QUANTIFICATION PROTOCOL FOR GRAVEL AND LIGHTLY SURFACED ROAD REHABILITATION PROJECTS:

ABRIDGED

Submitted to:

Alberta Environment

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Disclaimer

The following document presents an abridged version of the Gravel and Lightly Surfaced Road Rehabilitation Project protocol prepared for Alberta Environment which has completed an initial round of technical review. This document has been prepared as a means of supporting a broader stakeholder consultation process. As such, this document should not be used as a quantification protocol.

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1.0 Project and Methodology Scope and Description

This quantification protocol is written for the project developer completing gravel and lightly surfaced road rehabilitation using a process that involves recovering aggregate (without damaging the original road bed material – ie. crushing aggregate) from the existing road bed, mixing the materials to replenishing the design mix ratio and re-depositing the material forming a completely rehabilitated road surface. Some new material may also be required for the rehabilitation. Some familiarity with, or general understanding of, road maintenance and rehabilitation is expected.

The opportunity for generating carbon offsets with this protocol arises from the direct and indirect reductions of greenhouse gas (GHG) emissions by reducing the use of fossil-fuel derived energy during the rehabilitation of gravel and lightly surfaced roads. Under traditional rehabilitation, an incremental volume of aggregate or aggregate and binder (or other additive - hereafter referred to collectively as binder), would be laid on top of the existing road bed, requiring significant fossil fuel use from the sourcing, processing and transportation of these materials. Projects applying this protocol achieve fuel savings from the recycling of the recovered, processed aggregate from the existing road bed, reducing the amount of aggregate and binder needing to be sourced, processed and transported to the project site.

Typically, roads in need of rehabilitation are simply covered up with a new surface, consisting of 1.5 to 6 inches of new materials. The mining and transportation of aggregate or aggregate and binder for gravel or lightly surfaced roads produces greenhouse gas emissions, mainly through the combustion of fossil fuels to run excavation, processing and transportation equipment.

The project condition is the use of road rehabilitation equipment, which results in the recycling of the aggregate without significant stone fracturing or base contamination. Under this process, the existing road material is cut, separated and loosened from its base. This equipment should not fracture or damage the aggregate, minimizing the need for additional materials. This material is then retrieved, mixed with a small amount of new material if necessary, and re-laid forming a rehabilitated road surface. The reduction in the amount of new material used in the road rehabilitation process provides a reduction in the greenhouse gas emissions associated with the production and transportation of the aggregate or aggregate and binder used in road resurfacing. If sand, gravel or crushed stone are used as aggregate, the emissions factor as stated in the calculator is used. If other recycled or reclaimed materials are used, they are assumed to have no emissions associated with their production and are therefore not included in the calculations. **FIGURE 1.1** offers an organization of the project SS's into life cycle categories for a typical project.

The baseline condition for the road rehabilitation protocol is the resurfacing of the road using all new materials (aggregate or aggregate and binder). The production and transportation of the new material requires energy derived from the mining and combustion of fossil fuels. In the baseline condition, it is assumed that the aggregate used is either

sand, gravel or crushed stone. **FIGURE 1.2** offers an organization of the project SS's into life cycle categories for a typical baseline configuration.

To demonstrate that a project meets the requirements under this protocol, the project developer must supply sufficient evidence to demonstrate that:

1. The project involves the recovery, recycling and re-depositing of the materials from existing gravel and lightly surfaced roads, including some supplementation with new materials, as part of the rehabilitation of the road;
2. The rehabilitated road meets or exceeds the specifications for traditional resurfacing as dictated by the relevant standard (i.e. guideline or building code); and
3. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol.

Flexibility in applying the quantification protocol is provided to project developers in two ways:

1. The calculation of aggregate transportation distances may employ regional average distances from a mining site, if sufficient evidence can be provided; and

2. Site specific emission factors and other project specific factors may be substituted for the generic emission factors indicated in this protocol document. The methodology for generation of these emission factors must be sufficiently robust as to ensure reasonable accuracy.

The project proponent must be able to justify their approach in detail to apply any of these flexibility mechanisms.

FIGURE 1.1: Project Element Life Cycle Chart

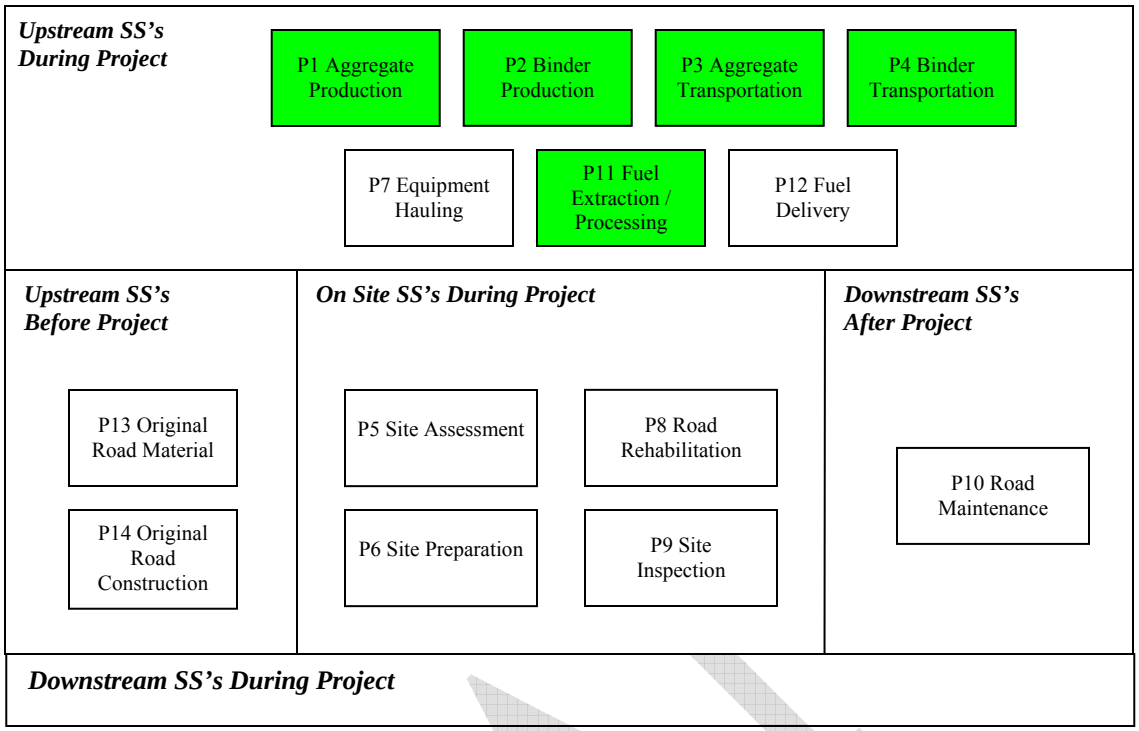
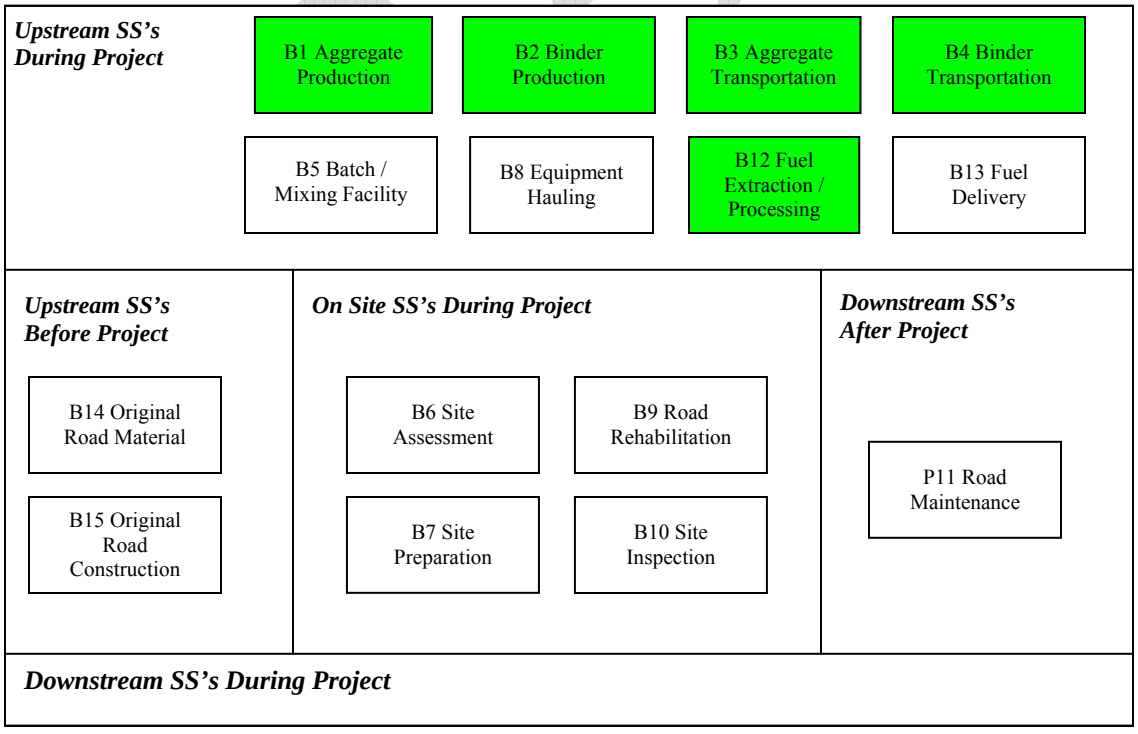


FIGURE 1.2: Baseline Element Life Cycle Chart



* Sources, sinks and reservoirs selected for measurement and monitoring under this protocol are highlighted.

2.0 Quantification of Identified Sources, Sinks and Reservoirs

Quantification of the reductions, removals and reversals for the sources, sinks and reservoirs selected for measurement and monitoring under this protocol will be completed using the methodologies outlined in **TABLE 2.1**, below. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Aggregate Production}} + \text{Emissions}_{\text{Oil Production}} + \text{Emissions}_{\text{Transportation Aggregate}} + \text{Emissions}_{\text{Transportation Oil}} + \text{Emissions}_{\text{Fuel Extract / Process}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Aggregate Production}} + \text{Emissions}_{\text{Oil Production}} + \text{Emissions}_{\text{Transportation Aggregate}} + \text{Emissions}_{\text{Transportation Oil}} + \text{Emissions}_{\text{Fuel Extract / Process}}$$

Where:

$\text{Emissions}_{\text{Baseline}}$ = sum of the emissions under the baseline condition.

- $\text{Emissions}_{\text{Aggregate Production}}$ = emissions under SS B1 Aggregate Production
- $\text{Emissions}_{\text{Binder Production}}$ = emissions under SS B2 Binder Production
- $\text{Emissions}_{\text{Transportation Aggregate}}$ = emissions under SS B3 Aggregate Transportation
- $\text{Emissions}_{\text{Transportation Binder}}$ = emissions under SS B4 Binder Transportation
- $\text{Emissions}_{\text{Fuel Extract / Process}}$ = emissions under SS B12 Fuel Extraction / Processing

$\text{Emissions}_{\text{Project}}$ = emissions under the project condition.

- $\text{Emissions}_{\text{Aggregate Production}}$ = emissions under SS P1 Aggregate Production
- $\text{Emissions}_{\text{Binder Production}}$ = emissions under SS P2 Binder Production
- $\text{Emissions}_{\text{Transportation Aggregate}}$ = emissions under SS P3 Aggregate Transportation
- $\text{Emissions}_{\text{Transportation Binder}}$ = emissions under SS P4 Binder Transportation
- $\text{Emissions}_{\text{Fuel Extract / Process}}$ = emissions under SS P11 Fuel Extraction / Processing

TABLE 1.1: Quantification Procedures

1. Project / Baseline SS	2. Parameter / Variable	3. Unit
Project SS's		
P1 Aggregate Production	$Emissions_{Aggregate\ Production} = Mass_{Aggregate} * EF_{CO2E\ Aggregate\ Production}$	
	Emissions due to the production and mining of aggregate / $Emissions_{Aggregate\ Production}$	kg of CO_2
	Mass of Aggregate used in road rehabilitation / $Mass_{Aggregate}$	kg
	Emissions factor for aggregate production / $EF_{CO2E\ Aggregate\ Production}$	kg CO_{2E}
P2 Binder Production	$Emissions_{Binder\ Production} = Vol.\ Binder * EF\ Binder_{CO2}$; $Vol.\ Binder * EF\ Binder_{CH4}$; $Vol.\ Binder * EF\ Binder_{N20}$	
	Emissions due to the production of binder used in lightly surfaced roads / $Emissions_{Binder\ Production}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Binder used in lightly surfaced roads / $Vol\ Binder_i$	L, m^3 or other
	CO_2 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CO2}$	Kg CO_2 per L, m^3 or other
	CH_4 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other
	N_20 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ N2O}$	kg N2O per L, m^3 or other
P3 Aggregate Transportation	$Emissions_{Aggregate\ Transportation} = \sum((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel_{CO2})$; $\sum((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ CH_4)$; $\sum((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ N_2O)$	
	$Emissions_{Aggregate\ Transportation}$	kg of CO_2 ; CH_4 ; N_2O
	Number of Loads for Each Job / $\#\ Loads_{Job\ Number\ i}$	-
	Distance Driven for each Job / $Distance_{Job\ Number\ i}$	km
	Fuel Efficiency of the vehicle used for each job / $Fuel\ Eff_{Job\ Number\ i}$	L per 100 km
	CO_2 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CO2}$	kg CO_2 per L, m^3 or other
	CH_4 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other
	N_20 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ N2O}$	kg N2O per L, m^3 or other
P4 Binder Transportation	$Emissions_{Binder\ Transportation} = \sum(\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel_{CO2})$; $\sum((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ CH_4)$; $\sum((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ N_2O)$	
	$Emissions_{Binder\ Transportation}$	kg of CO_2 ; CH_4 ; N_2O
	Number of Loads for Each Job / $\#\ Loads_{Job\ Number\ i}$	-
	Distance Driven for each Job / $Distance_{Job\ Number\ i}$	km
	Fuel Efficiency of the vehicle used for each job/$Fuel\ Eff_{Job\ Number\ i}$	L per 100 km
	CO_2 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CO2}$	kg CO_2 per L, m^3 or other
	CH_4 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other
	N_20 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ N2O}$	kg N2O per L, m^3 or other
P11 Fuel Extraction and Processing	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum(Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})$; $\sum(Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})$; $\sum(Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$	
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e
	Volume of Fossil Fuel Combusted for P1 and P2 / Vol_{Fuel}	L
	Including CO_2 Emissions Factor for Fuel Production and Processing / $EF\ Fuel_{CO2}$	kg CO_2 per m^3
	CH_4 Emissions Factor for Fuel Including Production and Processing / $EF\ Fuel_{CH4}$	kg CH_4 per m^3
	N_20 Emissions Factor for Fuel Including Production and Processing / $EF\ Fuel_{N2O}$	kg N2O per m^3

Baseline SS's		
B1 Aggregate Production	$Emissions_{Aggregate\ Production} = Length_{Road} * Mass_{Aggregate\ /\ km} * EF\ CO_{2E}$	
	$Emissions_{Aggregate\ Production}$	kg of CO_2 / tonne of aggregate
	$Length_{Road}$	meters
	$Mass_{Aggregate\ /\ km}$	Tonnes
B2 Binder Production	$Emissions_{Binder\ Production} = \sum (Vol.\ Binder_i * EF\ Binder_{i\ CO2}); \sum (Vol.\ Binder_i * EF\ Binder_{i\ CH4}) ; \sum (Vol.\ Binder_i * EF\ Binder_{i\ N20})$	
	$Emissions_{Binder\ Production}$	kg of CO_2 ; CH_4 ; N_2O
	$Vol\ Binder_i$	L, m^3 or other
	$EF\ Fuel_{i\ CO2}$	Kg CO_2 per L, m^3 or other
	$EF\ Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other
	$EF\ Fuel_{i\ N2O}$	kg N2O per L, m^3 or other
B3 Aggregate Transportation	$Emissions_{Aggregate\ Transportation} = \sum ((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel_{CO2}) ; \sum ((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ CH_4) ; \sum ((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ N_2O)$	
	$Emissions_{Aggregate\ Transportation}$	kg of CO_2 ; CH_4 ; N_2O
	$\#\ Loads_{Job\ Number\ i}$	-
	$Distance_{Job\ Number\ i}$	km
	$Fuel\ Eff_{Job\ Number\ i}$	L per 100 km
	$EF\ Fuel_{i\ CO2}$	kg CO_2 per L, m^3 or other
	$EF\ Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other
	$EF\ Fuel_{i\ N2O}$	kg N2O per L, m^3 or other
B4 Binder Transportation	$Emissions_{Binder\ Transportation} = \sum ((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel_{CO2}) ; \sum ((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ CH_4) ; \sum ((\#\ Loads_{Job\ Number\ i} * Distance_{Job\ Number\ i} * Fuel\ Eff_{Job\ Number\ i} * EF\ Fuel\ N_2O)$	
	$Emissions_{Binder\ Transportation}$	kg of CO_2 ; CH_4 ; N_2O
	$\#\ Loads_{Job\ Number\ i}$	-
	$Distance_{Project\ i}$	km
	$Fuel\ Eff_{Project\ i}$	L per 100 km
	$EF\ Fuel_{i\ CO2}$	kg CO_2 per L, m^3 or other
	$EF\ Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other
	$EF\ Fuel_{i\ N2O}$	kg N2O per L, m^3 or other
B12 Fuel Extraction and Processing	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$	
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e
	Vol_{Fuel}	m^3
	Including CO_2 Emissions Factor for Fuel Production and Processing / $EF\ Fuel_{CO2}$	kg CO_2 per m^3

APPENDIX A: Glossary of New Terms

The following definitions are critical to the appropriate interpretation of this quantification protocol.

Aggregate:	For the purposes of this protocol document, aggregate is any mass of hard, inert materials used for its load-bearing capacity. Aggregate can include natural rock or mineral fragments (e.g. gravel, crushed stone), as well as artificial, reclaimed or recycled materials.
Batch / Mixing Facility:	For the purposes of this protocol document, a batch / mixing facility is a facility where the aggregate and binder are mixed together to produce the mix for a cold mix road before being transported to the site.
Binder:	A substance with adhesive properties added to form dry ingredients into a solid mass (examples: Asphalt, Calcium Chloride, Lignum, etc.).
Lightly Surfaced Road:	Unpaved roads with controlled alignment, defined width, cross-section profile, and drainage.
Rehabilitation:	For the purposes of this protocol document, rehabilitation is the process by which a road is broken up and its material is re-used for its rehabilitation, using equipment and methodologies equivalent to those developed by Road Badger. This process may also include the use of some new materials.