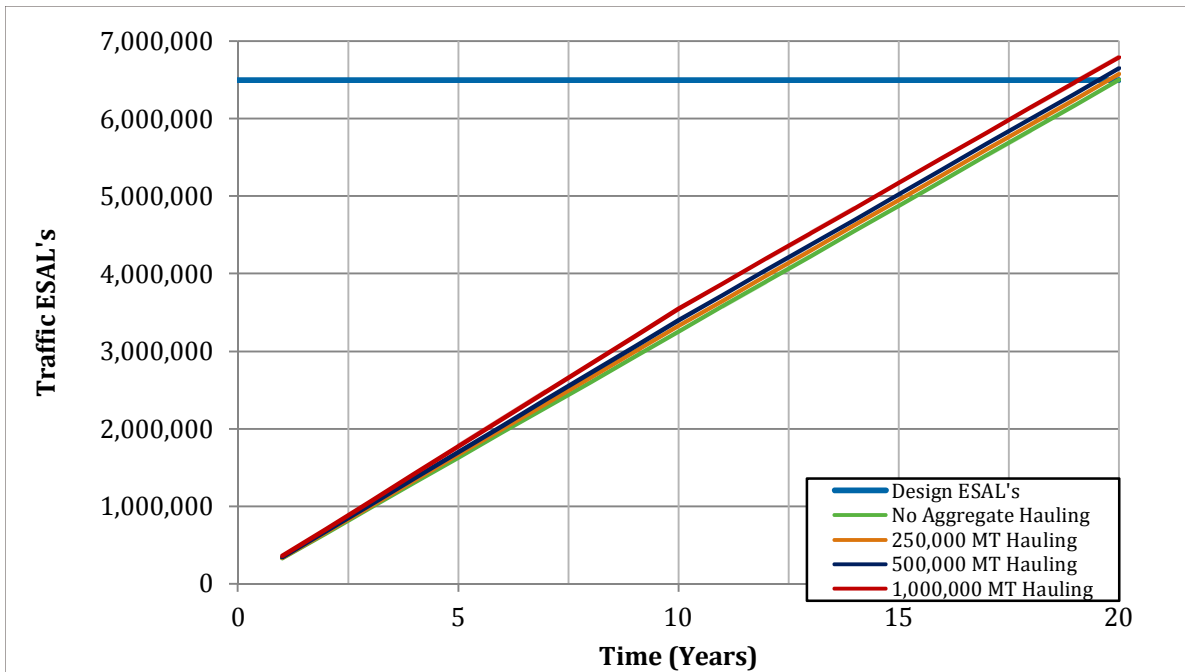


Figure G Impact of Aggregate Hauling on Cumulative ESAL's for Type A Pavement Structure

The data presented in Figure G indicates that the hauling assumed volumes of aggregates has minimal impact on the cumulative ESAL's of the thick pavement structure. The cumulative ESAL's will exceed the design ESAL's in year 18 and 19 and, therefore, will have minimal impact on the performance of the roadway.

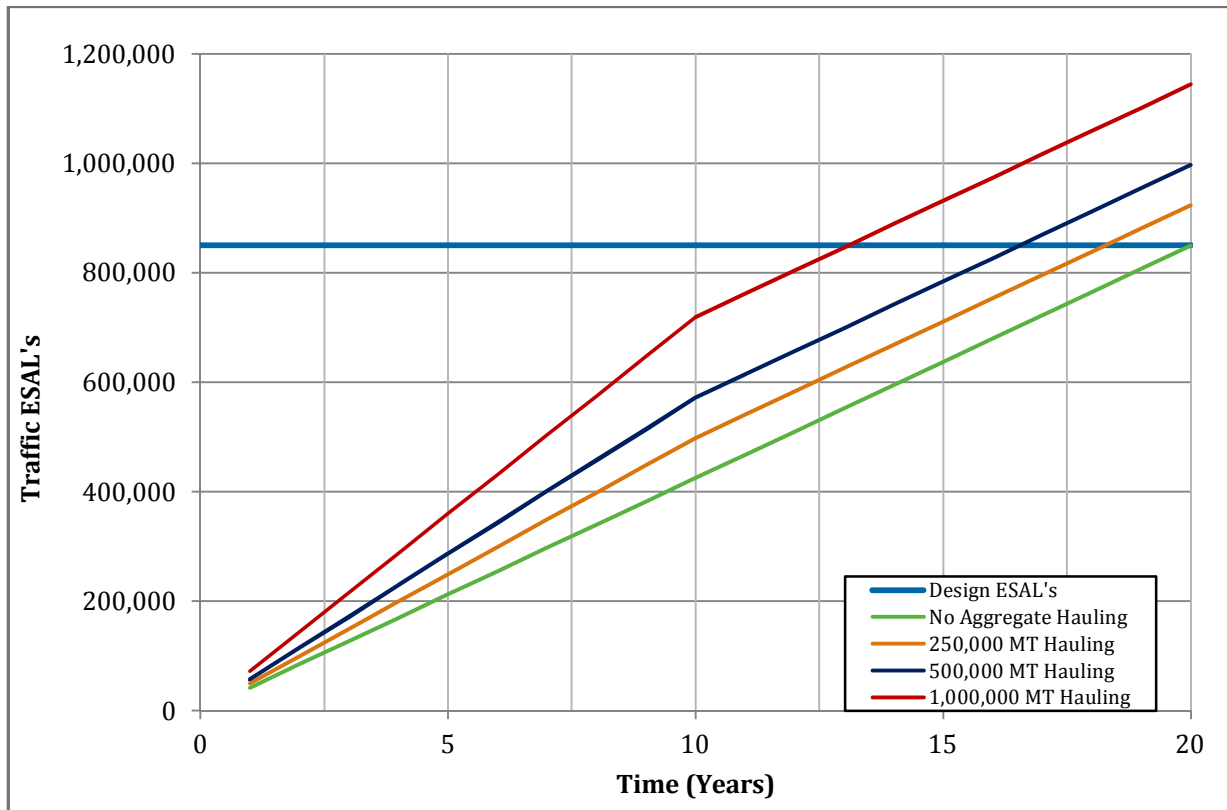


Figure H Impact of Aggregate Hauling on Cumulative ESAL's for Type B Pavement Structure

The data presented in Figure I H indicates that the hauling of aggregates will affect the pavement performance, especially at higher volumes. The cumulative ESAL's will exceed the design ESAL's in years 13 and 17 for the haul volumes of 1,000,000 MT and 500,000 MT respectively. As such, the hauling operation will affect the performance and maintenance and rehabilitation needs of the pavement structure.

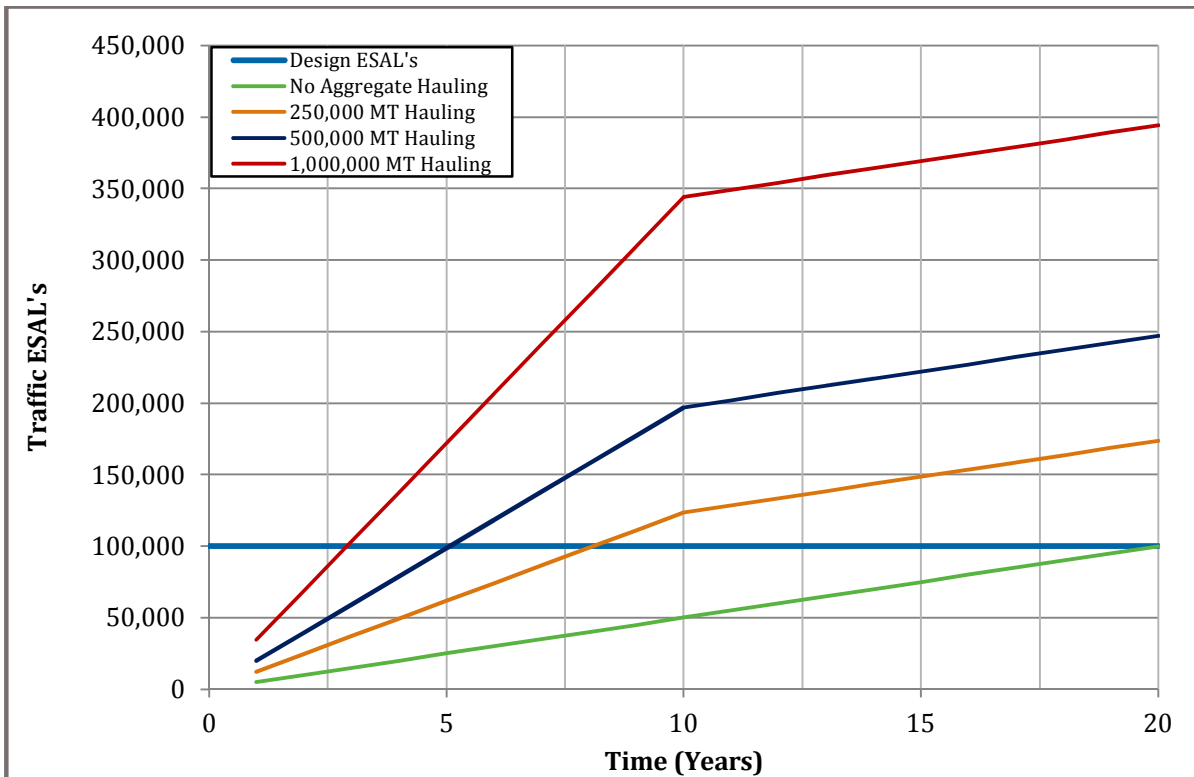


Figure I Impact of Aggregate Hauling on 'Type C' Pavement Structure

The data presented in Figure I indicates that aggregate hauling operations will adversely impact the thin pavement structures. As could be seen from the presented data, the cumulative ESAL's on the roadway will exceed the design ESAL's in as early as 3 years following the start of aggregate hauling operation in the worst case scenario. As such, the hauling operation will adversely affect the pavement performance.

The data presented in Figures G to I indicates that the thinner pavement structure would be more severely impacted by increases in additional heavy traffic. Traffic loadings generated by the lowest assumed haul volumes of 250,000 t over the thinner pavements could result in pavement failure in less than 2 years.

The impact of hauling 250,000 t, 500,000 t and 1,000,000 t aggregates on the service life of various pavement structures is summarized in Table 33.

Table 33. Pavement Service Life Used by Aggregate Hauling Operations

Pavement Type	Percent Reduction in 20-yr Service Life Due to Aggregate Hauling		
	250,000 t	500,000 t	1,000,000 t
A (thick)	1	2	5
B (intermediate)	9	17	35
C (thin)	74	147	294

Figure J illustrates the remaining service life of the various pavement types as a result of aggregate hauling of 1,000,000 tonnes.

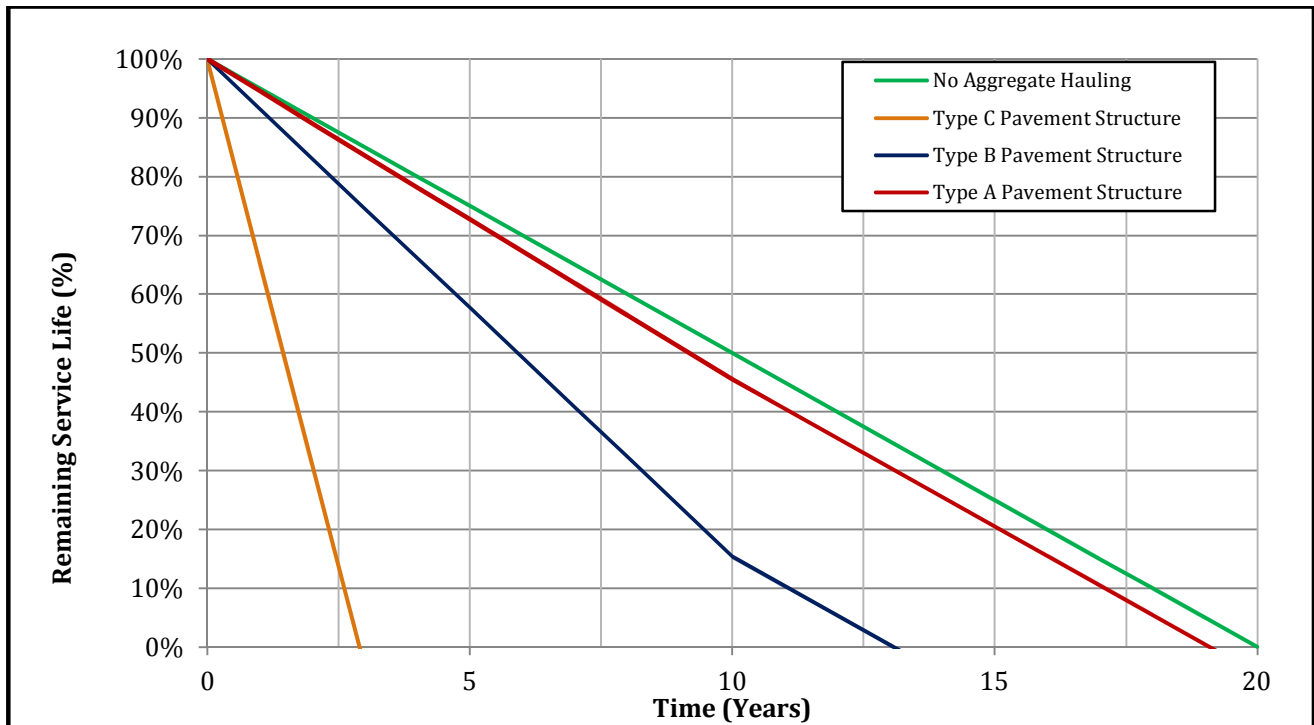


Figure J Impact of 1,000,000 MT of Aggregate Hauling on Pavements

The data presented in Figure J indicates that the hauling of 1,000,000 MT of aggregates will consume the entire service life of pavement Types C and B in 3 and 13 years respectively. The impact on Type A will be minimal, as its service life will be reduced by only 1 year.

16.0 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^{cxlvii}, 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.

17.0 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 and absorption or deflection present. This section will review noise and techniques to mitigate and buffer noise.

17.1 Noise Regulation

A number of agencies and jurisdictions have noise level limits and mitigation recommendations over certain levels. For example, the *Canada Occupational Health and Safety Regulations*, WorkSafe BC, and the *Reclamation Code*^{cxlviii} all have guidelines for the protection of workers.

The *Canada Occupational Health and Safety Regulations* stipulate that an employee's exposure to noise shall not exceed 87 dBA over an 8 hour period, and shall not exceed 84 dBA over a 16 hour period. It recommends a hazard investigation where employees are exposed to sound levels of at least 80 – 90 dBA on a regular basis^{cxlix}.

The *Reclamation Code*^{cl} 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.

WorkSafe BC states that, in BC, the permissible 100% dose of noise is 85dBA for 8 hours.

As noted in the *Reclamation Handbook*^{cli}, the *Mines Act* permit, as well as municipal bylaws, may outline the allowable noise levels of an operation, as well as hours of operation.^{clii}

17.2 Noise in the Environment

Noise effects can vary in the environment and community and is dependent on background noise levels, peak noise, time of day, the presence of absorbing or reflecting surfaces, frequency and duration. We measure sound in decibels (dB). The measure for sound in the environment is presented on a weighted scale, referred to as the 'A' weighting, designed to be similar to human hearing measured in db(A). It is a logarithmic scale. A rise in 10 dbA approximately corresponds with a doubling of sound.^{cliii} Typical noise levels for various activities are outlined in Table 34.

Table 34 Typical Noise Levels

Noise Level (dBA)	Activity
140	Threshold of Pain
125	Jet Take-off (100 m distance)
105	Pneumatic Chipper
100	Outboard motor, lawn mower, motorcycle, tractor, garbage truck
96	Use of Power Mower
90	Motorcycle at 8 m
88	Food Blender
84	Diesel Truck 65 km/h from 15 m
82	Pneumatic Drill from 15 m
80	Average Street Traffic
77	Passenger car at 7.5 metres
76	Living Room Music
70	Vacuum Cleaner
65	Business Office
60	Conversation in restaurant, background music
40	Living Room
15	Forest
0	Threshold of Hearing

*Adapted from BC MEM, 1998; ODPM 2005, and INC, 2013

A selection of typical aggregate operations machinery and their un-buffered noise levels is shown in Table 35.

Table 35 Projected Un-buffered Noise Levels for some Common Aggregate Machinery^{cliv}

Noise Source	Measurements	Projected Noise Levels without Barriers		
		300 m	600 m	900 m
Primary and Secondary Crusher	89 dBA at 30 m	69.0 dBA	63.0 dBA	59.5 dBA
Hitachi 501 shovel, loading	92 dBA at 15 m	66.0 dBA	60.0 dBA	56.5 dBA
Euclid R-50 pit truck, loaded	90 dBA at 15 m	64.0 dBA	58.0 dBA	54.4 dBA
Caterpillar 988 loader	80 dBA at 95 m	69.5 dBA	63.5 dBA	60.0 dBA

17.3 Local Noise Bylaws

The local governments regulate noise disturbance within the community through bylaws that regulate noise and blasting. A summary of the bylaws is outlined in Table 36.

Table 36 Local Noise Bylaw Summary

	Construction Time Windows	Blasting	Conditions / Exemptions
District of Lake Country	7:00 AM to 9:00 PM	Not specified	Special events or extensions under permit. Engine brakes restricted in neighbourhoods if considered a disturbance

Table 36 Local Noise Bylaw Summary

	Construction Time Windows	Blasting	Conditions / Exemptions
City of Kelowna	7:00 AM to 10:00 PM	Not specified	Special events under permit
District of West Kelowna – Good Neighbour Bylaw No.	7:00 AM to 8:00 PM	Permit Required	Commercial or industrial zoned activities when done with industry standards
District of Peachland Blasting Regulations Bylaw No. 701	Not specified	Permit Required	No Blasting except with permit
District of Peachland Noise Bylaw No. 1330	M-F 7:00 AM to 9:00 PM Sat 10:00 AM to 9:00 PM Sun & holidays 10:00 AM and Saturday	Refer to DoP Blasting Permit	Extensions available under permit for emergency work or for special events
RDCO Noise Control Bylaws No. 219, 403, 968, 1071	7:00 AM and 10:00 PM	Not specified	Aggregate extraction and processing equipment between the hours specified. Time extensions under permit
RDCO Subdivision and Development Servicing Bylaw No. 704	N/A	N/A	For sanitary sewer facilities, noise must not exceed 65 dB at property line or 20 m away (whichever is closer)

18.0 HEALTH - DUST

Dust is a common community concern of aggregate operations. This section reviews the nature of dust, standards, and best management practices for mitigation.

18.1 Dust Defined

Dust is defined as any particle up to 75 microns (μm) in size^{clv}. 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 10 μm , are referred to as PM_{10} also 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 ^{clvi}. 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.^{clvii}

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

18.2 Canada Wide Standards

Canadian Council of Ministers of the Environment has developed Canada Wide Standards (CWS) that outlines guidelines for PM_{2.5} and ozone targets. The standards are set for PM_{2.5} because it is the component of airborne dust that is the greatest health concern.

Specific to dust, the standard is:

- PM_{2.5} - 30 µg/m³, 24-hour averaging time, achievement to be based on the 98th percentile annual ambient measurement, averaged over 3 consecutive years, by 2010.

The calculations must include at least 18 valid measurements, hourly, over a 24 hour period.^{clx}

18.3 BC Waste Management Act

The BC *Waste Management Act* outlines regulations for the protection of air quality in British Columbia. It outlines emission guidelines, permits, fees, monitoring, the development of air quality objectives, and public education. It stipulates guidelines for vehicle emissions and burning. However, specific levels or management guidelines for particulate matter is not specified.

18.4 Greater Vancouver Regional District Concrete Emissions Bylaw

The Greater Vancouver Regional District has a concrete and concrete emissions bylaw^{clxi}. The bylaw restricts emissions from concrete production facilities based on visual opacity. It prohibits overfilling, and requires fabric filters for all discharges of air contaminants. It requires regular maintenance of filter mechanisms, spill containment, cleaning of on-site paved roads and dust suppression of paved roads.

18.5 Dust in the Environment

Environment Canada keeps an inventory of pollutant releases for substances in Canada, including PM_{2.5}. Table 37 outlines some common sources of PM_{2.5} produced in British Columbia in 2011^{clxii}.

Table 37 2011 Particulate Matter (PM_{2.5}) Emissions for British Columbia

Sector	PM _{2.5} (tonnes)
Asphalt Paving Industry	25
Cement Manufacture	131
Lime Manufacture	57
Concrete Batching & Products	806
Rock, Sand & Gravel Mining & Quarrying	258
Wood Industry - Sawmills	612
Wood Industry – Panel Board Mills	192
Residential Fuel Wood Combustion	10,939
Heavy Duty Diesel Vehicles	374
Tire Wear & Brake Lining	227
Meat Cooking - Residential	642
Meat Cooking - Commercial	428
Agriculture – Tilling & Wind Erosion	1036

Table 37 2011 Particulate Matter (PM_{2.5}) Emissions for British Columbia

Sector	PM _{2.5} (tonnes)
Dust from Paved Roads	24,774
Dust from Unpaved Roads	16,900
Forest Fires	23,630

* NPRI, 2013

18.6 Crystalline Silica

Silica is a main component of sand, soil, and rocks such as granite and quartzite. Applications vary depending on particle size.

- Lump silica (3 mm – 150 mm)
- Sand silica (75 µm – 3 mm)
- Silica flour (<75 µm)

Lump silica is used in smelting operations, to make silicon and silica brick. Lump silica is too large to inhale and therefore not a health concern. Sand is used in the production of concrete, asphalt paving, brick, and sandblasting materials. Flours are formed when quartz, quartzite, sand or sandstone is ground. Silica flour is used in ceramics, rubber, paints, and as an abrasive in soaps and household cleansers.^{clxiii}

The respiration of the small fraction silica is a health hazard, including the risk of silicosis, a fibrotic lung disease. It is considered a carcinogen, and has been linked to autoimmune disorders and kidney disease^{clxiv}. It is an occupational hazard for workers involved with blasting, stonecutting, rock drilling and quarry work.^{clxv} The Occupational Exposure Limits (OEL) for the respirable fraction is 0.025 mg/m³ for Canada and British Columbia.^{clxvi}

18.7 Aggregate Operations and Dust

The dust created by an aggregate operation will vary one from another, 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.

Larger particles will fall out more quickly than small ones, which travel farther. Most aggregate dust is over 10 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 3 µm can travel over 1000 m^{clxvii}. Most of the dust created by aggregate operations is at the nuisance level, as shown in Table 38.

Table 38 Dust Concerns and Typical Travel Distances by Physical Particle Size^{clxviii}

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	
PM ₁₀ (2.5 to 10 µ)	2.5 – 10 µm	Health (inhalable coarse particles)	1000 m	3%

Table 38 Dust Concerns and Typical Travel Distances by Physical Particle Size^{clxviii}

Dust Categories	Size μm	Concerns	Distance Traveled	Typical Percentage from Aggregate Pits
PM_{2.5} (less than 2.5μ)	< 2.5 - μm	Health (inhalable fine particles)	> 1000 m	3%

Results of a study of on-site dust emissions from an aggregate storage operation are shown in Table 39. Transportation is the highest source of dust in this scenario, followed by wind erosion.

Table 39 Sample Study of USA Dust Emissions from Aggregate Storage^{clxix}

Source Activity	% Total Emission	Emission Factor (kg dust/tonne aggregate)
Loading into Storage	12	0.016
Transportation	40	0.050
Reclaim from Stockpiles	15	0.020
Wind Erosion	33	0.045

18.8 Relative Efficiency of Dust Control Measures

The relative efficiency of various dust control measures has been studied in the US. Table 40 summarizes the efficiencies. Reduction of dust at the source is the most effective approach to air quality mitigation.

Table 40 Efficiency of Dust Control Measures

Activity	Control Method	Control Efficiency
Loading Stockpile	▪ Reducing drop height	25%
	▪ Telescopic chutes	75%
	▪ Conveyor sprays	75%
Wind Erosion from Stockpile	▪ Regular watering	80%
	▪ Surface crusting agent	Up to 99%
	▪ Vegetative wind break	30%
	▪ Lower pile height	30%
Speed Control	▪ Chemical surface treatment	50%
	▪ Speed control: 50 km/h	25%
	▪ Speed control: 32 km/h	65%
	▪ Speed control: 16 km/h	80%

* MEM, 2002; Thomas, 2000

19.0 HEALTH - RADON

This section reviews the nature of radon gas, its health effects, and the potential impacts of the product end use of using aggregate in a product such as concrete or sub-base in a building, which may have elevated levels of uranium.

19.1 Radon and Health

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^{clxxx}. 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, and 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^{clxxxi}. 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 .^{clxxii}

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.

19.2 Radon in Water

Research on radon indicates that elevated levels of radon concentrated in water sources are far less harmful than radon inhaled as a gas. The dissolution of minerals containing uranium may introduce elevated concentrations of the element into water sources. The Maximum Allowable Concentration (MAC) of uranium in drinking water has been set as 0.02 mg/L ^{clxxxiii}. Note that this value measures the mineralogical aspects of uranium not the radiological. This value established is such that no adverse health effects would occur from the ingestion of 1.5 L of drinking water per day containing uranium at this concentration over a 70 year lifetime. The Canadian Council of Ministers of the Environment (CCME) has established the water quality guideline value for the protection of freshwater aquatic life as 0.015 mg/L ^{clxxxiv}. CCME also provides guideline values for allowable uranium concentrations in soil, for commercial or agricultural use. CCME has established the water quality guideline value for the protection of livestock agriculture as 0.2 mg/L .^{xxxv}

19.3 Radon Gas

Research on radon indicates that elevated levels of radon concentrated in water sources are far less harmful than radon inhaled as a gas. However, radon in water, in particular well water can contribute to the concentration of radon gas within the indoor environment. The current guideline value for acceptable levels of radon gas in an indoor air environment such as a house is 200 Bq/m³ (Becquerels per cubic meter). This guideline value was established by the Federal Provincial Territorial Radiation Protection Committee (FRTRPC). There are no guidelines for radon gas in an outdoor open space.

19.4 Radon Standards

The Health, Safety and Reclamation Code sets limits for radiation exposure for workers, including radon exposure. For radon, it states that a worker shall not be exposed to a combination of radon decay products and gamma radiation totalling 20 millisieverts (mSv) averaged over 5 years or 50 millisieverts in a single year. In addition, the mine manager must undertake testing with calibrated instruments where there are indicators that uranium or thorium levels are in a grade of 0.05% by weight or greater^{clxxv}. Canada uses the International Commission on Radiological Protection (ICRP) recommendations to set radiation protection regulations, and the annual occupational dose allowable for members of the public is 1 mSv.^{clxxvi}

19.5 Uranium Occurrences

Uranium, in its pure form is silvery-white and weakly radioactive. It is a naturally-occurring element commonly found in rocks and soils. The concentration of uranium will vary based on location and type of the source material. Granitic rocks, alkaline sandstones and shale bedrock, for example will tend to have slightly higher concentrations of uranium^{clxxvii}. It is the heaviest of the naturally occurring elements and is present in the earth's crust at an average concentration of 3 parts per million^{clxxviii}. Uranium is both a chemical and radioactive material with variable chemical and physical forms, and as such it can be measured in units of mass or radioactivity^{clxxix}.

Soils and sediments will reflect the composition of their parent material (rock), which may result in higher uranium concentrations in areas of known mineralization. The Blizzard uranium deposit occurs in the Okanagan Highlands, in the eastern portion of the Western Cordillera, approximately 50 kilometers southeast of Kelowna. The project is currently owned by Boss Power Corp. and is at an advance exploration stage. This deposit is located outside of the RDCO boundary. Uranium concentrations in soil samples collected from within 13 km of the ore body ranged from 1.5 to 390 ppm. Uranium concentrations in soil samples collected outside of this area proximal to the ore body tended to range from 3 to 7 ppm, slightly above the average crustal abundance^{clxxx}

The Blizzard uranium deposit has been classified as a basal and channel conglomerate type deposit. Basal type uranium deposits in the Okanagan Plateau occur in poorly consolidated fluvial or lacustrine carbonaceous sediments. The term basal-type uranium deposit is applied to these deposits because they often occur in basal sequences of gravel and sand, which overlie a major unconformity, and at the base of a trapping impermeable layer^{clxxxi}. Additional areas of uranium mineralization within the RDCO boundary may contribute to above average uranium concentrations in bedrock sources.

Average crustal abundance can vary greatly depending on location; both on a regional scale, as well as at local scales, based on proximity to mineralization and associated rock type. It is important to understand the baseline concentrations of uranium present in a potential aggregate bedrock source to understand the potential for environmental or health impacts related to the rock disturbance.

19.6 Testing for Uranium and Radon

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.

Uranium levels in an area may also be evaluated using a measuring device, such as a Geiger counter or gamma scintillometer.

20.0 VISUAL IMPACTS

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*^{clxxxiii} 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. This table is included below.

Table 41 Key Viewpoint Visual Landscape Approach

Steps	Details
Step 1	<ul style="list-style-type: none"> ▪ Identify key viewpoints, e.g. <ul style="list-style-type: none"> – Roads – Residential areas – Footpaths / parks – Tourist facilities
Step 2	<ul style="list-style-type: none"> ▪ Determine the extent of potential visibility (directions and distances) ▪ Evaluate sensitivity of viewpoint

Table 41 Key Viewpoint Visual Landscape Approach

Steps	Details
Step 3	<ul style="list-style-type: none"> ▪ Determine the degree of obstruction or intrusion that will occur ▪ Determine the potential changes or the visual impact
Step 4	<ul style="list-style-type: none"> ▪ Modify the mine layout and operations to minimize visual concerns

(MEM, 2002)

Standards within British Columbia for visual impact assessments include the *Visual Impact Assessment Guidebook*^{clxxxiii} used for forestry projects and the *Manual of Aesthetic Design Practice*^{clxxxiv} 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. The *Guidebook* outlines steps involved in preparing a visual impact assessment. These steps include:

- Step 1: Planning and pre-field trip preparation
- Step 2: Conducting fieldwork
- Step 3: Developing design options and preparing visual simulations
- Step 4: Assessing visual simulations

The *Guidebook* outlines road techniques that mitigate visual impact and can be applied to aggregate operations. A selection of these guidelines is listed in Table 47.

A local example of effective visual screening, using berms and vegetation is shown in photos below.



Photo 5 Entry with vegetation and berm screening



Photo 6 Berm and vegetation visual and acoustic screening



Photo 7 Berm and retention of existing vegetation along roadway



Photo 8 Buffer of existing vegetation along roadway

21.0 COSTS

Costs of delivered aggregate include the product, processing, permitting, operation, reclamation, and transportation. Aggregate, by nature, is heavy and as such, the cost of transportation adds significantly to its overall cost. Transportation is also the cost that 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 also through taxes, as the various levels of government consume 60 percent of the aggregate produced in BC and fund the increased infrastructure life-cycle maintenance costs of roads, bridges, government buildings, hospitals and schools^{clxxxv}. Other jurisdictions are facing shortages of natural aggregate close to market. The City of Saskatoon, for example, has an average haul of natural aggregate of over 100 km, resulting in a cost of approximately \$32/tonne to market^{clxxxvi}. In the 1990s Kelowna aggregate prices rose over 50 percent following the transition of three gravel pits into subdivisions^{clxxxvii}.

In Kelowna, trucking costs an average of \$94 per load, based on 2012 producer's surveys, which equates to approximately \$10/tonne for transportation. If the average haul distance increases, this will have a direct impact on the cost of aggregate and resulting project costs.

22.0 SITE SUITABILITY ASSESSMENT

In order to achieve consistency with the referral process that takes into consideration potential impacts to the local community and environment, a template site suitability assessment (SSA) was prepared. A review of local bylaws and guidelines was undertaken to ensure the assessment was existing policy. The local policy review and site suitability assessment is outlined in this section.

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.

22.1 Local Policy Review

A review of the municipal land use policies of the RDCO and member municipalities was undertaken to ensure consistency with the SSA. The review did not identify any inconsistencies with the assessment. An overview of the documents reviewed is below.

City of Kelowna

The City of Kelowna Official Community Plan (OCP) states that the City will encourage the use and extraction of gravel resources and ensure appropriate redevelopment of gravel pits. The OCP requires that industrial sites obtain a development permit prior to any alteration of land, and further requires development permit application to be submitted in accordance with natural environment and water conservation guidelines, and hazardous condition guidelines within the Natural Environment Development Permit Area and Hazardous Conditions Development Permit Areas. The application process and permit requirements are outlined in Development Applications Procedures Bylaw. Soil Removal and Deposit Regulations Bylaw N. 9612 regulates and outlines permit application requirements and the application process.

District of West Kelowna

The District of West Kelowna OCP provides for the development of gravel extraction in industrial and resource areas subject to compatibility with neighbouring land uses and to compliance with Development Permit Guidelines. The OCP identifies biodiversity and environmentally sensitive areas under the Aquatic Ecosystem and Sensitive Terrestrial Ecosystem Development Permit Areas. The Soil Removal and Deposit Bylaw outlines the application process and permit requirements.

District of Lake Country

The District of Lake Country OCP identifies areas for future development of gravel extraction and areas to phase out and reclaim Gravel extraction pits. The OCP identifies and provides guidelines for development in Industrial Development Permit Area and Natural Environment Development Permit Area. The Development Application Procedures Bylaw outlines application requirements and the application process for Development Permits, and the Soil Regulations Bylaw outlines the requirement for and process to secure a permit to remove and deposit soil in the District.

District of Peachland

The OCP provides for the extraction and processing of sand and gravel subject to the issuance of a District permit and required Provincial permits. The District has established Development Permit Areas and guidelines and requires development permit applications to be submitted in accordance with OCP guidelines for applications in the Foreshore, Steep Slopes and Environmentally Sensitive Areas, as well as an Industrial Development Permit Area.

Regional District of Central Okanagan

Within the Region, the RDCO processes and issues development permits, OCP amendments, subdivision and rezoning applications in accordance with Development Procedure Bylaw No. 944, in accordance with the Regional Growth Strategy, Rezoning Bylaw #871 and the following Official Community Plans and Rural Land Use Bylaw:

Ellison

Ellison OCP provides for the approval of permits for gravel extraction in accordance with provincial Best Management Practices, and through the detailed environmental review and neighbourhood impact review as part of the Regional Districts development permit process. The OCP further establishes Development Permit Areas and guidelines for Aquatic Ecosystems, Rural Hillside Development and Sensitive Terrestrial Ecosystems.

Rural Westside

The Rural Westside OCP provides for mineral resource extraction, and outlines policies to provide direction to address land use conflicts, visual quality issues and environmental and waterway protection and enhancement guidelines through provincial Best Management Practices.

Brent Road and Trepanier

The Brent Road and Trepanier OCP supports mineral resource extraction in the area designated as Rural Resource, and establishes Permit Areas and guidelines for Aquatic Ecosystems Development, Rural Hillside Development and Sensitive Terrestrial Ecosystems Development.

South Slopes

The South Slopes OCP Bylaw outlines Development Permit Guidelines for resource applications in Aquatic Development Permit Areas, Terrestrial Development Permit Areas and Hillside Development Permit Areas, in accordance with Best Management Practices.

Joe Rich Rural Land Use Bylaw

The Rural Land Use Bylaw identifies current land use regulations, subdivision requirements, and development permit applications. Permit Areas and guidelines are established for Aquatic Ecosystems, and Sensitive Terrestrial Ecosystems.

22.2 Site Suitability Assessment

In order to achieve consistency with the referral process that takes into consideration potential impacts to the local community and environment, a template site suitability assessment (SSA) was prepared. 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 Assessment was prepared based on the integration of current standards, inventories and regional land use and permitting areas. It incorporated:

- Land use;
- Environmentally Sensitive Development Permit Areas;
- Hazardous Development Permit Areas;
- Provincial Aquifer Mapping;
- Visual Sensitivity, using provincial standards and BMPs;
- Adjacency for dust and noise;
- Roads and traffic;
- Greenhouse gas; and
- Mitigation and reclamation plans.

The Site Suitability Assessment 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 by local government staff is proposed, to be confirmed by their council or board. See Appendix F for the Site Suitability Assessment.

23.0 RECOMMENDATIONS

Recommendations for each project component are included in this section.

23.1 Site Suitability Assessment

The Site Suitability Assessment (Appendix F) provides the structure and process through which the other project component recommendations are completed. This approach will provide a clear and consistent approach to *Mines Act* referrals within the RDCO. The process is intended to establish a protocol of communications between the MEM and local governments in the RDCO.

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) 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)

23.2 Sand and Gravel Pits

The results of the sand and gravel mapping and volume assessment are limited to the accuracy available through a desktop study. For a more accurate assessment of volume and quality of aggregate, fieldwork and the preparation of cross sections is required.

A site suitability assessment should be approved prior to any field investigation planning. Assuming that the result of the assessment is positive, the field investigation should consist of:

- Delineate the area to be studied;
- Determine the potential depth of the sand and gravel deposits from the desktop study;
- Depending on the level of accuracy, plan for a subsurface investigation based on test pit excavations, borehole drilling and/or geophysical investigation;
- Carry out a field reconnaissance of the area to be studied;
- Logging and material sampling;
- Prepare cross sections and establish potential volumes;
- Confirm quality of materials for various end uses based on laboratory testing.

Note that for field investigation, logging should be conducted only as required to undertake the field investigation. Prior to the issuance of a *Mines Act* permit, any tree removal should adhere to applicable tree protection bylaws, natural area development permit requirements, and Ministry of Forests requirements for tree cutting on Crown Land.

23.3 Bedrock Sources of Aggregate

The investigation of bedrock aggregate potential described herein is preliminary. Additional information will be required to support the classifications and to confirm aggregate potential. Any additional investigation should follow a step wise process of delineating the potential resource.

It is recommended that the first step be a field reconnaissance of areas defined by the desktop study as being of high potential. The field reconnaissance work should verify geological classification of the material and assess the suitability of the bedrock source for the use intended.

A sampling program should be implemented to collect representative samples for a suite of laboratory tests to determine the suitability of the physical characteristics of the material. Samples could be selected from bedrock outcrops by way of chip samples or collected from drill core, if available. The selection of samples and sample sites should focus on ensuring that representative samples of the selected rock types are collected.

The specific end use of the material should be considered prior to determining the selection of suitable geochemical and structural/strength tests. The following laboratory tests may be required to confirm the

suitability of the material for various end uses. The tests may be completed in a phased approach with more detailed and numerous sampling required as a project develops. Tests may include:

- Grain Size Analysis – Determines % of stone, sand, and fines in the aggregate material;
- Los Angeles Abrasion Loss – Measure of competence and durability of the aggregate;
- Magnesium Sulphate Soundness Loss – Measure of weathering of the aggregate;
- Petrographic Number Analysis – Geotechnical examination of competent rock particles in the aggregate;
- Absorption Analysis – Susceptibility of the aggregate to penetration by liquids; and
- Micro-Deval Abrasion Loss – Test resistance of aggregates to degradation by abrasion.

In addition to testing the material for aggregate suitability, geochemical test work will be required to evaluate acid rock drainage and metal leaching potential of the various rock units. There are also additional tests required if the material is to be used for road materials or concrete testing, which has more stringent criteria for aggregate parameters.

Pending positive test results, a drill program is recommended to determine thickness of bedrock and calculate volumes of potential aggregate material. During the drill program there is also a need to further verify geological classification of the material and specifically assess whether the physical characteristics are consistent with the intended end use. Sample collection and analysis may also be a component of the drill program.

In addition to confirming the physical parameters of the bedrock material, there should be ongoing work to evaluate the feasibility of the bedrock source from a perspective external to meeting the physical criteria.

23.4 Recycling

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

- Local governments should earmark and zone industrial sites to be maintained for stockpiling and processing of concrete, asphalt and aggregate waste, close to market, in perpetuity. Tools for this should be investigated, but may include covenant or purchase by local or provincial government. The source of recycled aggregates will always be in the urban core. In order to reduce the requirements for trucking, and its resulting road impacts, costs and greenhouse gases, recycling facilities should be maintained close to market. While in some cases, on-site recycling (crushing and screening) using mobile equipment is achievable, in many cases it is not. For these projects, a nearby recycling facility in each municipality will be critical to achieve the District's goals of greenhouse gas, road impact and cost reduction.

Review and Revise Specifications

- Review and revise specifications that allow for a greater component of recycled material for certain applications, as is done currently in other jurisdictions. For example, specifications that allow a greater percentage of RAP in the asphalt mix, and a greater percentage of both RAP and RCA in roadway base course and sub-base courses, would help increase the use of recycled aggregate in the RDCO.
- Work together at a regional level to establish clear specifications and policy for recycled aggregates within the region, and promote the same at the provincial level (e.g. MMCD), which maximize the use of recycled aggregates where appropriate.
- Coordinate policy among local governments and institutions.

Establish a Technical Group

- The District should establish a technical group, part of an Aggregate Advisory Committee, including representatives from local 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.
- Review Quality Control (QC) and Quality Assurance (QA) policies from other jurisdictions (e.g. UK *BRE Digest 433*^{clxxxviii} and *The Quality Protocol: for the Production of Aggregates from Inert Waste*^{clxxxix}).

Tender Policies and Construction Techniques that Encourage Recycling

- Encourage tender policies that require or promote recycling. For example, local governments and institutions (e.g. health and education agencies) should require the use of recycled aggregates in their projects.
- Local governments and institutions should require the submission for prices for both:
 - Demolition & disposal costs; and
 - Deconstruction & reuse (including any revenue generated from salvage of reusable materials.)

Public Education

- Educate the public on success stories.

23.5 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 a reconnaissance level environmental assessment conducted by a QEP be undertaken for each potential site has, 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 MWLAP's recommended BMPs for site inventory information^{cxc}. (See Appendix F)

At the local government level, an Environmental Development Permit (EDP) or Environmentally Hazardous Areas Permit (EHDP) is required if the proposed site is within an EDP or EHDP Areas, according to the local Official Community Plan. This process enables the local government to assess impacts of the operation at a site level, with respect to sensitive ecosystems, water bodies, erosion control, and fish and wildlife habitat.

23.6 Environmental - Planning

The Site Suitability Assessment incorporates the EDP and the EDHP as a step to assess potential impacts to sensitive or hazardous areas at the time of application. This captures ecologically sensitive areas, sites adjacent to waterbodies, and locations of vulnerable aquifers in the region (Figure 9). The EDP or EHDP assessment should follow the requirements for professional reports of the local government.

For sites that are not within an EDP or EDHP area, the applicant should check with the Conservation Data Centre of BC, to ensure that there are no known occurrences of rare or endangered plant or wildlife species on the property or adjacent properties, which may be compromised by the pit development. In addition, the site should be checked for nests of raptors, herons and owls, which are protected under the BC *Wildlife Act*. If clearing is to be done between April 1st and August 1st, the site should be checked by a registered biologist to ensure there are no active nests. The applicant should note that in the Okanagan, there are many ground nesting species of birds. These too, are protected, and yet often not apparent or expected.

The DWK has a development permit requirement for new industrial operations.

23.7 Environment - Operations

In addition to the MWLAP guidelines for planning, the *AO BMP Handbook^{cxc}* has examples and details for best management practices from planning to operation, and through to reclamation. These BMPs should be followed from the initiation stage through to site reclamation. A summary of these BMPs are included in Table 42, below. In addition to the AO BMP Handbook, the MFLNRO document *Develop with Care 2012: Environmental Guidelines for Urban and Rural Land Development* includes objectives, requirements and guidelines for project development and operation at the site level. It provides guidelines to protect and manage aquatic resources, endangered species, sensitive ecosystems and specialized habitats. Section 5.7 of the *Develop with Care 2012* document outlines specific guidelines for the Thompson Okanagan.

Table 42 Best Management Practices from the Aggregate Operators Handbook

BMP	Description / Use	Addresses
Stormwater Management		
Buffer Zone	A naturally vegetated or replanted area around the perimeter of the aggregate site or an environmentally sensitive area. Its purpose is to: <ul style="list-style-type: none"> ▪ Minimize erosion ▪ Improve water quality ▪ Intercept dust ▪ Reduce noise ▪ Act as wildlife corridor 	Visual, Dust, Water Quality

Table 42 Best Management Practices from the Aggregate Operators Handbook

BMP	Description / Use	Addresses
Check Dams	A small, temporary dam within a ditch, drainage, swale, or channel. Its purpose is to: <ul style="list-style-type: none"> Reduce the gradient of the ditch, which slows the water thereby lowering its ability to cause erosion and allowing sediment to settle out 	Water Quality
Constructed Wetlands	A modified or constructed shallow pond for the treatment of sediment-laden waters by wetland vegetation. The purpose of these wetlands are to: <ul style="list-style-type: none"> Receive and temporarily hold sediment-laden waters to prevent downstream surface water pollution Provide biological treatment to help meet acceptable turbidity standards 	Water Quality
Ditches	Open drainage works ranging from shallow, narrow, frequently dry ditches, to wide, deep, permanently wetted ditches. Their purpose is to: <ul style="list-style-type: none"> Capture and control stormwater runoff and to direct it off site Divert stormwater runoff around a site 	Water Quality
French Drain	A hole or trench filled with coarse aggregate. Its purpose is to: <ul style="list-style-type: none"> Hold collected water until it percolates into the ground 	Dust, Water Quality
Retention Basin	A pond to hold stormwater and filter out sediment. Its purpose is to: <ul style="list-style-type: none"> Retain stormwater runoff and to remove the majority of the sediment within the stormwater, by settling 	Water Quality
Silt Fence	A temporary linear filter barrier of burlap or synthetic filter fabrics and posts. Its purpose is to: <ul style="list-style-type: none"> Be used below disturbed areas to remove or reduce sediment in stormwater runoff and sheet or rill erosion 	Water Quality
Slope Drain	A flexible tube or conduit extending from the top of a cut or fill slope to the bottom. Its purpose is to: <ul style="list-style-type: none"> Temporarily conduct concentrated stormwater runoff down the face of a cut or fill slope without causing erosion on or below the slope 	Water Quality
Erosion Control		
Backfilling	Using lifts of overburden or waste rock to restore a face or mined out area to a specified reclamation slope. Its purpose is to: <ul style="list-style-type: none"> Reduce slope angles to specific or standard reclamation criteria and the hazard if a slope failure 	Visual, Dust
Bioengineering	Erosion and sediment control structures made from stalks of live willow shrubs that continue to grow once placed in soil. Its purpose is to: <ul style="list-style-type: none"> Prevent erosion with their physical structure until established plants can provide permanent erosion protection Jump-start the establishment of self-sustaining vegetation on exposed hillsides 	Visual, Dust
Erosion Control Blanket	A temporary protective blanket laid on top of exposed soil vulnerable to erosion. Its purpose is to: <ul style="list-style-type: none"> Prevent washing away of planted seed and erosion of the prepared seedbed until the area becomes established providing permanent erosion control 	Dust
Grading	Reshaping the ground surface to prepare the site for processing equipment, stockpile areas, etc. Its purpose is to: <ul style="list-style-type: none"> Provide suitable topography for post-mining land uses Facilitate equipment operation and stockpiling Control surface runoff Minimize soil erosion and sedimentation 	

Table 42 Best Management Practices from the Aggregate Operators Handbook

BMP	Description / Use	Addresses
Outlet Protection	A rock-lined apron and flow area at the outlet of a pipe or culvert, paved flume, lined waterway, or other flow system. Its purpose is to: <ul style="list-style-type: none"> Prevent scour and erosion at water conveyance outlets Minimizes the potential for downstream erosion by reducing stormwater velocity 	Water Quality
Tarps	A piece of woven fabric or plastic sheeting material used to temporarily cover soil, raw materials, or equipment to provide protection from wind and rain	Dust
Tillage	The roughening of exposed soil with horizontal grooves running across the slope. Its purpose is to: <ul style="list-style-type: none"> Shape the surface of the soil and create pockets that prevent runoff, minimize pondage, and catch and retain moisture 	
Topsoil Management	Salvaging, storing, and using topsoil for rehabilitation. Its purpose is to: <ul style="list-style-type: none"> Retain site topsoil for rehabilitation and/or permit requirements Preserve topsoil quality during moving and storage 	Water Quality, Environmental Protection
Vegetation Cover	Establish ground cover with via trees, shrubs, or perennial plants. Its purpose is to: <ul style="list-style-type: none"> Minimize or control dust and erosion, enhance water quality, and facilitate reclamation 	Visual, Dust
Noise and Dust		
Berm	An elongated, raised barrier constructed of overburden, topsoil, or aggregate by-product, commonly seeded with grasses and topped with larger vegetation. Its purpose is to: <ul style="list-style-type: none"> Intercept noise, dust, and the views of an operation, as well as act as a storage option for overburden material 	Noise, Dust, Visual
Drop Height	Reducing the distance material is dropped from conveyors and/or loading equipment. Its purpose is to: <ul style="list-style-type: none"> Minimize and control the amount of dust released into the atmosphere and decrease the noise generated by material impacting truck beds 	Dust
Dust Skirt	Rubber skirts around aggregate where it drops onto a stockpile or into a truck from a conveyor or hopper. Its purpose is to: <ul style="list-style-type: none"> Contain falling aggregate and shield it from wind exposure, thereby reducing dust, cleanup costs, and preventing material segregation 	Dust
Equipment Selection	Selecting equipment based on its energy consumption, noise output, exhaust configuration, compatibility with other equipment on site, and compatibility with approved mine plan	Noise, Dust
Haul Roads Planning	A system of roads within an aggregate mining operation. Its purpose is to: <ul style="list-style-type: none"> Facilitate safe and efficient operation of mobile equipment while minimizing environmental impacts 	Noise, Dust, Visual
Material Corrals	Three-sided storage bays made from interlocking pre-cast concrete blocks. Its purpose is to: <ul style="list-style-type: none"> Keep specialized products and material clean and segregated, especially in tight locations 	Dust
Sinking the Plant	Locating noise generating stationary equipment, such as a processing plant, at a low location on the property. Its purpose is to contain noise and dust	Noise, Dust, Visual
Street Cleaning	Sweeping or cleaning the site entrance, the public roadway, and onsite paved roads on a regular or as needed basis. Its purpose is to: <ul style="list-style-type: none"> Reduce dust and stormwater sediment loading and maintain a clean appearance at the site entrance and adjacent public roads 	Dust

Table 42 Best Management Practices from the Aggregate Operators Handbook

BMP	Description / Use	Addresses
Vibration Reduction	The reduction or minor ground movements generated by production blasts, crushers, and haul trucks driving over rough ground. This is achieved by maintaining smooth and even road surfaces	Noise
Water Spray	The use of water sprays, sprinklers, mists, or foams wherever dust is created at the aggregate site	Dust
Wheel Washer	A washing pit or trough that removes rocks and dirt from vehicle wheels and wheel wells as they drive through. Its purpose is to: <ul style="list-style-type: none"> Reduce the amount of dirt and rock carried by aggregate vehicles onto public roads, this lessening the need for street sweeping and preventing windshield damage 	Dust
Wind Protection	Any structure or method to block or reduce wind flow. This reduces the exposure of dust-generating material to wind, which maintains air quality	Dust
Risk Management		
Env. Timing Windows	A work schedule that does not conflict with critical life stages for fish and wildlife. These work windows are established by federal or provincial regulatory agencies and vary depending on the proposed activities, location, and habitat type	Environmental Protection
Fences	A man-made or natural barrier than can reduce the amount of noise and dust leaving the site, create a visual barrier, and prevent trespassing thereby minimizing liability to the proponent	Risk Management, Dust, Visual
Lighting Management	The planning and installation of a lighting system that facilitates safe and secure operations, while minimizing offsite visual nuisance. This provides a safe working environment, extended hours of operation, and security to the site after hours	Risk Management
Signage	Information and warning signs for the public and site visitors. This ensures that visitors are aware of potential hazards and deters unauthorized persons from entry	Risk Management
Pollution		
Oil / Water Separator	A pond or tank that separates petroleum products from water using the different in liquid density. This removes any petroleum products that are present prior to the release or reuse of water	Water Quality
Pollution Prevention	Any structure, practice, or method used to manage potential pollutants that are used or stored at an aggregate operation. This prevents or minimizes contamination of stormwater and groundwater by protecting and containing chemicals and petroleum products	
Scheduled Maintenance	The regular program of maintenance for vehicles and equipment on site. This reduces the number of equipment breakdowns, amount of down time, and frequency of spills or fuel leaks	Risk Management, Water Quality
Settling Pond	Settling ponds remove silt and suspended clays from water used for washing aggregate, and/or from dirty stormwater	Water Quality

* Summarized from Aggregate Operators Best Management Practices Handbook for BC – Volume II – Best Management Practices (MEM, 2002)

In addition to the above, the *BC Weed Control Act* requires land owners to control weeds on their property that are listed as noxious in BC. The MFLNRO and the Invasive Species Council have BMP documents that provide advice for noxious weed management.

It is important to note that it is the responsibility of the proponent to be aware of and undertake activities that adhere to all relevant federal and provincial legislation and local government bylaws.

23.8 Groundwater

Recommendations for groundwater management planning, and to avoid and mitigate potential impacts to groundwater are outlined in this section.

Groundwater Assessment

As part of the Site Suitability Assessment (Appendix F), an overview groundwater assessment is recommended for all sites to assess potential impacts to groundwater.

A groundwater assessment should include:

- Aquifer characterization and depth to aquifer from final elevation of the pit or quarry;
- Evaluation of soil and/or rock permeability within groundwater area of interest on-site and adjacent to pit or quarry;
- Effects assessment for water quality and quantity for water wells on-site and adjacent to the pit or quarry;
- Potential for Metal Leaching or Acid Rock Drainage (ML-ARD);
- Fuel Management Plan and Spill Response Plan;
- Septic System Design Plan (if applicable); and
- Water Demand Assessment.

The assessment should include mitigation measures, where necessary, including monitoring wells for sites and conditions of elevated and ongoing risk to groundwater.

Vulnerable Groundwater Aquifers

The proponent should undertake a hydrogeological assessment by a QEP to determine if the operation has any potential to impact groundwater levels or quality. If potential impacts are identified, the assessment should include a plan to avoid and/or mitigate such impacts.

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

- **Adjacent Groundwater Resource.** For a given site and layout, the proponent should conduct a hydrogeological assessment to establish baseline conditions of groundwater quality, and those physical hydrogeological factors needed to demonstrate that the proposed operation will not lead to water quality degradation, or damaging well interference or mounding in nearby water wells or septic systems. If a new water well or washing drainage area is planned on site, the proponent should incorporate this well and infiltration area in the hydrogeological assessment assuming it is pumping or draining at the highest planned operational rates.
- **Metal Leaching & Acid Rock Drainage.** If indicators of possible ML-ARD are present, testing should be conducted to confirm or deny the presence of ML or ALD. Materials with the potential for ML-ARD should not be used as a source of aggregate since they may be damaging to the environment, and could

result in substantial expenses to the operator for removal costs and associated environmental liability issues.^{cxcii}

For all sites, an application should include:

- **Fuel Management Plan and Spill Response Plan.** A plan for the management, control and mitigation of fuel storage, including a Spill Response Plan, and related environmental risks that adheres to current best management practices for aggregate operations, as set forth in the *AO BMP Handbook*^{cxciiii}.

For a proposal with a septic field, the application should include:

- **Septic System Design Plan.** For all sites, the proponent should provide a plan for the siting, design and operation of any on-site septic systems adhering to current standard practices, as set forth in the *Sewerage System Standard Practice Manual, Version II*^{cxciiv}.

For a proposal with a well or municipal water requirements, the application should include:

- **Water Demand Assessment.** The proponent should determine the water demand for the operation and approach pertinent water supplier to determine what portion of the demand can be serviced by installed infrastructure. For the remaining demand, the proponent should conduct an assessment using a qualified professional to determine a favourable option for an alternative water supply (either surface water or groundwater source) which does not substantially degrade the quantity or quality of surface water or groundwater on or near the site.
- If a new well is planned, then the siting, construction and operation of the well should adhere to the *BC Ground Water Protection Regulations*^{cxcv}, described in the *Ground Water Protection Handbook*^{cxcvi}, and should be incorporated into hydrogeological assessments as required for other factors.

23.9 Infrastructure Impacts

Review of the infrastructure impacts results indicates that the hauling of aggregates over most municipal roads will reduce the expected life of the road and increase maintenance and rehabilitation costs.

Based on the data presented above, 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. Efficiencies with respect to time of travel, maintenance of vehicles and pavement performance would be realized through the proper planning and selection of the aggregate haul routes and road upgrading prior to the beginning of hauling.

Overloading of the trucks results in increased wear and tear of the pavement structure. The wear and tear of the pavement structure increases exponentially with vehicle loading over the legal limits. A truck loaded 10 percent above the legal loads (on the Tandem axle only) would result in a 17 percent increase in ESAL's per truck. Similarly, a truck loaded 20 percent above the legal limits would result in 35 percent increase in ESAL's per truck. This indicates that if all of the trucks on the roads were loaded at 20 percent above the legal load limits, they would result in a 35 percent reduction in the service life of the pavement. Therefore,

it is recommended that efforts be made to prevent the overloading of the vehicles beyond the legal load limits.

This evaluation has been generalized to illustrate the impact of aggregate hauling on pavement infrastructure. Other factors such as pavement surface drainage, age of the pavement at the time of initiation of aggregate hauling, roadway cross section and truck speed etc. also influence the pavement performance, but cannot be precisely factored into such examples.

23.10 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.^{cxcvii} The trucking company can cover lads, reduce speed, implement driver training, time trips to avoid rush hours and / or school start and finish times. They wash trucks and paint their trucks with appealing colours or graphics.

Recommended mitigation measures for traffic concerns, in accordance with the *AO BMP Handbook*^{cxcviii}, are outlined in Table 43, below.

Table 43 Off-Site Aggregate Traffic Concerns and Mitigating BMPs and Other Measures

Local Traffic Concern	Description	BMPs & Other Measures
Noise	<ul style="list-style-type: none"> ▪ The large engines used to power dump trucks, and their heavy-duty braking systems, are substantially louder than domestic motor vehicles, often drawing negative attention to the trucks 	<ul style="list-style-type: none"> ▪ Equipment Selection ▪ Driver training
Driver Behaviour	<ul style="list-style-type: none"> ▪ The heavy loading, high noise levels and large size of dump trucks accentuate their movements, and may create the impression of aggressive driving ▪ The nature of product delivery businesses, where time is money, may encourage aggressive driving behaviour 	<ul style="list-style-type: none"> ▪ Driver training
Truck Visibility	<ul style="list-style-type: none"> ▪ Industrial vehicles and dump trucks are big and noticeable, heightening perceptions regarding aggregate supply and delivery traffic 	<ul style="list-style-type: none"> ▪ Signage ▪ Turning lights
Vibration	<ul style="list-style-type: none"> ▪ Heavy vehicles, especially during hard braking, can cause ground vibrations which may be felt up to 250 metres away, depending upon local soil conditions and the sensitivity of local buildings (e.g., rattling china cabinets) 	<ul style="list-style-type: none"> ▪ Driver training
Traffic Volume	<ul style="list-style-type: none"> ▪ On low-volume roads, dump trucks from local aggregate operations may significantly increase local traffic ▪ On already over-subscribed, high-volume roads, added truck traffic will aggravate existing problems ▪ Large trucks are readily noticed, and it may seem like there are more of them than there actually are 	<ul style="list-style-type: none"> ▪ Trip timing
Dust	<ul style="list-style-type: none"> ▪ Dust can be generated by: <ul style="list-style-type: none"> – <i>blow-off</i> from inside the box – <i>bounce-out</i> from rough roads or fast braking 	<ul style="list-style-type: none"> ▪ Wheel Washer ▪ Avoiding overload

Table 43 Off-Site Aggregate Traffic Concerns and Mitigating BMPs and Other Measures

Local Traffic Concern	Description	BMPs & Other Measures
	<ul style="list-style-type: none"> - fall-off from exterior box ledges from sloppy loading - mud-fall off from the underside of a truck onto the road 	<ul style="list-style-type: none"> ▪ Loading chutes ▪ Truck sheeting ▪ Wash trucks
Visual Impacts	<ul style="list-style-type: none"> ▪ Large high-sided trucks can cause obstruction or block views away from construction sites, dump trucks can seem out of place and intrude upon a setting such as a residential area 	<ul style="list-style-type: none"> ▪ Berm ▪ Fencing ▪ Hedges
Landscape Character	<ul style="list-style-type: none"> ▪ Large trucks can mar the perception of tranquility and wildness 	<ul style="list-style-type: none"> ▪ Berm ▪ Hedges
Detachment	<ul style="list-style-type: none"> ▪ Residents, pedestrians, and other road users can feel separated and cut off because of the perceived difficulty of crossing a road heavily traveled by large trucks 	<ul style="list-style-type: none"> ▪ Crossing lights ▪ Pedestrian bridges
Fear and Intimidation	<ul style="list-style-type: none"> ▪ The volume, size of trucks, speed of traffic and proximity to people increases the likelihood of pedestrian and cyclist fear and intimidation ▪ This factor is also influenced by road width, curb presence and shoulder size 	<ul style="list-style-type: none"> ▪ Fencing ▪ Road widths ▪ Speed reductions ▪ Shoulders ▪ Sidewalks
Highway Safety	<ul style="list-style-type: none"> ▪ Increases in traffic volume result in increased road safety hazards for all road users, pedestrians and residents 	<ul style="list-style-type: none"> ▪ Fencing ▪ Speed reductions
Fencing • speed reductions	<ul style="list-style-type: none"> ▪ Heavy-load traffic can damage roads, depending upon the age and grade of the pavement and construction standards 	<ul style="list-style-type: none"> ▪ Avoiding overload ▪ Road standards ▪ Road upgrades

23.11 Noise Attenuation

As noted in the *AO BMP Handbook - Volume I^{ccix}* there are a number of options and best management practices for noise control possible during site layout, operation. Noise attenuation can be achieved by interceptors, site layout modifications, protecting the equipment, driving trucks slower and a number of other mitigation measures. Mitigation starts at the planning stage, and continues through operations.

Noise - Planning

As outlined in the *AO BMP Handbook^{cc}*, for inclusion in their NoW application, the applicants should prepare a plan for noise and its reduction, and document it. From the Handbook, the plan would include:

- Noise generating activities;
- Off-site facilities that are noise sensitive;
- Potential noise reflectors (mine faces, hillsides, hard ground and water), topographic hollows and noise absorbing areas (wood lots, shrub areas, grasses);
- Placement of berms, stockpiles and tree buffers to create or enhance noise-dampening locations for the site or to act as noise barriers;

- Plans to locate noise-generating activities and haul roads in suppressing locations and away far from noise-sensitive facilities;
- Procedures to avoid noise generation and contain noise; and
- Designation of existing trees and shrubs as perimeter barriers on noise sensitive sides of the operation.

Noise - Site Layout

Significant noise reduction can be attained by equipment placement and strategy of excavation such as by leaving berms, facing the excavation away from noise sensitive areas and other techniques. A list of such techniques is included below:

- Locate haul roads and processing equipment low in the site;
- Orient working faces to reflect noise into dampening areas;
- Screen noise with first stage operations;
- Use stockpiles to interrupt noise;
- Use buildings to act as an acoustic barrier;
- Restrict noise generating activities to sheltered areas; and
- Create 'sensitive zones' within which activities are limited.

Noise - Interception

Interceptors include putting up berms and fences between the noise and the receptors. The potential sound reduction using interceptors are noted in Table 44, below:

- Place berms and plant vegetation to intercept noise transmission to sensitive areas.
- Install and maintain acoustic fencing and barriers.

Table 44 Typical Noise Reduction using Interceptors

Buffer	Reduction in Adjacent Noise Levels
3 metre tall wooden fence	10 dBA
3 m berm, sloped 3:1, with a 1 m wall on top	10.2 dBA
6 metre tall wooden fence	15 dBA
Containment of equipment in building	15 dBA

Adapted from MEM, 2002, Cole et al., 1999, and MOTH, 1997

Noise - Operations

There are many ways to reduce noise impacts during daily operation. Operational noise attenuation techniques are listed below:

- Minimize the drop height of material;

- Surround the crusher with stockpiles of material to buffer sound;
- Use equipment within their design capacity;
- Select equipment that has low noise emissions;
- Maintain roads to ensure smooth running surfaces;
- Stagger engine starts;
- Maintain equipment;
- Train staff in noise reduction operation practices;
- Fit equipment with acoustic barriers;
- Keep mobile equipment speeds low;
- Use non-audible back-up alarms (flashing lights);
- Vegetate exposed surfaces such as overburden with fast growing plants and ground covers;
- Use rubber linings in chutes, dumpers and transfer points to dampen noise;
- Use baffles around washing drums and rubber mats around processing equipment;
- Turn off equipment when not in use;
- Avoid revving engines;
- Direct noise away from sensitive areas whenever possible;
- Enclose equipment when possible; and
- Close truck tailgates when possible.

23.12 Dust Control

As outlined in the *AO BMP Handbook^{cci}*, dust control planning includes both site layout and operational procedures. Applicants should prepare a plan for dust control, and document it. 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.

Recommended mitigation measures for dust control, in accordance with the *AO BMP Handbook*, are outlined in Table 45 below.

Table 45 Dust Generating Activities and Recommended Mitigation Measures

Stage / Strategy	Activity	Dust Reduction Measures	BMPs & Measures – MEM (2002) Volume II - BMPs
Site Layout – Minimize Creation	Site Layout	<ul style="list-style-type: none"> ▪ Locate haul roads and stock piles down-wind from neighbours ▪ Reduce stock pile height and use gentle slopes ▪ Use conveyors instead of haul roads ▪ Restrict dust generating activities to sheltered areas ▪ Create 'sensitive zones' where dusty activities are limited ▪ Remove vegetation progressively, only when the area is ready for extraction ▪ Retain vegetation at the perimeter, especially down-wind of operations ▪ Surface roads with dust free material ▪ Use wind-breaks, netting screens, semi-permeable fences ▪ Use treed berms near dust generators, receptors or at the perimeter of the site 	<ul style="list-style-type: none"> ▪ Vegetation Cover ▪ Site Layout
Operations Control Escape	Topsoil & Overburden Handling	<ul style="list-style-type: none"> ▪ Remove vegetation progressively, only when the area is ready for extraction ▪ Seal and seed surfaces as soon as practicable ▪ Protect exposed material with tarps, within voids or by topographical features ▪ Spray exposed surfaces regularly to maintain surface moisture ▪ Minimize handling 	<ul style="list-style-type: none"> ▪ Tarp ▪ Restrict grubbing ▪ Vegetative Cover ▪ Minimize handling ▪ Seal surfaces ▪ Wind Protection ▪ Seed / Hydroseed ▪ Water Spray
	Drilling & Blasting	<ul style="list-style-type: none"> ▪ Use dust extraction equipment, filters & collectors, on drilling rigs ▪ Use mats when blasting ▪ Drill using water 	<ul style="list-style-type: none"> ▪ Dust extraction / filters ▪ Dust removal ▪ Water
	Extraction & Handling	<ul style="list-style-type: none"> ▪ Reduce drop heights ▪ Keep working faces as small as possible ▪ Orient face to reduce impact of prevailing wind ▪ Use sprays and mists at dust sources ▪ Fit wind-boards / hoods at conveyors & transport points ▪ Maintain equipment 	<ul style="list-style-type: none"> ▪ Drop Height ▪ Site Layout ▪ Vegetation Cover ▪ Water spray
	Loading	<ul style="list-style-type: none"> ▪ Reduce drop heights ▪ Protect activities from wind 	<ul style="list-style-type: none"> ▪ Drop Height ▪ Wind Protection
	Crushing & Screening	<ul style="list-style-type: none"> ▪ Enclose crushers and use bag house ▪ Use backstops for wind protection ▪ Use water sprays 	<ul style="list-style-type: none"> ▪ Wind Protection ▪ Water Spray ▪ Enclosure

Table 45 Dust Generating Activities and Recommended Mitigation Measures

Stage / Strategy	Activity	Dust Reduction Measures	BMPs & Measures – MEM (2002) Volume II - BMPs
		<ul style="list-style-type: none"> ▪ Use equipment within design capacity ▪ Maintain equipment 	
	Stockpiling	<ul style="list-style-type: none"> ▪ Dampen material ▪ Protect from wind or store under cover ▪ Screen material to remove dusty particles prior to external storage 	<ul style="list-style-type: none"> ▪ Tarp ▪ Water Spray ▪ Screen out fines
	Conveyor Transport	<ul style="list-style-type: none"> ▪ Protect using wind and roof boards ▪ Shelter transfer points from wind ▪ Use scrapers to clean belts and collect scrapings for disposal ▪ Minimize drop heights ▪ Use water sprays 	<ul style="list-style-type: none"> ▪ Drop Height ▪ Wind Protection ▪ Belt Cleaning ▪ Roof Boards ▪ Water Spray
	Transport – Onsite Truck	<ul style="list-style-type: none"> ▪ Restrict vehicle speed ▪ Pave, water or treat haul roads ▪ Wheel or body wash at an appropriate distance from site entrance ▪ Load and unload in areas protected by wind ▪ Use water sprays ▪ Shake dirt off of trucks with rumble bars ▪ Provide a surfaced road between vehicle washing facilities and site exit 	<ul style="list-style-type: none"> ▪ Speed Limits ▪ Drop Height ▪ Street Cleaning ▪ Wheel Washer ▪ Sheet Vehicles ▪ Water Spray
	Transport – Offsite Truck	<ul style="list-style-type: none"> ▪ Sheet or tarp loads ▪ Wheel or body wash at an appropriate distance from site entrance ▪ Use road sweeping ▪ Do not overload 	<ul style="list-style-type: none"> ▪ Street Cleaning ▪ Wheel Washer ▪ Bucket Covers
Air Quality Dust Removal		<ul style="list-style-type: none"> ▪ Use treed berms near dust generators, receptors or at the perimeter of the site ▪ Use sprinklers, sprayers or mist 	<ul style="list-style-type: none"> ▪ Berm ▪ Vegetation Cover ▪ Water Spray
Cessation		<ul style="list-style-type: none"> ▪ Shut down the operation if, due to unique weather conditions (e.g. extreme wind) the extended dispersion of dust cannot be avoided 	

* Adapted from MEM, 2002; Thomas, 2000, ODPM 2005

23.13 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.

Radiation levels in an area may also be evaluated using a measuring device, such as a Geiger counter or gamma scintillation.

23.14 Visual Impact Mitigation

Visual impact planning and mitigation measures have been adapted from the *Visual Impact Assessment Guidebook*^{ccii}. Recommendations are based on the *AO BMP Handbook, Volume II*^{cciii} and the *Manual of Aesthetic Design Practice*^{cciv}.

Table 46 Visual Impact Mitigation Techniques for On-site Road Construction

Stage	Techniques
Design and Layout	<ul style="list-style-type: none"> ▪ Design roads with landform – climb in hollows and drop off ridges ▪ Take advantage of non-visible areas and existing screening ▪ Align roads diagonally on mid-slope roads
Construction	<ul style="list-style-type: none"> ▪ Reduce cut and fill slopes
Restoration	<ul style="list-style-type: none"> ▪ Revegetate slopes

* Adapted from MOF, 2001

The *Manual of Aesthetic Design Practice*^{ccv}, while specific to highway design and construction, outlines visual quality mitigation techniques and assessment procedures. A summary of these mitigation techniques is included in Table 47.

Table 47 Visual impact Mitigation Techniques for Access Design and Screening

Stage	Techniques
Vegetation Clearing and Grubbing	<ul style="list-style-type: none"> ▪ Undulate the forest edge ▪ Leave roots intact to encourage root sprout ▪ Provide variety in vegetation, species, heights and formation ▪ Flag out individual trees or clusters of trees to retain ▪ Preserve snags where they do not pose a safety hazard ▪ Retain natural vegetation wherever possible
Design	<ul style="list-style-type: none"> ▪ Curve and offset entry, with vegetation buffer to screen pit

Table 47 Visual impact Mitigation Techniques for Access Design and Screening

Stage	Techniques
	<ul style="list-style-type: none"> ▪ Intersect entry at 90°, to minimize exposure of pit to road ▪ Undulate slopes (avoid consistently graded slopes) ▪ Incorporate and integrate with naturally occurring landforms ▪ Retain natural drainage channels ▪ Create undulating berms, not parallel to road (avoid continuous slopes and lines) ▪ Integrate berm with adjacent terrain
Restoration	<ul style="list-style-type: none"> ▪ Reflect natural vegetation habitat ▪ Fragment vegetation edge by using clumps of vegetation instead of rows, and varying species and height ▪ Plant hardy, fast growing, drought tolerant vegetation ▪ Plant native plants to minimize maintenance ▪ Plant woody plants for long term erosion control ▪ Hydroseed slopes for erosion control ▪ Use bioengineering techniques for slope stabilization

*Adapted from MOTH (1991)

Planning

As outlined in the *AO BMP Handbook^{ccvi}*, 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 viewscales;
- Potential visual impacts (e.g. structures and equipment);
- Topography;
- Conditions pre-development and anticipated conditions post-development; and
- Local landscape character.

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 multiple mitigation measures may need to be combined to achieve results. The *Manual of Aesthetic Design Practice^{ccvii}* 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
- the use of bioengineering for erosion control on permanent slopes.

The *AO BMP Handbook^{ccviii}* suggests a number of techniques and measures for reducing the visual impact of operations. Best management practices are outlined in Table 48, below.

Table 48 Strategies for Visual Impact Mitigation

Control Strategy	Visual Landscape Control Measures	BMPs & Measures – MEM (2002) Volume II - BMPs
Concentration	<ul style="list-style-type: none"> ▪ Concentrate activities and equipment together ▪ Move extraction and related activities systematically together as the pit is excavated ▪ Re-contour and vegetate as the work continues 	<ul style="list-style-type: none"> ▪ Progress development
Interim	<p style="text-align: center;">Site Selection</p> <ul style="list-style-type: none"> ▪ Orient operation to limit the visibility of the working faces ▪ Stagger or curve the access to avoid direct views into the pit or quarry ▪ Ensure sufficient land is available for landform modeling, perimeter treatment and planting ▪ Consider the topography and the potential for existing natural screening ▪ Keep mine elements a similar scale and size to that of the local landscape ▪ Design lighting to avoid light pollution 	<ul style="list-style-type: none"> ▪ Revegetation
Concealment	<p style="text-align: center;">Site Selection</p> <ul style="list-style-type: none"> ▪ Orient operation to limit the visibility of the working faces ▪ Stagger or curve the access to avoid direct views into the pit or quarry ▪ Ensure sufficient land is available for landform modeling, perimeter treatment and planting ▪ Consider the topography and the potential for existing natural screening ▪ Keep mine elements a similar scale and size to that of the local landscape ▪ Design lighting to avoid light pollution <p style="text-align: center;">Method of Work</p> <ul style="list-style-type: none"> ▪ Work away from major sight lines ▪ Phase extraction to limit the area of active disturbance ▪ Perform progressive reclamation ▪ Consider alternative extraction methods ▪ Design and locate processing plan to reduce visibility, giving attention to colour, cladding, height of structures, etc. <p style="text-align: center;">Screening</p> <ul style="list-style-type: none"> ▪ Construct and plant berms ▪ Build rock / earth walls instead of fencing ▪ Retain existing vegetation wherever possible 	<ul style="list-style-type: none"> ▪ Berm ▪ Fences ▪ Lighting management ▪ Sinking the plant ▪ Boundary planting ▪ Entrance layout ▪ Painting ▪ Progressive reclamation

Table 48 Strategies for Visual Impact Mitigation

Control Strategy	Visual Landscape Control Measures	BMPs & Measures – MEM (2002) Volume II - BMPs
	<ul style="list-style-type: none"> ▪ Consider temporary planting at long term operating sites <p style="text-align: center;">Camouflage</p> <ul style="list-style-type: none"> ▪ Consider colour and cladding of buildings and plant, within safety margins ▪ Limit the height of structures, stockpiles and waste dumps as far as possible and design with shallow gradients <p style="text-align: center;">Hauling</p> <ul style="list-style-type: none"> ▪ Locate loading facilities to minimize their visibility ▪ Route internal haul roads to avoid punctuating the skyline ▪ Route external truck routes to avoid sensitive properties and landscapes ▪ Screen internal and external routes with berms where necessary <p style="text-align: center;">Housekeeping</p> <ul style="list-style-type: none"> ▪ Maintain the internal quarry environment (e.g. remove scrap and keep stockpile areas tidy) ▪ Undertake regular weed control of on and off site planting areas ▪ Keep external roads clean and mud-free, including the access and visitor facilities 	
Innovative / Outreach	<ul style="list-style-type: none"> ▪ Site tours to familiarize community with operation ▪ Construct viewpoints ▪ Information signage 	<ul style="list-style-type: none"> ▪ Signage ▪ Tours

23.15 Roles and Responsibilities

All parties have responsibilities with respect to effective and cooperative planning and managing aggregate production and/ or its transportation. Table 49 includes a general outline of roles and responsibilities for operators, agencies, and local government staff.

Table 49 Roles and Responsibilities for Aggregate Planning and Management

Agency or Group	Current Responsibility	Potential Additional Role
Fisheries and Oceans Canada	<ul style="list-style-type: none"> ▪ Review application referrals that may have an impact under the <i>Federal Fisheries Act</i> 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans
Environment Canada	<ul style="list-style-type: none"> ▪ Review application referrals that may have an impact under the <i>Migratory Birds Convention Act</i>, <i>Wildlife Act</i> or the <i>Species at Risk Act</i> 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans
Transport Canada	<ul style="list-style-type: none"> ▪ Review application referrals that may have an impact under the <i>Navigable Waters Act</i> 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans
Ministry of Energy and Mines	<ul style="list-style-type: none"> ▪ Pit and quarry permitting under the <i>Mines Act</i> and the <i>Mineral Tenure Act</i> ▪ Public consultation if deemed required by the Inspector ▪ Determination of assessments and mitigation measures if deemed required by the Inspector ▪ Coordination of permit referrals ▪ Inspect operations in accordance with permit requirement, the 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans ▪ Participate on an Aggregate Advisory Committee

Table 49 Roles and Responsibilities for Aggregate Planning and Management

Agency or Group	Current Responsibility	Potential Additional Role
	<i>Mines Act, Mineral Tenure Act and the Health, Safety and Reclamation Code</i>	
Ministry of Forests, Lands and Natural Resource Operations	<ul style="list-style-type: none"> ▪ Review application referrals ▪ Process permits when required under the <i>Water Act, Fish Protection Act & Riparian Areas Regulation (RAR), BC Wildlife Act, Forest Act, Forest and Range Practices Act, Heritage Conservation Act, and the Weed Control Act</i> 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans ▪ Participate on an Aggregate Advisory Committee
Integrated Land Management Bureau	<ul style="list-style-type: none"> ▪ Process crown lease tenure / licence of occupation for operations on Crown Land ▪ Receive volume based royalty for operations on Crown Land 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans related to aggregate production on Crown Lands
Agricultural Land Commission	<ul style="list-style-type: none"> ▪ Process applications for operations on ALR Land under the <i>Agricultural Land Reserve Act and the Soil Conservation Act</i> 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans related to aggregate production on ALR lands
Ministry of Environment	<ul style="list-style-type: none"> ▪ Review applications that may trigger an assessment under the <i>BC Environmental Assessment Act, the Drinking Water Protection Act, the Public Health Act, or the Greenhouse Gas Reduction Targets Act</i> 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans
Ministry of Transportation and Infrastructure	<ul style="list-style-type: none"> ▪ Review applications regarding impacts to provincial highways and when a permit is required for an entrance onto a controlled highway 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans ▪ Participate on an Aggregate Advisory Committee
Local Government	<ul style="list-style-type: none"> ▪ Review referrals that may impact local bylaws or require permits, including Environmental Development Permits and Soil Removal and Deposit Bylaws ▪ Enforce local bylaws, such as Noise Control Bylaws ▪ Planning for long term aggregate supply and demand 	<ul style="list-style-type: none"> ▪ Participate on an Aggregate Advisory Committee
Aggregate Producers	<ul style="list-style-type: none"> ▪ Undertake permitting and operation in accordance with federal and provincial legislation and local bylaws 	<ul style="list-style-type: none"> ▪ Participate on an Aggregate Advisory Committee
Public	<ul style="list-style-type: none"> ▪ Provide comments when referred for public consultation if deemed necessary by the Mines Inspector 	<ul style="list-style-type: none"> ▪ Review short and long term aggregate plans

24.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

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, which designed to accommodate aggregate transport. The transport route may run through residential areas or school zones, 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 well as 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.

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

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GLOSSARY

CRD	Recycled aggregates from construction, renovation and demolition (CRD) waste, may have remnants of other materials other than concrete, brick and masonry, such as deleterious material such as glass or bitumen
RAP	Recycled asphalt concrete pavement (RAP) produced by full removal of the asphaltic pavement layer
Fines	Rock particles less than 80 microns
RCA	Recycled concrete aggregate (RCA) made from crushed concrete only, no other materials
Asphalt millings	Product resulting from milling the top 25 to 50 mm of asphaltic pavement
Hot In-place	Recycling of asphaltic pavement with equipment that resurfaces the road using asphaltic pavement millings in place
GBC	Granular base course – unbound layer in a road that is directly below the asphalt or concrete bound layer, giving the pavement structure strength and sub-drainage
$L_{EQ}(T)$	The equivalent of steady sound level of a noise, energy averaged over time (T), e.g. $L_{EQ}(8)$ is averaged over 8 hours, $L_{EQ}(16)$ is averaged over 16 hours.
L_{EX}	The exposure level of noise, measured in decibels, energy-averaged over a specified amount of time (typically 8 hours). It would be the same noise exposure if varying noise would be consistent over 8 hours
Polygon	An area on a map with relatively consistent geological or ecological characteristics

FIGURES

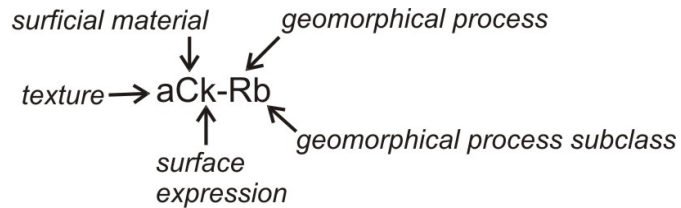
Figure 1	Study Area
Figure 2	Natural Sand and Gravel Potential
Figure 3	Overburden Classification within Study Area
Figure 4	Bedrock Geology Map of the RDCO
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APPENDIX A

POLYGON LABEL DESCRIPTIONS AND TERRAIN LABELS

APPENDIX A-1: POLYGON LABEL DESCRIPTIONS AND TERRAIN LABELS

LEGEND



TERRAIN LABEL

TEXTURE

Symbol	Name	Size (mm)	Other Characteristics
a	blocks	>256	Angular particles
b	boulders	>256	Rounded and subrounded particles
c	clay	<.002	
d	mixed fragments	>2	Mix of rounded and angular particles
g	gravel	>2	Mix of boulders, cobbles and pebbles
k	cobble	64-256	Rounded and subrounded particles
m	mud	<.062	Mix of silt and clay
p	pebble	2-64	Rounded and subrounded particles
r	rubble	2-256	Angular particles
s	sand	2-.062	
x	angular fragments	>2	Mix of rubble and blocks
z	silt	.062-.002	

SURFICIAL MATERIALS

Symbol	Name	Description
C	colluvial	Products of mass wastage
D	weathered bedrock	From in situ material
E	eolian	Materials deposited by wind action
F	fluvial	River deposits
FA	fluvial "active"	Active river channel
FG	glaciofluvial	Fluvial materials deposited by meltwater streams
I	ice	Permanent snow, glaciers and icefields
L	lacustrine	Lake sediments, includes littoral deposits
LG	glaciolacustrine	Sediments deposited in glacial lakes
M	morainal (till)	Material deposited directly by glaciers
O	organic	Accumulation/decay of vegetative matter
R	bedrock	Bedrock covered by less than 10 cm
U	undifferentiated	Layered sequence; three layers or more

SURFACE EXPRESSION

Symbol	Name	Description
a	moderate slope	Unidirectional surface; 27 - 49%
b	blanket	A mantle of unconsolidated materials; >1m thick
c	cone	A sector of a cone; >26%
d	depression	A sharply demarked hollow
f	fan	A sector of a cone; <27%
h	hummocky	Hillocks and hollows; irregular plan; 27 - 70%
j	gentle slope	Unidirectional surface; 6 - 26%
k	moderately steep	Unidirectional surface; 50 - 70%
m	rolling	Elongate hillocks; parallel in plan; 6 - 26%
p	plain	Unidirectional surface; 0-5%
r	ridged	Elongate hillocks; parallel in plan; 27-70%
s	steep	Steep slopes; >70%
t	terraced	Stepped topography and benchlands
u	undulating	Hillocks and hollows; irregular in plan; 0 - 26%
v	veneer	Mantle of unconsolidated material; 10 cm to 1 m thick
w	mantle of variable thickness	Surficial material of variable thickness; 0 to about 3 m

GEOMORPHOLOGICAL PROCESSES

Symbol	Name	Description
A	avalanches	Terrain modified by snow avalanches
C	cryoturbation	Sediment modified by heaving and churning
E	channeled	Channel formation by glacial meltwater
F	slow mass movement	Slow downslope movement of masses of cohesive or non-cohesive material and/or bedrock
F"	initiation zone	Initiation zone of slow mass movement processes
H	kettled	Depressions due to the melting of buried glacier ice
I	irregular channel	A single, clearly defined main channel displaying irregular turns and bends
J	anastamosing channel	A channel zone where channels diverge and converge around vegetated islands
L	surface seepage	Abundant surface seepage
M	meandering channel	Channels characterized by regular patterns of bends with uniform amplitude and wave length
N	nivation	Erosion beneath and along the margin of snow patches
P	piping	Subterranean erosion by flowing water
R	rapid mass movement	Rapid downslope movement of dry, moist or saturated debris
R"	initiation zone	Initiation zone of rapid mass movement
S	solifluction	Slow downslope movement of saturated overburden across a frozen or otherwise impermeable substrate
U	inundation	Seasonally under water due to high water table

GEOMORPHOLOGICAL PROCESSES

Symbol	Name	Description
V	gully erosion	Ravines due to erosion by various processes
Z	periglacial processes	Solifluction, cryoturbation and nivation processes occurring within a single unit

GEOMORPHOLOGICAL PROCESS SUBCLASSES

Symbol	Name	Symbol	Name
b	rockfall	m	slump in bedrock
c	soil creep	p	lateral spread in bedrock
d	debris flow	r	rockslide
e	earthflow	s	debris slide
g	rock creep	u	slump in surficial material
k	tension cracks	x	slump-earthflow
j	lateral spread in surficial material		

Adapted from Howes, D.E. and Kenk, E. 1997. Terrain Classification System for British Columbia (Version 2), Recreational Fisheries Branch, Ministry of Environment, and Surveys and Resource Mapping Branch, Ministry of Crown Lands, Victoria, B.C., 101 pp.

For more information, refer to Howes and Kenk 1997.

SOIL DRAINAGE CLASSES

x	very rapidly drained	water is removed from the soil very rapidly in relation to supply
r	rapidly drained	water is removed from the soil rapidly in relation to supply
w	well drained	water is removed from the soil readily but not rapidly
m	moderately well drained	water is removed from the soil somewhat slowly in relation to supply
i	imperfectly drained	water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season
p	poorly drained	water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen
v	very poorly drained	water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen

Where two drainage classes are shown:

- if the symbols are separated by a comma, e.g., "w,i", then no intermediate classes are present;
- if the symbols are separated by a dash, e.g., "w-i", then all intermediate classes are present

APPENDIX A-2

Refer to Appendix X-1 for Terrain Label Descriptions

1. High Potential for Gravels

- a. polygons with existing gravels pits (but no rock quarries)
- b. TDEC_1 = 7, 8, 9, 10, blank AND SURFM_1 = FG AND SURF_E1A = p, j, a, k, s, t, f, m, r, f, c AND SSURFM_1 = FG, blank or null AND DRAIN_1 = x, r, w, m, blank AND DRAIN_2 = x, r, w, m, blank AND DRAIN_1A = x, r, w, m, blank AND DRAIN_1B = x, r, w, m, blank
- c. SURFM_1 = F AND SURF_E1A = t, p, j AND DRAIN_1 = x, r, w, blank AND DRAIN_2 = x, r, w, m, blank AND DRAIN_1A = x, r, w, blank AND DRAIN_1B = x, r, w, m, blank

2. Moderate Potential for Gravels

- a. TDEC_1 = 4, 5, 6 AND SURFM_1 = FG AND SURF_E1A = p, j, a, k, s, t, f, m, r, f, c AND SSURFM_1 = FG, blank or null AND DRAIN_1 = x, r, w, m, blank AND DRAIN_2 = x, r, w, m, i, blank DRAIN_1A = x, r, w, m, blank AND DRAIN_1B = x, r, w, m, i, blank
- b. SURFM_1 = FG AND SURF_E1A = u, h, d AND SSURFM_1 = FG, blank, null AND DRAIN_1 = x, r, w, m, blank AND DRAIN_2 = x, r, w, m, i, blank DRAIN_1A = x, r, w, m, blank AND DRAIN_1B = x, r, w, m, i, blank
- c. TDEC_1 = 7, 8, 9, 10, blank AND SURFM_1 = FG AND SURF_E1A = p, j, a, k, s, t, u, h, m, r, d, f, c AND SURF_E1B = p, j, a, k, s, t, u, h, m, r, d, f, c, b, blank AND SSURFM_1 = FG, blank, null AND DRAIN_1 = x, r, w, m, blank AND DRAIN_2 = x, r, w, m, i, blank DRAIN_1A = x, r, w, m, blank AND DRAIN_1B = x, r, w, m, i, blank
- d. SURFM_1 = F AND SURF_E1A = t, p, j AND DRAIN_1 = x, r, w, m, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = x, r, w, m, blank AND DRAIN_1B = x, r, w, m, i, blank
- e. SURFM_1 = C, F AND SURF_E1A = f AND SSURFM_1 = F, FG, blank AND DRAIN_1 = x, r, w, m, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = x, r, w, m, blank AND DRAIN_1B = x, r, w, m, i, blank

- f. SURF_EIA = x, v, b, w AND SSURFM_1 = FG, F AND DRAIN_1 = x, r, w, m, blank AND DRAIN_2 = x, r, w, m, i, blank DRAIN_1A = x, r, w, m, blank AND DRAIN_1B = x, r, w, m, i, blank
- g. TTEX_1A = g, s, AND SURFM_1 = A

3. Low Potential for Gravels

- a. SURFM_1 = FG AND SURF_E1A = x, v, w, b AND SURF_E1B = p, j, a, k, s, t, u, h, m, r, d, f, c AND SSURFM_1 = FG, blank, null, F, M, AND DRAIN_1 = x, r, w, m, i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = i, x, r, w, m, blank AND DRAIN_1B = x, r, w, m, i, blank
- b. SURFM_1 = FG AND SURF_E1A = p, j, a, k, s, t, f, m, r, f, c, u, h, d, b, AND SSURFM_1 = FG, F, blank, AND DRAIN_1 = i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = i, blank AND DRAIN_1B = x, r, w, m, i, blank
- c. SURFM_1 = F AND SURF_EIA = t, p, j, AND DRAIN_1 = i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = i, blank AND DRAIN_1B = x, r, w, i, m, blank
- d. SURFM_1 = C, F AND SURF_EIA = f AND SSURFM_1 = F, FG, blank AND DRAIN_1 = i, blank AND DRAIN_2 = x, r, w, m, i, blank DRAIN_1A = i, blank AND DRAIN_1B = x, r, w, m, i, blank
- e. SURFM_1 = M AND SURFM_ST1 = 1 AND SURF_E1A = p, j, a, k, s, t, f, m, r, f, c, u, h, d
- f. SURF_EIA = x, v, b, w AND SSURFM_1 = M AND SSURFM_ST1 = 1 AND SSURF_E1A = p, j, a, k, s, t, f, m, r, f, c, u, h, d
- g. where SURF_E1A = blank, SURFM_1 = FG, F AND SSURFM_1 = FG, blank, null, M, F AND DRAIN_1 = x, r, w, m, i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = x, r, w, m, i, blank AND DRAIN_1B = x, r, w, m, i, blank
- h. SURF_EIA = x, v, b, w, p, j, a, k, s, t, u, h, m, r, d, f, c AND SSURFM_1 = FG, F AND DRAIN_1 = x, r, w, m, i, blank AND DRAIN_2 = x, r, w, m, i, blank DRAIN_1A = x, r, w, m, i, blank AND DRAIN_1B = x, r, w, m, i, blank

- i. SURFM_1 = FG, F AND SURF_EIA = b AND SURF_E1B = blank AND SSURFM_1 = FG, blank, null AND DRAIN_1 = x, r, w, m, i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = x, r, w, m, i, blank AND DRAIN1B = x, r, w, m, i, blank
- j. SURFM_1 = FG AND SURF_E1A = p, j, a, k, s, t, f, m, r, f, c, u, h, d, b, AND SSURFM_1 = L, LG, M, R AND DRAIN_1 = x, r, w, m, i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_1A = x, r, w, m, i, blank AND DRAIN_1B = x, r, w, m, i, blank
- k. TDEC_2 = 3, 4, 5 AND SURFM_2 = FG, F AND SURF_E2A = p, j, a, k, s, t, f, m, r, f, c, d, h, u AND DRAIN_1 = x, r, w, m, i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_2A = x, r, w, m, i, blank AND DRAIN_2B = x, r, w, m, i, blank
- l. TDEC_2 = 3, 4, 5 AND SURF_E2A = x, v, w, b AND SSURFM_2 = FG, F AND SSURF_E2A = p, j, a, k, s, t, f, m, r, f, c, d, h, u AND DRAIN_1 = x, r, w, m, i, blank AND DRAIN_2 = x, r, w, m, i, blank AND DRAIN_2A = x, r, w, m, i, blank AND DRAIN_2B = x, r, w, m, i, blank
- m. SURFM_1 = U AND SURF_E1A = p, j, a, k, s, m, r, u, d, f, c, h

4. Thick Till Polygons

- a. SURFM_1 = M AND SURFM_ST1 = blank AND SURF_E1A = p, j, a, k, s, t, u, h, m, r, d
- b. SURF_EIA = x, v, b, w AND SSURFM_1 = M AND SSURFM_ST1 = blank AND SSURF_E1A = p, j, a, k, s, t, u, h, m, r, d
- c. SURFM_1 = M AND SURFM_ST1 = blank AND SURF_E1A = b AND SURF_E1B = p, j, a, k, s, t, u, h, m, r, d
- e. SURF_EIA = x, v, b, w AND SSURFM_1 = M AND SSURFM_ST1 = blank AND SSURF_E1A = b AND SSURF_E1B = p, j, a, k, s, t, u, h, m, r, d

5. No Gravel Potential (based on existing terrain mapping)

- a. all remaining polygons

APPENDIX B

AGGREGATE SUPPLY AND DEMAND ANALYSIS STUDY – PRODUCER SURVEY



A TETRA TECH COMPANY

Date: _____ **Producer Survey** _____

Contact: _____

Company: _____

Email: _____ Phone No: _____

Address: _____ Fax No: _____

File No: Aggregate Supply and Demand Analysis Study

Central Okanagan Growth Management Strategy

Aggregate Supply and Demand Analysis Study – Producer Survey

The Regional District of the Central Okanagan (RDCO) has initiated an Aggregate Supply and Demand Analysis Study, as part of the Central Okanagan Regional Growth Strategy. EBA Engineering Consultants Ltd. has been selected as the consultant to prepare the study. The objectives of the study are to:

- Update aggregate supply and demand data for a time horizon of 20, 50 and 100 years, including using current terrain mapping and geology maps for aggregate potential;
- Provide an analysis of potential constraints to production based on other land uses / elements; and
- Provide a site suitability assessment checklist, including site limiting factors such as surface or groundwater conditions, environmental sensitivity and land use, to analyze potential limitations to aggregate production.

We appreciate your help in completing this survey. All information received will be confidential. The information will be used to determine general trends for the industry within the Okanagan, such as: average hauling distance, average volume per year for the District, and so on. Details on individual operations will not be published. We have included space at the end of the survey for your comments and concerns. This information will also be helpful in completing the study. Additional pages may be added if required.

Natural Sand and Gravel - Estimated Use

Roads (construction and maintenance)	_____	%	
Concrete production (incl. mortar sand)	_____	%	
Asphalt production	_____	%	
Structural fill	_____	%	
Landscaping	_____	%	
Other uses	_____	%	Please specify _____
<i>Total</i>	100	%	

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company
 150, 1715 Dickson Avenue
 Kelowna, BC V1Y 9G6 CANADA
 p. 250.862.4832 f. 250.862.2941

Volume (Estimated #s for general information)

Total Natural Sand and Gravel - Volume

Total average raw sand and gravel volume per year from pit	_____	cubic m./m. tonne
Estimated percentage waste (e.g. overburden, silty sand)	_____	%
Estimated percentage marketable sand and gravel	_____	%
Total	100	%

Marketable Aggregate Volume

Total estimated sand and gravel volume for 2012	_____	cubic m./m. tonne
Total sand and gravel average volume / year for last 5 years	_____	cubic m./m. tonne
Total sand and gravel average volume / year for last 10 years	_____	cubic m./m. tonne

Recycled Aggregate Volume

Recycled asphalt	_____	cubic m./m. tonne
Recycled concrete	_____	cubic m./m. tonne
Other	_____	Please specify _____

Natural Sand and Gravel Composition End Use

Sands (less than 4.75 mm)	_____	%
Gravels (greater than 4.75 mm)	_____	%
Crushed material	_____	%
Topsoil	_____	%
Waste	_____	%
Other	_____	% Please specify _____
Total	100	%

Quarried Rock

Total raw rock volume per year from quarry	_____	cubic m./m. tonne
Estimated percentage waste (e.g. overburden, etc.)	_____	%
Estimated percentage rock – crushed aggregate	_____	%
Estimated percentage rock – large dimension	_____	%
Total	100	%

Rock Volume

Total rock volume production per year _____ cubic m./m. tonne
 Total rock volume for 2012 _____ cubic m./m. tonne
 Total rock average volume per year for last 5 years _____ cubic m./m. tonne
 Total rock average volume per year for last 10 years _____ cubic m./m. tonne

Rock Composition End Use

Road Fill Aggregate	_____	%	
Decorator Rock (e.g. shale, granite)	_____	%	
Rip Rap	_____	%	
Dimension stone (e.g. gneiss)	_____	%	
Waste	_____	%	
Other	_____	%	Please specify _____
<i>Total</i>	100	%	

Note that field work is not a component of this study. Therefore, any detail on specific geological characteristics would be extremely helpful to determine relative potential in similar rock types elsewhere in the valley. Some questions on geological characteristics and rock types are included below.

Rock for Aggregate Crush: Of rock crushed for aggregate, please describe:

Abrasion resistance _____
 Sand equivalent _____
 Fracture count _____

If analytical results are available, please provide as an attachment.

For rock used as aggregate crush, describe the geological characteristics of the material including:

Grain size _____
 Mineralogy _____
 Rock type _____

Reserve – Aggregate and Rock

Total estimated volume of reserve – aggregate _____ cubic m./m. tonne
Total estimated volume of reserve – rock _____ cubic m./m. tonne

Estimated life remaining in pit/quarry at present production levels (in # of years) _____

Overburden Depth

Average overburden depth _____ metres
Range in overburden depth from _____ to _____ metres

General comments about over burden composition (e.g. topsoil, aggregate fill, etc.)

Ground Water

Average depth to ground water _____ metres
Range in depth to ground water from _____ to _____ metres

General comments about depth to ground water:

Well Use

Do you use any on-site water wells for drinking water, production uses, irrigation or other uses? Describe no. of wells, their use and average annual groundwater used (m³/year):

Acid Rock Drainage and Metal Leaching

Do you know of or foresee any issues relating to acid rock drainage or metal leaching due to operations as your site? Comments on assessments, monitoring or mitigation:

Water Use

Average annual water use for production _____ Cubic m.

Typical transportation Routes

Average truck size _____ (capacity cubic m./m. tonne) # axels _____
Average # trucks per day _____
Average # trucks per week _____

Hauling distances

Range of hauling distances from _____ to _____ kilometres
Average hauling distance _____ kilometres
General area of service:

Costs (Attach price list – optional)

Trucking costs

Truck _____ \$ per hour
Truck & pup _____ \$ per hour

Reclamation Plans

Reclamation plans available? Yes No

Anticipated Use after Reclamation (e.g. Agricultural, Industrial, Forest, etc.)

Comments on reclamation plans:

General comments and/or concerns to help us better direct focus of aggregate study (e.g. planning policy, permit process, future land designation, transportation issues, etc.)

EBA Engineering Consultants Ltd.

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APPENDIX C

SURFICIAL GEOLOGY

APPENDIX C: SURFICIAL GEOLOGY

1.0 ORIGIN OF NATURAL SAND & GRAVEL DEPOSITS

Understanding the underlying geology and nature of recent surficial materials is important to the location of aggregates useful for construction. The following describes the origin of natural sand and gravel deposits. Deposits of specialty materials such as landscape rock and clays suitable for brick are also covered.

1.1 Sand and Gravel versus Bedrock Sources of Aggregate

Natural sands and gravels in the landscape have typically been brought down by water, by either glacial or modern rivers. Sand and gravel deposits, as well as till and clays over bedrock, are known as surficial materials. The following sections will outline the origin and characteristics of different surficial materials.

1.2 Topography and Bedrock Geology of the Central Okanagan

The Central Okanagan is located at the eastern edge of the Thompson Plateau, a subdivision of the Interior Plateau Physiographic Region (Holland, 1976). The Thompson Plateau consists of a gently rolling upland surface of low relief. Elevations range from 342m at Okanagan Lake to 1600m in the upland regions. The rivers and streams of the area drain into Okanagan Lake that ultimately flows into the Columbia River system via Okanagan River.

The description of the bedrock geology for the study area is taken from Tempelman-Kluit (1989) and Jones (1958). The present physiography dates back four hundred million years when plate tectonics welded the former Pacific Ocean to the margin of the North American continent. This created ridges of metamorphic and plutonic bedrock orientated in a north-south direction. About 50 million years ago (early Tertiary), plate tectonics caused uplift of the area accompanied by extensive volcanism (extrusion of the Kamloops Group). A long period of relative stability followed, during which erosion and deposition formed a low-relief landscape with gentle slopes and low hills. During late Tertiary, the area was subject to uplift again, followed by a renewed period of downcutting, with the stream valleys deeply incising into the old erosion surface.

2.0 GLACIAL HISTORY AND THE ORIGIN OF SURFICIAL DEPOSITS

At the beginning of the last major glacial episode (Fraser Glaciation), ice accumulated in the high mountains and then gradually spread to valleys and lowlands. About 14,500 years ago, when the Cordilleran Ice Sheet was thickest and most extensive at the climax of Fraser Glaciation, ice flowed generally southward across the study area (Fulton, 1965). The rounded ridge tops suggest that the entire area was completely overridden by ice at this time, depositing till at the bottom of the glacier.

Deglaciation occurred between about 14,000 and 11,000 years ago. As the ice cap melted the uplands emerged from beneath the ice before lower areas (Fulton, 1969). As the glacier, now confined to the valley floor, lowered, several large meltwater channels formed along the margin of the ice on mid-elevation slopes. As the ice downwasted further, extensive glaciofluvial sediments were deposited, largely on the mid

and lower slopes on the eastern side of the valley. These deposits typically occur in the landscape as glaciofluvial terraces, fans and raised deltas. Elevations of these deposits range generally from 400m to 600m. Examples of these surficial deposits occur in East Kelowna, Crawford Estates, Southwest Mission, and the east side of Wood Lake.

Ice-tongues blocked drainage so that Glacial Lake Penticton (Roed, 1995) was created, depositing glaciolacustrine sediments (silts and clays) along the valley bottom. Locations of clays in the Central Okanagan include the Glenmore Valley and the Klassen Road area in North Rutland.

The clays that were deposited by glacial lakes hold some potential for brick manufacturing.

During post-glacial times, natural processes have re-worked some glacial sediments and weathered bedrock to redistribute them as colluvium (sediments moved by gravity) and fluvial (sediments moved by post-glacial rivers and streams) sediments. Creeks and rivers that have graded to the present day lake level have downcut into glacial deposits creating terraces, benches, and steep-sided scarps.

This section gives the typical characteristics of surficial materials in the Central Okanagan.

2.1 Glaciofluvial Materials

Glacial meltwater streams near the end of the most recent glaciation deposited glaciofluvial materials. Sands and gravels accumulated along ice margins and on top of melting ice (ice contact deposits), and downstream of glaciers (outwash plains). Where outwash streams flowed onto flat ground, fans were formed. Where outwash streams drained into former lakes, deltas were created. Postglacial streams have cut down through some outwash plains and fans transforming them into terraces. Glaciofluvial sediments commonly overlie till.

Glaciofluvial materials consist of sand and gravel with small quantities of finer material. Sorting and bedding characteristics are variable depending on the mode and site of deposition.

Gravels range from unsorted to well sorted, and bedding can range from absent to well-defined. Gravels tend to be subangular to subround. Ice-contact deposits may have distorted bedding, slump structures and faults as a result of settling and collapse due to melting of supporting ice.

The sands and gravels of glaciofluvial materials form a matrix that is highly porous and permeable, and thus they form relatively dry and well drained sites. The material is non-cohesive, and so tends to slump when exposed in steep slopes (greater than 70%) and road cuts. Glaciofluvial sands and gravels are primary potential sources of aggregate.

2.2 Fluvial Materials

Streams have deposited fluvial gravels in post-glacial time. These sediments are loose, non-cohesive and the deposits are highly porous and permeable. Associated landforms, such as floodplains and parts of fans that are close to stream-level, have high water tables and are moderately to imperfectly drained. Floodplains are subject to periodic inundation during high flows. Fluvial terraces stand above present day creek-levels and are relatively well drained and dry, and good locations for roads and landings.

The particle size of fluvial sediments vary in accordance with the stream velocity at the location of deposition. For example, in the upper reaches of a stream, where water velocities are high, the sediments deposited will be boulders, cobbles and gravels. As the stream goes further into the floodplain, the velocity will slow, releasing sands and silts. Some fluvial deposits will have environmental constraints relating to aggregate production. Active stream corridors, for example, are protected under the Fisheries Act and the Fish Protect Act and Riparian Areas Regulation. All activities in these areas must adhere to the Land Development Guidelines for the Protection of Aquatic Habitat (Chilibeck, 1995). A fluvial terrace, on the other hand, may be a suitable distance away from an active channel, and therefore may be accessible for the purposes of aggregate extraction. Fluvial deposits must be considered on a site specific basis.

2.3 Till

Till is deposited directly by glacier ice and usually exists as a veneer, blanket, or mantle of variable thickness over the underlying bedrock surface. It typically consists of a fine-grained matrix (silts and clays) that surrounds and supports clasts (particles of sands, gravels, cobbles and boulders) of a variety of sizes, shapes and rock types. Till characteristics, such as grain size distribution and consolidation grain size distribution, vary according to specific processes of deposition by glacier ice. These deposits can be highly variable and gradations in texture and consolidation can vary over short distances. Over the last 12,000 years, the upper half metre to one metre of these deposits have weathered creating loose, permeable soils.

Thick till deposits have been mapped as a potential source for sand and gravel. However, while potential sand and gravel deposits occur, till has a large percentage of silts and clays that typically form the matrix of these deposits. While sands, gravel, and cobbles will occur, the quantity of fines present generally make gravel extraction less economically viable, due to a high waste content and demanding processing requirements.

2.4 Colluvium

Colluvial materials have accumulated during post-glacial time as a result of gravity-induced slope movement, such as soil creep and landslides. The physical characteristics of colluvium are closely related to its source and mode of accumulation.

Four processes generally create colluvial deposits. These are rockfall from bedrock bluffs, soil creep in weathered bedrock, mass movement processes in gullies (debris flows and debris slides), and rockslides and rock slumps.

Rockfall from bedrock bluffs typically forms talus slopes. Talus is typically loosely packed rubble or blocks with little interstitial silt and sand near the surface, and is rapidly or well drained.

Colluvial veneers and blankets develop where weathered bedrock has been loosened and moved downslope by gravitational processes such as soil creep. The characteristics of this colluvium closely resemble those of the material it was derived from. It is loosely packed and usually well drained. These slopes are mainly located on the mid and upper slopes and the gully walls of the larger, deeply incised creeks.

Colluvial fans and cones form at the base of steep gullies due to deposition by debris flows. These deposits are generally compact, and sorting may range from poorly sorted to well-sorted. The deposit may or may not be matrix supported, where the matrix is usually sand.

Rockslides and deep-seated slumps in bedrock result in hummocky, irregular colluvial deposits. Rockslide deposits consist of loosely packed rubble and blocks with little or no interstitial silt and sand and are well drained. Rock slump deposits contain blocks and rubble with little or no interstitial silt and sand.

While colluvium has some potential as an aggregate source, the physical and chemical properties of colluvial deposits vary. Its value as an aggregate supply will depend on the nature of its source rock and the process of its formation. Colluvium may occur primarily as broken rock, such as a talus deposit. Alternatively, it may contain a matrix of sands, as may be found in fans in the base of gullies produced by debris flows. The source rock will also determine the chemical suitability of a particular colluvial deposit for aggregate production. For example, colluvial deposits that contain pyrite, (such as those which occur in the Wilson Landing area), have an acidity which will react with concrete, and, as such, provide a poor aggregate resource.

2.5 Glaciolacustrine Materials

Glaciolacustrine materials consist of fine sediments that accumulated in ice-dammed lakes. Fine sand, silt, and clay (“rock flour”), initially produced by glacial abrasion, have been transported to the lakes by meltwater streams. Fine sediments tend to remain suspended in the lake, and then slowly settle to the lake bottom. Glaciolacustrine sediments typically consist of interlayered silt, clay, and fine sand. Dropstones from floating melting ice, ranging up to boulder-size, may be embedded in the finer material. The sediments are usually slowly permeable to impermeable and are generally moderately to highly cohesive, depending on the percentage of clay. Beach sediments tend to be sands and gravels, and are loose and porous.

Glaciolacustrine deposits are considered to have poor (tertiary) potential for sand and gravel production. There is potential, however, for deposits with high clay content to have potential for brick production. Within the Central Okanagan, glaciolacustrine deposits with high clay contents occur in the Glenmore Valley, and near Klassen Road in North Rutland.

2.6 Lacustrine Materials

Lacustrine sediments consist of fine particles that settle out of suspension in lakes and coarser sediments that accumulate along the shoreline (littoral zone). Fine sand, silt, and clay are transported in suspension by streams to lakes where they settle to the lake bottom. Sand, pebbles, and cobbles are deposited on the shore by wave action. These sediments may be sub-aerial on beaches, due to seasonal fluctuation in water levels and where lake basins have drained. These sediments are usually slightly permeable to impermeable and are generally moderately to highly cohesive depending on the percentage of clay.

Lacustrine deposits have been mapped as having low (tertiary) potential for aggregate production. While some shoreline deposits may have an appropriate particle size distribution, there are environmental constraints in terms of excavation procedures along lake shores.

APPENDIX D

GEOLOGICAL STRATIGRAPHIC UNITS

Appendix D-1 – MINFILE Database

The following information summarizes the MINFILE database for the eight dominant stratigraphic units, based on cumulative area, encountered within the study area of the RDCO. The MINFILE database compiles information on geological showings, producers, and past producers for various types of commodities, including aggregate. The text is copied directly from the MINFILE Database, accessed through the MINFILE Mineral Inventory website, www.empr.gov.bc.ca/mining/geoscience/minfile, in January and February 2013.

Reference: Ministry of Energy, Mines and Natural Gas, BC. 2013. MINFILE: Mineral Inventory. Accessed: www.empr.gov.bc.ca/mining/geoscience/minfile, January-February 2013.

Each body of information is preceded by a heading that lists four pieces of information. They are in order: The # of MINFILE Data point corresponding to labelling on Figure A-1; Designation as Producer/Showing/Occurrence; Name of Producer/Showing/Occurrence; Type of Commodity.

Unit PrPzShm

25 Producer - Canyon, Okanagan Gneiss, Rainbow Granite, Kettle Valley – Dimension Stone/Flagstone

The Canyon area is underlain by gently dipping rocks of the Proterozoic Shuswap Terrane consisting of gneiss and schist. Kettle Valley Stone Company produces decorative rock from the gneiss. Records indicate production was occurring at the quarry as early as 1999 and was ongoing in 2005. Production may have occurred prior to 1999. The product is marketed as “Rainbow Granite”.

By 2004, the Kettle Valley Stone Company of Kelowna employed about 40 people year round, mainly at its processing plant where raw material is brought from several quarries including the Canyon.

www.kettlevalleystone.com

10 Showing – Angel Hot Spring – Travertine Used as building material, paving patios and garden paths, most frequently used stones in modern agriculture

Angel Hot Spring is above the McCullough road in the canyon section of Klo Creek drainage basin, approximately 300 metres below the Kettle Valley railway cut, on the lower northern slope of Little White Mountain.

The area is underlain by gently dipping Shuswap gneiss and schist and small outliers of Chilcotin basalt accompanied by criss-crossing feeder dikes. The basalts range in age from Miocene to recent history and these rocks and associated fissures are believed to be a geothermal source. The area is within a region of high geothermal potential that includes much of the central and southern parts of the Okanagan Valley that is characterized by geothermal gradients ranging up to 70 degrees Celsius/kilometre.

Over a long period of time the stream has built a large mound of tufa 300 metres long, 150 metres wide, and up to 8 metres thick along the bottom of the valley of Angel Creek. The deposit consists of grey to brownish, crudely bedded, cellular carbonate tufa (travertine), forming successive lenses, each ranging from several centimetres to more than a metre thick, intercalated with gravel, logs, standing tree trunks, branches and twigs. The numerous cavities in the tufa are mostly the casts of twigs, sticks and other decaying or decayed and dissipated organic debris.

Analyses of the tufa obtained from 5 samples, collected from the length of the mound, show a range in CaO from 51.92 to 53.88 per cent, MgO from 0.26 to 0.44 per cent, Fe₂O₃ from 0.09 to 1.03 per cent, Al₂O₃ from 0.06 to 0.43 per cent,

and SiO₂ from 0.37 to 1.73 per cent. There is a slight increase in SiO₂ and Fe₂O₃ distally from the spring and an overall decrease in Al₂O₃. In general the composition is similar to the Clinton tufa deposit. X-ray diffraction analyses of the 5 samples (courtesy of Jim McLeod of the Cominco Laboratory, Vancouver, B.C.) indicate that the predominant mineral in the tufa is calcite.

49 Showing – James Lake, Jock – Copper Wollastonite

The JAMES LAKE showing is located 300 metres west of James Lake and approximately 18 kilometres northeast of Kelowna.

The showing consists of flat-lying, banded, calcium silicate skarn, which is overlain and underlain by gneissic rocks of the Upper Proterozoic Shuswap Metamorphic Complex. It is comprised of red, brown and green garnet, with local concentrations of fine-grained wollastonite and diopside. Pyrite and chalcopyrite are present in the skarn, and the enclosing gneiss is locally pyritic.

Skarn occurs for approximately 230 metres with about 100 metres of gneiss in between along a northwest trending roadcut (Personal Communication, Z.D. Hora, 1996). Also included in this occurrence is a smaller exposure of calcium silicate skarn, which outcrops for 20 metres along a roadcut, 680 metres southwest of the main exposure (Personal Communication, Z.D. Hora, 1996).

The property was examined for its precious and base metal potential by W.D. Yorke-Hardy, R.G. Irving and J.H. Wright in 1988-89. The results were discouraging and they concluded that the rock may be suitable for lapidary purposes. There are no records to suggest that the wollastonite potential has yet been evaluated.

9 Developed Prospect – Hydraulic lake, TYEE, Kettle – Uranium

The HYDRAULIC LAKE deposit is located in the Hydraulic Creek valley 1.5 kilometres north of Hydraulic Lake and approximately 24 kilometres southeast of Kelowna.

Work on the property, prior to the uranium moratorium in 1980, consisted of geological and radiometric surveys and extensive diamond drilling. In 1976, Tye Lake Resources Ltd. drilled 29 holes for a total of 1,619 metres. In 1977, Noranda Exploration Company drilled 2,423 metres in 39 diamond-drill holes and 4,522 metres in rotary holes. In 1978, Placer Development optioned the property and carried out 360 metres of diamond drilling in 9 holes. Metallurgical testing of the uranium ore was done by Placer in 1979. PNC Exploration (Canada) Co. Ltd. conducted wide-spaced drilling in the north part of the deposit.

The deposit is underlain by hornblende-biotite granodiorite orthogneiss of the Upper Proterozoic Shuswap Metamorphic Complex. The deposit occupies the northern part of a southeast trending, structurally-controlled Miocene paleochannel, which overlies the metamorphic rocks. This paleochannel varies in width from 100 to 200 metres and is mineralized for a length of approximately 1000 metres, although ore-grade material is confined to a length of 500 to 600 metres. The average thickness of the deposit is 50 metres. The paleohydrologic gradient from northwest to southeast is about 2 per cent. The basalt formerly covering the deposit has been stripped off as a result of uplift and glaciation and the deposit is now covered by relatively impermeable beds of varved clay and glacial till. The olivine basalt and the fluvial sediments of the Miocene Chilcotin Group form the plateau basalt.

Conglomerate blankets the basement complex and also comprises thick horizons throughout the sedimentary sequence. Interbedded within the conglomerate units are much thinner horizons of fine to coarse-grained sandstone and minor mudstone. Fragments of slightly decomposed and carbonized wood and other forms of organic material are

abundantly scattered throughout the sediments. Organic material within iron sulphide-rich zones of the deposit has been completely broken down to form humic acids, which have precipitated together with uranium in voids within the conglomerate.

Although marcasite is scattered throughout the mineralized paleochannel, there are two zones, corresponding to two small depressions in the basement complex, where marcasite is in sufficient quantity to cement the conglomerate.

Ningyoite, gummite and autunite are reported. It occurs mainly as star-shaped concretions and accretionary masses surrounding clasts and marcasite grains in carbonaceous filled voids. The uranium content of the sediments gradually increases with depth, the basal conglomerate often containing more than 0.1 per cent uranium.

Ore reserves of the southern part of the deposit are estimated at 2,055,697 tonnes averaging 0.031 per cent uranium (grade stated as 0.0366 per cent U3O8) (Paper 1979-6). Reserves of the northern part are estimated, by wide-spaced drilling, at over 1,000,000 tonnes of 0.017 per cent uranium (grade stated as 0.02 per cent U3O8) (Paper 1979-6). Conversion used for U3O8 to uranium is 0.848.

Unit EPeMK

50 Showing – Mount Swite Agate – Agate Gemstones

The Mount Swite agate locality is accessed from the Bear Creek (Lambly Creek) road via the Hidden Creek logging road that passes approximately 2 kilometres east of the summit.

The agates consist of quartz and cristobalite filling amygdaloids and fissures in the Attenborough Creek member. The amygdaloids are commonly elongated almond-shaped structures (0.5 to 5 cm), filled with fine grained blue-grey quartz, cristobalite and white plume opal aligned parallel to flow direction of the lava.

Thunder eggs are larger agates (baseball size) with radiating quartz crystals lining vugs and/or chalcedony in variegated horizontal or concentric bands on cavity floors or walls. Agates are believed to form within gas cavities of volcanic host rocks when microcrystalline chalcedony fibres nucleate on vug walls and grow inward. Oscillatory zoning and iris banding is the result of variations in silica concentrations in solutions at the tips of the growing chalcedonic fibers forming smooth and regular or botryoidal surfaces parallel to the banding (Heaney and Davis, 1995). The most probable source of the silica-rich solutions is the host Attenborough Creek andesite.

Analyses of the andesite from different locations shows uniform composition and excess silica based on norm calculations. It is concluded that part of the excess silica, accompanied by fluids and gases, moved from the andesite lava to gas cavities and fracture openings during the original lava cooling process.

38 Past Producer – Kelowna – Clay

The KELOWNA clay showing is located in the Mount Dilworth area within the present Kelowna city limits. William Haug and Sons Brickworks used the clay to make bricks from before 1932 to 1940.

Mount Dilworth is formed of flow-banded dacite lavas of the Eocene Penticton Group, Marama Formation. To the north are trachyte to trachyandesite lavas and pyroclastic rocks of the Penticton Group, Marron Formation. Mount Dilworth is surrounded by glacial lake sediments on all sides, except on the southeast, where there are raised alluvial fans, terraces and deltas. Insufficient information exists to determine if the showing is a lacustrine deposit, or if it is a clay alteration zone in the volcanic rocks.

The clay was of two types: a light-yellow clay with some stones, and a hard dark-brown, non-calcareous clay. It was noted that the clay works well with 23.3 per cent water, although somewhat short. It was safe drying at 80 degrees centigrade with an average shrinkage of 4.6 per cent. The firing characteristics of the light yellow clay are: 04 cone, 16.5 per cent absorption, 1.3 per cent shrinkage, light pink colour, and soft with some scum. The firing characteristics of the dark brown clay are: 2 cone, 7.5 per cent absorption, 6 per cent shrinkage, brown red colour, and very hard with scum. Overall, the poor colours and scumming make the clay unattractive. It was also noted that the abundance of iron stain was due to the concretions in the clay (Bulletin 30, p. 51).

31 Past Producer – Mission Creek, Will 1-12, Gallaghers Canyon – Gold

The MISSION CREEK placer gold occurrence is found in the Mission Creek gravels downstream from an exposure of a Quaternary conglomerate in Gallagher's Canyon. This area is located within the Kelowna City municipal limits, approximately 12 kilometres east of the mouth of Mission Creek.

The conglomerate, which is believed to be the source of the gold, is underlain by epiclastic and pyroclastic rocks of the Eocene Penticton Group, White Lake Formation. These rocks have been thrust westward forming northerly trending, over-turned folds. The Mission Creek fault, located less than a kilometre to the south, exposes gneiss of the Upper Proterozoic Shuswap Metamorphic Complex.

The conglomerate is an interglacial alluvial deposit which is contained within a sequence of gently, eastward sloping glacial tills. Immediately underlying the conglomerate is a buff coloured, banded silt containing fragments of bituminous material. The conglomerate, as exposed in the upper reaches of Gallagher's Canyon, is a competent but interstitially friable, and limonitic weathering rock. The clasts are closely packed, and are composed of well-rounded to angular granite, diorite and argillite pebbles, cobbles and fragments. The interstitial material is predominately siliceous (quartz sand?). The conglomerate is conformably overlain by a well-bedded dark volcanic, averaging 1 metre in thickness. This volcanic may be related to the Pleistocene Lambly Creek Basalt eruptions to the west. It is speculated that the conglomerate, which outcrops as a rusty weathering gravel at the exit of Gallagher's Canyon, is actually the Rutland aquifer (Roed M.A. (1995): Geology of the Kelowna Area and Origin of the Okanagan Valley).

Early records of placer gold mining on Mission Creek date from 1876, although the discovery is credited to William Peon in 1861. Small-scale placer mining of the creek gravels continued intermittently until the 1930s. Recorded production (Bulletin 28, page 63) of gold during the period 1876 to 1895 was 20558 grams (661 troy ounces). Sluicing of the underlying silts and excavation of an 8-metre adit in the conglomerate is thought to date from the early to mid-1970s. Very high gold assays were reported from 8 overburden drillholes in 1975; however, they could not be reproduced by subsequent sampling. Much of Gallagher's Canyon is now covered by the Scenic Canyon Regional Park.

Unit MJgd

81 Showing – Esperon3, Esperon, Dobbin, ESP – Molybdenum – ASSESSMENT REPORT available

The Esperon 3 showing is located 28 kilometres north northwest of Kelowna, north of Terrace Creek.

In this area, Middle Jurassic quartz monzonite of the informally named Terrace Creek batholith intrudes argillaceous sediments of the Upper Triassic to Lower Jurassic Nicola Group. The stock is cut by diorite plugs and dikes which are cut by quartz monzonite and aplite dikes. The intrusive rocks are cut by Tertiary basalt dikes related to overlying Eocene Penticton Group volcanic rocks.

Chloritized and sericitized porphyritic quartz monzonite hosts molybdenum mineralization. Quartz veinlets carry traces of disseminated molybdenite and pyrite.

In 1979 and 1980, Cominco Ltd. carried out geological mapping, induced polarization and magnetometer surveys.

82 Prospect – Esperon 1, Esperon, Dobbin – Molybdenum – ASSESSMENT REPORT available

The Esperon 1 prospect is located 29 kilometres north-northwest of Kelowna, south of Dun Waters Creek.

In this area, Middle Jurassic quartz monzonite of the informally named Terrace Creek batholith intrudes argillaceous sediments of the Upper Triassic to Lower Jurassic Nicola Group. The stock is cut by diorite plugs and dikes which are cut by quartz monzonite and aplite dikes. The intrusive rocks are cut by Tertiary basalt dikes related to overlying Eocene Penticton Group volcanic rocks.

Chloritized and sericitized porphyritic quartz monzonite hosts molybdenum mineralization. Quartz veinlets carry disseminated molybdenite and pyrite. A 25-metre chip sample assayed 0.021 per cent molybdenum (Assessment Report 8664).

About 600 metres to the east, straddling Dun Waters Creek, quartz veins carrying disseminated molybdenite cut chloritized and sericitized porphyritic quartz monzonite, adjacent to diorite, and a quartz monzonite dike intruding argillites.

In 1979-80, Cominco Ltd. carried out geological mapping, induced polarization and magnetometer surveys

83 Showing – Esperon 2, Esperon, Dobbin, ESP – Molybdenum, Tungsten – ASSESSMENT REPORT available

The Esperon 2 showing is located 29 kilometres north-northwest of Kelowna, north of Dun Waters Creek.

In this area, Middle Jurassic quartz monzonite of the informally named Terrace Creek batholith intrudes argillaceous sediments of the Eocene Penticton Group. The stock is cut by diorite plugs and dikes which are intruded by quartz monzonite and aplite dikes. The intrusive rocks are cut by Tertiary basalt dikes related to volcanic rocks which overlie the older rocks.

Chloritized and sericitized quartz monzonite porphyry hosts molybdenum mineralization. Quartz veinlets, usually 1 to 10 centimetres thick, carry blebs of molybdenite, scheelite and pyrite. The bottom 8 metres of the drill hole assayed 0.025 per cent molybdenum (Assessment Report 8664). A 30-metre section above this zone assayed 0.045 per cent tungsten (Assessment Report 8664).

Another drill hole, 800 metres to the southeast, encountered 4.5 metres of 0.021 per cent molybdenum.

In 1979 and 1980, Cominco Ltd. carried out geological mapping, induced polarization, magnetometer and percussion drill programs.

84 Showing – AT, DUN, Esperon 18, Esperon, Dobbin – Molybdenum, Copper – ASSESSMENT Report Available

The AT showing is located 29 kilometres north-northwest of Kelowna, north and west of Dun Waters Creek.

In this area, Middle Jurassic quartz monzonite of the informally named Terrace Creek batholith intrudes argillaceous sediments of the Upper Triassic to Lower Jurassic Nicola Group. The stock is intruded by diorite plugs and dikes which are cut by quartz monzonite and aplite dikes. The intrusive rocks are cut by Tertiary basalt dikes related to volcanic rocks which overlie the older rocks.

Chloritized and sericitized, moderately fractured quartz monzonite porphyry hosts molybdenum and a trace of copper mineralization. Quartz veinlets, usually 1 to 10 centimetres thick, carry disseminated molybdenite, pyrite and traces of chalcopyrite. Pyrite and molybdenite occur on fracture planes. Alteration is associated with the quartz stockwork and the fractures.

About 1 kilometre to the northwest, sericite and epidote-altered quartz monzonite porphyry hosts quartz veinlets carrying a trace of disseminated molybdenite.

In 1966-67, Noranda Exploration Co. Ltd. carried out soil geochemistry and trenching programs. In 1972, Canadian Johns- Manville Co. Ltd. carried out a soil geochemistry survey. In 1979-80, Cominco Ltd. carried out geological mapping, induced polarization and magnetometer surveys.

96 Past Producer – Whiteman Creek - Gold

The Whiteman Creek showing is located 19 kilometres west- southwest of Vernon, on Whiteman Creek.

In this area, Devonian to Triassic sedimentary and volcanic rocks of the Harper Ranch Group are unconformably overlain by Upper Triassic to Lower Jurassic Nicola Group sedimentary and volcanic rocks. These units are intruded by Middle Jurassic granitic rocks of the informally named Terrace Creek batholith. Eocene Coryell granitic rocks intrude and are in fault contact with the Middle Jurassic intrusions. Eocene Pentiction Group volcanic rocks overlie the igneous and sedimentary rocks.

Quaternary gravels along the creek host placer gold mineralization. In 1915, hydraulic placer mining leases were granted. The recorded production is 90 grams of placer gold, during 1936-40 (Bulletin 28).

98 Showing – Bouleau Creek – Gold

The Bouleau Creek showing is located 19 kilometres west- southwest of Vernon, on Bouleau Creek.

In this area, Devonian to Triassic sedimentary and volcanic rocks of the Harper Ranch Group are unconformably overlain by Upper Triassic to Lower Jurassic Nicola Group sedimentary and volcanic rocks. These units are intruded by Middle Jurassic granitic rocks of the informally name Terrace Creek batholith. Eocene Coryell granitic rocks intrude and are in fault contact with the Middle Jurassic intrusions. Eocene Pentiction Group volcanic rocks overlie the igneous and sedimentary rocks.

Quaternary gravels along the creek host placer gold mineralization. In 1915, hydraulic placer mining leases were granted

75 Showing – Bald – Uranium – ASSESSMENT REPORT available

The Bald showing is located 20 kilometres north of Kelowna; about 2 kilometres west of Okanagan Lake.

In this area, Upper Triassic to Lower Jurassic Nicola Group sedimentary and volcanic rocks have been intruded by Middle Jurassic granitic rocks of the informally named Terrace Creek batholith. Outliers of Eocene Pentiction Group volcanic and sedimentary rocks overlie the older units.

A Recent organic bog, overlying Middle Jurassic quartz monzonite, hosts uranium mineralization. A 1.4 metre sample of homogeneous black organic muck with cedar wood fibre and roots assayed 0.035 per cent uranium, with 0.3 metre of 0.125 per cent uranium (Assessment Report 7973).

In 1978-79, Canadian Occidental Petroleum Ltd. carried out geological mapping, soil geochemistry, a radiometric survey and trenching

76 Showing – TICK – Molybdenum – ASSESSMENT Report available

The Tick showing is located 25 kilometres southwest of Vernon, between Wood and Okanagan lakes.

Rhyolitic porphyry of the Eocene Coryell Intrusions intrudes Middle Jurassic porphyritic quartz monzonite of the informally named Terrace Creek batholith. Spherulitic and miarolitic textures in the porphyry indicate a high intrusion level. The intrusions cut metamorphic rocks of the Shuswap Terrane and are overlain with patches of volcanic rocks of the Eocene Penticton Group.

The K-feldspar porphyry hosts Tertiary, possibly Eocene, molybdenum mineralization. A 5-metre chip sample assayed 0.02 per cent molybdenite (Assessment Report 1694).

In 1968, Agricola Mines Ltd. carried out geological mapping and soil sampling.

“Granite is the predominant rock type on the property and a later porphyritic, acidic intrusive/extrusive lies to the south and east of the granite. The porphyry lies in the contact with the metamorphic complex of gneisses, metasediments and altered volcanics which may be in part Monashee Group. Pegmatite as dikes and sills are common in this complex and diabase dikes are present in the granites and earlier rocks” Assessment Report

73 Showing – Nova, Nova 2 – Molybdenum – Assessment Report Available

The Nova showing is located 25 kilometres southwest of Vernon on the west shore of Wood Lake.

A rhyolitic porphyry of the Eocene Coryell Intrusions intrudes Middle Jurassic porphyritic quartz monzonite of the informally named Terrace Creek batholith. Spherulitic and miarolitic textures in the porphyry indicate a high level of intrusion. These cut metamorphic rocks of the Shuswap Terrane and are overlain with patches of Penticton Group volcanic rocks. The Okanagan Valley fault zone is centered along Wood Lake.

The fine-grained, moderately fractured K-feldspar porphyry hosts Tertiary, possibly Eocene, molybdenum mineralization. Molybdenite and pyrite occur in fractures, shears and sheared quartz veinlets in argillized rhyolite. This mineralized zone is at least 75 metres wide and strikes 070 degrees with a moderate southerly dip. Assay values range from 0.56 per cent molybdenite over 0.9 metres to 0.023 per cent molybdenum over 12 metres (Assessment Report 8922).

In 1968, Agricola Mines Ltd. carried out geological mapping and soil sampling.

101 Showing – Whiteman Jasper – Gemstones

The Whiteman Jasper showing is located 15 kilometres west- southwest of Vernon, on the south side of Whiteman Creek.

In this area, Devonian to Triassic sedimentary and volcanic rocks of the Harper Ranch Group are unconformably overlain by Upper Triassic to Lower Jurassic Nicola Group sedimentary and volcanic rocks. These units are intruded by Middle Jurassic granitic rocks. Eocene Coryell granitic rocks intrude and are in fault contact with Middle Jurassic intrusions. Eocene Penticton Group volcanic rocks overlie the igneous and sedimentary rocks.

Unconsolidated Quaternary sediments along the creek host placer(?) jasper. The jasper is fine-grained and red

Unit LTrJgd

1 Showing – Lakeview, Silver Bell, Silver Cup, Sue Lyla No. 2 – Zinc, Copper, Lead Molybdenum

The LAKEVIEW showing is located approximately 1.5 kilometres west of Peachland. The showing consists of disseminated sphalerite, chalcopyrite, pyrite, galena, and molybdenite within granodiorite of the Early Jurassic Pennask Batholith. The southern side of the mineralized zone, which measures approximately 100 by 300 metres, is bounded by a feldspar-porphry syenite intrusion. Amphibolite dikes are present along the north side. Propylitic alteration of the granodiorite is pervasive in the mineralized zone.

The property was optioned in 1957 by Canadian Exploration Limited, who carried out a program of stripping (6000 square metres), and 211 metres of diamond drilling in 8 holes. The results were discouraging and the option dropped. In 1965, King Resources Ltd. carried out a program of mapping, prospecting and trenching. Their work included examination of the LYLA NO. 2 showing, now known as the LAKEVIEW. They found a shaft 5 metres deep sunk on a quartz vein which contained fine to medium-grained pyrite and minor galena and sphalerite. Azurite and malachite were noted on nearby joint surfaces. The shaft was reported to have been sunk in the late 1890s by the Camp Hewitt Gold Mining Company. In 1967, a trenching program was funded by Pine Pacific Mines Ltd. and Slave Pacific Mines Ltd. Seventeen trenches were excavated for a total of approximately 490 metres of trenching. In 1979-80, Brenda Mines Ltd. carried out a program of prospecting and soil geochemistry. The program identified a lead-zinc soil anomaly in the vicinity of the LAKEVIEW showing.

Another mineral occurrence, the SILVER CUP, is included with this showing, and is believed to be located several hundred metres to the east. Mineralization consists of minor amounts of magnetite, hematite, pyrite, chalcopyrite and chalcocite in small shears and slickensided low-angle fractures. These are hosted by an epidote- chlorite-biotite-potassium feldspar altered gabbro. Pyroxenite, hornblendite, gneiss and porphyritic dacite are also present. Malachite staining is noted near contacts. No additional information is available on the SILVER CUP occurrence.

6 Past Producer – Peachland Limestone, Camp Hewitt 1, Deep – Limestone

The Peachland Limestone deposit is located within the Peachland District Municipality approximately 750 metres west of Pincushion Bay on Okanagan Lake.

Limestone was quarried at this site for the production of lime sometime in the 1920s and 1930s. The amount of limestone quarried is not recorded. The quarry is approximately 55 metres long by 28 metres wide, and is excavated in a north trending limestone outcrop of the Triassic-Jurassic Nicola Group. The limestone outcrops to the northeast, suggesting that it forms a 200 metre wide band which trends northeast for about 800 metres in greenstone. Thin bedded limestone in the quarry strikes north-northeast and dips moderately to the west. The limestone is very fine to medium-grained and has a colour index of 4, indicating that it is grey to bluish grey in colour (Open File 1992-18, page 137). Graphitic seams and traces of pyrite are present.

8 Showing – Brae 1 - Gold, Silver - ASSESSMENT REPORT available

The BRAE 1 showing is located approximately 1 kilometre southwest of Spring Lake and 5 kilometres northwest of Peachland.

The showing is a quartz vein hosted by granodiorite of the Early Jurassic Pennask Batholith. The vein is brecciated and contains pyrite. A sample of the vein assayed 0.5 gram per tonne gold and 37.3 grams per tonne silver (Assessment Report 16921).

The area was prospected by N.C. Lenard in 1986-87, although old trenches indicate that earlier, unrecorded work has been carried out.

16 Showing – Gayle – Copper, Molybdenum – ASSESSMENT REPORT available

The GAYLE skarn is located approximately 8.5 kilometres from Peachland.

This area, west of Okanagan Lake, saw intensive exploration for copper-molybdenum porphyry deposits in the late 1960s. However, the only recorded work at this location is a 1967 soil geochemical report by J.F. McIntyre, who noted the presence of skarn. The geochemical survey identified a copper anomaly in the vicinity of the showing.

The skarn occurs at the contact between Triassic-Jurassic Nicola Group limestone and marble, and granodiorite of the Early Jurassic Pennask Batholith. The skarn is a medium to coarse-grained garnet-epidote skarn, with garnet predominant. Pyrite and minor amounts of chalcopyrite and molybdenite are found in the skarn member along veins and shears.

18 Showing - BOLIVAR EAST, OKA – Gold – ASSESSMENT REPORT available

The BOLIVAR EAST prospect is located on the east side of Bolivar Creek, approximately 14 kilometres west-northwest of Peachland.

The area is underlain by a pendant of Triassic-Jurassic Nicola Group andesite and lesser interbedded hornfelsed sediments and skarn. Granodiorite and diorite of the Early Jurassic Pennask Batholith intrude the Nicola Group rocks. These intrusive rocks outcrop several hundred metres to the south.

Exploration in this area, for gold bearing quartz veins and shear zones, dates back to the 1890s when the ALMA MATER (082ENW017) and the SILVER KING (082ENW018) were developed. During the 1960s and early 1970s the entire area west of Okanagan Lake was subject to a major exploration effort directed at copper-molybdenum porphyry deposits.

Beginning in 1986 the gold potential of Nicola Group skarns was investigated by Fairfield Minerals Ltd. During the following 2 years Fairfield carried out a major program of soil sampling, prospecting, linecutting, geological mapping, magnetometer surveys, trenching and 6000 metres of reverse circulation drilling. Exploration focused on a number of mineral occurrences within the Nicola Group, including: BOLIVAR WEST (082ENW098), BOLIVAR EAST, BOLIVAR ROAD (082ENW100), BOLIVAR CREEK (082ENW101), IRON HORSE (082ENW025), and CAP (082ENW026).

In 1988, a joint venture between Fairfield Minerals Ltd. and Placer Dome Inc. funded a 6000 metre reverse circulation drill program. In the BOLIVAR EAST area 1 inclined and 5 vertical holes were drilled for a total of 758.81 metres. Holes were spotted to test gold soil anomalies and gold showings in fractured volcanics and skarn exposed in trenches. Gold assays from 3 holes exceeded 0.5 gram per tonne (Assessment Report 18711). The best intersection, 7.07 grams per tonne gold over 1.52 metres in hole 88-32, was associated with a fine to medium-grained siliceous rock (Assessment Report 18711). Elevated gold values were found throughout the section which was taken as evidence of structural control on mineralization. All intersections with gold values of greater than 0.5 gram per tonne had associated pyrite and in hole 88-31, a trace of arsenopyrite.

In 1994, a hole (170 metres) was drilled to test mineralization previously detected in drilling. The hole intersected 16.2 grams per tonne gold over 1.0 metre, within a 2.5-metre section averaging 9.38 grams per tonne gold

(Assessment Report 24026). The values occur in an altered zone of sericitized and silicified sheared mudstone and greywacke; a flake of visible gold and traces of pyrite and arsenopyrite occur.

20 Showing - BOLIVAR WEST, OKA – Gold – ASSESSMENT REPORT available

The BOLIVAR WEST prospect is located on the west side of Bolivar Creek, approximately 15 kilometres west-northwest of Peachland.

The area is underlain by a pendant of Triassic-Jurassic Nicola Group andesite and lesser interbedded hornfelsed sediments and skarn. Granodiorite and diorite of the Early Jurassic Pennask Batholith intrude and underlay the Nicola Group rocks. These intrusive rocks outcrop several hundred metres to the south and west of the prospect.

Exploration in this area, for gold bearing quartz veins and shear zones, dates back to the 1890s when the ALMA MATER (082ENW017) and the SILVER KING (082ENW018) were developed. During the 1960s and early 1970s the entire area west of Okanagan Lake was subject to a major exploration effort directed at copper-molybdenum porphyry deposits.

Beginning in 1986 the gold potential of Nicola Group skarns was investigated by Fairfield Minerals Ltd. During the following 2 years Fairfield carried out a major program of soil sampling, prospecting, linecutting, geological mapping, magnetometer surveys, trenching and 6000 metres of reverse circulation drilling. Exploration focused on a number of mineral occurrences within the Nicola Group, including: BOLIVAR WEST, BOLIVAR EAST (082ENW099), BOLIVAR ROAD (082ENW100), BOLIVAR CREEK (082ENW101), IRON HORSE (082ENW025), and CAP (082ENW026).

In 1987, Fairfield undertook a major trenching program on their OKA claim group. In the BOLIVAR WEST area, gold mineralization was found in a northeast trending quartz vein and arsenopyrite veinlets. A grab sample assayed 22.9 grams per tonne gold (Assessment Report 18711).

In 1988, a joint venture between Fairfield Minerals Ltd. and Placer Dome Inc. funded a 6000 metre reverse circulation drill program. In the BOLIVAR WEST area 6 vertical holes were drilled for a total of 808.25 metres. Holes were spotted to test several gold soil anomalies and to evaluate weak gold mineralization found in strongly fractured, quartz veined volcanic rocks exposed in trenches. Gold assays from 4 holes exceeded 0.5 gram per tonne (Assessment Report 18711). The best intersection, 14.33 grams per tonne gold over 1.52 metres in hole 88-26, was associated with an iron stained, fine-grained siliceous rock (Assessment Report 18711). Elevated gold values were not correlatable along bedding between the drillholes, and they were found in all rock types, including granodiorite, andesite, and a fine-grained siliceous rock. This was thought to suggest structural control on mineralization. The projection of the mineralized quartz vein found in 1987, passes immediately north of hole 88-26 and this vein may have been intersected by the drillhole. No arsenopyrite was noted in the drillholes but minor amounts of pyrite were common.

In 1994, 2 holes (291 metres) were drilled to test mineralization intersected in the previous drilling. One hole encountered pyrite, sphalerite and arsenopyrite, with minor gold, in a quartz-calcite vein.

17 Past Producer – SILVER KING, RAT 1, OKA, GREATA, BIG DADDY - Silver, Gold, Lead, Molybdenum, Copper, Zinc – ASSESSMENT REPORT available

The Silver King mine is located approximately 16 kilometres north-northwest of Peachland. The area is underlain by granodiorite of the Early Jurassic Pennask Batholith. Outcrops of Triassic- Jurassic Nicola Group sedimentary and volcanic rocks occur approximately 500 metres to the northeast.

Work on the property dates back to the late 1890's when underground development work was commenced by the Canadian-American Mining and Development Company. As of 1898 the workings consisted of a 4.5-metre shaft, a 33-metre tunnel and a 6-metre crosscut on the shear zone. Also constructed on this shear was an 8-metre winze with a 12-metre crosscut. Gold in quartz veins, in a shear zone, was reported to be free milling (Minister of Mines Annual report 1898, page 1130). Limited production is recorded during the period 1939 to 1941, when a total of 244 tonnes of ore were mined which yielded 15,116 grams of silver and 1,618 grams of gold (Minister of Mines Annual Report Index No. 3, page 213).

In 1963, molybdenite is reported to have been discovered in old waste dumps in the area by R. S. Taylor and J. E. Nott. The area, including the Alma Mater (082ENW017) and the Silver King occurrences, was subsequently staked as the Rat No. 1-26 and the Big Daddy No. 13 mineral claims for Orville Burkinshaw. Trenching and test-pitting was carried out in the vicinity of the old workings in 1964. The results of this program were not recorded; however, it was observed that mineralization consists of threads and stringers of molybdenite with sparse coarse pyrite and rare chalcopyrite. All of the mineralization was associated with a white, siliceous, fine-grained but unevenly textured rock locally termed "white rock". In thin section, the rock was seen to be comprised chiefly of quartz with much altered plagioclase, carbonate, and phlogopite mica with lesser apatite and cordierite.

In 1965, Dr. M.C. Robinson, in a report for King Resources Ltd. notes that there was little evidence of work since the 1890's and that the lack of stoping in the workings suggest that the shipped tonnages, if any, cannot have been significant. In 1965, the workings consisted of an adit collared in granodiorite and in a zone of northerly trending and southerly dipping shearing. Quartz with pyrite and minor very fine-grained grey sulphides including galena are present along the slips and disseminated in the shear and wallrock. A crosscut driven northeasterly from a point 21 metres from the portal follows a shear containing small veins, lenses, and masses of quartz, quartz-pyrite and solid pyrite. The innermost 27 metres of the tunnel explores a strong zone of shearing 0.3 to 1.2 metres thick. The zone strikes northerly and dips to the east at 50 to 65 degrees. It is composed largely of gouge and crushed rock. The zone is poorly to non-mineralized, except for quartz and minor amounts of pyrite.

In 1967 Anuk River Mines Ltd. carried out geological and geochemical surveying, trenching and 305 metres of diamond drilling in 3 holes. The geochemical survey did not produce anomalies. Mineralization in the drill core was sparse and consisted of black sphalerite with minor amounts of chalcopyrite and pyrite. The hostrock in all three holes was sheared quartz diorite, or granodiorite, with few or no quartz veins but containing epidote, calcite and chlorite seams and veinlets.

In 1978, Brenda Mines Ltd. restaked the area, including both the Alma Mater (082ENW017) and the Silver King showings, as the Greata III to V and Greata IX and X claim blocks. Geological and geochemical surveys done in 1978 were followed up by an I.P. survey and exploration drill program in 1979. Two diamond-drill holes, for a total of 79 metres, were drilled in the vicinity of the Silver King to test the extent of a sericitized diorite. The results were discouraging, only traces of molybdenum were encountered and the sericite alteration zone was found to be only 9 metres thick (Assessment Report 7872).

In 1986, Cordilleran Engineering staked the Oka 1 - 11 claim block, which included the Silver King and Alma Mater showings, for Fairfield Minerals Ltd. Their exploration program in 1986 included prospecting and sampling of the Silver King showing. Grab sample assays returned silver values as high as 68 grams per tonne (Assessment Report 15834). Gold assays were uniformly low. Details of sample mineralogy are lacking, as are base metal assays, but the highest silver values were from samples collected in the vicinity of the shaft. The work for Fairfield Minerals was

mainly focused on gold occurrences to the east, including: Bolivar West (082ENW098), Bolivar East (082ENW099), Bolivar Road (082ENW100), Bolivar Creek (082ENW101), Iron Horse (082ENW025), and Cap (082ENW026).

32 Showing - WP-CATI, BILL, BRUCE – Copper – ASSESSMENT REPORT available

The WP-Cati showing is located 1 kilometre west of the Brenda mine (092HNE047) tailings pond, approximately 19 kilometres northwest of Peachland.

The showing consists of copper (chalcopyrite?) mineralization exposed in outcrops of a porphyritic quartz diorite of the Early Jurassic Pennask Batholith, locally known as the Brenda stock. The mineralization is believed to be hosted by quartz veins. Trachyte dikes and post-mineralization lamprophyre cut across the property.

During the exploration boom of the late 1960s this showing was held by Buttle Lake Mining Ltd. and Trojan Consolidated Mines Ltd. In 1967 they carried out a limited induced polarization survey on an area about 1 kilometre to the north of the WP-CATI showing. Weak anomalies were identified, which were subsequently drilled later that year. The results of the drilling are not on record.

34 Showing – Mac - Molybdenum, Copper

The MAC showing is located approximately 500 metres southwest of the Brenda mine mill site and approximately 21.5 kilometres northwest of Peachland. The area covered by the MAC claims adjoins the Brenda mine property (092HNE047).

This area is underlain by granodiorite and porphyritic quartz diorite of the Early Jurassic Pennask Batholith, which is locally known as the Brenda stock.

Fractured granodiorite contains small amounts of chalcopyrite and pyrite on or near veins and stockworks similar to those on the Brenda mine property (Minister of Mines Annual Report 1966, page 185). Lamprophyre and trachyte porphyry dikes trend easterly and are approximately 1 metre wide.

The MAC claims were held by Anuk River Mines Ltd. during the exploration boom around the Brenda mine in the late 1960s. In 1966, they carried out a major program which included 23 percussion drillholes and 1207 metres of diamond drilling in 15 holes. No assessment reports were filed on this program; however, other sources (Minister of Mines Annual Report 1966, page 185) state that all of the drillholes were collared in granodiorite, and that small amounts of copper and sub-economic molybdenum were encountered. Notations on a surface plan of the property indicate that drill cores assayed as high as 0.152 per cent molybdenum; copper values were less than 0.2 per cent (Property File - Anuk River Mines Ltd.(1966): Surface Plan). The plan does not indicate if these are average or best assays.

37 Past Producer – Brenda, Brenda Mine, Copper King - Copper, Molybdenum, Silver, Gold, Zinc, Lead – ASSESSMENT REPORT available

The Pennask Mountain area is mainly underlain by a roof pendant comprising westerly younging, Upper Triassic sedimentary and volcanoclastic rocks of the Nicola Group. These are intruded and enclosed to the north, east and south by plutonic rocks of the Early Jurassic Pennask batholith and Middle Jurassic Osprey Lake batholith. Both the Nicola rocks and the Pennask batholith are unconformably overlain by Tertiary sediments and volcanics of the Princeton Group.

The Brenda copper-molybdenum deposit is within the "Brenda stock", a composite quartz diorite/granodiorite body which forms part of the Pennask batholith. Several ages and compositions of pre and post-ore dikes cut the stock. The deposit is approximately 390 metres from the contact with Nicola Group rocks to the west.

Nicola Group tuffs, volcanic breccias and flows adjacent to the Brenda stock have been altered to "schistose hornfels". This hornfels, which is as wide as 450 metres, is characterized by the development of bands and aligned lenses of felted brown to black biotite. Schistosity generally strikes roughly parallel to the intrusive contact and dips west at 30 to 70 degrees. The schistose hornfels grades westerly into recognizable west-dipping volcanic rocks which in turn are overlain by greywacke, argillite and shales.

The Brenda stock is a composite, zoned quartz diorite to granodiorite body which can be divided into two units. Unit 1 is of quartz diorite composition and contains abundant mafic minerals (hornblende > biotite) and angular quartz grains, whereas unit 2 is porphyritic granodiorite and contains fewer mafic minerals (biotite > hornblende), well-defined biotite phenocrysts and subhedral quartz grains. The contact between units 1 and 2 is generally gradational, but locally sharp. At sharp contacts, unit 2 is chilled against unit 1.

Dikes of several ages and compositions cut the Brenda stock. At least four types, aplite-pegmatite, andesite, trachyte porphyry and basalt, have been identified in the Brenda orebody. Similar dikes, as well as felsite, dacite and quartz diorite have been mapped beyond the limits of economic mineralization. The aplite-pegmatite dikes are cut by all other dikes and by all mineralized fractures. The andesite dikes have been altered and mineralized during ore formation. Two types of quartz diorite dikes are found and both are cut by quartz-sulphide veins. Dacite porphyry and felsite dikes are also cut by quartz-sulphide veins.

A trachyte porphyry dike up to 4.5 metres wide and 300 metres in strike length is exposed in the Brenda pit. A weakly mineralized vein was observed in the dike which suggested an intermineral age for the dike. Further evidence has clearly shown that the dikes cut all stages of mineralization, except some of the latest quartz veins (Canadian Institute of Mining and Metallurgy Special Volume 15). Several post-mineral hornblende lamprophyre dikes also occur within the Brenda orebody and are probably genetically related to the trachyte porphyry dikes.

Irregular, branching basalt dikes, probably related to Tertiary volcanism, have been intruded along pre-existing fault zones. They cut all phases of mineralization and alteration.

Initial potassium-argon dating of two samples from the Brenda mine area resulted in different ages for hornblende (176 Ma) and biotite (148 Ma). Interpretation of these results suggests that the Brenda stock crystallized about 176 million years ago. Biotite samples from the pit area have been dated at about 146 Ma, which probably represents the age of mineralization (Canadian Institute of Mining and Metallurgy Special Volume 15).

Faults in the Brenda pit are expressed as fracture zones in which the rock is intensely altered to clay minerals, sericite, epidote and chlorite. These fracture zones range in width from a few centimetres to 9 metres. Most strike 070 degrees and dip steeply south. Northwest-striking faults exhibit left-lateral movement. The faults transect all mineralization, except some calcite veins. Sulphides, especially molybdenite, have been smeared along fault planes. Shear zones are wider and more numerous in the north half of the pit, where they control bench limits.

The Brenda orebody is part of a belt of copper-molybdenum mineralization that extends north-northeast from the Nicola Group-Brenda stock contact. Mineralization of economic grade (0.3 per cent copper equivalent) is confined to a somewhat irregular zone approximately 720 metres long and 360 metres wide. Ore-grade mineralization extends

more than 300 metres below the original surface. Lateral boundaries of ore-grade mineralization are gradational and appear to be nearly vertical.

Primary mineralization is confined almost entirely to veins, except in altered dike rocks and in local areas of intense hydrothermal alteration which may contain minor disseminations. The grade of the orebody is a function of fracture (vein) density and of the thickness and mineralogy of the filling material. The average total sulphide content within the orebody is 1 per cent or less. Chalcopyrite and molybdenite, the principal sulphides, generally are accompanied by minor, but variable, quantities of pyrite and magnetite. Bornite, specular hematite, sphalerite and galena are rare constituents of the ore. Johnson (1973), in a study of 17 samples from the deposit, reported minor pyrrhotite, mackinawite, carrollite, cubanite, ilmenite, rutile and native gold(?), as well as several secondary sulphides (Canadian Institute of Mining and Metallurgy Special Volume 15). Pyrite is most abundant in altered andesite dikes and in quartz-molybdenite veins. The ratio of pyrite to chalcopyrite in the orebody is about 1:10, with the chalcopyrite content diminishing beyond the ore boundaries.

Because mineralization is confined almost entirely to veins in relatively fresh homogeneous rock, the veins are divided into separate stages, based on crosscutting relations and their mineralogy and alteration effects on the host rock. The vein density within the orebody is not uniform. Ranges are recorded from less than 9 per metre near the periphery of the orebody to 63 per metre and occasionally 90 per metre near the centre of the orebody. Some veins have very sharp contacts with wallrocks, but most contacts are irregular in detail where gangue and sulphide minerals replace the wallrock. A vein may show features characteristic of fracture-filling in one part and of replacement in another. Mineralized solutions were introduced into fractures and, during development of the resultant veins, minor replacement of the wallrock ensued.

The chronological stages of mineralization are as follows: (1) biotite-chalcopyrite (oldest); (2) quartz-potassium feldspar-sulphide; (3) quartz-molybdenite-pyrite; (4) epidote-sulphide-magnetite; and (5) biotite, calcite and quartz. Stages 1 through 4 are all genetically related to a single mineralizing episode, which was responsible for the orebody. Stage 5 represents a later, probably unrelated, event(s) (Canadian Institute of Mining and Metallurgy Special Volume 15). Stage 2 veins form the bulk of the mineralization in the deposit, and are the most important source of ore.

Hydrothermal alteration at the Brenda deposit generally is confined to narrow envelopes bordering veins. These alteration envelopes commonly grade outward into unaltered or weakly propylitic-altered rock. Where veins are closely spaced, alteration envelopes on adjacent veins may coalesce to produce local areas of pervasive alteration. For the most part, hydrothermal alteration at the Brenda deposit is exceptionally weak for a porphyry copper system.

Four types of alteration are recognized in the Brenda deposit, three of which are related to the mineralizing process. Two of these are potassic (potassium feldspar) and biotite, and the other is propylitic. Later argillic alteration has been superimposed on the system along post-mineral faults.

Potassium feldspar and biotite alteration generally are separated in space, but locally occur together. Both types of alteration accompanied sulphide deposition. Potassium feldspar replaces plagioclase adjacent to most stage 2 and, to a lesser extent, stage 3 veins. These irregular envelopes range in width from a centimetre or less up to a metre, with an average of about 2 centimetres. Potassium feldspar also occurs as a minor constituent of stage 1 veins.

Hydrothermal biotite replaces magmatic mafic minerals (hornblende, biotite) and, more rarely, plagioclase in host rock adjacent to stage 2 and especially stage 3 veins. These envelopes of hydrothermal biotite range in width from less than 1 millimetre to several centimetres.

Weak to intense propylitic alteration, which is characterized by the development of chlorite and epidote, as well as less obvious microscopic sericite and carbonate, is sporadically distributed throughout the Brenda stock. Large areas within the orebody have not been propylitized and in these areas, veins with potassic alteration envelopes clearly cut across propylitized quartz diorite, indicating an early hydrothermal or even a pre-ore origin for the propylitization (Canadian Institute of Mining and Metallurgy Special Volume 15). A second period of propylitization accompanied the development of stage 4 veins and is reflected as envelopes of epidote and chlorite.

Locally intense argillic alteration is confined to post-mineral fault zones where the hostrock has been highly shattered. Kaolinite, sericite and epidote have almost completely replaced the hostrocks.

Surface weathering, which is expressed predominantly by the development of limonite, extends as a highly irregular blanket over the mineralized zone for depths ranging from a few metres to greater than 30 metres. In this weathered area, limonite stains all fractures. Fault zones have been especially susceptible to surface weathering, and the argillic alteration of these zones may be primarily the result of groundwater action. Secondary minerals developed during weathering, all highly subordinate in quantity to limonite, include malachite, azurite, hematite, ferrimolybdate, powellite and cupriforous manganese oxides. Cuprite, covellite, chalcopyrite, native copper, tenorite and ilsemannite are rare constituents.

Copper-molybdenum mineralization in the Brenda deposit was developed during several sequential stages, all of which constitute one mineralizing episode. Each stage occupies unique sets of fractures, which are filled with specific combinations of metallic and gangue minerals. Although the attitudes of veins in each stage are unique in detail, most stages include conjugate steeply dipping sets of northeast and northwest striking veins. If these veins occupy shear fractures, it is probable that they were formed by generally east-west compressive forces. Examination of the structure in the Nicola Group rocks to the west reveals that north-northwest and north trending fold axes also indicate an east-west compression. It is suggested that intermittent east-west compressional forces intensely fractured the rocks of the Brenda stock during several stages of time and tapped a hydrothermal source, either a later phase of the Brenda stock or a separate intrusive system. As each stage of fractures developed, hydrothermal fluids introduced vein material which healed the fractures. Renewed build-up of compressional forces again fractured the rocks, which were again healed. Repetition of this sequence can explain all stages of mineralization within the Brenda deposit. East-west compression continued after ore deposition ceased and produced prominent east-northeast and northwest striking shear zones (Canadian Institute of Mining and Metallurgy Special Volume 15).

The Brenda mine began production in early 1970 with measured geological (proven) reserves of 160,556,700 tonnes grading 0.183 per cent copper and 0.049 per cent molybdenum at a cutoff of 0.3 per cent copper equivalent [eCu = % Cu + (3.45 x % Mo)]. The mine officially closed June 8, 1990.

40 Showing – George Lake, North Brenda - Copper, Molybdenum

The GEORGE LAKE showing is located on the northwest side of George Lake, approximately 23 kilometres northwest of Peachland.

The showing consists of copper (chalcopyrite?) and molybdenum (molybdenite?) mineralization exposed in outcrops of a porphyritic quartz diorite of the Early Jurassic Pennask Batholith, locally known as the Brenda stock. Barren quartz-microcline veins are noted in the area. During the exploration boom around the Brenda mine (092HNE047) in the 1960s this showing was held by the Noranda Exploration Company Limited.

42 Showing – Long Lake East – Copper

The LONG LAKE EAST showing is located on the east side of Long Lake, approximately 23 kilometres northwest of Peachland.

The showing consists of copper (chalcopyrite?) mineralization exposed in outcrops of porphyritic quartz diorite of the Early Jurassic Pennask Batholith, locally known as the Brenda stock. During the exploration boom around the Brenda mine (092HNE047) in the 1960s this showing was held by Noranda Exploration Company Limited.

46 Showing - PAN, TRE, JO, DAN, COLD - Copper, Molybdenum – ASSESSMENT REPORT available

The PAN showing is located in the upper reaches of the Trepanier Creek gorge, approximately 24 kilometres northwest of Peachland.

The property is underlain by porphyritic quartz diorite of the Early Jurassic Pennask Batholith, locally known as the Brenda stock.

Sulphide mineralization on the PAN showing is structurally controlled, and is found as fracture-coatings and vein-fillings in flat joints and northwest trending vertical fractures. The area of mineralization is characterized by a greater abundance of veins and fracture-fillings accompanied by rock alteration. These consist of pyrite-epidote, secondary biotite, chlorite, and quartz veins. The veins are often accompanied by K-feldspar alteration selvages and chlorite-sericite alteration of the host is common. There is no apparent zonation to the hydrothermal alteration, nor is there a pyrite halo. Molybdenite was noted in one location at the main PAN showing. Numerous chalcopyrite-pyrite exposures exist in the Trepanier Creek gorge for approximately 1 kilometre downstream from the main PAN showing. These exposures are included in the PAN occurrence.

The property was explored by Canadian Superior Exploration Ltd. in 1969, who carried out a soil sampling program northeast of the gorge. Noranda Exploration Company Ltd. explored this general area during the 1960s; however, it is not recorded if work was carried out in the Trepanier Creek gorge. In 1974, Canadian Occidental Petroleum Ltd. explored the gorge and adjacent area to the east with a program of geological mapping, rock and soil geochemistry, and a magnetometer survey. They found that soil geochemical anomalies coincided with known mineralization; likewise, stream sediment anomalies were found draining areas of known mineralization, especially on the west side of Trepanier Creek. The magnetometer survey was inconclusive.

47 Showing - TREPANIER GORGE, TRE 1,2 - Copper, Molybdenum – ASSESSMENT REPORT available

The TREPANIER GORGE prospect is located in the upper reaches of the Trepanier Creek gorge, approximately 24 kilometres northwest of Peachland.

The property is underlain by porphyritic quartz diorite of the Early Jurassic Pennask Batholith, locally known as the Brenda stock. Alteration of the quartz diorite is generally confined to fractures and to narrow alteration envelopes around those fractures. Four main alteration assemblages have been noted; quartz-hematite-pyrite, chlorite-epidote-potassium feldspar, biotite-chalcopyrite, and chlorite. The dominant trend of these fractures is northwest, in contrast to the northeast trend at the Brenda mine (092HNE047). Chalcopyrite mineralization is present as very thin fracture fillings. Crosscutting relationships indicate that the chalcopyrite fracture fillings are oldest. Malachite is found in the Trepanier Creek gorge in both horizontal and steeply dipping fractures, and is associated with pyrite and chalcopyrite. Molybdenite has not been noted in the gorge but has been logged in drill core. Molybdenite has been noted in trenches to the north and west, where it is associated with quartz and hematite, but only rarely with chalcopyrite.

The showing was part of the extensive property holdings of Noranda Exploration Company Ltd. Numerous trenches, roads, and drillholes were left in this general area by Noranda; however, the results of their work was not filed for assessment. In 1975-76, Canadian Occidental Petroleum carried out geological mapping, rock and soil geochemical surveys, and completed 2 diamond-drill holes. Hole 75-1 intersected sporadic chalcopyrite and molybdenite mineralization over the entire 123.44 metres, averaging 0.0272 per cent copper and 0.004 per cent molybdenum (Assessment Report 5691). The last 2.1 metres (121.34 - 123.44 metres) intersected a vertical fracture which assayed 0.29 per cent copper and 0.37 per cent molybdenum (Assessment Report 5691). Hole 75-2, located 800 metres to the north, was not as highly mineralized as hole 75-1; it contained more pyrite instead.

The NORTH BRENDA-CENTRAL showing (082ENW003) is located 1 kilometre to the northwest.

Unit PrPzog

68 Showing - COPPER KING, KIK, PETE – Copper – ASSESSMENT REPORT available

The Copper King showing is located 21 kilometres southeast of Vernon, below the flood level of Swalwell Lake.

In this area, metamorphic rocks of the Shuswap Terrane are intruded by Middle Jurassic granitic rocks. Volcanic and sedimentary rocks of both Eocene and Miocene ages cap the older rocks.

Feldspar amphibolite gneiss hosts copper mineralization. Pyrite, traces of copper mineralization and specks of native copper occur in foliated seams and in fractures.

The first record of this occurrence is in 1929. In 1967, Kokanee Moly Mines Ltd. conducted soil geochemistry. In 1973-75, Westley Mines Ltd. carried out magnetic, electromagnetic and induced polarization surveys. In 1975, Granges Exploration conducted a program of soil geochemistry and drilling. In 1977, Union Carbide completed a program of exploration on the D.M., Leal and Sue claims. Westley Mines Ltd. completed an electromagnetic survey in 1981.

72 Showing – Reef - Agate, Gemstones – ASSESSMENT REPORT available

The Reef showing is located 23 kilometres south-southwest of Vernon between Wood Lake and Clark Creek.

In this area, east of the Okanagan Valley fault zone, sedimentary and volcanic rocks of the Devonian to Triassic Harper Ranch Group are in probable fault contact with metamorphic rocks. Middle Jurassic granitic plutons intrude Shuswap Terrane metamorphic rocks. Eocene Penticton Group and Miocene Chilcotin Group volcanic and sedimentary rocks cap areas of older rock.

In the Penticton Group, an agate-rhyolite bed contains abundant yellow-orange chalcedonic carnelian(?) agate within pyroclastic flow rocks, possibly representing a sinter. The bed is about 5 metres thick and extends over an area of at least 600 by 300 metres. The bed, part of the informally named Trepanier Rhyolite, unconformably overlies monzonite and granodiorite, and underlies Penticton Group felsic tuffs and Miocene fluvial sediments and basalt flows.

In 1977-79, Union Oil Company explored the Miocene sediments for uranium. Geological mapping, hydrogeochemical, radiometric, airborne magnetometer and drill programs were conducted.

74 Showing – Stewart, Winfield – Gold – ASSESSMENT REPORT available

The Stuart showing is located 23 kilometres south-southwest of Vernon, between Wood Lake and Clark Creek.

In this area, east of the Okanagan Valley fault zone, sedimentary and volcanic rocks of the Devonian to Triassic Harper Ranch Group are in probable fault contact with metamorphic rocks. Middle Jurassic granitic plutons of the informally named Terrace Creek batholith intrude the older rocks. Eocene Penticton Group and Miocene volcanic and sedimentary rocks cap areas of older rock.

The basal, partly cemented, well rounded, quartz pebble gravels of Miocene fluvial deposits host placer gold mineralization. The fluvial deposits unconformably overlie Middle Jurassic monzonite and granodiorite and/or volcanic rocks of the Penticton Group. The Miocene sediments are commonly overlain by Miocene basalt flows. The gold is pure (850 fine), of a reddish colour, and is found as flattened pellets up to 2 millimetres in size, with some very fine gold reported. Garnet and a little magnetite occur with the gold.

By 1936, an exploration drift of 30 metres had been completed. Between 1933 and 1945, a total of 2330 grams of placer gold production (refer to 082LSW093) was reported from the Winfield camp (includes 082LSW019, 093 and 142). In 1977-79, Union Oil Company explored the Miocene sediments for uranium. Geological mapping, hydrogeochemical, radiometric, airborne magnetometer and drill programs were conducted.

77 Showing - AITKENS/STABLES, WINFIELD – Gold – ASSESSMENT REPORT available

The Aitkens/Stable showing is located 21 kilometres south- southwest of Vernon, between Ribbleworth and Clark creeks.

In this area, east of the Okanagan Valley fault zone, sedimentary and volcanic rocks of the Devonian to Triassic Harper Ranch Group are in probable fault contact with metamorphic rocks of the Shuswap Terrane. Middle Jurassic granitic plutons intrude the older rocks. Eocene Penticton Group and Miocene Chilcotin Group volcanic and sedimentary rocks cap areas of older rock.

Basal, partly cemented, well-rounded, quartz pebble gravels of Miocene fluvial deposits host placer gold mineralization. The fluvial deposits unconformably overlie gneissic rocks containing amphibolite and/or volcanic rocks of the Penticton Group. The fluvial deposits extend over a 5000 by 1500 by 60 metre area and includes the Ribbleworth (082LSW019), Stuart (082LSW072) and Winfield (082LSW093) showings. The Miocene sediments are commonly overlain by Miocene plateau basalt flows. The gold is pure (850 fine), of a reddish colour, and is found as flattened pellets up to 2 millimetres in size, with some very fine gold reported. Garnet and a little magnetite occur with the gold.

By 1936, an exploration drift had been completed. A total of 2330 grams of placer gold production, between 1933 and 1945, has been reported from the Winfield camp. In 1977-79, Union Oil Company explored the Miocene sediments for uranium. Geological mapping, hydrogeochemical, radiometric, airborne magnetometer and drill programs were conducted.

78 Showing - RIBBLEWORTH, WINFIELD – Gold – ASSESSMENT REPORT available

The Ribbleworth showing is located 20 kilometres south-southwest of Vernon, between Ribbleworth and Clark Creeks.

In this area, east of the Okanagan Valley fault zone, sedimentary and volcanic rocks of the Devonian to Triassic Harper Ranch Group are in probable fault contact with metamorphic rocks. Middle Jurassic granitic plutons intrude the older rocks. Eocene Penticton Group and Miocene volcanic and sedimentary rocks cap areas of older rock.

The basal, partly cemented, well rounded, quartz pebble gravels of Miocene fluvial deposits host placer gold mineralization. The fluvial deposits unconformably overlie gneissic rocks containing amphibolite, and/or volcanic rocks of the Penticton Group. The Miocene sediments are commonly overlain by Miocene plateau basalt flows. The gold is pure (850 fine), of a reddish colour, and is found as flattened pellets up to 2 millimetres in size, with some very fine gold reported. Garnet and a little magnetite occur with the gold. The fluvial deposits, including 082LSW072, 93 and 142, are estimated to cover a 5000 by 1550 by 60 metre area.

Old exploration shafts have been located. In 1977-79, Union Oil Company explored the Miocene sediments for uranium. Geological mapping, hydrogeochemical, radiometric, airborne magnetometer and drill programs were conducted.

Unit MiPiCvb

None MINFILE Points.

Unit EPev

63 Showing - ZUMAR, ZUMAR 2, ZUMAR GOLD, ZUMAR 2-4 - Gold, Silver, Copper, Zinc, Lead – ASSESSMENT REPORT available

The Zumar prospect is located 16 kilometres northwest of Kelowna, west of Terrace Creek.

In this area, Devonian to Triassic Harper Ranch Group sedimentary and volcanic rocks have been intruded by Middle Jurassic granitic rocks. Outliers of Eocene Penticton Group volcanic and sedimentary rocks overlie the older units.

A quartz vein in metamorphosed Harper Ranch Group basaltic to andesitic flows hosts gold, silver, lead, zinc and copper mineralization. Pyrite, some of which is coarse-grained, and minor chalcopyrite are irregularly disseminated in the vein. The 0.3 to 0.4 metre-thick, massive, occasionally vuggy, brecciated or shattered vein has a known strike length of 230 metres and a down dip extension of at least 65 metres. The vein is cut by an Eocene(?) dike. The wallrocks are strongly fractured, with heavy hematite coating of fractures, and exhibit pervasive sericitic alteration. In 1980, two lots of hand-cobbed vein material (totalling 55.1 tonnes) were shipped as a bulk sample, returning an averaging gold grade of 4.7 grams per tonne, 42 grams per tonne silver, 0.09 per cent copper, 0.10 per cent lead and 0.10 per cent zinc (Assessment Report 21600).

In 1979-82, Zumar Resources Ltd. carried out trenching, bulk sampling and drilling. In 1986-87, Skyworld Resources and Development Ltd. conducted magnetometer, soil geochemistry, geological mapping, trenching and drilling programs.

69 Showing - OYAMA 2 – Uranium – ASSESSMENT REPORT available

The Oyama 2 showing is located on the west side of Okanagan Lake about 8 kilometres west of Okanagan Centre.

The area is underlain by Eocene volcanic and sedimentary rocks of the Penticton Group and Middle Jurassic granitic rocks. These comprise andesite, sandstone, conglomerate, argillite and quartz monzonite and granodiorite.

The Eocene sediments are slightly enriched with uranium mineralization. One 0.5-metre chip sample from an outcrop assayed 0.017 per cent U308 (Assessment Report 6727). A percussion drill- hole, entirely in volcanic rocks, recovered no radioactive rock chips.

Mapping, sampling and one drillhole were completed in 1978 by Du Pont of Canada Exploration Ltd.

71 Showing - ESPERON 17 - Molybdenum, Zinc – ASSESSMENT REPORT available

The Esperon 17 showing is located 23 kilometres north-northwest of Kelowna, south of Esperon Creek.

In this area, Middle Jurassic quartz monzonite of the informally named Terrace Creek batholith intrudes argillaceous and calcareous sediments of the Devonian to Triassic Harper Ranch Group. The stock is cut by plugs and dikes of diorite which are intruded by quartz monzonite and aplite dikes. The intrusive rocks are cut by Tertiary basalt dikes related to volcanic rocks which overlie the older rocks.

Chloritized and sericitized quartz monzonite hosts molybdenum and zinc mineralization. Quartz veinlets carry disseminated molybdenite and pyrite.

About 1000 metres to the west, quartz veinlets carrying pyrite and trace sphalerite occur in a porphyritic quartz monzonite.

In 1979-80, Cominco Ltd. carried out geological mapping, induced polarization and magnetometer surveys.

88 Showing – Shorts Creek – Coal

The Shorts Creek showing is located 28 kilometres west-southwest of Vernon, on the steep north slopes of Shorts Creek.

In this area, Middle Jurassic granite intrudes Devonian to Triassic sedimentary and volcanic rocks of the Harper Ranch Group. A major graben-like Eocene basin of Penticton Group volcanic and sedimentary rocks extends north-south across Shorts Creek.

A 30 to 60-metre thick basal conglomeratic unit of the Penticton Group hosts an impure bituminous coal seam. The coal-bearing beds, striking 100 degrees and dipping 20 degrees north, are about 30 metres above the base of the sediments. The coal occurs as narrow beds intercalated with thin layers of shale and can be traced for about 1 kilometre on surface, averaging about 1.5 metres thick.

The first reference to this occurrence is from 1905. By 1932, a 24-metre shaft and a 12-metre tunnel had been completed.

90 Showing – Shorts Creek Agate - Agate, Gemstones

The Shorts Creek Agate showing is located 25 kilometres west- southwest of Vernon, north of Shorts Creek.

In this area, Devonian to Triassic sedimentary and volcanic rocks of the Harper Ranch Group are intruded by Middle Jurassic granitic rocks. Extensive Eocene Penticton Group volcanic and sedimentary rocks overlie the older units.

Penticton Group volcanic rocks host agates. Amygdules of agate were found along a logging road leading to the plateau north of Shorts Creek.

104 Developed Prospect - BRETT, BRETT MAIN, BRETT 1, BRETT 1-4, DISCOVERY, R.W., TR 1, MAIN SHEAR, WHITEMAN CREEK, BONANZA – Gold, Silver – ASSESSMENT REPORT available

In 1939, a Vernon prospector discovered auriferous quartz veins in the Granite Batholith on what is now the Brett 2 claim, about one kilometer east of what is now termed the high-grade section of the main shear zone.

In 1983, Charles Brett encountered significant concentrations of angular gold when panning the subsidiary tributaries of Whiteman Creek and subsequently staked Brett claim group, transferring the group to Huntington Resources Inc. the same year. In 1985, road construction into the area uncovered a steeply dipping shear zone approximately two meters wide referred to as the Main Shear Zone. A significant quartz vein, the RW Vein, was also exposed during road construction. In 1986, sixteen (16) NQ diamond drill holes totaling 795 meters were completed. In 1987, a joint venture between Huntington Resources Inc. and Lancana Mining Corporation, completed thirty-two NQ diamond drill holes totaling 2,900 meters. Detailed geochemical sampling east of Brett Creek yielded anomalous gold values in the "New Discovery Zone", a zone similar to the Main Shear zone. In 1988, an exploration program of over \$700,000 was conducted on the property. Work consisted of diamond and reverse circulation drilling. The drilling program continued into 1989.

In late 1991 the Beaton/Vicore Mining Contracting Group was offered the mining rights to the property and Vicore commissioned Egil Livgard, P. Eng. to evaluate the high grade section of the property. However, the Beaton/Vicore group could not raise financing for the project. In 1993 an agreement was signed between Huntington and Liquid Gold Resources Ltd. and 24 trenches were excavated to bedrock and sampled along the Main Shear Zone. In November 1993, Liquid Gold drilled nineteen reverse circulation drill holes into the RW Vein and Bonanza zones. Later during the winter of 1993-1994, new road was established to a portal site and buildings were installed to support underground development.

Underground development began in late November 1994 and continued until February 10, 1995. During this period approximately 1400 tonnes of mineralized development muck was stockpiled. However, Huntington terminated the agreement with Liquid Gold, and shortly thereafter Vicore Mining Developments Ltd. placed a lien against the property due to unpaid bills. In 1995 and 1996, Huntington Resources Inc excavated pits, over a 115 meter length of the RW Vein, and a 55 meter length of the Main Shear Zone. This produced approximately 291 tonnes of ore averaging 28 grams per tonne gold and 64 grams per tonne silver. This was shipped to the Cominco smelter at Trail for processing. The lien which Vicore Mine Development Ltd. placed against the property went to court in mid 1998 and in December 1998 Vicore was awarded a 100 per cent interest in the Brett property.

In 2004, the Brett property was acquired and explored by Mosquito Consolidated Gold Mines Ltd and Running Fox Resources Corp. The 2004 work included soil surveys, trenching, geological mapping, prospecting, re-sampling of old core, and drilled 2,776 metres in 17 drillholes. This work resulted in discovery of several new soil anomalies and mineralized zones.

The Brett epithermal gold silver prospect is located 28 kilometres west of Vernon, on the steep north slope of Whiteman Creek Valley. The prospect comprises the Main Shear zone which hosts the Discovery vein (part of the Bonanza zone), the R.W. vein and the TR-1 and TR-21 zones.

In this area, Devonian to Triassic sedimentary and volcanic rocks of the Harper Ranch Group are intruded by Middle Jurassic granitic rocks of the informally named Terrace Creek batholith. Eocene Penticton Group or Kamloops Group volcanic rocks overlie the igneous and sedimentary rocks. Eocene Coryell rhyodacite porphyry to syenite plugs and dikes intrude these rocks.

A shear zone within the Penticton Group volcanic rocks hosts gold and silver mineralization. The 1500 metre long shear strikes 155 degrees, dips 80 degrees west for at least 250 metres depth and is 2 to 15 metres wide. Mineralization occurs with quartz and chalcedony in veins, vein stockworks and brecciated veins, in fracture controlled zones near or within the shear zone, and in altered, more porous trachyandesite tuffs and flows adjoining

the shear. The veins have crustiform, banded and vuggy textures. Minor mineralization is present in a Coryell feldspar porphyry dike which fills much of the shear zone, however, most mineralization appears to pre-date the dike. Mineralization is largely structurally controlled but is, in part, lithologically controlled. Pyrite, gold, electrum and minor argentite occur.

Gold mineralization varies from very fine-grained in volcanic rocks to coarse flakes in quartz veining. Most of the gold seems to be concentrated within a 200-metre strike length, in the Bonanza zone and the R.W. vein; furthermore the best gold values appear to occur between the 1230-metre and 1240-metre elevations. Intense clay alteration is prominent in portions of the shear zone. The tuffs have suffered chlorite-epidote-calcite-hematite alteration changing to clay(illite)-sericite-silica alteration adjacent to the shear zone.

In 1988, a percussion-drill hole intersected a high grade zone which assayed 100 grams per tonne gold over 44 metres (Property File - Huntington Resources Inc., Statement of Material Facts, July 21, 1989). Average grades and true thickness are in the range of 4 grams per tonne gold over 2 metres, however no grade and tonnage figures are available. The R.W. vein is located 15 metres west of the Main Shear Zone and may be the northwest continuation/offset or an offshoot of the main vein which hosts the Bonanza Zone.

The Discovery vein and the Gossan zone (082LSW132) were discovered in 1984; the Main Shear zone and the R.W. vein were discovered in 1986. The New Discovery zone (082LSW131) was discovered in 1987 and the East zone (082LSW084) in 1988.

In 1984-89, Huntington Resources Ltd. carried out geological mapping, soil geochemistry, trenching and drilling. Similar exploration was continued by Corona Corporation during 1987-89. In 1990, Huntington carried out some drilling. Exploration was resumed in 1993.

Estimated reserves of the Bonanza zone (along a 150-metre section) are 11,970 tonnes grading 39.12 grams per tonne gold (Stockwatch, July 11, 1996).

During 1994-1995, Liquid Gold Resources Inc., under an option agreement with Huntington, completed a 240-metre long adit from the 1205-metre level under the Bonanza zone. An estimated 1090 tonnes of mineralized rock, averaging 5.76 grams per tonne gold were extracted and stockpiled outside the portal.

Huntington Resources Ltd. concentrated its 1995 work on mining in the high grade R.W. gold vein. Closely spaced sampling of the vein yielded an average grade of 34.35 grams per tonne gold over a strike length of 51.3 metres and across a true width of 0.44 metre. Drilling in previous programs has tested the vein over a vertical range of at least 25 metres. Mining began in August 1995 and continues on schedule; ore is being stockpiled. The 240-metre adit on the 1205-metre level has been rehabilitated and a 15-metre raise was driven in the Bonanza zone. Also in 1995, with support from the Explore B.C. Program, Huntington Resources successfully bypassed an underground caved area securing access to the Bonanza zone and collected a 250 tonne surface bulk sample of the R.W. vein which averaged 34.2 grams per tonne gold, confirming previous surface sampling of this vein (Explore B.C. Program 95/96 - M27).

On July 9, 1996, Huntington trucked approximately 225 tonnes of ore from the R.W. vein to Cominco's smelter at Trail for processing and sale. The anticipated grade is 34.18 grams per tonne gold and 63.43 grams per tonne silver. A second shipment of 275 tonnes, with an expected grade of 42.86 grams per tonne gold, will be shipped later in July.

Along with other work on the Brett property by Mosquito Consolidated Gold Mines in 2004, a new area called the Bonanza East zone, located about 50 metres east of the Main Shear, was examined. A drillhole intersected 1.31 metres grading 162 grams per tonne gold, plus two lower grade sections hosted by tuff.

106 Showing - GOLD STAR, SUNDAY, BORDER, CENTRAL – Gold, Silver – ASSESSMENT REPORT available

The Gold Star showing is located 29 kilometres west of Vernon, on the steep north slope of Whiteman Creek Valley.

The area is underlain by Devonian to Triassic sedimentary and volcanic rocks of the Harper Ranch Group which have been intruded by Middle Jurassic granitic rocks. Eocene Penticton Group and Kamloops Group volcanic rocks overlie the igneous and sedimentary rocks. Eocene Coryell rhyodacite porphyry to syenite plugs and dikes intrude these rocks.

Penticton Group pyritic tuffaceous rocks host gold mineralization. Samples from drilling analysed 2.15 grams per tonne gold and 16 grams per tonne silver over 3.0 metres (Assessment Report 19797).

In 1984-87, Brican Resources Ltd. carried out geological mapping, soil geochemistry, VLF-EM surveys, trenching and drilling.

Unit CPH

51 Showing – Spod – Gold – ASSESSMENT REPORT available

The SPOD showing is located on the east side of Blue Grouse Mountain, approximately 8.5 kilometres north-northwest of Kelowna.

The property covers a sequence of andesitic volcanic rocks of the Eocene Penticton Group, Marron Formation. These are cut by a northwest trending felsic dike. The dike varies in width from 1 to 10 metres and has been traced along strike for approximately 1500 metres. The host andesite has been silicified in a contact zone up to 3 metres wide along the dike. Both the dike and andesite are cut by 2 stages of quartz veining. The veins are up to 1 centimetre in thickness, vuggy, and contain fine-grained disseminated pyrite. Weak propylitic alteration is common in the andesite. The Marron Formation volcanics are underlain by a pendant of Devonian-Triassic Harper Ranch Group metasediments.

Early, unrecorded work on the showing is evidenced by a small shaft found on the property by J. Stushnoff in 1987. His prospecting efforts that year identified anomalous gold geochemistry associated with the felsic dike. The property was optioned by QPX Minerals Inc. in 1988, and during the winter of 1988-89 Mine Quest Exploration Associates Ltd. on behalf of QPX carried out a program of soil sampling, geological mapping, and a VLF-EM geophysical survey. The surface work identified several anomalies which were then tested by a 5-hole 272.8-metre reverse circulation drill program. Hole depth varied from 32.0 to 89.9 metres with a sample interval of 3.05 metres. The best drill intersection, from 4.6 metres to 7.6 metres in hole 88-1, assayed 0.785 grams per tonne gold (Assessment Report 18499). It was collared to test below a channel sample which had assayed 1.87 grams per tonne gold over 1 metre (Assessment Report 18499).

Another gold vein occurrence, the BLUE HAWK (082ENW002), is located approximately 2 kilometres to the north.

52 Showing - JUBILATION, NOGAN – Gold, Silver – ASSESSMENT REPORT available

The JUBILATION showing is located 1 kilometre northwest of Lambly Lake, approximately 16 kilometres northwest of Peachland.

The showing, comprising several quartz veins, occurs in metasediments of the Devonian-Triassic Harper Ranch Group. Quartz diorite of the Jurassic Okanagan Intrusions outcrops 1 kilometre to the south.

The JUBILATION showing was found in 1980 during a prospecting program funded by Cominco Ltd. It consists of hornfelsed limy argillite which is bleached, altered and cut by quartz veinlets. A sample which contained 5 per cent quartz and 1 per cent pyrite, assayed 1.04 grams per tonne gold and 9.6 grams per tonne silver (Assessment Report 9186).

Subsequent prospecting and geological mapping by M. Morrison in 1986-1987 identified a hornblende diorite intrusive to the northeast of the showing and re-interpreted the showing as being part of a large shear zone. Contact metamorphic effects appear to increase toward the southeast and fade toward the northwest. A soil sample collected in this area by Morrison contained 0.840 gram per tonne gold (Assessment Report 16504). This attracted the attention of Chevron Canada Ltd. who optioned the property in 1987 and carried out an unsuccessful trenching program. They dropped the option and did not file an assessment report on their work. In 1989, M. Morrison carried out a magnetometer survey over the area. The results did not prove useful in delineating mineralized fault zones

53 Showing – Syrup – Copper – ASSESSMENT REPORT available

The SYRUP showing is located 4 kilometres west-northwest of Lambly Lake and approximately 15.5 kilometres northwest of Peachland.

The showing consists of several small quartz veins and stringers in a hornfelsed zone in Devonian-Triassic Harper Ranch metasediments. Outcrops of quartz diorite of the Jurassic Okanagan Intrusions are found 1 kilometre to the south. The showing was found by Rea Gold Corporation in 1989.

Mineralization consists of rusty, vuggy quartz veins and stringers in an area of pyritic hornfelsed metasediments. A sample of a 3-centimetre wide quartz vein containing 15 per cent pyrite assayed 0.0535 per cent copper (Assessment Report 19570). Minor silica-clay alteration was noted on fractures near the sample site. Pyrrhotite is common along bedding planes in the adjacent black shales.

57 Showing – Shear – Silver, Lead – ASSESSMENT REPORT available

The SHEAR showing is located on Bald Range Creek, approximately 6 kilometres west of Wilson Landing.

The showing is a quartz stockwork, containing pyrite and minor amounts of galena, which strikes 023 degrees and dips 46 degrees north. It is hosted by andesite, which may be part of the Triassic- Jurassic Nicola Group. The area is underlain by arc clastics of the Devonian-Triassic Harper Ranch Group.

The property was found in 1985 by N.C. Lenard. A grab sample of the rusty weathering quartz stockwork from the east edge of the zone assayed 18.5 grams silver per tonne (Assessment Report 14784).

58 Showing - JACK, FLAP - Silver, Copper, Antimony, Arsenic – ASSESSMENT REPORT available

The JACK showing is located between West Lake and Islahtl Lake, approximately 21 kilometres northwest of Westbank.

The showing is a quartz-carbonate vein hosted in greenstone and andesite which may be part of the Triassic-Jurassic Nicola Group. The general area is underlain by arc clastic rocks of the Devonian- Triassic Harper Ranch Group.

The showing was discovered in 1989 by Rea Gold Corporation who funded a prospecting program for precious metals in this area. The quartz-carbonate vein is mineralized with pyrite and minor amounts of tetrahedrite. Assay results from samples of this mineralization include: 123.2 grams of silver per tonne, 0.0253 per cent antimony, and 0.0345 per cent arsenic (Assessment Report 19579). An adjacent sample assayed 0.0454 per cent copper (Assessment Report 19579).

A different Jack showing (082LSW118) occurs to the north on the southwest flank of Eileen Mtn. This showing is also a quartz vein and a sample assayed 2.79 grams per tonne gold (Assessment Report 19579).

Appendix D Geological Stratigraphic Units

Stratigraphic Unit	Cumulative Area (m²)	Rock Type	Polygon ID #	Unit Summary	Original Description from SOURCE	Additional Information from MINFILE Database	Aggregate Potential (based on rock type)
PrPzShm	826,634,349	metamorphic rocks, undivided	8,46,70	PrPzShm - Proterozoic to Paleozoic Shuswap Assemblage undivided metamorphic rocks	Undivided quartzofeldspathic gneiss, biotite-quartz schist (commonly with sillimanite, kyanite, garnet or staurolite), amphibolite, quartzite, marble, calc-silicate rock and skarn; abundant and locally dominant pegmatite, muscovite granite, granodiorite	Sushwap Assemblage is primarily described as being composed of schists and gneiss. Generally orthogneiss.	Moderate
EPeMK	460,489,370	undivided volcanic rocks	27,29,32,33,35,37,42,45,48,50,54	EPeMK - Cenozoic - Penticton Group - Marron, Kettle River, Springbrook, Marama and Skaha Formations undivided volcanic rocks	Alkalic and calcalkaline volcanics	Mount Dilworth is formed of flow-banded dacite lavas of the Eocene Penticton Group, Marama Formation. To the north are trachyte to trachyandesite lavas and pyroclastic rocks of the Penticton Group, Marron Formation. The Mission Creek gold occurrence is hosted in a conglomerate that is underlain by epiclastic and pyroclastic rocks of the Eocene Penticton Group, White Lake Formation.	Moderate
MJgd	409,001,959	granodioritic intrusive rocks	74,75,80,101,109,110	MJgd - Mesozoic - Unnamed granodioritic intrusive rocks	Granodiorite, quartz diorite, diorite, quartz monzonite	In the area of the Esperon 3 showing, Middle Jurassic quartz monzonite of the informally named Terrace Creek batholith intrudes argillaceous sediments of the Upper Triassic to Lower Jurassic Nicola Group. The stock is cut by diorite plugs and dikes which are cut by quartz monzonite and aplite dikes. The intrusive rocks are cut by Tertiary basalt dikes related to overlying Eocene Penticton Group volcanic rocks.	High
LTrJgd	258,391,577	granodioritic intrusive rocks	81	LTrJgd - Mesozoic - Unnamed granodioritic intrusive rocks	Granodiorite, quartz diorite, quartz monzonite; lesser monzonite, diorite and gabbro		High
PrPzog	240,470,545	orthogneiss metamorphic rocks	111	PrPzog - Proterozoic to Paleozoic - Unnamed orthogneiss metamorphic rocks	Granodioritic orthogneiss, mylonitic gneiss, paragneiss, amphibolite; minor quartzite, marble, garnet-biotite-quartz schist; may in part be equivalent to the Grand Forks gneiss		Moderate
MiPiCvb	183,274,782	basaltic volcanic rocks	5,7,9,10,12,13,14,16,18,20,21,34,36,39,49,65,67,68,73,78,86,93,95,98	MiPiCvb - Cenozoic - Chilcotin Group basaltic volcanic rocks	Non-marine 'Plateau Basalts'		Moderate
EPev	171,711,979	undivided volcanic rocks	60,79,83,85,88,89,90,91,94,96,99,104,112	EPev - Cenozoic - Penticton Group undivided volcanic rocks	(also coded as 156008050) ??Mixed alkalic and calcalkaline transtensional volcanics and associated fluvial and lacustrine sediments -- Hornblende-biotite-quartz-feldspar porphyry -- Biotite-hornblende-plagioclase porphyry; biotite-quartz-plagio		Moderate
CPH	149,831,110	volcaniclastic rocks	23,31,43,55,57,58,59	CPH - Paleozoic - Harper Ranch Group volcaniclastic rocks	Arc clastics, basement to Quesnellia		Moderate
EPeK	91,726,224	mudstone, siltstone, shale fine clastic sedimentary rocks	22,25,26	EPeK - Cenozoic - Penticton Group - Kettle River and Springbrook Formations mudstone, siltstone, shale fine clastic sedimentary rocks	Siltstones		Low

Appendix D Geological Stratigraphic Units

Stratigraphic Unit	Cumulative Area (m²)	Rock Type	Polygon ID #	Unit Summary	Original Description from SOURCE	Additional Information from MINFILE Database	Aggregate Potential (based on rock type)
MJOgd	75,306,979	granodioritic intrusive rocks	3,38,51	MJOgd - Mesozoic - Okanagan Batholith granodioritic intrusive rocks	Granodiorite		High
DTrHsf	66,812,207	mudstone, siltstone, shale fine clastic sedimentary rocks	62,66,69,84,97,102,103,108	DTrHsf - Paleozoic to Mesozoic - Harper Ranch and(?) Nicola Groups mudstone, siltstone, shale fine clastic sedimentary rocks	Argillite, phyllite, volcanic sandstone, semischist, meta-augite porphyry and chlorite schist; local carbonate		Low
MJgr	54,149,155	granite, alkali feldspar granite intrusive rocks	1,4,40,61,63	MJgr - Mesozoic - Unnamed granite, alkali feldspar granite intrusive rocks	Porphyritic granite, granodiorite, monzonite		High
KOL	39,725,115	intrusive rocks, undivided	2,11,17	KOL - Mesozoic - Okanagan Batholith - Ladybird and Valhalla intrusions intrusive rocks, undivided	Granite and granodiorite; includes Ladybird (Tertiary) and Valhalla intrusions		High
TrJN	37,361,151	calc-alkaline volcanic rocks	6,15,28	TrJN - Mesozoic - Nicola Group calc-alkaline volcanic rocks	Basic and intermediate lavas, volcanoclastics, interbedded sediments		Moderate
Egr	25,551,495	granite, alkali feldspar granite intrusive rocks	100,105	Egr - Cenozoic - Unnamed granite, alkali feldspar granite intrusive rocks	Granite, monzonite		High
ECsy	15,634,519	syenitic to monzonitic intrusive rocks	0,19,24,106,107	ECsy - Cenozoic - Coryell Plutonic Suite syenitic to monzonitic intrusive rocks	Syenite, monzonite, granite		High
PCgs	11,251,704	greenstone, greenschist metamorphic rocks	71,72,76,77,82	PCgs - Paleozoic - Chapperon Group greenstone, greenschist metamorphic rocks	Metamorphosed siliceous and calcareous argillites; greenschists of volcanic and sedimentary origin; minor serpentized ultramafic rocks		Moderate
uTrNE	9,506,130	basaltic volcanic rocks	114	uTrNE - Mesozoic - Nicola Group - Eastern Volcanic Facies basaltic volcanic rocks	Mafic breccia and tuff with augite and hornblende-phyric clasts; local intercalated argillite		Moderate
QLc	5,274,261	basaltic volcanic rocks	30,41,44,47,52,53,56	QLc - Cenozoic - Lambly Creek Basalt basaltic volcanic rocks	"Valley basalt" olivine tholeiite		Moderate
EKav	2,699,764	undivided volcanic rocks	87	EKav - Cenozoic - Kamloops Group undivided volcanic rocks	Basalt, andesite, dacite, trachyte, rhyolite; related tuffs and breccias; minor amounts of mudstone, shale, sandstone and conglomerate; includes Dewdrop Flats Formation		Moderate
uTrNsf	2,092,156	mudstone, siltstone, shale fine clastic sedimentary rocks	115	uTrNsf - Mesozoic - Nicola Group mudstone, siltstone, shale fine clastic sedimentary rocks	Sedimentary facies: shale, argillite, siltstone, sandstone, phyllite, tuff; local polymict conglomerate, limestone, greenstone and chloritic phyllite		Low
EPes	360,447	undivided sedimentary rocks	92	EPes - Cenozoic - Penticton Group undivided sedimentary rocks	Includes Marron, Kettle River and Springbrook formations		Low

*All information is sourced from BC Ministry WebMaps data. Aggregate Potential is based on EBA's interpretation of the lithologies based on literature reviews.

APPENDIX E

GREENHOUSE GAS CALCULATOR

Appendix E: Greenhouse Gas Calculator

Aggregate	Mass	Route	Processing Emissions	Transportation Emissions	Total Emissions	Emission Factor
	(t)	(km)	(CO ₂ e kg/ t)	(CO ₂ e kg)	(CO ₂ e kg)	CO ₂ e kg / t-km
Natural Sand and Gravel	500	100	956.40	1977.83	2,934.23	0.06
Quarried Rock	500	100	4,064.86	1977.83	6,042.69	0.12
Recycled Asphalt	500	100	2,709.30	1977.83	4,687.13	0.09
Recycled Concrete	500	100	1,442.70	1977.83	3,420.53	0.07

Aggregate	Mass of Aggregate (t)	Emission factors (CO ₂ e kg/t)	Emissions (CO ₂ e kg)
Natural Sand and Gravel ⁽¹⁾	500	1.9128	956.40
Quarried Rock ⁽²⁾	500	8.1297	4,064.86
Recycled Asphalt ⁽¹⁾	500	5.4186	2,709.30
Recycled Concrete ⁽³⁾	500	2.8854	1,442.70

User Input
Reference
Calculation

Reference:

1: Emission factor for natural sand and gravel extraction and processing taken from: Athena Institute. 2008. A Life Cycle Perspective on Concrete and Asphalt Roadways: Embodied Primary Energy and Global Warming Potential.

2: Emission factor for quarried rock taken from: Christopher Holt Lewis O'Toole and Philip Sullivan. 2010. Quantifying Greenhouse Gas Emission Reductions When Utilizing Road Recycling Maintenance Processes.

3: Emission factor for Recycled Concrete taken from US EPA.
<http://www.epa.gov/climatechange/waste/downloads/Concrete.pdf>

Method:

1) Emission factor for natural sand and gravel

Electricity and diesel are considered as energy sources for extraction and processing. The electricity use for processing coarse and fine aggregate is different. The average electricity consumed for coarse and fine aggregate processing is used. Environment Canada emission factors for electricity and diesel were used (<http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=AC2B7641-1>). The energy consumed for aggregate extraction and processing from natural sands and gravels is summarized

Step	Energy Source	GJ/tonne
Extraction	Diesel	0.027
Processing	Electricity	0.0216

Unit conversion

Energy	Energy content (MJ/unit of fuel)	CO ₂	CH ₄	N ₂ O	Unit of EF
Electricity (kwh)	3.60	24	0.0060	0.0006	g/kwh
Diesel (L)	42.63	2663	0.1330	0.4000	g/L

Fuel Combustion	Emission factors (kg/GJ fuel)			
Fuel	CO ₂	CH ₄	N ₂ O	CO ₂ e
Electricity	6.67	0.00	0.00	6.75
Diesel	62.47	0.00	0.01	65.44

2) Emission factors for quarried rock

Aggregate is produced by crushing rocks at appropriate rock sources. The following processes are considered by producing aggregate from quarried rock.

- Rock blasting
- Transportation of rock to crusher
- Crushing, screening and stockpiling

The emission factor for quarried rock was taken from the study - Quantifying Greenhouse Gas Emission Reductions When Utilizing Road Recycling Maintenance Processes by Christopher Holt Lewis O'Toole and Philip Sullivan in 2010.

Quarried Rock	CO ₂	CH ₄	N ₂ O	CO ₂ e
	kg/tonne			
Extraction and Processing	7.96	0.01	0	8.13

3) Emission factor for recycled asphalt

The processes for recycling asphalt include Recycled Asphalt Pavement (RAP) recovering and RAP crushing. The Canada average emissions for RAP processing in Athena (2006) were taken.

RAP	CO ₂	CH ₄	N ₂ O	CO ₂ e
	kg/tonne			
Recovering and crushing	5.4	0	0	5.42

4) Emission factor for recycled concrete

Recycling of concrete involves crushing, sizing and blending to provide suitable aggregates for various purposes. Concrete may also contain metals (such as rebar) and waste materials that need to be removed. The energy consumed by the recycling process is taken from U.S. Environmental Protection Agency (US EPA). Diesel is assumed to be the only energy source in the

Material	per tonne of aggregate (GJ)
Recycled aggregate	0.00441

	INPUTS	Emission factor (CO2 e kg /L)	Emission factor CO2 e kg /km	Total emissions CO2 e kg
Natural Sand and Gravel				
Total route (km)	100			
Mass(t)	500			
Mass per load (t) ⁽¹⁾	24			
Vehicle fuel consumption (L/km) ⁽²⁾	0.353			
Vehicle Fuel	Diesel (Heavy-duty)	2.69	0.95	
Total emissions CO2e kg				1977.83
Quarried Rock				
Total route (km)	100			
Mass(t)	500			
Mass per load (t) ⁽¹⁾	24			
Vehicle fuel consumption (L/km) ⁽²⁾	0.353			
Vehicle Fuel	Diesel (Heavy-duty)	2.69	0.95	
Total emissions CO2e kg				1977.83
Recycled Asphalt				
Total route (km)	100			
Mass(t)	500			
Mass per load (t) ⁽¹⁾	24			
Vehicle fuel consumption (L/km) ⁽²⁾	0.353			
Vehicle Fuel	Diesel (Heavy-duty)	2.69	0.95	
Total emissions CO2e kg				1977.83
Recycled Concrete				
Total route (km)	100			
Mass(t)	500			
Mass per load (t) ⁽¹⁾	24			
Vehicle fuel consumption (L/km) ⁽²⁾	0.353			
Vehicle Fuel	Diesel (Heavy-duty)	2.69	0.95	
Total emissions CO2e kg				1977.83

User Input
Reference
Calculation

Assumptions

- 1 Only include km's to mixing location
- 2 Vehicle has the same fuel consumption for different fuels

Reference

- 1 VOLVO articulated haulers A25E as a reference model. Load capacity 24 tonnes.
- 2 Natural Resources Canada, 2008 Canadian Vehicle Survey Update Report, <http://oee.nrcan.gc.ca/publications/statistics/cvs08/chapter1.cfm>
Heavy trucks, diesel use. Unclear on whether data is for empty or full loads or average.

Greenhouse gas

Three greenhouse gas (GHG) emissions are considered in this study, including CO₂, CH₄ and N₂O. CH₄ and N₂O emissions are converted to CO₂ equivalent (CO₂ e) using the Global Warming Potential (GWP) by the following equation.

GHG	GWP
CO ₂	1
CH ₄	21
N ₂ O	310

$$\text{CO}_2 \text{ e (tonnes)} = (\text{CO}_2 \text{ tonnes} \times 1) + (\text{CH}_4 \text{ tonnes} \times 21) + (\text{N}_2\text{O tonnes} \times 310)$$

Data requirements

the required input data is highlighted in blue cell



The data need to input

- 1) Amount of aggregate needed. one or more combination masses of aggregate can entered Tab "processing level"
- 2) Distance of aggregate transportation to mixing area
- 3) Vehicle capacity
- 4) Vehicle fuel consumption

From the drop-down list, choose truck fuel

- 5) Vehicle Fuel

Output - GHG emissions summary

Tab "GHG emissions summary" provides the emissions by different types of aggregate, emissions are presented by CO₂ e/t-km

Road Transportation	Emission factors (kg/L)			
Mobile Combustion	CO2	CH4	N2O	CO2e
Gasoline (Heavy-duty)	2.29	0.00	0.00	2.33
Diesel (Heavy-duty)	2.66	0.00	0.00	2.69
Natural Gas Vehicles	0.00	0.00	0.00	0.00
Biodiesel	2.45	0.00	0.00	2.49
Ethanol	1.49	0.00	0.00	1.52

Global Warming Potential	
CO2	1
CH4	21
N2O	310

Reference:

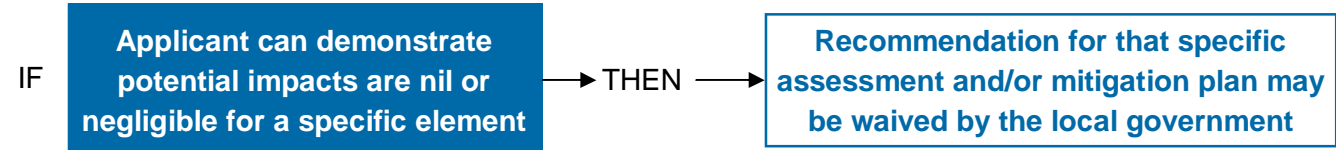
Emission factor taken from Environment Canada. <http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=AC2B7641-1>

APPENDIX F

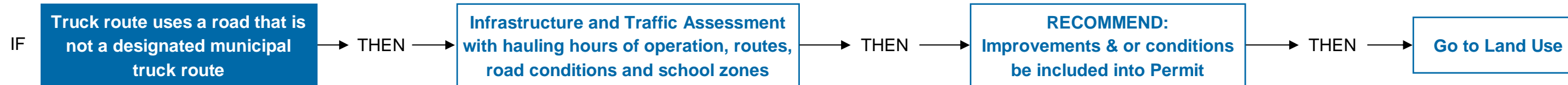
SITE SUITABILITY ASSESSMENT

The SAA is a system for assessing aggregate permit applications and mitigation for potential impacts. Should the local government deem that the mitigation measures for one or more project elements are not adequately mitigated, the local government may recommend non-support of the application.

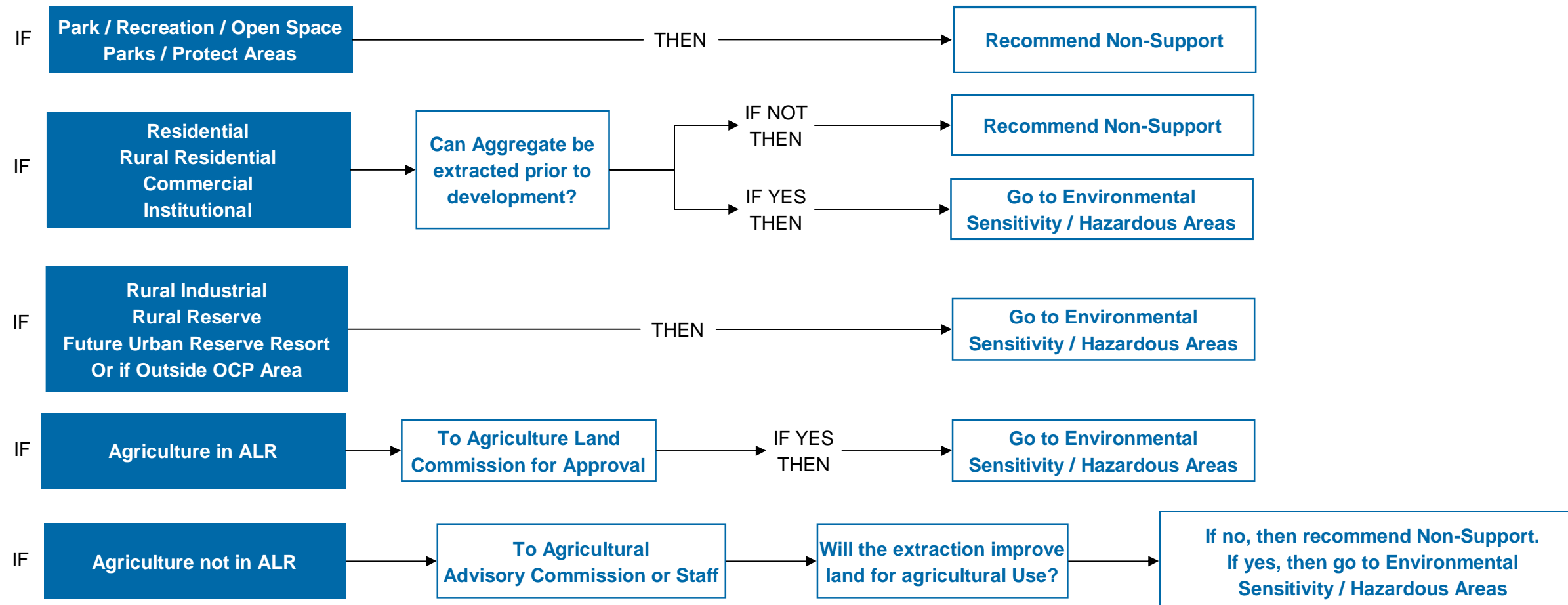
Assessment Process



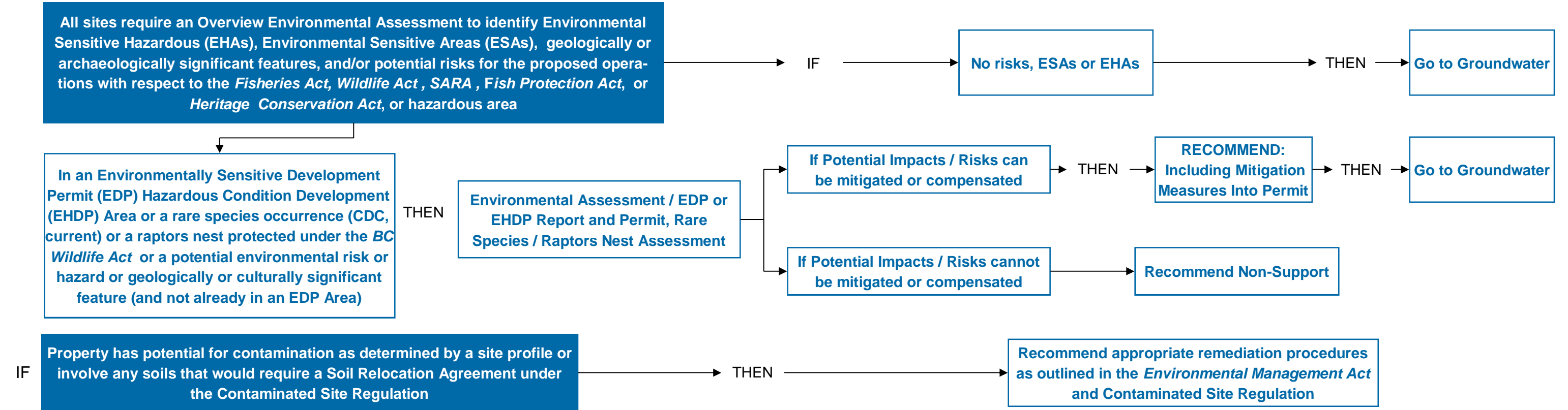
Road and Traffic



Land Use



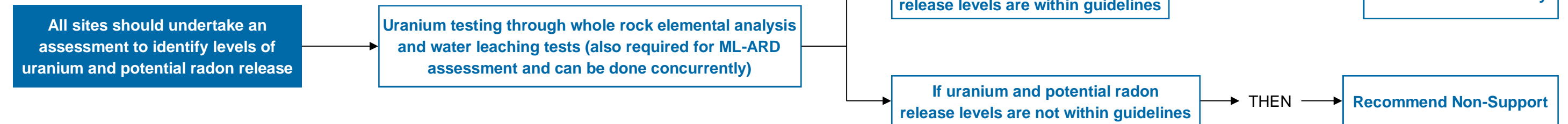
Environmental Sensitivity / Hazardous Areas



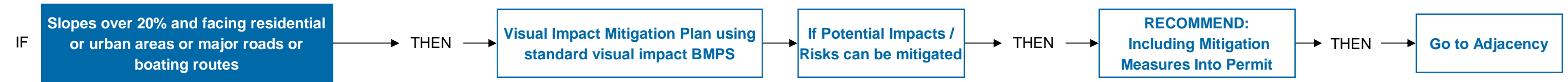
Groundwater



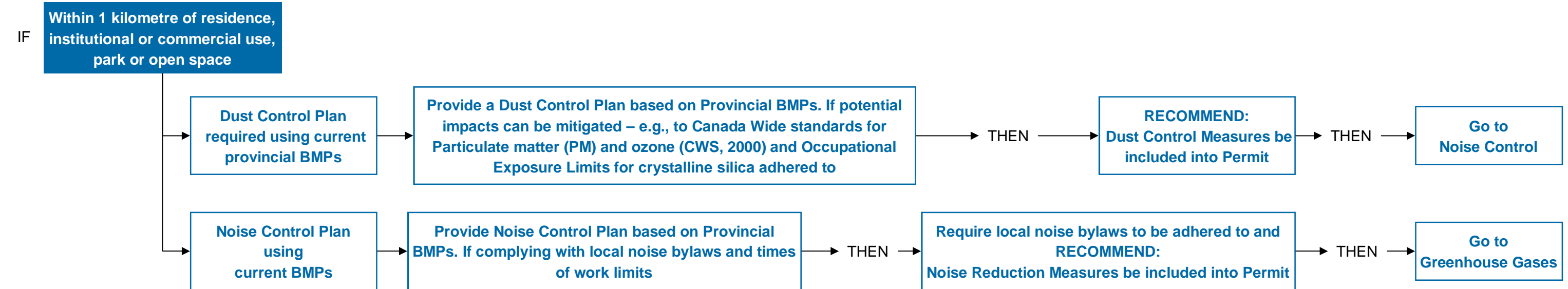
Health



Visual Sensitivity



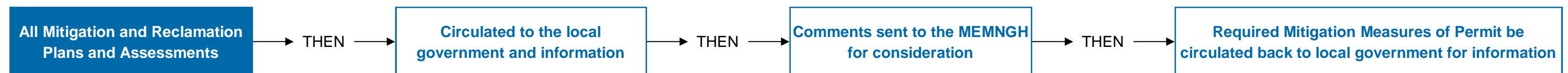
Adjacency



Greenhouse Gases



Mitigation and Reclamation Plans —Circulation



APPENDIX G

REVIEW OF EXISTING GUIDELINES AND REGULATIONS SURROUNDING THE RADIOACTIVE CONTENT OF CONSTRUCTION AGGREGATE (HEALTH CANADA, 2012)

Review of Existing Guidelines and Regulations Surrounding the Radioactive Content of Construction Aggregate: Production and Use

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Scope

This document is intended to provide a brief overview of various approaches to the regulation of NORM, as related to aggregate, seen in Canada and internationally. This document does not represent a final and comprehensive review of all relevant guidelines and regulations. However, this document may be used as a starting point from which a more detailed review could be completed.

Introduction

Aggregate can generally be defined as several hard, inert materials, such as sand, gravel, slag or crushed stone.¹ Aggregate is produced and used for a number of purposes, including for use in concrete and concrete products, in road and railroad bases, for snow and ice control, filtration and as construction fill.² All rock products, such as aggregate, contain some amount of Naturally Occurring Radioactive Material, or NORM. Most commonly this radioactive material is uranium and the products of the uranium decay series. The amount of uranium present in rocks is generally small, between 1 and 3 parts per million (ppm).³ However, some rock types may have higher than average uranium contents, including: light-coloured volcanic rocks, granites, dark shales, phosphate containing sedimentary rocks and metamorphic rocks derived from these various rock types.³ Radon gas (²²²Rn) is also formed during the decay of uranium, therefore the aggregate itself may generate and release some amount of ²²²Rn.³

Aggregate may be regulated based on the gamma radiation emitted from the various daughter products in the uranium decay series, or it may be regulated based on its ²²²Rn exhalation rate. It may also be regulated at the *point of production* (mining), or at the *point of use*, for instance in building materials. This review will look at the guidelines and regulations relevant to the production and use of aggregate in several countries, as well as the recommendations of a few multi-national scientific bodies.

Canada

Point of production

In Canada, the regulation of the mining industry is the responsibility of the provincial authorities.⁴ A brief overview of the relevant provincial regulations does not indicate that there are any restrictions on the radioactive content of rocks mined for aggregate.^{5,6,7,8,9,10,11}

Point of use

The radioactive content of aggregate falls within the scope of Health Canada's *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)*, although building materials and

aggregate are not mentioned specifically within the guideline.¹² In order to ensure that the doses to members of the public remain below the regulated dose limit of 1 mSv a⁻¹ (milliseivert per year)¹³, Health Canada's guideline recommends the use of a dose constraint for NORM of 0.3 mSv a⁻¹.¹² It should be noted that the NORM guidelines also provide Derived Working Limits (DWL) which may be applicable at the point of production.

In regards to the amount of ²²²Rn produced by the aggregate, Health Canada has also set the *Canadian Radon Guideline* for dwellings at 200 Bq m⁻³.¹⁴ This guideline applies to the total ²²²Rn concentration from all sources within a residential home.

United States

Point of use

In their research to develop a ²²²Rn-control construction standard, the US Environmental Protection Agency (EPA), along with the Florida Radon Research Program (FRRP), examined ²²²Rn generation from aggregates used in concrete floors.¹⁵ They found that the aggregate had a lower emanation rate than the cement component, and that concretes with a ²²⁶Ra concentration of less than 2 pCi g⁻¹ (approximately 74 Bq kg⁻¹) contributed to less than 10% of the ²²²Rn entry into the home.¹⁵

The EPA does not have any regulations limiting the radioactive content of building materials. To limit ²²²Rn exposure, the EPA recommends testing a home for ²²²Rn after completion of building, rather than testing the building materials individually.¹⁶ All new homes should be built with a ²²²Rn mitigation system installed, which could be activated if needed.^{16, 17}

Australia

Point of production

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has published the *Code of Practice & Safety Guide: Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*. In this guide, they outline a limit of 1 Bq g⁻¹ (Becquerel per gram) for NORM. Below this level, handling of the rocks would be considered inherently safe for workers.¹⁸ This guideline level is based on the exclusion criteria for NORM provided by the International Atomic Energy Agency (IAEA).¹⁹ Levels above this limit may also be determined to be safe; however, they would need to be assessed on an individual basis.¹⁸

Point of use

There are currently no regulations in place to limit the amount of radioactivity in building materials in Australia, although this has been flagged as an issue requiring future discussions.²⁰

United Kingdom

Point of production

The UK Health Protection Agency (HPA) has conducted a study on the radioactive content of aggregate not made with natural stone, but made with slag from steel production.²¹ Doses to workers varied

depending on the type of work conducted. Workers responsible for the production of the aggregate received an annual dose of 0.018 mSv, road workers handling with the aggregate received an annual dose of 0.063 mSv and workers producing building materials with the aggregate received an annual dose of 0.019 mSv. They considered the dose to members of the public living in homes with building material made from the slag aggregate, and calculated a dose of 0.081 mSv a^{-1} , including the dose from ^{222}Rn .²¹

In the United Kingdom, regulation of workers exposure to NORM falls within *The Ionising Radiation Regulations*. The limit on effective dose for any employee of 18 years of age or over is 20 mSv in any calendar year.²²

Point of use

The HPA has adopted the following provisions by the European Commission for radioactive content of building materials (which will be discussed in further detail in a following section)²³:

- The amount of radium in building materials should be restricted to at least a level where it is unlikely that it could be a major cause for the indoor ^{222}Rn concentration exceeding 200 Bq m^{-3}
- Gamma doses from building materials should be limited to less than 1 mSv y^{-1}
- Controls on building materials should be based on a dose criterion in the range of $0.3\text{-}1.0 \text{ mSv y}^{-1}$

Beyond these general controls, the HPA has not placed any specific limits on the radioactive content in building materials, including aggregate.²³

Ukraine

Point of use

Regulations on the gamma radioactivity of building materials can be found in the radiation safety standard, *Norms of Radiation Safety*, produced by the International Nuclear Safety Center (INSC) in Ukraine.²⁴ Unfortunately, this document is only available in Ukrainian; however, a brief translation of the relevant information has been provided.²⁵ The effective activity of natural radionuclides in building materials can be determined with the following formula²⁵:

$$A_{ef} = A_{Ra} + 1.31(A_{Th}) + 0.085(A_K) \quad (1)$$

Where A_{ef} is the effective activity, A_{Ra} , A_{Th} and A_K are the activity concentrations of ^{226}Ra , ^{232}Th , and ^{40}K , respectively, and 1.31 and 0.085 are weighting factors for ^{232}Th and ^{40}K with respect to ^{226}Ra . Depending on the A_{ef} , there are four possible classes defining how the building material may be used²⁵:

- Class I: Less than or equal to 370 Bq kg^{-1} , no restriction on use for building materials
- Class II: More than 370 Bq kg^{-1} , but less than or equal to 740 Bq kg^{-1} , can be used for industrial development and road construction
- Class III: More than 740 Bq kg^{-1} , but less than or equal to 1350 Bq kg^{-1} , can be used for road construction, construction of dams, construction of other objects near which individuals do not spend more than 50% of the working day
- Class IV: More than 1350 Bq kg^{-1} , cannot be used for building materials

Based on the translated section of the Norms of Radiation Safety, it does not appear that there are any restrictions on building materials related to the ^{222}Rn exhalation rate.

Finland

Point of use

The Finland Radiation and Nuclear Authority (STUK) states that the gamma activity concentration of stone aggregates should be measured for any aggregate intended for use in building construction if it is acquired from an area in which background radiation is known to be above average.²⁶ However, STUK has asserted that the activity concentrations of all stone aggregates used in building construction will be measured throughout Finland, regardless of the background concentration.²⁶ In order to assess whether the activity concentration of the stone aggregate is acceptable for use in building materials, the following formula is applied²⁶:

$$I_1 = \frac{C_{Th}}{200} + \frac{C_{Ra}}{300} + \frac{C_K}{3000} \quad (2)$$

Where, C_{Th} , C_{Ra} and C_K are the activity concentration values of ^{232}Th , ^{226}Ra and ^{40}K in the aggregate, expressed in Bq kg^{-1} . If the activity index, I_1 , is less than or equal to 1, the material can be used as building material without restriction.²⁶

Finland does not appear to have restrictions on radiation in building materials related to ^{222}Rn exhalation; however, they do have a ^{222}Rn guideline of 400 Bq m^{-3} in existing dwellings, and 200 Bq m^{-3} for new construction.²⁷

European Commission

Point of production

The European Commission recommends a guideline level of effective dose or workers of 100 mSv in a five year period, with a maximum effective dose of 50 mSv in any single year. This guideline includes doses from naturally occurring radionuclides. However, it is up to the member states to identify the specific type of work that must be restricted.²⁸

Point of use

Equation (2) from the Finnish guidance also appears in the European Commission's guidance on gamma radiation in building materials.²⁹ However, the maximum acceptable value of the activity index, I_1 , depends on the dose criterion selected (either 0.3 mSv a^{-1} or 1 mSv a^{-1}) and on the amount of the material to be used.²⁹

Table 1: Acceptable activity index (I_1) values²⁹

Dose Criterion	0.3 mSv a^{-1}	1 mSv a^{-1}
Materials used in bulk amounts, e.g. concrete	$I_1 \leq 0.5$	$I_1 \leq 1$
Superficial and other materials		

with restricted use, e.g. tiles,
boards, etc.

$$I_1 \leq 2$$

$$I_1 \leq 6$$

The European Commission cautions that Equation (2) should only be used as a screening tool, and any actual decision on restricting the use of a material should be based on a detailed dose assessment, considering the typical use of the material in question.

The European Commission also recommends a design level for ^{222}Rn exposure in future constructions of 200 Bq m^{-3} . They state that the restriction on the concentration of ^{226}Ra based on gamma exposure (Equation (2)) should limit the ^{222}Rn exhalation rates to levels that are unlikely to cause indoor ^{222}Rn concentrations to exceed the 200 Bq m^{-3} guideline.²⁹

Organisation for Economic Co-operation and Development

Point of use

Equation (2) for restricting the gamma radiation from building materials is again found in a report by the Organisation for Economic Co-operation and Development.³⁰

In addition to their recommendations on restriction of gamma dose from building materials, the OECD also considered incremental dose to ^{222}Rn and its daughter products.³⁰ Specifically, they considered the dose from ^{222}Rn and its daughter products that would be received due to the ^{226}Ra activity concentration in the material located under a concrete foundation (aggregate). The OECD considered three different ^{226}Ra activity concentrations, as follows³⁰:

Table 2: Activity concentrations of ^{226}Ra considered by the OECD.³⁰

Level	^{226}Ra Activity Concentration (Bq kg^{-1})
Representative Level	50
1 st Enhanced Level	100
2 nd Enhanced Level	200

For each ^{226}Ra level, the OECD calculated an exposure in WLM (Working Level Months) for the case of a completely permeable concrete foundation, a completely intact concrete foundation, and a median value between the extremes of permeable and intact.³⁰

Table 3: ^{222}Rn exposure in WLM calculated by the OECD.³⁰

Level	Permeable Foundation	Intact Foundation	Median Foundation
Representative Level	0.20	0.09	0.15
1 st Enhanced Level	0.39	0.16	0.3
2 nd Enhanced Level	0.78	0.33	0.6

The OECD did not recommend a specific activity concentration of ^{226}Ra to limit the ^{222}Rn concentration from building materials. They also noted that their calculations involved several assumptions, which could have a large impact on the results. These assumptions include the ^{222}Rn emanation rates for concrete and soil, and the ventilation rates of the home.³⁰

Conclusions

Most national authorities and multi-national scientific bodies offer some form of a guideline for worker doses, generally similar to the International Commission on Radiological Protection (ICRP) recommendations of 100 mSv over a five-year period, with a maximum of 50 mSv in any one year.³¹ However, with the exception of Australia, they do not offer a specific guideline level for the radioactive content in rocks that are mined for the production of aggregate. The Australian Government recommends the use of the IAEA's exemption criteria for NORM of 1 Bq g⁻¹, above which an assessment of worker safety would need to be completed.^{18,19}

Most national authorities and multi-national scientific bodies also offer some form of a guideline for doses to members of the public, either a dose limit of 1 mSv a⁻¹, a dose constraint of 0.3 mSv a⁻¹, and a ²²²Rn guideline of approximately 200 Bq m⁻³. Some national authorities do place restrictions on the radioactive content of building materials, most commonly to limit the gamma exposure. It is less common to find restrictions on the ²²²Rn exhalation rate of building materials, although the European Commission indicates that restricting the gamma exposure will also effectively limit the ²²²Rn exhalation rate.²⁹

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APPENDIX H

EBA'S GENERAL CONDITIONS – GEO-ENVIRONMENTAL REPORT AND GEOTECHNICAL REPORT

GENERAL CONDITIONS

GEO-ENVIRONMENTAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's Client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by EBA in its reasonably exercised discretion.

4.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's Client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's Client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

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Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

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