Comparative Lifecycle Emissions Analysis

Capital City Paving

April 2026

Introduction

Company Overview

Capital City Paving Ltd. is a locally owned paving company serving Greater Victoria and South Vancouver Island, specializing in asphalt production, paving services, and pavement rehabilitation across a range of infrastructure, commercial, and residential projects. Through investments in innovative processing systems the company is actively working to reduce emissions and waste to support more sustainable construction practices.

Purpose of the Study

The purpose of this comparative lifecycle emissions analysis is to quantify and compare the greenhouse gas (GHG) emissions associated with the production of natural aggregate and repurposed aggregate used in Capital City Paving operations. The analysis evaluates two equivalent scenarios that deliver the same functional output for various construction and road-building applications and quantifies the difference in lifecycle emissions between the two material pathways.

Aggregate production is a key input in road construction and infrastructure development, and the sourcing and processing of aggregate materials can contribute significantly to lifecycle emissions. As municipalities and infrastructure developers increasingly prioritize low-carbon construction practices, understanding the emissions implications of material choices is becoming increasingly important.

This study compares the lifecycle emissions associated with:

- **Repurposed Aggregate (RA)**, a product produced from construction and demolition materials through a washing and processing system, and
- **Quarried Aggregate (QA)**, a product representing the equivalent pathway of conventional material supply pathway of quarried aggregate.

By evaluating these two scenarios on a consistent functional basis, the analysis identifies the relative emissions impacts of each pathway and highlights potential emissions reductions associated with the use of repurposed materials.

Intended Use

The results of this analysis are intended to support Capital City Paving in understanding the GHG implications of aggregate sourcing decisions. The findings may also inform discussions with municipal clients and other stakeholders interested in reducing the carbon footprint of infrastructure projects.

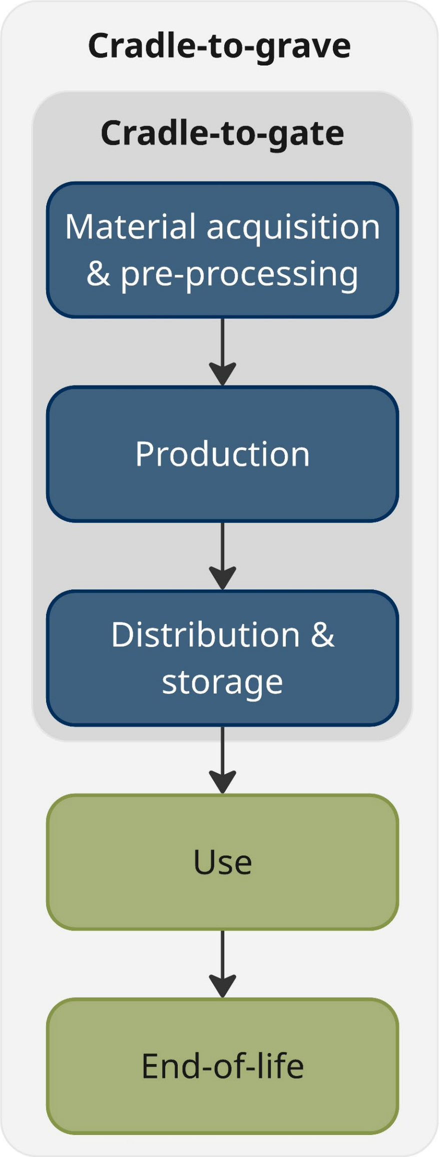
What is a Comparative Lifecycle Emissions Analysis?

A lifecycle emissions analysis (LCA) investigates the greenhouse gas (GHG) emissions impact that one product has throughout its lifecycle. A product's lifecycle is typically assessed with one of two boundaries: cradle-to-grave, which looks at all the emissions impacts from the product's "cradle" (i.e., the start of its "life", such as when the raw materials used to make the product are extracted from the earth) to its "grave" (i.e., when the product is thrown away, repurposed, or otherwise disposed of). The second boundary option is cradle-to-gate. This boundary ends the product's lifecycle when the product is sold to an end user and is typically used with intermediary products where the end use is not known.

A comparative LCA looks at two products that deliver the same function but have variance in their lifecycle. It is used to help a business understand the impacts of its decisions in product manufacturing and, in some cases, may allow a business to report a reduction in emissions intensity of a given product based on process changes.

Product LCAs are typically broken down into the following components:

- **Material acquisition & pre-processing:** Starts when raw materials are extracted from nature and ends when these materials enter the production facility.
- **Production:** Starts when raw materials enter the production facility and ends when the production of the product is completed.
- **Distribution & storage:** Starts when the product leaves the production facility and ends when the consumer takes possession of the product.
- **Use:** Starts when the consumer takes possession of the product and ends when the product is disposed of.
- **End-of-life:** Starts when the consumer disposes of the product and ends when the product is landfilled, returned to nature, or repurposed for use in another product.



Methodology Summary

This study compares the GHG emissions from two ways of producing aggregate used in construction: using natural quarried rock and using repurposed material from construction waste. The analysis is based on the repurposed process, and then an equivalent version of the quarried aggregate process was built to make sure a like-for-like comparison is made.

Key emission sources include:

- **Transportation:** Diesel fuel used to transport waste soil to the facility and respective byproducts to the fill site
- **Drilling & Blasting (*QA*):** Diesel fuel and explosives used to extract rock from the quarry
- **Crushing & Sorting (*QA*):** Diesel and electricity used in machinery to crush and size aggregate
- **Hydrovac Processing:** Emissions from electricity generation used to run machinery
- **Aggwash Processing (*RA*):** Emissions from electricity generation used to run machinery
- **Material Handling & Stockpiling:** Diesel-powered equipment used to move and store materials

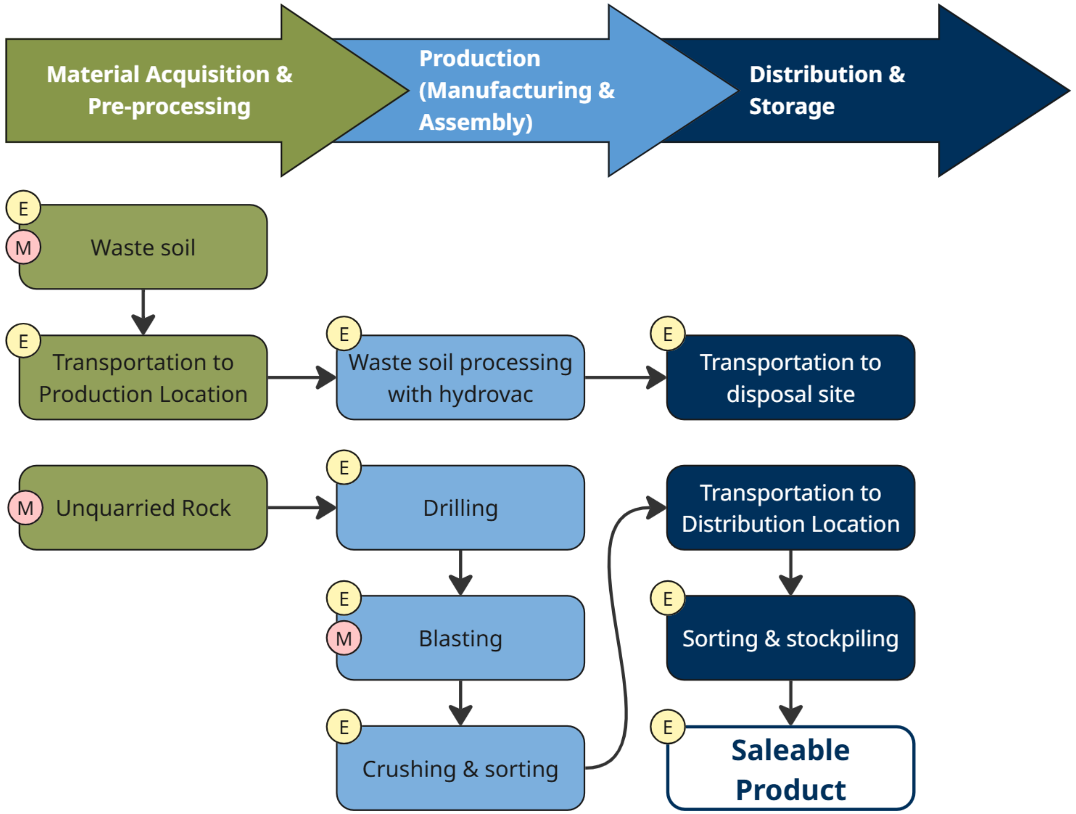
To calculate emissions, total annual activity (total material processed over the course of a year) was used and then converted to a per tonne basis, allowing for a consistent comparison between scenarios.

This is a cradle-to-gate assessment, meaning it includes emissions from when materials are first handled through to when the final product is ready for sale. It does not include how the material is used or what happens at the end of its life, as these stages are expected to be similar across both scenarios. Aggregate can be used in a wide range of applications, and including these stages would not provide further insight into the differences between the two products, as they serve the same function.

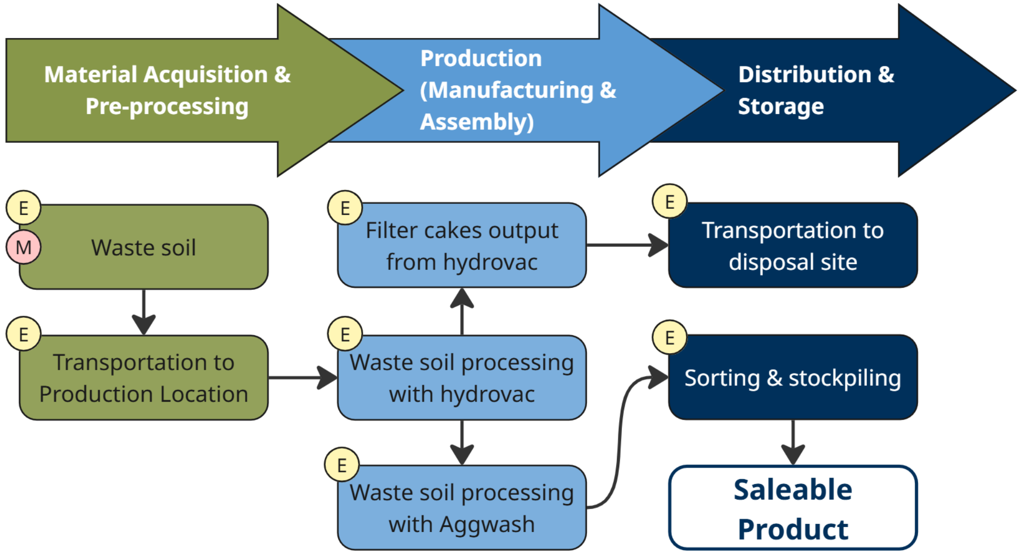
Further details on assumptions, data sources, and calculations are provided in the Appendix.

Process Maps

Quarried Aggregate



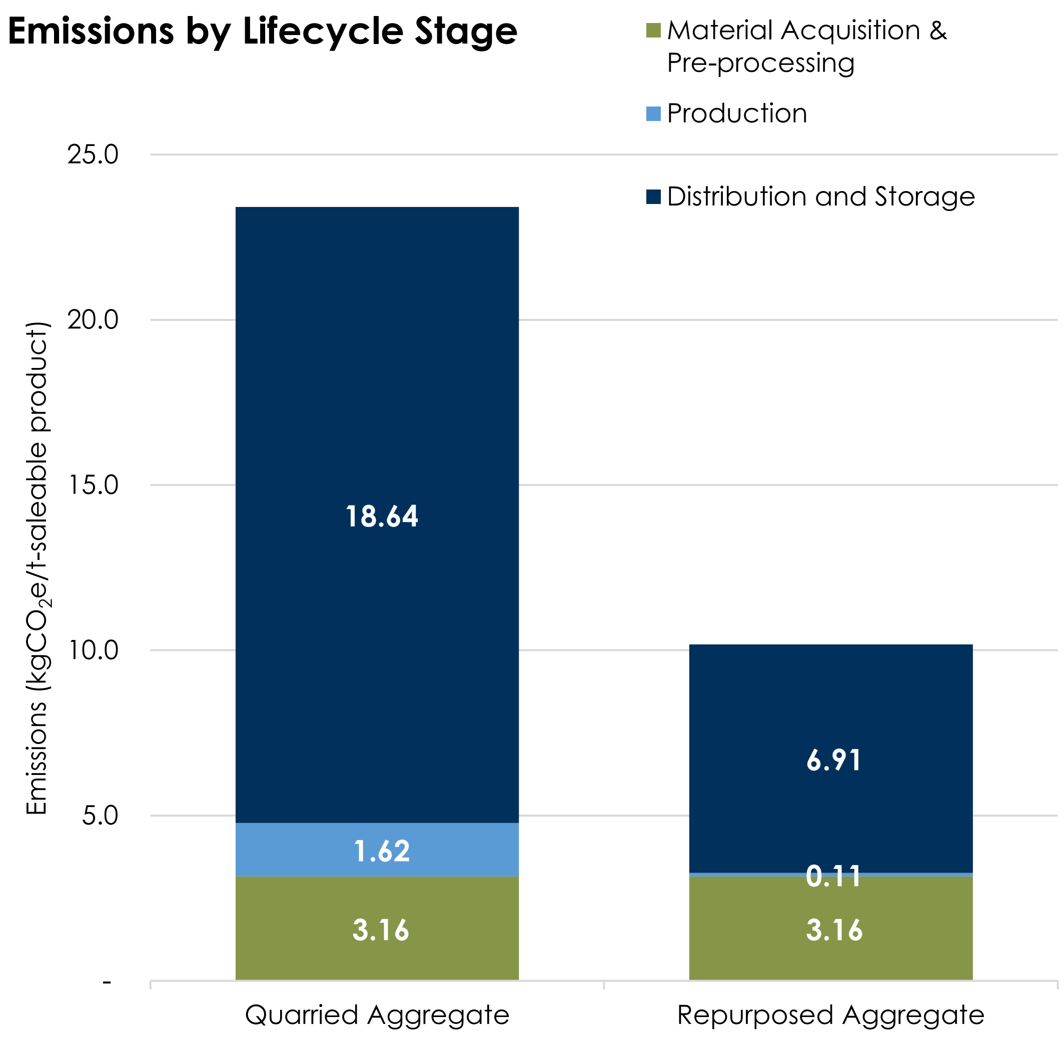
Repurposed Aggregate



Legend

- M Material inputs
- E Energy inputs
- ⇆ Process Flows

Comparative Analysis



This study demonstrates that the emissions intensity of Capital City Paving's Repurposed Aggregate (RA) is 10.18 $kgCO_2e$ per tonne of saleable product. This is a reduction of 57% (13.24 $kgCO_2e$) compared to the equivalent use of Quarried Aggregate (QA). As Material Acquisition & Pre-processing is equivalent in both scenarios, changes to emissions result from:

Production:

- Emission reductions for RA occur due to the lack of quarrying activities (drilling, blasting, crushing, and sorting).
- Additional emissions for RA occur due to the energy consumption of the Aggwash system. However, as this system is powered by electricity and connected to the low carbon BC Hydro electricity grid, these emissions make up <1% of RA emissions.

Distribution & Storage:

- For each tonne of waste material processed by CCP, the volume of waste material that is transported to the Duncan fill side is decreased by 75%, resulting in the largest reduction in emissions.

Quarried Aggregate	Repurposed Aggregate	Difference
23.42	**10.18**	**57%**
$kgCO_2e$/tonne of saleable product	**$kgCO_2e$/tonne of saleable product**	**Lower Emissions**

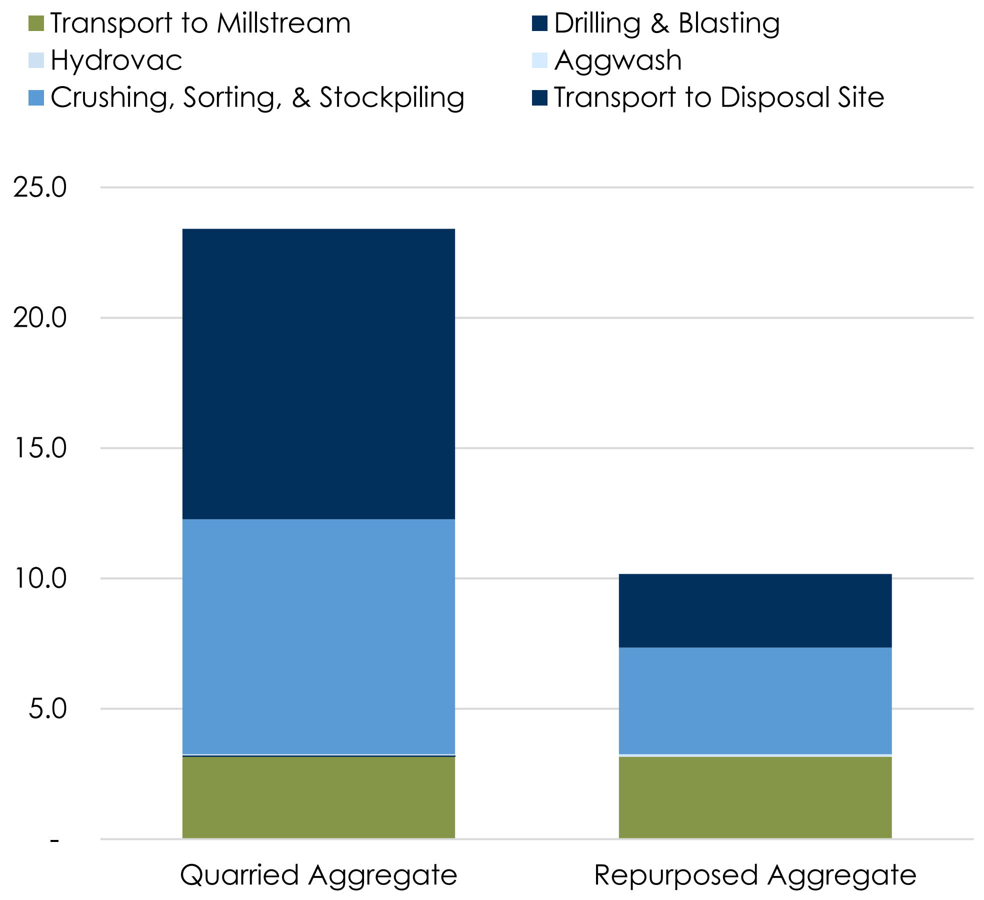
Comparative Analysis

This figure provides a breakdown of emissions by specific process stage.

Cumulatively, the Hydrovac and Aggwash, inclusive of stockpiling, contribute 4.19 $kgCO_2e$/t-saleable product. By comparison, quarrying activities, including stockpiling, contribute 9.11 $kgCO_2e$. This demonstrates that, as a like-for-like replacement for quarrying, material recycling is 54% less emissions intensive than quarrying.

	Quarried Aggregate	Repurposed Aggregate
Transport to Disposal Site	11.1	2.83
Crushing, Sorting, & Stockpiling	9.01	4.09
Aggwash	0	0.06
Hydrovac	0.05	0.05
Drilling & Blasting	0.06	0
Transport to Millstream	3.16	3.16

Emissions by Process Stage



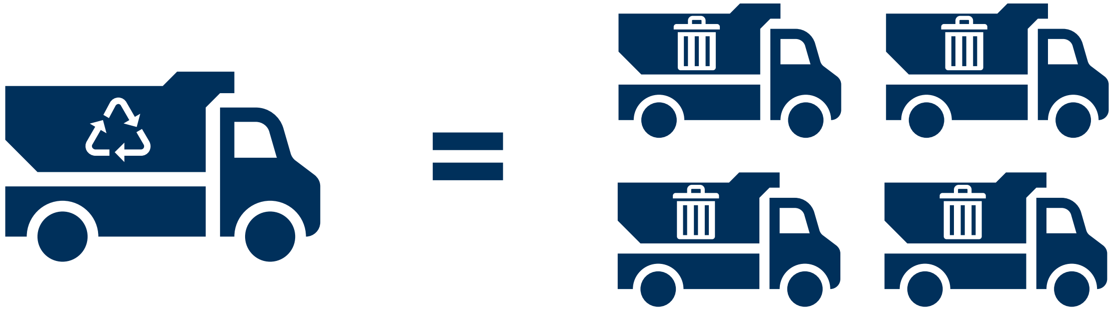
Comparative Analysis

To further contextualize the results of this study, comparisons can be drawn between the presented emissions figures and more easily understood metrics, both at a per tonne of material level and aggregated across a year of activity.

As discussed, the Repurposed Aggregate demonstrates an emissions reduction of 13.24 $kgCO_2e$ per tonne of saleable product. This is approximately equivalent to the emissions produced when burning 4.9 litres of diesel fuel or using 780 kWh of electricity in BC.

Records show that, in 2025, 69,000 tonnes of waste material were delivered to CCP's Millstream facility. Given the results of this study, an equivalent amount of material processed using Repurposed Aggregate could reduce greenhouse gas emissions by approximately 914 tCO_2e. This is roughly equivalent to removing 213 gasoline-powered cars from the road for one year.

Taking the results of this study and applying them to a single, 25-tonne load of waste material highlights a useful comparison: in the QA scenario, transporting waste material to the disposal site results in 78.89 $kgCO_2e$ from fuel consumption for each load. Repurposing 5.96 tonnes of material, less than 25% of one of these truck loads, fully offsets these emissions. This demonstrates that, for every 25 tonnes of material repurposed, emissions are reduced in a volume equivalent to over four trips to the disposal site.



Reduces annual emissions by 914 tCO_2e

Equivalent to removing 213 cars from the road annually

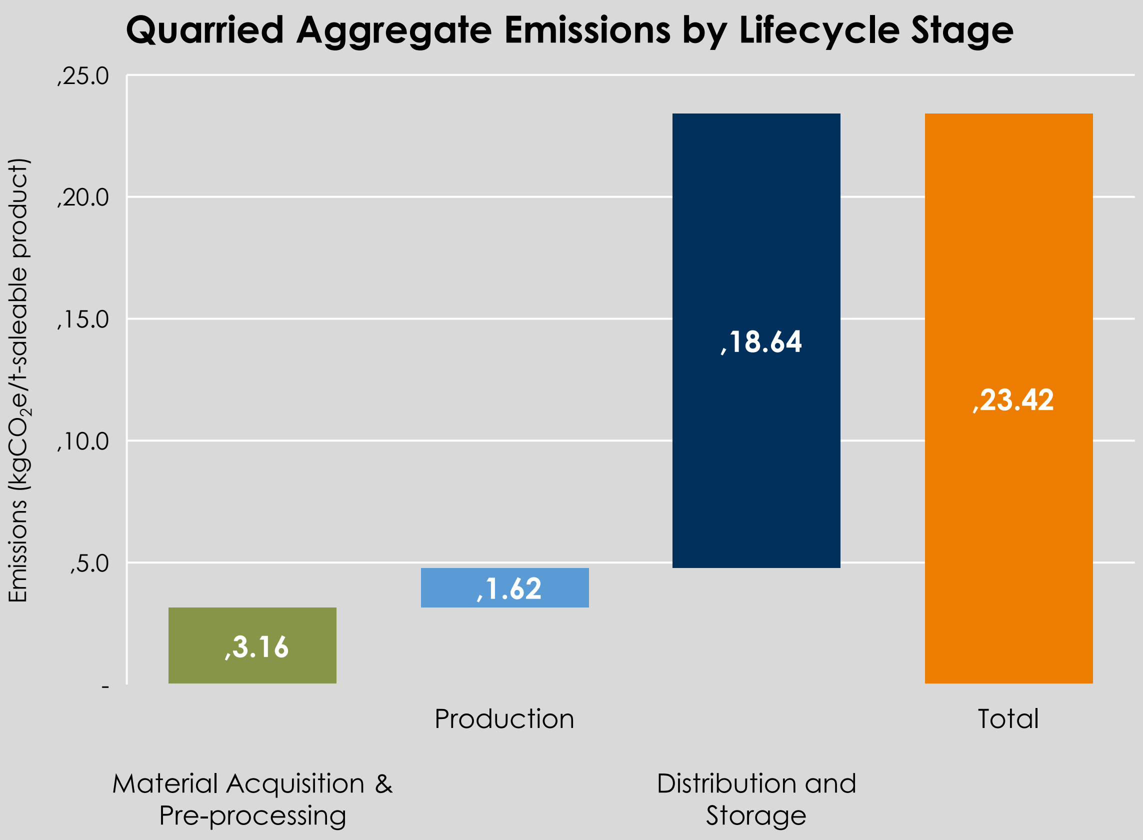
Emissions savings equivalent to 780 kWh of BC electricity per tonne of repurposed material

Emissions savings equivalent to 4.9 litres of diesel per tonne of repurposed material

LCA Results

Quarried Aggregate Inventory Results

For quarried aggregate, nearly 80% of emissions occur during the distribution and storage phase, which includes the stockpiling of quarried material and the transport of waste soil to the disposal site in Duncan. Transport of waste soils to CCP's property, processing of these soils, and quarrying of natural aggregate account for the remainder.

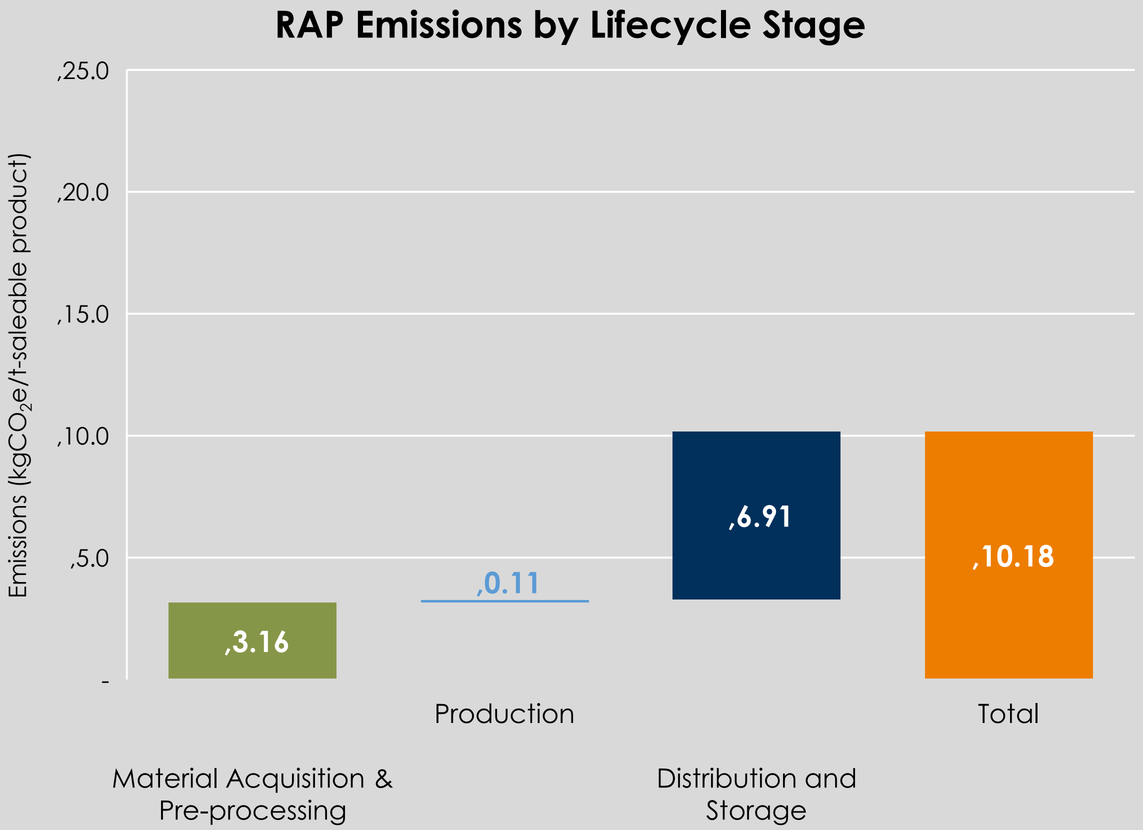


Total Inventory Results **23.42** **$kgCO_2e$/tonne saleable product**

	Removals	Emissions
Biogenic Inventory Results	0.00 $kgCO_2e$	0.00 $kgCO_2e$
Non-Biogenic Inventory Results	0.00 $kgCO_2e$	23.42 $kgCO_2e$
Inventory Results: Percent of Total Inventory by Lifecycle Stage		
Material acquisition and pre-processing		13.5%
Production		6.91%
Distribution & Storage		79.6%
Use & End of life		Not Applicable
Inventory Results: Carbon Storage		
Embedded product carbon not released at the end of life		Not quantified
Embedded product carbon leaving the gate of a cradle-to-gate inventory		Not quantified
Amount of process emissions stored as a result of emission storage		Not Applicable
Inventory Results: Cradle-to-gate and gate-to-gate		
Cradle-to-gate: material acquisition & pre-processing, production, distribution & storage		23.42 $kgCO_2e$/tonne saleable product
Gate-to-gate: production, distribution & storage		20.26 $kgCO_2e$/tonne saleable product

Repurposed Aggregate Inventory Results

The transport of waste soil to the Millstream site accounts for 31% of emissions due to the total emissions impact being lower. 68% of emissions occur during the distribution & storage stage, which includes transportation of Hydrovac cakes to the disposal site, as well as stockpiling of materials. 1% of emissions occur during the production phase during which the Hydrovac and Aggwash systems are used.



Total Inventory Results

10.18 kgCO_2e/tonne saleable product

	Removals	Emissions
Biogenic Inventory Results	0.00 kgCO_2e	0.00 kgCO_2e
Non-Biogenic Inventory Results	0.00 kgCO_2e	10.18 kgCO_2e
Inventory Results: Percent of Total Inventory by Lifecycle Stage		
Material acquisition and pre-processing		31.0%
Production		1.05%
Distribution & Storage		67.9%
Use & End of life		Not Applicable
Inventory Results: Carbon Storage		
Embedded product carbon not released at the end of life		Not quantified
Embedded product carbon leaving the gate of a cradle-to-gate inventory		Not quantified
Amount of process emissions stored as a result of emission storage		Not Applicable
Inventory Results: Cradle-to-gate and gate-to-gate		
Cradle-to-gate: material acquisition & pre-processing, production, distribution & storage		10.18 kgCO_2e/tonne saleable product
Gate-to-gate: production, distribution & storage		7.02 kgCO_2e/tonne saleable product

Appendices

1. General Information & Scope

Company	Capital City Paving (CCP)	
Contact Information	**Contact Name and Role**	Sam Powell, Environmental Coordinator
	Email Address	spowell@capitalcitypaving.com
Inventory Date and Version	**Inventory Date**	April 2026
	Inventory Version	First Inventory

Information	**Quarried Aggregate**	**Repurposed Aggregate**
Studied Product Name	Quarried Aggregate	Repurposed Aggregate
Studied Product Description	This natural quarried aggregate is purchased by municipalities to be used for a variety of purposes. This lifecycle includes the removal of waste soil, which is processed and then disposed of.	This repurposed aggregate is produced through advanced processing using an AggWash system before being sold to municipalities as an alternative to a quarried aggregate product.
Unit of Analysis	A mass (tonnes) of quarried material equivalent to what would be quarried in an average year.	A mass (tonnes) of repurposed material equivalent to what would be quarried in an average year.
Functional Unit	One (1) tonne of saleable quarried aggregate material.	One (1) tonne of saleable repurposed aggregate material.
Reference Flow	Same as the functional unit.	
Type of Inventory	Cradle-to-gate (intermediate product)	
Additional GHGs Included in the Inventory	Not Applicable	
Sector Guidance or Product Rules	Not Applicable	
Link to Previous Inventory Reports	First Inventory, Not Applicable	
Disclaimer	The results presented in this report are unique to the assumptions and practices of Capital City Paving. This report includes results for both the "Quarried Aggregate" and the "Repurposed Aggregate" products and has been completed in a fashion that allows for comparability between the results for these two products. However, the results are not meant as a platform for comparability for other companies and/or products. Even for similar products, differences in lifecycle boundary, functional unit, and data quality may produce incomparable results. For more information, the reader may refer to the GHG Protocol Product Life Cycle Accounting and Reporting Standard for a glossary and additional insight into the GHG inventory process.	

2. Boundary Setting

Lifecycle Stage	Quarried Aggregate Description	Repurposed Aggregate Description
Material Acquisition & pre-processing	Activities include removal and transport of waste soil from various sites within municipality boundaries to CCP's processing site.	Activities include removal and transport of soil from various sites within municipality boundaries to CCP's processing site
Production	Activities include processing of waste soil using hydrovac system; quarrying of natural aggregate product inclusive of blasting, extraction, processing, and transport; crushing of aggregate as well as sorting using conveyors and heavy machinery.	Activities include advanced washing of soils using both the Hydrovac system and Aggwash system; sorting of processed material using conveyors and heavy machinery.
Distribution & storage	Activities include transport and stockpiling of crushed and sorted material at place of sale.	Activities include transport and stockpiling of washed and sorted material at place of sale.
Use	Outside of boundary	
End-of-life	Outside of boundary	

Other Boundary Information	
Non-attributable processes included in the inventory	Not applicable
Excluded attributable process, service, material, or energy flows	Not applicable
Justification for a Cradle-to-gate boundary	Use and end-of-life impacts vary greatly depending on how and where the product is used. Aggregate products can be used for many different applications and there is no data to suggest which application is the most likely. Additionally, once the aggregate has been used it is typically permanent and therefore does not have a defined end-of-life.
Time Period	Defined as one year of activity (in this case, 2025-01-01 to 2025-12-31) to align with unit of analysis. Product lifespan is considered indefinite.

3. Allocation and Data Collection & Data Quality

Allocation	
Methods used to avoid or perform allocation	The services performed by Capital City Paving are not exclusive to those described by either the Quarried Material scenario or repurposed Aggregate scenario. As such, allocation was performed by tracking activity and trip-specific data (e.g., diesel fuel consumed per trip for transporting waste soil from the processing site to the fill site, including the empty backhaul).
Displaced emissions and removals using the closed loop approximation method	Not applicable

Data Collection & Quality	
Statement on overall data quality	A comprehensive data collection framework was established to allow for retrieval of data specific to the activities outlined within the use cases described within this report. Overall, data quality is very good when assessed against standard quality criteria including Technology, Time, Geography, Completeness, and Reliability.

Significant Processes

Significant Process Name	**Data Source(s)**	**Data Quality**		**Efforts to improve data quality**
Transportation from work site to treatment site	No activity-specific data available. Data were estimated based on the data provided to describe the activity of transporting waste materials from the treatment site to the disposal site (see the significant process below). Google maps driving directions were used to determine the driving distance from municipal centres to the treatment site.	Technology	Very Good	For future assessments, obtaining accurate fuel consumption reports from customers transporting material to the treatment site would produce the highest quality results.
		Time	Very Good	
		Geography	Very Good	
		Completeness	Poor	
		Reliability	Fair	
Transport from treatment site to disposal Site	Fuel consumption was recorded for two separate round trips from the treatment site to the disposal site. A purchase summary was provided to show the starting volume of fuel as well as the required fill volume to replace fuel consumed during the round trip.	Technology	Very Good	For future assessments, conducting a larger number of fuel consumption recordings would provide a more detailed average accounting for variance in weather, truck performance, load size, and other factors influencing fuel consumption.
		Time	Very Good	
		Geography	Very Good	
		Completeness	Very Good	
		Reliability	Good	

4. Uncertainty

Source of Uncertainty	Description of Uncertainty
General Statement on Uncertainty	Uncertainty occurs when a component of the system analysis cannot be demonstrably verified as free of inaccuracies. Uncertainties are generally classified into one of three categories: scenario uncertainty, parameter uncertainty, and model uncertainty.
Scenario Uncertainty	
Aggwash Energy Consumption	A full year of operational data was not available for the Aggwash system. Because of this, the actual electricity consumption profile during operation is unknown. Instead, system specifications were used in conjunction with guidance from the manufacturer to estimate the electricity consumption profile of the system.
Quarried Aggregate Product Boundary	The Quarried Aggregate includes the impact of waste soil transport, processing, and disposal in addition to the impacts of quarrying raw materials. In lifecycle terms, the waste soil could be considered a separate product and so not applicable to this inventory. However, waste soil is the raw material used for the Repurposed Aggregate. Because of this, waste soil is included within the Quarried Aggregate boundary to allow for comparability between the two products. In light of this, the results of the Quarried Aggregate **must only** be used for comparison to the Repurposed Aggregate and cannot be used for any forms of external reporting or marketing.
Parameter Uncertainty	
Emission Factors	Emission factors were not available for individual explosives used in quarry blasting. As such, an available factor for ammonium nitrate fuel oil (ANFO) was applied to all explosives. Emissions from explosives are immaterial to the product inventory so this approach was deemed acceptable. Wherever possible, emission factors are obtained from official government publications. For more information on emission factor sources, see the 'Emission Factor Reference & Glossary' page of this report.
Global Warming Potential Factors	The global warming potential factors used in this report are from Chapter 7 of the Intergovernmental Panel on Climate Change's AR6 report. Gases relevant to this inventory are carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4).
Model Uncertainty	
Calculations	The calculation model relies on verifiable activity data when available. In cases where data were unavailable, verifiable activity data that could serve as a proxy for other activities were used. For others, emissions were estimated using client figures from equipment run time reports and total fuel consumption.

5. Assurance

Assurance Type	Third party verification by Synergy Enterprises
Level of assurance achieved or critical review findings	Reasonable
Summary of the assurance process	The assurance provider reviewed source data, calculations, and the report for any errors, omissions, or misstatements. The assurance provider also reviewed the report to ensure it meets the requirements of the Product Life Cycle Accounting and Reporting Standard.
Relevant competencies of the assurance providers	Heidi Grantner, verification and assurance provider, completed in alignment with the requirements and competencies specified in ISO 14064-3:2019 and ISO 14065:2020
Explanation of how any potential conflicts of interest were avoided	The verification was completed by a verification practitioner at Synergy Enterprises who has expertise in GHG inventories but was not involved in the GHG inventory of the two products assessed in this report.

6. Setting Reduction Targets & Tracking Inventory Changes

Base inventory and current inventory results	This is the base inventory
Reduction target, if established	Not applicable
Changes made to the base inventory, or if no change was made, the threshold used to determine that recalculation was not needed	Not applicable
Appropriate context identifying and describing significant change(s) that trigger base inventory recalculation	Not applicable
The change in inventory results	Not applicable
Explanation of steps taken to reduce emissions	Not applicable

7. Additional Information

1. The intent of this study is to ascertain the estimated GHG emissions intensity of Capital City Paving's repurposed aggregate product as described by the "Repurposed Aggregate" scenario. The resulting GHG emissions intensity figure should be considered the relevant "Inventory Result" for reporting purposes.

To help Capital City Paving understand the results of this inventory, an additional scenario was calculated. The Quarried Aggregate scenario describes raw materials that are sourced from Capital City Paving's quarry using standard quarrying techniques. This scenario includes the impact of waste soil transport, processing, and disposal in addition to the impacts of quarrying raw materials. In lifecycle terms, the waste soil could be considered a separate product and so not applicable to this inventory. However, waste soil is the raw material used for the Repurposed Aggregate. Because of this, waste soil is included within the Quarried Aggregate boundary to allow for comparability between the two products.

In light of this, the results of the Quarried Aggregate must only be used for comparison to the Repurposed Aggregate and cannot be used for any forms of external reporting or marketing.

2. Future iterations of this study could aim to identify sub-products produced in the Repurposed Aggregate for more granular reporting. Sub-products could also include a defined use, which would allow the boundary of this assessment to be extended to a full cradle-to-grave lifecycle.

Emission Factor References & Glossary

1. Environment Canada's National Inventory Report (1990-2023); Part 2 & 3
https://publications.gc.ca/collections/collection_2025/eccc/En81-4-2023-2-eng.pdf
https://publications.gc.ca/collections/collection_2025/eccc/En81-4-2023-3-eng.pdf

2. Toward Sustainable Mining (2014); Energy and Greenhouse Gas Emissions Management Reference Guide
EnergyandGreenhouseGasEmissionsManagementReferenceGuide2014.pdf

3. Klanfar, M., Korman, T., Kujundžić, T. (2016); Fuel consumption and engine load factors of equipment in quarrying of crushed stone
(PDF) Fuel consumption and engine load factors of equipment in quarrying of crushed stone

4. California Emissions Estimator Model (2022); APPENDIX E CONSTRUCTION AND OPERATIONAL ENERGY CONSUMPTION CALCULATIONS
Appendix E-Construction Fuel Consumption Calculations1.pdf

5. Canada Energy Regulator (2016); Energy conversion tables
Energy conversion tables - Canada.ca

6. Ormond Machinery (n.d.); AggWash 60-1/60-2 Technical Specification
ucm03_081373.pdf

7. Elite Hydrovac Services (2019); Hydrovac Services
Elite-Hydrovac-Services-Web.pdf

8. The Engineering Toolbox (2026); Soil – Earth Weight and Composition
Soil - Earth Weight and Composition

Term	Description
Biogenic	Carbon emissions generated from sources naturally occurring in the carbon cycle (i.e. organic matter), rather than the result of fossil fuel combustion.
Cradle-to-gate	A lifecycle inventory boundary that includes material acquisition & pre-processing, production, and distribution & storage.
Cradle-to-grave	A lifecycle inventory boundary that includes material acquisition & pre-processing, production, distribution & storage, use, and end-of-life treatment.
Emissions Factor	The volume of emissions created by an emissions producing activity (i.e. fuel combustion), calculated based on the amount of the activity (volume, distance, etc.).
GHG	Greenhouse Gas (emissions): Atmospheric gasses contributing to the greenhouse effect, including Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), etc.
$kgCO_2e$ & tCO_2e	Kilograms or tonnes of carbon dioxide equivalent: a combined term capturing the emissions from various GHGs.
Tonne saleable product (t saleable product)	A unit representing one metric tonne of material that is suitable for sale. Combined with $kgCO_2e$, provides the unit of measure used in this report: $kgCO_2e$ per tonne of saleable product ($kgCO_2e$/t saleable product)
kWh	Kilowatt-Hour: Common unit for measuring electrical consumption

synergy

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