METHODOLOGY ASSESSMENT REPORT FOR THE USE OF FOAM STABILIZED BASE (FSB) AND EMULSIFIED ASPHALT MIXTURES IN PAVEMENT APPLICATION – FIRST ASSESSMENT

RUBY CANYON ENGINEERING

Document Prepared By: Ruby Canyon Engineering

Methodology Title	Use of Foam Stabilized Base (FSB) and Emulsified Asphalt Mixtures in Pavement Application	
Version	1.96	
Methodology Category	Methodology	X
	Methodology Revision	
	Module	
	Tool	
Sectoral Scope(s)	Sectoral Scopes 4 and 6. Material Manufacturing, Construction	

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Summary:

Ruby Canyon Engineering, Inc. (RCE) was retained by Global Resource Recyclers, Inc. (GRR) to perform the methodology first assessment of the Use of Foam Stabilized Base (FSB) and Emulsified Asphalt Mixtures in Pavement Application, (Methodology v. 1.96) (Methodology). The Methodology provides guidance and procedures for the quantification of greenhouse gas (GHG) emission reductions by substituting hot mix asphalt (HMA) with FSB and/or other emulsified asphalt mixtures.

The purpose and scope of the methodology first assessment was to evaluate whether the Methodology was prepared in accordance with VCS program requirements. RCE's assessment included a detailed review of the eligibility criteria, baseline scenarios and emissions, project boundaries and definitions, standardized methods applied, and data and parameters not monitored.

RCE assessed the Methodology against VCS requirements found in the VCS Methodology Approval Process, the VCS Standard, the VCS Program Guide, and the VCS Guidance for Standardized Methods.

RCE's first assessment included a total of 58 findings, including those submitted by the VCS Approved Standardized Methods Expert. GRR provided satisfactory responses to all of RCE's corrective action requests, clarifications, and requests for additional documentation.

RCE confirms that any uncertainties associated with the methodology assessment were addressed by GRR as part of the assessment process.

RCE confirms all methodology assessment activities, including objectives, scope and criteria, level of assurance, and the activity method and methodology revisions conform to the VCS Program Version 3.7 and VCS Standard Version 3.7. RCE concludes without any qualifications that the Use of Foam Stabilized Base (FSB) and Emulsified Asphalt Mixtures in Pavement Application, (Methodology v. 1.96), meet the requirements of the VCS, and recommends that the VCS approve the methodology.

This assessment reconciliation is a review of the findings determined in the second assessment of the methodology. RCE approved all the findings, observations, and responses presented in the second assessment report.

Table of Contents

1 INTRODUCTION

1.1 Objective

The purpose of the Methodology first assessment was to evaluate whether the Use of Foam Stabilized Base (FSB) and Emulsified Asphalt Mixtures in Pavement Application, (Methodology v. 1.96), was prepared in accordance with VCS program requirements. RCE confirmed that the Methodology met the conditions for a first assessment of a methodology under the VCS Methodology Approval Process.

1.2 Summary Description of the Methodology

The Methodology provides a framework for the quantification of GHG emission reductions associated with the production and use of FSB and asphalt emulsions as substitutes for HMA. The GHG emission reductions are realized from projects due to decreased raw material production, reduced material hauling, and lower material heating temperatures, largely due to the increased use of reclaimed asphalt pavement (RAP).

This methodology utilizes GHG emissions performance benchmarks for the crediting baseline that are derived from surveys of projects typical to the baseline scenario. Emission reductions of FSB and asphalt emulsions pavement application are the differences between actual emissions from the project activity and the baseline emissions calculated from the crediting baseline performance benchmark.

Additionality is demonstrated against a performance benchmark, which is set at the same level as the crediting baseline. An autonomous improvement factor is incorporated in the performance benchmark for additionality demonstration and baseline crediting to reflect gradual increases in the use of RAP in pavement application.

2 ASSESSMENT APPROACH

2.1 Method and Criteria

RCE conducted the assessment methods in accordance with the VCS Methodology Approval Process and standard GHG accounting and auditing procedures. RCE conducted a detailed review of the eligibility criteria, baseline scenarios and emissions, performance benchmark, project boundaries and definitions, standardized methods applied, calculations, and data and parameters available at validation and monitored. In addition, RCE assessed the documents' structure and clarity, including the clear definition of key terms. The Standardized Methods Expert assessment focused on the appropriateness of the performance benchmark with respect to environmental integrity and limiting free-riding while providing an appropriate level of financial incentive.

The RCE team followed the following VCS criteria:

- VCS Standard v3.7, June 2017

- VCS Program Guide v3.7, June 2017
- VCS Guidance for Standardized Methods v3.3, October 2013

2.2 Document Review

RCE and RCE's Standardized Methods Expert conducted a detailed review of the methodology, subsequent revisions, calculation methods, and supporting documents. RCE's review focused on the development, applicability, and implementation of the performance benchmark, with particular attention to the use of the benchmark by a potential project proponent. Similarly, RCE's review of the entire methodology was from the eye of a potential project proponent in terms of clarity and application to a potential project. Both RCE and our Standardized Methods Expert reviewed the documents for conformance to the VCS Program Guide, the VCS Standard, the VCS Guidance for Standardized Methods, and other guidance documents.

The final list of documents received and reviewed by the RCE assessment team is provided in Appendix A.

2.3 Interviews

The RCE assessment team conducted interviews with the methodology proponent and their technical consultant throughout the assessment process. The interviews were used to discuss methodology assumptions, conservativeness, calculations and assumptions, VCS requirements, as well as to resolve corrective action requests, clarifications, and other methodology issues. Several rounds of teleconferences were needed to resolve all outstanding issues. The following table identifies the team members and stakeholders involved in the interviews.

Dates	Attendees	Topics
6/30/2015	Sara Berman, Michael Coté, Bonny Crews, Phillip Cunningham, Qingbin Cui, Ellen Liu, Harrold Green, Andrew Beauchamp	Kick-off Meeting – Group discussed the scope of methodology assessment and specific areas of focus.
8/12/2015	Sara Berman, Michael Coté, Bonny Crews, Phillip Cunningham, Zach Eyler, Dan Shaw, Qingbin Cui, Ellen Liu, Harrold Green	Round One of Findings – Group discussed most of the items contained in Findings 1.0, focusing on the main concerns of clarity and conformance to VCS methodology standards, and development of the performance benchmark.
11/11/2015	Sara Berman, Bonny Crews, Phillip Cunningham, Qingbin Cui, Ellen Liu Harrold Green, Samantha Phillips	Round Two of Findings – Group discussed corrective actions and clarifications to Findings 2.0.
1/21/2016	Sara Berman, Bonny Crews, Phillip Cunningham, Dan Shaw, Qingbin Cui, Harrold Green, Andrew Beauchamp	Review next steps in validation process, how to involve VCS to assist GRR

3/10/2017	Bonny Crews, Phillip Cunningham, Jessica Wade-Murphy, Diana Gutierrez, Harrold Green, Dan Shaw, Ellen Liu	Review of Findings, including discussion of greenhouses gases included and their justifications
8/14/2017	Jessica Wade-Murphy, Diana Gutierrez, Harrold Green, Qingbin Cui,	Discussion of CL8 and CL16 from the Findings.
10/31/2017	Bonny Crews, Diana Gutierrez, Harrold Green	Exit Meeting –

2.4 Assessment Team

Bonny Crews – Lead Assessor

Bonny Crews is a microbiologist with broad experience in soil, water, and environmental applications; she has a strong scientific and technical background with excellent communication skills. Bonny has a B.S. in Biology from St. Edward's University and an M.S. in Microbiology from Colorado State University where she studied the effects of oil shale retort on soil microorganism function. Bonny has a strong commitment to sustainable development. Specific interests in the greenhouse gas sector include landfill gas to energy projects, biogas production from agricultural wastes, composting and co-digestion of agro-industrial wastes, and alternative energy projects. Bonny is an accredited lead verifier for the livestock, organic waste digestion, and landfill sectors for the Climate Action Reserve (CAR). Additionally, Bonny is an accredited lead verifier for The Climate Registry (TCR), the American Carbon Registry (ACR) and the California Air Resources Board (ARB). Bonny is also an RCE-designated lead verifier and validator to the British Columbia (BC) Pacific Carbon Trust (PCT).

In various roles as Lead Verifier, Senior Reviewer, Team Member, and Project Lead at Ruby Canyon, Ms. Crews has participated in numerous projects that include GHG inventories, verifications, project and protocol validations, research, and consulting. Prior to joining Ruby Canyon, Bonny worked for seven years at Atlantic Richfield's research laboratory in Plano, TX. There she was a technical expert with the environmental support group, and served as the in-house expert on bioremediation and other biological environmental remediation methods. She has given presentations at national conferences, and written technical reports and journal articles. Bonny enjoys environmental problem-solving and working with multi-disciplinary teams.

Phillip Cunningham – Assessment Team Member

Phillip Cunningham is an environmental scientist at Ruby Canyon Engineering. His involvement at the company includes auditing a variety of carbon offset project types as well as greenhouse gas (GHG) inventories under voluntary and mandatory reporting programs, assessing spreadsheet functionality, and consulting. His recent activities include assisting with the development of the U.S. EPA GHG national inventory for underground and surface coal mine methane and abandoned mine methane emissions, evaluating the carbon neutrality of refuse derived-waste-to-energy projects and consulting for a large fertilizer company.

He is an approved Lead Verifier for Landfill, Livestock, Ozone Depleting Substances, Coal Mine Methane, Organic Waste Digestion, Organic Waste Composting and Nitric Acid Production project protocols under the Climate Action Reserve; an Air Resources Board (ARB) accredited Lead Verifier for Livestock, Ozone Depleting Substances and Coal Mine Methane project verifications; has worked as Lead Verifier under The Climate Registry verifying greenhouse gas emission inventories for local governments, universities, a transportation company and a variety of other industrial sectors; and a Lead Verifier for carbon offset projects and emissions inventories under the British Columbia offset regulation and British Columbia Reporting Regulation.

Phillip Cunningham graduated from Colorado Mesa University with a B.S. in Environmental Science & Technology in 2011. Prior to joining Ruby Canyon, Phillip worked for the Colorado Department of Agriculture at the Palisade Insectary and as a research assistant for the City of Grand Junction.

Michael Coté – Assessment Team Member

Michael Coté is an experienced environmental engineer in the climate change industry with skills in inventory analysis, baseline methodology development, project evaluation and feasibility, emission reductions calculations, and validation/verification of greenhouse gas (GHG) offset projects and corporate inventories. He has worked in various aspects of the environmental and green energy industry for the past 26 years, from project identification, feasibility and development, to verification and registration in various GHG programs. For the past 12 years, Mr. Coté has specialized in voluntary and compliance carbon markets including the development and qualification of greenhouse gas (GHG) emission reduction projects and corporate GHG inventories.

Beginning in 2005, Mr. Coté and partner Ronald Collings founded Ruby Canyon Engineering Inc. (RCE), an organization dedicated to facilitating and qualifying GHG emission reduction projects (primarily targeting methane-to-energy projects from vented and fugitive methane emission sources) as well as providing corporate GHG inventory services. In addition, Mr. Coté led RCE's effort to receive its ANSI-accreditation as an ISO 14065 verification body in October 2009, and has since managed RCE's GHG validation and verification activities. Since receiving its accreditation, RCE has completed over 600 GHG validation/verifications. Mr. Coté has authored numerous GHG emissions baseline methodologies and project documents that have been submitted to U.S. EPA, the United Nations Framework Convention on Climate Change (UNFCCC), California Air Resources Board, Voluntary Carbon Standard, and the American Carbon Registry. He earned his Bachelor of Science degree (magma cum laude) in Environmental Science and Waste Management from Mesa State College in 1997.

Zach Eyler – Assessment Team Member

Zach serves as a Vice President for Ruby Canyon, utilizing his broad experience with greenhouse gas (GHG) programs and renewable energy to assist on a variety of work including GHG verifications, technical research and other client projects. In addition, he assists the company in understanding GHG regulations and policies across North America and internationally, using this knowledge to analyze potential new areas of growth. Specifically, Zach is helping lead Ruby Canyon's expansion into California's AB 32 cap-and-trade program as well as new Canadian province GHG programs in Quebec and Ontario. Zach also serves as Ruby Canyon's representative on a variety of GHG registry stakeholder groups that assist in the development of high level protocol and verification standards for new GHG programs. Zach has completed a wide range of verification work for projects across registries (PCT, CAR, TCR, ACR) including landfills, livestock, oil/gas, fuel switching, ODS, nitric acid production, and GHG entity inventories. Zach is currently an accredited Lead Verifier for the CAR, PCT and ACR programs. Zach is also an ARB accredited Lead Verifier and Project Specialist for livestock and ODS projects.

Prior to joining Ruby Canyon, Zach worked at Element Markets since 2008 where he managed over 15 carbon offset projects, and conducted all GHG policy and regulatory analysis to support the company's trading activities and client relationships in the U.S. and Canada. He also served as a company representative on carbon offset working groups including the Coalition for Emission Reduction Policy (CERP) and the Canadian Industry Provincial Offsets Group (IPOG). He holds a Bachelor's degree in Environmental Technology from NC State University and a Master's of Environmental Management from Duke University's Nicholas School of the Environment.

Nina Pinette – Independent Technical Reviewer

Nina Pinette is an environmental scientist at Ruby Canyon Engineering applying her experience in technical research, data collection and analysis, and report writing to qualifying greenhouse gas emission (GHG) reduction projects. Her recent activities at Ruby Canyon include work on various carbon offset projects under both voluntary and compliance standards. Nina has knowledge of GHG emissions regulations in the United States and Canada including the U.S. EPA's Mandatory GHG Reporting Rule, British Columbia's Emission Offset Regulation, British Columbia's Greenhouse Gas Industrial Reporting and Control Act (GGIRCA) including the Greenhouse Gas Emission Reporting Regulation and Greenhouse Gas Emission Control Regulation, and California's AB 32. She has contributed to EPA white papers on coal mine methane and the EPA active coal mine methane and EPA abandoned coal mine methane inventories and has coauthored Project Descriptions for coal mine methane offset projects for the Voluntary Carbon Standard.

Nina is a team member for RCE's GHG validation and verification work in U.S. and Canadian carbon markets. She is an accredited Lead Verifier for the California Air Resources Board (ARB) for GHG Emissions Data Reports and Offset Project Data Reports under title 17 of the California Code of Regulations. She is an ARB-accredited Lead Verifier and Project Specialist for livestock, ozone depleting substances, and mine methane capture project verifications; a Lead Verifier for Nitric Acid Production, Ozone Depleting Substances, Coal Mine Methane, Livestock, and Landfill project protocols under the Climate Action Reserve (CAR); a lead verifier for projects under the British Columbia offsets program; and a lead verifier for project verifications under the Verified Carbon Standard (VCS). She is also a Lead Verifier for entity verifications for the British Columbia Reporting Regulation, The Climate Registry, and the Massachusetts GHG Emissions Reporting Program which include assessing GHG emissions from a variety of sources: industrial processes, mining operations, landfills, electricity generation, and the transportation sector. Nina is also an accredited verifier for the Airport Carbon Accreditation (ACA) program.

Nina received her B.S. in environmental science with a second major in political science from Muhlenberg College in Allentown, Pennsylvania in 2009. Her studies included travel to

Bangladesh to study climate change and sustainable development and to Kenya to study community conservation initiatives.

Jessica Wade-Murphy de Jiménez – VCS Standardized Methods Expert

Jessica Wade-Murphy de Jiménez is an adviser on climate change mitigation, based in Colombia and fluent in English and Spanish. She has dedicated more than ten years to public and private sector initiatives to reduce greenhouse gas (GHG) emissions, especially in the application of financial incentives to achieve mitigation of GHGs. She offers a wealth of experience with the development, review and application of greenhouse gas accounting methodologies and is currently one of the twelve members of the Methodologies Panel of the UNFCCC's Clean Development Mechanism. Jessica has developed and reviewed standardized methods for defining central elements of GHG mitigation projects, like baseline and additionality, for clients including CAF – Development Bank of Latin America, UNFCCC, EPRI, Volkswagen AG, and Solvay, for a variety of sectors and project types. Under the Verified Carbon Standard, she contributed to VM0022 Quantifying N_2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction, and VM0028 Methodology for Carpooling. Jessica holds a Bachelor's degree in Biological Sciences from the University of Chicago and a Master's of Science from Utrecht University (Netherlands).

2.5 Resolution of Findings

The methodology assessment included a total of eight rounds of evaluation by the assessment team, with the final assessment closing out all outstanding issues – concluding that the methodology was in conformance with VCS rules. Findings related to corrective action requests, clarifications, and requests for additional documentation were resolved during each round of evaluation, or went to further evaluation. The RCE assessment team submitted an updated Findings to GRR during each round of assessment, while GRR responded with corrective actions, revised methodology, additional documents, as well as written responses in the Findings. For larger issues that required additional dialog, the RCE assessment team and GRR discussed the details via teleconferences throughout the assessment process.

During the methodology assessment process, RCE identified 39 items requiring a response including corrective action requests, clarifications, and additional documentation requests. Additionally, the Standardized Methods Expert identified 19 items requiring a response, for a total of 58 items.

During the early assessment rounds, there were several discussions surrounding the complicated statistical analysis of projects used to develop the alternate baseline, which ultimately resulted in GRR removing those methods. Additional discussion refined the development and application of the performance benchmark, and use of the methodology equations by a project proponent. GRR refined and clarified the equations for more consistent use and application by project proponents.

RCE requested several revisions to improve the clarity and comprehension of the methodology for consistent use among varied project proponents. GRR also worked with VCS to revise the methodology to align with the typical structure and usability of other VCS methodologies.

There is a summary of all the findings and their resolutions in Appendix B.

3 ASSESSMENT FINDINGS

The RCE assessment team found the methodology to be in full compliance with the VCS Standard and other VCS requirements. The team followed a methodological approach to the assessment, using the VCS Methodology Approval Process and the VCS Validation and Verification Manual. Key elements of the methodology assessment included:

- Performance Benchmark for Additionality and Crediting baseline
- Project Boundaries
- Baseline Scenarios

During the assessment, the RCE team sought several clarifications from VCSA to ensure the development of a clear and consistent methodology. The RCE assessment team concluded that the methodology provides proper guidance for a potential project proponent implementing the methodology.

3.1 Relationship to Approved or Pending Methodologies

There is currently no approved or pending methodology under the VCS Program, or any other approved GHG programs, which accounts for the quantification of emission reductions using FSB and asphalt emulsions in flexible pavement as a project activity. Accordingly, approved and pending VCS, Climate Action Reserve (CAR), and Clean Development Mechanism (CDM) methodologies for all sectoral scopes were reviewed to determine if any of the existing methodologies could be reasonably revised to meet the objective of this proposed methodology; however, none were identified.

This methodology provides a framework for the quantification of emission reductions associated with the production and installation of FSB and asphalt emulsions as substitutes for hot mix asphalt. Methodologies that reference a baseline of traditional methods of HMA application were reviewed and are listed below. These methodologies were found not to include foam stabilized base and asphalt emulsions, and neither could be suitably revised to accommodate the details of the GRR methodology.

- VM0030 - Methodology for Pavement Application using Sulphur Substitute, v1.0. The use of FSB and asphalt emulsions is not included in this methodology.
- VM0031 - Methodology for Precast Concrete Production using Sulphur Substitute, v1.0. The use of FSB and asphalt emulsions is not included in this methodology.

3.2 Stakeholder Comments

No stakeholder comments were received during the public comment period.

3.3 Structure and Clarity of Methodology

The RCE assessment team confirmed that the final version of the methodology was written in a clear, logical, concise, and precise manner. In addition, RCE confirmed the document closely followed the most recent VCS templates and that the criteria and procedures are well documented in the appropriate sections of the document. RCE confirmed that the terminology used in the methodology is consistent with the VCS Program and generally accepted GHG accounting practices.

The RCE assessment team determined that the words *must, should*, and *may* were used appropriately and consistently to denote firm requirements, (non-mandatory) recommendations and permissible or allowable options, respectively. Additionally, the RCE assessment team concluded the criteria and procedures in the final version of the methodology are written in a manner that can be understood and applied readily and consistently by project proponents. The criteria and procedures are written in a manner that allows projects developed with this methodology to be unambiguously audited against them.

3.4 Definitions

RCE confirmed that all key term definitions are appropriately and clearly defined, and are consistently used in the methodology. The terms are listed in alphabetical order and include key acronyms that are used in the methodology.

3.5 Applicability Conditions

Below is a list of the applicability conditions for potential projects.

		Explanation of whether…	
Condition	**Overall applicability condition**	**Applicability condition is written in a sufficiently clear and precise manner**	**Conformance with the applicability condition can be demonstrated at the time of project validation**
1.	Project activities include the construction of all types of roads and parking lots (patching projects) in the United States	Yes	Yes
2.	Project activities should use any of the following methods: • FSB produced using the CCPR process, • FSB produced using the CIR process, • FSB produced using the FDR process, • CCPR process using asphalt	Yes, terms are common construction parlance and are defined in the methodology	Yes

	emulsions, • CIR process using asphalt emulsions, • FDR process using asphalt emulsions.		
3.	Production plants may serve multiple pavement types, including, but not limited to, roadway and parking lots.	Yes, but does allow for inclusion of other applications	Yes
4.	Project activities may have a HMA or WMA surface layer but must have at least one FSB or asphalt emulsions base layer.	Yes	Yes

All applicability conditions are appropriate for the project activities targeted by the methodology and are specific to the replacement of traditional asphalt technologies with FSB or asphalt emulsions. The RCE assessment team concluded the applicability conditions are specific and clearly defined for appropriate use by a project proponent.

3.6 Project Boundary

The project boundary includes project raw material acquisition to product installation, and complies with the cradle-to-gate assessment principle. The approach for identifying the project boundary is appropriate as the methodology focuses on replacement of materials affecting the asphalt production and application process.

The RCE assessment team concluded that the included GHG sources are appropriate to each of the specific project types covered by the methodology; included sources are materials, production facilities, installation equipment, and transport of materials. Excluded GHG sources include maintenance and excavation of the applied pavement, which is appropriate due to the high variability of practices in each region. Diagrams for the boundary for each of the project types are clear and appropriate to the specific project activities. Additionally, the methodology correctly excludes GHGs that are considered de minimis to the project activities.

3.7 Baseline Scenario

The baseline scenario for projects utilizing this methodology is a paving project that uses the traditional hot mix asphalt (HMA) or warm mix asphalt (WMA). The RCE assessment team found this to be an appropriate baseline determined from national data on paving application. The team reviewed sources from the Environmental Protection Agency and the National Asphalt Paving Association in support of this conclusion.

This methodology uses a performance method for the crediting baseline. The emissions associated with an HMA or WMA project serve as the performance benchmark; the baseline projects are stratified by project type (patching / parking lot, or roadway) as well as by hauling distance. The emissions associated with project scenarios of a similar type were compared to the baseline performance benchmark. The performance benchmark is decreased annually by 0.1kgCO_2e/t as an autonomous improvement factor to reflect the gradual increase in the use of RAP in HMA pavements, in agreement with sources from the National Asphalt Paving Association and taking into account historical trends.

The performance benchmark developed for this methodology was derived from a survey of paving projects in a few geographic regions, using HMA and WMA technologies, for comparison to similar projects using FSB (project scenario). RCE and the VCS expert reviewed the inputs from the surveys, the comparison of materials in the baseline and project scenarios, and the equations used to calculate the performance benchmark. All inputs and equations were correct and appropriate for a project proponent to compare the baseline and project scenarios.

3.8 Additionality

This methodology uses a performance benchmark to demonstrate additionality. The project proponent must also demonstrate regulatory surplus by confirming the use of foam stabilized base in paving projects is not mandated or required by any legislation. The methodology appropriately instructs the project proponent to refer to the most recent version of the VCS Standard for guidance on regulatory surplus.

The performance benchmark is the same as the crediting baseline and was developed for this methodology was derived from a survey of paving projects in a few geographic regions, using HMA and WMA technologies for comparison to similar projects using foam stabilized base (project scenario). RCE and the VCS expert reviewed the inputs from the surveys, the comparison of materials in the baseline and project scenarios, and the equations used to calculate the performance benchmark. The methodology calculates a mean and standard deviation for three project classifications (patching, <= 40 miles; patching, >= 40 miles; and roadway) to determine the additionality performance benchmark defined as a threshold that surpasses the 80th percentile of existing HMA producers. This was an appropriate determination of the performance standard. All inputs and equations were correct and appropriate for a project proponent to compare the baseline and project scenarios.

3.9 Quantification of GHG Emission Reductions and Removals

3.9.1 Baseline Emissions

Baseline emissions for this methodology are calculated using a crediting baseline based on the production and application of traditional paving materials that include hot mix asphalt. The equations include all GHG emission sources for each of the paving project types to be compared to the project scenario using foam stabilized base in place of hot mix asphalt.

RCE confirmed that all of the equations used in the baseline performance benchmark calculation are correct and include the appropriate emission factors. Additionally, RCE confirmed there are procedures in place to account for missing or estimated data, and appropriate discount factors applied.

3.9.2 Project Emissions

Project emissions for this methodology are calculated according to the type of foam stabilized base material production process used in the project scenario. Both project types include fossil fuel use for hauling distance of materials with an appropriate emission factor, fossil fuel use for on-site equipment with an appropriate emission factor, amount of material produced, and electricity usage with appropriate emission factor.

RCE confirmed that GRR captured all potential sources of project emissions for each project type, and that the equations for calculating project emissions were correct. Additionally, RCE confirmed that all emission factors are correct, and there is appropriate guidance to update the emission factors to the most current available.

3.9.3 Leakage

RCE concurred with GRR that there is no leakage in the proposed methodology as the only differences in the baseline and project are within the project boundary.

3.9.4 Net GHG Emission Reductions and Removals

The methodology lists all equations for the calculation of net GHG emission reductions and removals. There is a detailed explanation of the performance benchmark and the procedure for comparing the project emission index to the performance benchmark. The RCE assessment team and the Standardized methods expert reviewed all the algorithms and equations and found them to be appropriate and without error. Additionally, the procedures for calculating net GHG emission reductions and removals are clear and can be consistently applied by project proponents.

3.10 Monitoring

Data Parameter	Assessment Team Findings
EF_M – Material emission factor for calculation of material production emissions. Available at validation.	Emission factor is appropriate. Source of values applied are appropriate. Correct application and schedule for update.
EF_T – Truck emissions per mile travelled for calculation of baseline and project scenario delivery emissions. Available at validation.	Emission factor is appropriate. Source of values applied are appropriate. Correct application and schedule for update.
EF_{EQ} – Equipment emissions per hour for calculation of baseline and project scenario emissions. Available at validation.	Emission factor is appropriate. Source of values applied are appropriate. Correct application and schedule for update.
EF_{EL} – Electricity emission factor for calculation of baseline and project scenario emissions. Available at validation.	Emission factor is appropriate. Source of values (eGRID summary tables) applied are appropriate. Correct application and schedule for update.
CF – Conversion factor: the percentage of equipment operating time in the total labor time. Available at validation.	Conversion factor is appropriate. Source of values applied are appropriate. Correct application.
DF - For conservativeness, a discount factor (DF) should be applied when a map distance calculator is used to estimate hauling distance. DF is equal to 0 if using actual logged miles. Used for calculation	Discount factor is appropriate. Source of values applied are appropriate. Correct application.

Data Parameter	Assessment Team Findings
of baseline and project scenarios. Available at validation.	
W_M – Monitored quantity of each raw material used to produce HMA or FSB or asphalt emulsions. Used for calculation of project scenario material emissions.	Weight is appropriate. Source of values applied are appropriate. Correct application.
$Distance_P$ – Monitored total miles that trucks travel to supply raw materials to HMA plant or FSB plant. Used in calculation of project scenario to-plant emissions.	The total miles that trucks travelled to supply raw materials to HMA plant or FSB plant
$Distance_S$ – Monitored total miles that trucks travelled to supply products to job site. Used in calculation of project scenario to-plant emissions.	Distance is appropriate. Source of values applied are appropriate. Correct application.
C_{EL} – Monitored electricity consumption of the whole plant. Used in calculation of project scenario in-plant production emissions.	Parameter is appropriate. Source of values applied are appropriate. Correct application.
Project amount – Monitored output quantity of FSB and asphalt emulsions. Used in calculation of project scenario emissions	Parameter is appropriate. Source of values applied are appropriate. Correct application.
HR_{EQ} – Monitored total operating hours of on-site use of equipment. Used for calculation of project scenario equipment emissions.	Parameter is appropriate. Source of values applied are appropriate. Correct application.
HR_{LA} – Monitored total labor hours of on-site use of equipment. Used for calculation of project scenario equipment emissions.	Parameter is appropriate. Source of values applied are appropriate. Correct application.
DE – Monitored density of FSB or asphalt emulsions. Used for calculation of project scenario emission reductions.	Parameter is appropriate. Source of values applied are appropriate. Correct application.
LC – Monitored layer coefficient of FSB or asphalt emulsions. Used for calculation of project scenario emission reductions.	Parameter is appropriate. Source of values applied are appropriate. Correct application.
L – Monitored length of damaged pavement. Used for calculation of project scenario installation emissions.	Parameter is appropriate. Source of values applied are appropriate. Correct application.
S – Monitored running speed of cold recycler. Used for calculation of project scenario installation emissions.	Parameter is appropriate. Source of values applied are appropriate. Correct application.

The methodology instructs project proponents to detail the procedures for collecting and reporting all data and parameters listed in the monitoring plan. Input data should be checked for typical errors, including inconsistent physical units, unit conversion errors, typographical errors caused by data transcription from one document to another; and missing data for specific time periods or physical units. All data collected as a part of monitoring process should be archived electronically and be kept at least for two years after the end of the last project crediting period. All direct measurements should be conducted with calibrated measurement equipment according to relevant industry standards. Where direct measurements are not applied, project proponents must demonstrate the values used for the project are reasonably conservative, considering the uncertainty associated with these values.

4 ASSESSMENT CONCLUSION

The RCE assessment team concludes that the *Use of Foam Stabilized Base (FSB) and Emulsified Asphalt Mixtures in Pavement Application, (Methodology v. 1.96)* adheres to the methodology assessment criteria established for the first assessment. RCE concludes without qualifications or limitations that the *Use of Foam Stabilized Base (FSB) and Emulsified Asphalt Mixtures in Pavement Application, (Methodology v. 1.96)* meets the requirements of the VCS Program Guide, VCS Standard, VCS Guidance Standardized Methods, and the VCS Methodology Approval Process. As a result, RCE recommends that VCSA approve the methodology as prepared by GRR.

5 REPORT RECONCILIATION

RCE reviewed the document, "Second assessment report for the "Use of foam Stabilized base (FSB) and emulsified asphalt mixtures in pavement application" prepared by SCS Global Services (SCS), dated 29 May 2018. The assessment of v 1.96 of the methodology was approved by SCS. The report lists 18 findings and two observations that were issued during the course of the assessment. For each of the findings and observations, RCE reviewed the finding/observation, the project personnel response, and the auditor response. RCE concurs with the resolution of each of the findings and observations and finds no need for further assessment.

6 EVIDENCE OF FULFILMENT OF VVB ELIGIBILITY REQUIREMENTS

RCE met the eligibility requirements set out in the VCS Methodology Approval Process and VCS Standard based on its experience and accreditation in VCS Sectoral Scopes 4 and 6 and ANSI Scope 2, and used a standardized methods expert as part of the assessment team.

7 SIGNATURE

Signed for and on behalf of:

Name of entity: Ruby Canyon Engineering, Inc.

Signature: ____________________

Name of signatory: Bonny Crews

Date: 21 November 2018

8 APPENDIX A – DOCUMENTS REVIEWED

Bemanian, Sohila, et.al. (2006). *Cold In-Place Recycling and Full-Depth Reclamation Projects by Nevada Department of Transportation, State of the Practice*. Transportation Research Record: Journal of the Transportation Research Board, No 1949.

Emissionary, Inc. (2015 - 2017). *The Use of Foam Stabilized Base (FSB) and Emulsified Asphalt Mixtures in Pavement Application*, Versions 1.1 – 1.96.

Kim, Hyoungkwan (2013). *Assessment of Greenhouse Gas Emissions from Road Construction*. Yonsei University.

Diane J. Mundt , et.al (2009) *A Review of Changes in Composition of Hot Mix Asphalt in the United States*. Journal of Occupational and Environmental Hygiene, 6:11, 714-725, DOI: 10.1080/15459620903249125

NAPA (2012). *Manual of NAPA's Greenhouse Gas Calculator*. National Asphalt Pavement Association, Lanham, MD. <https://www.asphaltpavement.org/ghgc/GHGC%20v4%20instructions.pdf>. Page 3.

NAPA (2017). *Asphalt pavement industry survey on recycled materials and warm-mix asphalt usage:2014*. National Asphalt Pavement Association.

United Nations Framework Convention on Climate Change. (2005). *Report of the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol on its First Session, held at Montreal from 28 November to 10 December 2005.*

U.S. Department of Transportation (2011). *Reclaimed Asphalt Pavement in Asphalt Mixtures: State of the Practice*. Publication no. FHWA-HRT-11-021.

U.S. EPA (2000). *Hot Mix Asphalt Plants, Emission Assessment Report*. EPA-454/R-00-019.

Weber, Christopher, et. al. (2009). *The 2002 US Benchmark Version of the Economic Input-Output Life Cycle Assessment (EIO-LCS) Model*.

Additional materials reviewed included spreadsheets with calculations and survey response samples.

9 APPENDIX B – SUMMARY OF FINDINGS

Finding	Description	Project Proponent Response & Action
CAR1	Section 2. Summary Description of the Methodology: Per the instructional guidance in the VCS Methodology Template, please keep the summary concise and leave specific details to the pertinent sections of the methodology.	Section 2 has been rewritten concisely. The content that has been removed includes specific details about HMA and FSB productions, description of emission reduction opportunities, and the existing implementation barriers. This section emphasizes on the objectives, key applicability conditions, baseline scenario, and quantification framework. Please see the changes on pages 4and 5.
CAR2	Section 4. Applicability Conditions: The items in this section should clarify how a project activity applies to the methodology, without broad concepts of additionality that pertain to all projects. From the instructional guidance in the VCS Methodology Template: This methodology is applicable under the following conditions: • <Condition> • …	The format of Section 4 has been changed to strictly follow the instructional guidance in the VCS Methodology. Please see the changes on page 7-8.
CAR3	The VCS Methodology Template instructions require that, "The methodology must be written in a clear, logical, concise and precise manner, to aid readability and ensure consistent application by intended users." In order to comply with this, please engage a technical writer or similar editor to proofread the Methodology; there are numerous typos, grammatical errors, and unclear sentences that interfere with the document's readability.	As is seen in Version 1.3, the methodology has been revised to take the VCS Methodology Template instructions into account.
CAR4	Throughout the document please note the following language usage as set forth in the VCS Methodology Template v3.3: The methodology must use key words *must, should* and *may* appropriately. Consistent with best practice, must is to be used to indicate a firm requirement, should is to be used to indicate a (non-mandatory) recommendation and may is to be used to indicate a permissible or allowable	In the 11-13-15 version of the Methodology, GRR, clarified uses of the terms.

	option. The term *shall* is reserved for VCS program documents and is generally not appropriate for methodologies.	
CAR5	The "control group method" of quantifying GHG emissions reductions has a high potential for variability among project proponents (PPs) who might be applying the method. The method effectively asks the PP to develop an alternate performance benchmark for a separate geographic region. However, the data that are subjected to the suggested ANOVA statistical analysis are collected by the individual PPs, rather than from a single dataset from which all PPs would obtain data. And, these data are also highly variable in that they are collected as surveys from different individuals, and can be considered anecdotal in some instances. This, combined with each PP performing a complicated statistical analysis (for which they may not have experience), raises the risk and variability of the output of each developed "control group method" beyond what is reasonable for a standardized methodology. Please comment on this and provide justification for use of the "control group method" in light of this variability.	This method was removed from the methodology.
CAR6	The performance benchmark is derived from data that were collected in a limited geographic region: the upper mid-Atlantic region of the United States. According to Section 4.3.5 of the VCS Standard, "It may be necessary to stratify and establish multiple performance benchmarks, or to limit the applicability of the methodology to comply with [the requirement that geographic scope is considered]." Please demonstrate that the performance benchmark is applicable to all geographic regions of the United States. Alternatively, if the performance benchmark is not applicable to all regions of the United States, the methodology developers should establish multiple performance benchmarks that are applicable to all geographic regions of the United States.	The performance benchmark is applicable to all geographic regions with the following evidences. First, the study of Mundt (2009) indicates that HMA production throughout the country is being done in the same way other than difference in additives. As the proportion of additives are often less than 2%, the production difference due to additives can be reasonably ignored. Second, our sample was selected to consider the most critical variables that may affect HMA emissions. The data on those variables can explain the possible variance of nationwide HMA emissions. Detailed discussion on this issue can be found at the attached document "Full response to CAR 6.". Also, see document titled "Car 6_Mundt (2009), p.1 for 2% reference.

CAR7	The data presented for the development of the performance benchmark were gathered from surveys submitted to the methodology developers, who requested the information from several facilities. Surveys were completed by various individuals, likely with different backgrounds and knowledge of data collection (as opposed to simply gathering information). Please explain what measures were taken to ensure the data were collected consistently and accurately, and how the data were validated and normalized so that they could be subjected to a rigorous statistical analysis.	The data are reported with exactly the same format because a consistent survey form is used for all the facilities. The values of energy consumption for each facility are directly obtained from monthly utility bills. The values of mix design are obtained from facility production manuals. The values of equipment use are obtained from contractor's daily reports. Thus, those data cannot be subjectively changed by data reporters. The accuracy of those data has been double checked by the executive V.P. of each plant before being submitted to the methodology developers. A sample of the original surveyed data is provided as a seperate pdf file "CAR 7_Sample Data".
CAR8	Additionality, as discussed in Section 7 of the Methodology, is determined by comparison of the Project to the Performance Benchmark. If a Project Proponent chooses to develop their own baseline with the "control group method" or the "adjusted baseline method", there are no specific guidelines in the methodology for determining additionality in these cases. Please revise the methodology to offer a means of assessing additionality in these situations.	The "control group method" and the "adjusted baseline method" were removed from the methodology.
CAR9	The type of sampling method that occurred with regards to the HMA plants and projects is termed "convenience sampling" (a sample drawn without any underlying probability-based selection method) and is a non-probability sampling technique where the sample size is selected based on accessibility. This type of sampling is common for pilot or case studies and involves the following limitations: a. Systematic bias b. Limitation in generalization and inference making about the population c. Low external validity of the study The HMA plants and projects were willing to participate in the survey and were selected because of this willingness. This cannot be considered probability sampling where each individual in the population has an equal chance of being selected (in this case the population of all HMA plants and projects in the U.S.).	The HMA plants were selected to represent nationwide production characteristics, as opposed to willingness-based selection. Our sample covers all possible types of fuel used for plant combustion, including natural gas, oil, and propane. The proportion of each fuel type approximately represents fuel structure of HMA plants nationwide. Also, our sample includes the plants with RAP percentages from 5% to 43%, representing the typical range for RAP usage nationwide. Furthermore, our sample includes the plants with hauling distance ranging from 20mi to 70mi. This represents the typical conditions in the pavement projects those are using local aggregates and those are importing aggregates from other places. In addition to the above evidence, our sampling method has been approved by Professor William Gasarch from Department of Math at the UMD.

CAR10	In response to the sample size determination, GRR provided an equation from “Statistics for Engineering and the Sciences”. This equation uses the standard deviation of the total population; however the standard deviation in the equation is that of the sample (the plants and projects surveyed), not the population. RCE believes it is inappropriate to use a statistical inference (the equation provided) because the sampling method is one set of convenience sampling data.	In practice, a sample standard deviation can be used to approximate the population standard deviation. The sample size calculation example in "Statistics for Engineering and the Sciences" uses a sample standard deviation to estimate the population standard deviation. The use of this approximation has also been approved by Prof. William Gasarch from Department of Math at the UMD. Please refer to the attached letter "CAR 10_Sample Size Evaluation Letter". The validity of this approximation can also be found in course material from Boston University at http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_Power/BS704_Power_print.html
CAR11	The following are citation from the VCS Standard Chapter 4 Methodology Requirements 4.1.17 1) “The methodology shall provide a description and analysis of the current distribution of performance within the sector as such performance relates to the applicability of the methodology or each performance benchmark.” The statistical analysis does not “provide a description and analysis of the current distribution of performance within the sector” as data cannot be inferred about the population of all HMA and roadway projects.	A description of the current distribution of HMA performance has been added to Section 7. Please see the changes on pages 12 and 13.
CAR12	The following are citation from the VCS Standard Chapter 4 Methodology Requirements 4.1.17 3) b) “…Participation by experts shall be pro-actively sought and facilitated. Consultation that does not involve a representative group of experts shall be deemed insufficient.” A person with a background in statistical sampling, statistics or mathematics was not engaged to review the sampling procedure that GRR performed and believes that the panel was incomplete.	Professor William Gasarch from Department of Math at the UMD has been engaged to review the statistical method.
CAR13	Please review the comparison of the Baseline and Project activities’ emissions to be quantified and remove sources that are identical in the Baseline and Project.	Identical sources have been removed from Section 8.
CAR14	Section 6. Baseline Scenario: “Typically HMA requires more than 70% virgin aggregates…”. P. 3 contains a similar reference to “~80% virgin quarried	The statements have been revised. They are consistent as "more than 70% virgin aggregates…". Please see the change on page 4.

	aggregate". This is inconsistent, please rectify.	
CAR15	For transparency and clarity, please provide full calculations of equations in text, such as those in Section 7.	Full calculations related to the performance benchmarks in Section 7 have been provided in Appendix A on pages 29 to 34. Calculation equations related to FSB projects have been provided in Section 8.2 on pages 15 to 18.
CAR16	For transparency and clarity, please explain with more detail the equation inputs to be used by a potential Project Proponent. Also, it would be useful for the validation to provide a sample set of calculations from a real baseline project to which you could apply a potential FSB project.	Project inputs have been further explained in Section 8.2 and summarized in the tables in Section 9.2. A sample calculation for a FSB project has been provided as a separate Excel spreadsheet "Calculation Example for CAR 16." for your reference.
CAR17	Section 9.1.1 Please provide the value applied and justification for all data/parameters listed. Include further explanation of the electricity emission factors: are these regionally based, such as eGRID factors? 2nd Response: RCE recommends using the actual reference to the EPA eGRID summary tables, which are updated regularly.	The value applied and justification for all parameters have been added to the tables in Section 9.1.1. Electricity emission factors are regionally based, which has been explained in Section 9.1.1 on page 20. 2nd Response: EPA eGRID summary tables have been used as a reference and added to the reference list.
CAR18	In various sections throughout the methodology, there are discussions of current usage of recycled asphalt pavement (RAP) in hot mix asphalt (HMA) applications along with associated references. The references appear to refer to the use of RAP with warm mix asphalt (WMA). Please find applicable references to support the statements in the methodology.	The reference has been updated to NAPA (2017), which refers to the use of RAP with both HMA and WMA. The percentage of WMA is 30.8 % in the reference (See page 12).
CAR19	Please update all references to the use of recycled asphalt shingles (RAS) and RAP inclusion in HMA/WMA technologies to the most recent available. Additionally, please update the reference to the current state of HMA usage in the United States: Section 6. Baseline, states a >90% usage cited in a 2006 reference.	The use of RAP has been updated based on NAPA (2017). The percentage increased to 20.4% in 2014. Please see the changes in Section 7. The HMA usage data has also been updated in Section 6.
ADR1	In all documentation provided, please indicate specifically where the document contains information to support the methodology. Highlighting, specific page numbers, and other means of detailed location will be helpful.	Emissionairy noted the specific page numbers in an edited version of the methodology; the changes have not been incorporated into an updated version of the methodology. Subsequently submitted references have more detailed information regarding specific location(s) of referenced information.
ADR2	Please provide the data that comprise the performance benchmark analyses,	Emissionairy provided spreadsheets of inputs to the performance benchmark analysis.

	in an excel spreadsheet. Also include specific information regarding the methods of data collection and validation that confirmed consistent information from the various sources. Please describe how the set of data sources was determined.	
ADR3	Paragraph 2 of Section 7, Step 2 states: "According to the CDM Tool for the Demonstration and Assessment of Additionality, the performance benchmark is defined that [sic] 80% of existing HMA producers are exceed [sic] the benchmark emission level." Please refer to the specific location in the CDM tool where the 80% benchmark is defined.	Emissionairy offered the following response: "The reference for determining the performance benchmark is provided as attachment "CDM modalities". The place of 80% threshold is explained on page 12 in the methodology document."
ADR4	Please provide documentation to confirm that post-installation maintenance and product life of the FSB is comparable to HMA in targeted applications.	Studies from Pennsylvania, Nevada and Virginia DOTs have been cited to demonstrate that the use of FSB and asphalt emulsions, with a thick enough structural layer of HMA as surface course, can provide at least the same performance compared to conventional HMA pavements. A full response of this finding can be referred to a separate document "Full response to ADR.4.". The DOT studies have also been attached as separate pdf files labeled as ADR 4a,4b, and 4c.
CL1	Section 8.4: "For the adjusted baseline methodology, the predetermined baseline emission needs to be adjusted annually according to empirical prediction of an expert panel." Please describe the "empirical prediction" process, and the nature of the "expert panel" to include how the panel is chosen and whether the same panel is employed for each annual adjustment.	The referred statement doesn't exist in the latest submitted version. The adjustment of performance benchmark is described in Section 7, supported by the studies from National Asphalt Pavement Association.
CL2	Section 2: Summary description is inconsistent in two references to temperature required to heat the liquid in the FSB process; 310F and 300F	"300F" has been changed to "up to 310F" on page 5.
CL3	Section 5: Table 2 lists GHG sources included in/excluded from project boundary. GHGs CO_2, CH_4, and N_2O are included. However, the equations to	CO_2 equivalency (CO_2e) is used in project GHG emission calculation. CO_2e is a quantity that describes, for a mixture of greenhouse gas including CO_2, CH_4 and N_2O, the amount of

	calculate the project GHG emissions only include emission factors for CO2. Please clarify and provide justification of inclusion of CH4 and N2O as GHGs. 2nd Response: RCE understands GWP. The intention of the finding is to justify quantifying GHGs that are typically found in de minimis levels.	CO2 that would have the same global warming potential (GWP). The GWP for CH4 over 100 years is 25 and for N2O is 298. This means emitting 1 ton of CH4 and N2O is equivalent to emitting 25 and 298 tons of CO2. Take material emission calculation for example, CMUGDI (2008) reported producing 1 million dollars of cement emitted 11,400 tons of CO2, 5.24 tons of CH4 and 0.03 tons of N2O. Therefore, the total CO2e should be 11540 tons = 11,400 + 25*5.24 + 298*0.03. 2nd Response: As the emissions of CH4 and N2O are minimal in pavement projects, these emission sources could be excluded from project boundary
CL4	Section 7: Step 2 describes the calculation of the baseline scenario (use of HMA in a project). The strata descriptions refer to patching projects whereas the project types in Table 3 refer to parking lot projects. Please clarify.	In this document, patching projects and parking lot projects are the same. To avoid confusion, parking lot projects have been changed to patching projects in Table 3.
CL5	Please provide some guidance and explanation of what constitutes a project under this methodology. 2nd Response: Specifically, explain how a project proponent might include multiple paving projects under this methodology. See Sections 3.2 and 3.3 of the VCS Standard v3.6 for guidance.	A project has been explained in Section 7 on pages 12 and 13. 2nd Response: Calculations for multiple CCPR and CIR projects have been added to Section 8.2 and Section 8.4.
CL6	Please provide additional explanation and guidance to a project proponent regarding the calculation of net GHG emission reductions and removals. How do the calculated baseline emissions relate to the crediting baseline/performance benchmark?	The explanation for benchmark calculation has been added to Appendix A on page 33.
CL7	Section 3. of the methodology, Definitions, includes a definition for WMA (warm mix asphalt). The term is not used elsewhere in the methodology. Given the reduced GHG emission potential for WMA based on the decreased amount of heat required, please include a discussion of the FSA technology and its relation to WMA as	WMA is a subcategory of HMA and it is often defined as HMA that is produced within a target temperature discharge range using department approved WMA additives or processes. NAPA's 2014 statistics shows that approximately one third of HMA projects in the U.S. used WMA technologies (NAPA 2017). Both HMA and WMA serve as the baseline technologies. The above description has been

	you have done for HMA.	added to Section 6. Regarding the emission reduction potential of WMA, please refer to the Sheet "Note 1".
CL8	What are the procedures for missing data; what is the ramification for not monitoring data? 2nd Response: GE mentions use of estimations for missing data. Please include provisions for verification of the data. How will data be documented for verification? Estimations must be conservative, and perhaps apply a discount factor for any estimated data for conservativeness. 3rd Response: The discount factor was added to Section 9.1.1 on p. 23, and to the text describing Equation 3 on p. 16. Please clarify the use of the DF; in the parameter box, the DF data unit is between 0 and 1 yet all references to use of the DF apply 1.1. Also clarify that the DF is equal to 0 if using actual logged miles. Equations 3 and 4 should include the DF in the equation, as well as in the list of equation inputs, in the form of "... x (1 + DF)"	A disscusion on missing data has been added to Section 8.2.1. Typical situations include a lack of equipment operation hours, and a lack of material or product hauling distance. 2nd Response: The data documenting requirements have been added to both missing data cases. The use of discount factor has been introduced to the estimation of hauling distance. Please see the changes on pages 16 and 17. 3rd Response: Hauling distance = Map distance × (1+DF) was added on page 16. Equations 3 and 4 have been updated to the form of "…X (1+DF)". It has been clarified in the parameter box that DF is equal to 0 if using actual logged miles.
CL9	Equation 2 – emission factor units from Table 9.1.1 do not match material emission factor unit in Equation 2 (need to convert from kg to tonne or clarify). There are other materials in the plant surveys besides those listed in Table 9.1.1; why is crushed rock, sand, gravel and manufactured aggregates not included as materials Table 9.1.1? What are the references for the emission factors?	The unit of material emission factor is kgCO2e/kg, which means the kilogram of CO2 emitted from consuming 1 kilogram of material. Emission factors of crushed rock, sand, gravel and manufactured aggregates have been added to Table 9.1.1. The values come from ICE database - Hammond G., and Jones, C. (2011).
CL10	Why was delivery of RAP to the plant not included in the surveys?	RAP is considered as the waste from existing pavement. In a road rehabilitation project, RAP should be transported to another place no matter which pavement technology is used. Delivery of RAP is considered as the demolishment process of existing pavement, so its emission is not included in the FSB project emission.
CL11	Equation 3 – distance to plant is listed	Number of trips have been added to the

	as miles; however, the amount of trips needs to be defined. Alternatively, could clarify that miles is equal to distance times number of trips.	equations. Please see the changes in Section 8.2.1.
CL12	Equation 3 – For the calculation of emissions from receiving material/delivering material, will the same MPG factor be used for all vehicles or will this be vehicle specific?	The MPG factor will be the same for all vehicles as they are all dump trucks.
CL13	Equation 8 – the equation lists kg CO2e / hour; the emission factors in Appendix B are kg / hour. Please clarify what the 'kg' is referring to (kg CO2 or CO2e).	The unit is kgCO2e/hour. It has been clarified in Appendix B.
CL14	Equation 9 – the conversion factor (CF) does not match those in plant surveys. Is there a reason the CF's in Table 9.1.1 are different than those of the plant surveys?	We collected the parameters of "Percentage utilization (PU)" and used them to calculate "Conversion factors (CF)". A explanation for the calculation is in Table 9.1.1 on page 22. The data are consistent.
CL15	Table 4 lists two 'Patching Project (<40mile)'; one should be '(>40mile)'.	This typo has been corrected.
CL16	Section 9.3: this discussion of data outliers follows the description of the measured parameters that are inputs to the calculation equations. Please explain what measured data might contain outliers. Most of the data seem very straightforward and easily measured, e.g., time, distance, weights, etc. 2nd Response: RCE recommends this section be removed from the methodology. The application of statistical techniques to determine the presence of an outlier is outside the realm of this type of data. Incorrectly recorded data must be used as recorded; the project proponent should not eliminate data that were incorrectly measured or recorded. Project Proponents, during verification, can propose a methodology deviation for procedures relating to monitoring and measurement. Alternatively, the PP can propose a Project Description deviation if the activity differs from the individual project's PDD.	Outliers may be contained in data that are hard to be monitored, such as equipment operation hours. Especially when projects comprise of multiple segments, equipment often has long idling time that may be counted as operation time and causes reported operation hours longer than usual. The above explanation has been added to Section 9.3 Treatment of data outliers (page 30). 2nd Response: This section has been removed from the methodology.

VCS Approved Standardized Methods Expert Findings		
1	1) The performance benchmark metric for the crediting baseline should be included in section 6, Baseline Scenario. 2) The equations to calculate the baseline emissions should be included in section 8.1, baseline emissions. 2nd Response: Accepted, but in section 8.1 please adjust: 1) Improve sentence referring to Appendix A, for example "Appendix A describes the calculation of the baseline emissions performance benchmark." 2) Move to the appendix the text, "The emissions associated with materials, to-plant delivery, in-plant production are estimated through the survey of hot mix producers; and, the emissions associated with to-site delivery and on-site installation are estimated through the survey of patching and roadway projects." 3) Fix reference to table number	Based on the email response on 4/18, we revised Section 6 by making reference to the performance benchmarks in Table 3. In Section 8.1, we added some explanations on the calculation of baseline emissions based on emission intensities, and made reference to the method in Section 8.4. 2nd Response: 1) The sentence has been improved based on your advice. 2) The text has been moved to appendix. 3) Table number has been corrected.
2	As presented, it is not entirely clear that both the additionality benchmark and baseline benchmark become more stringent over time. Section 7 should refer to the table of factors for the years 2014-2020 (Table 4) to provide absolute clarity that the additionality benchmark decreases (becomes more stringent) in the same way as the baseline crediting benchmark.	A table for the changes in performance benchmarks has been added in Section 7.
3	Sections 7 and 8.4: The metric is defined based on output, in terms of kg of CO2 per tonne of asphalt. The metric should be defined in tonnes of CO2 per unit output.	The current metric is defined in kilograms of CO2 per unit output. This unit could keep four effective decimal digits, which is more accurate than using the unit of tonnes of CO2. We added notes below Tables 3, 4 and 5 about the conversion between different units.
4	The methodology does not provide an accurate description of the current distribution of performance in the	(1) FSB and asphalt emulsions are not a WMA technology. WMA technology is very similar to HMA technology. (2) WMA description has

	sector, nor does it provide a complete picture of the measures available for improving emissions performance in the sector. For example, current information has not been applied: the average percentage of RAP used in asphalt mixtures has increased from 15.6 percent in 2009 to 20.4 percent in 2014. Also, the methodology does not describe WMA as another technology reducing emissions in the sector; this technology is becoming more commonly applied in the USA. In 2014, WMA was about one-third of the total asphalt mixture market, having increased its share 577% since 2009, whereas the methodology cites 2006 data about the share of WMA. (1) Clarify if FSB and asphalt emulsions are considered a WMA technology. (2) Include WMA in the description and analysis of the current distribution of performance within the sector. (3) Use the most current information to describe the distribution of technology & performance within the sector, and remove the NAPA 2006 reference, which is outdated. 2nd Response: Accepted, but in section 6, please adjust: 1) Suggest change the first sentence to, "The baseline scenario for projects applying this methodology is the project where HMA, or the subcategory WMA, is applied to both the surface and base layers." 2) Delete the added text, "The HMA project also includes the use of WMA, given that they often use the same specification. WMA is a subcategory of HMA and it is often defined as HMA that is produced within a target temperature discharge range using department approved WMA additives or processes. "	been added to Sections 6 and 7. (3) The distribution of current technologies has been updated based on NAPA (2017). NAPA (2006) has been removed from reference list. 2nd Response: 1) The first sentence has been revised based on your advice. 2) The text has been deleted. 3) EPA (2015) shows that Hot mix asphalt (HMA) is the industry standard for production, with more than 94 percent of U.S. roads paved with HMA. This document is available online at https://www3.epa.gov/warm/pdfs/Asphalt_Concrete.pdf (page 2). This reference has been added to the methodology document.

	3) Add a reference demonstrating that HMA (and WMA) are the main paving materials used in the USA.	
5	Appendix C: Expert Panel Review: It appears that the performance benchmark has not taken into account adequately the use of RAP in HMA production or the increasing use of WMA production. Explain whether the performance benchmark adequately accounts for use of RAP in HMA production and WMA production, given the NAPA 2014 statistics, or adjust the performance benchmark.	The average percentage of RAP in our survey is 23%, closed to NAPA 2014 statistics 20.3%. The average percentage of WMA in our survey is 19%, less than NAPA 2014 statistics 32%. The difference in WMA percentage will not lead to the adjustment of performance benchmark. For details please refer to the Sheet "Note 1".
6	Appendix C: Expert Panel Review: The main consultation seems to have taken place in the form of one meeting. The extent to which the experts were able to review the performance benchmark prior to the meeting is not clear. Clarify all the steps included in the expert consultation, including any documentation provided to the experts ahead of the meeting and how much in advance of the meeting (e.g. days).	The Expert Review Panel meeting took place on June 23, 2014 at the University of Maryland, College Park Campus. In advance of the meeting the following timeline shows the efforts to convene a panel in accordance with the VSC Standardized Methods Expert Consultations document.
7	Section 2,3,6,7,8: The methodology provides 3 different benchmarks: two for parking lot paving projects and one for road paving projects. However, the terminology applied is confusing as both "patching" and "parking lot" is used to refer to the first type of project. Whereas "patching" seems like a different type of activity than "parking lot paving". Clarify the relationship between "patching" and "parking lot" projects, and make any necessary corrections to the methodology text or benchmarks to ensure consistency.	"Patching" and "Parking lot" projects have the same meaning in this methodology. They have been named consistently as "patching projects" to avoid confusion.
8	Section 4: The applicability conditions mention "FDR process", whereas this is hardly	FDR is a cold recycling technique that is very similar to CIR. The only difference is that FDR pulverizes full thickness of the asphalt

	mentioned in the rest of the methodology. Describe FDR, how commonly it is used, and its emissions performance, in the context of whether it can be considered to be a technology whose application requires intervention of the carbon market, or remove it from the methodology.	pavement (8 to 12 inches), while CIR only pulverizes the top and base layers (6 to 8 inches). As noted in the definition of FDR, the emission from FDR can be quantified using the same method as CIR. To make it clear, FDR has been added to the calculation sections of CIR.
9	Section 4: The applicability conditions state that the methodology does not apply to "project activities that include the use of warm mix asphalt or hot mix asphalt…". Nevertheless, it appears that the paving projects that will use this methodology must use HMA, since FSB is used as a base layer below an HMA surface layer. Clarify this issue, which may include clarifying the applicability conditions to describe more precisely the type of project activities to which the methodology applies.	FSB projects may use HMA as surface layer. Relevant applicability condition has been changed to "Project activities could have a HMA surface layer but must have at least one FSB or asphalt emulsions base layer.", and the methodology is not applicable to "project activities that only have warm mix asphalt or hot mix asphalt base layers."
10	Sections 4, 7, and 8: The uniformity of geographic scope in terms of HMA production and application was clarified during the assessment. Nevertheless, the role of grid emission factors in the performance benchmark is not clear. Explain whether regional differences in grid emission factors can be ignored in the performance benchmark, and why.	The differences can be reasonably ignored because grid emission only account for about 1% of total project emission.
11	Sections 2,3,6,7, and 8: The information stated about baseline practices (percent of HMA used in pavement construction, average percent of RAP used in HMA) is outdated, such that the performance benchmark for the crediting baseline probably does not describe the most plausible baseline scenario. Explain how the performance benchmark for the crediting baseline represents the most plausible baseline scenario or the aggregated baseline scenario, or adjust the performance benchmark to improve	The average percentage of RAP in our survey is 23%, closed to NAPA 2014 statistics 20.3%. The average percentage of WMA in our survey is 19%, less than NAPA 2014 statistics 32%. The difference in WMA percentage will not lead to the adjustment of performance benchmark. For details please refer to the Sheet "Note 1".

	its representativeness.	
12	Sections 2,3,6,7, and 8: The standardized method has not been developed using the most current information. Update the information used to justify the appropriateness of the standardized method.	The distribution of current technologies has been updated based on NAPA (2017).
13	Section 6: 1) Only HMA is identified as a baseline. However recent data show that HMA represents only around 67% of asphalt application (2014). 2) It is not clear to what extent HMA versus other materials are used in the specific application where FSB or asphalt emulsions may be applied, i.e. as a pavement base layer. 3) The threshold has been set in line with EB65 Annex 23, Appendix I, not the CDM M&P. 1) Correct or justify use of HMA only as baseline technology. 2) Clarify the alternative technologies specifically in the case of pavement base layers, i.e. where FSB can be applied. 3) Correct the reference to the UNFCCC document used for setting the threshold.	1) The baseline technology contains both HMA and WMA technologies, as described in Section 6. 2) It has been clarified in Section 6 that, in the base scenario, HMA or WMA should be applied to both surface and base layers. FSB is used to replace base layers. 3) The correct reference is UNFCCC (2006). "Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol". Framework Convention on Climate Change. page. 17
14	Section 8, Appendix A: The data on GHG from HMA road paving installation, from Michigan Technological University, seems adequately reliable. However: 1) the selection of MTU data applied for the calculation of installation emissions ("Materials Emissions") is not analogous to the emissions sources used for calculation of installation emissions from the parking lot projects. The equivalent emission source as presented in MTU PE-2 would appear to be "Equipment Emissions". 2) the MTU data were collected from projects using a variety of paving technologies, not only HMA.	1) PE-2 Equipment emission has been used to calculate installation emissions for roadways. Table A4 in Appendix A has been changed to present equipment emissions. 2) Only HMA projects have been selected to do the calculation. The performance benchmark for roadway projects has been updated accordingly, as shown in Table 3 in Section 7. 2nd Response: 1) We didn't directly take the asphaltic tonnage from the MTU website because for some projects, their reported values contain not only HMA but also other curing materials. Instead, we took data from their material query list NO. 904 Asphaltic Materials, divided by the asphalt emission

	1) and 2) Review and explain emissions sources considered in the case of installation emissions for roadways (road paving). 2nd Response: 1) Please double check all the "asphaltic materials" numbers since they do not seem to match the reports on the MTU website. 2) To enable identification, please use a more specific name for the projects (for example, full name, i.e. "US-31 HMA Reconstruct"). 3rd Response: 2) Closed. 1) In the material query list, why are "asphalt mix" materials not considered, instead of or along with "asphaltic materials"? Please demonstrate that the materials included for the calculation of baseline emissions represent the same scope of the materials that will be considered for project emission calculations. 4th Response: 1) It is not clear why "I-69 Concrete reconstruct" project consisting of "10.14 miles of concrete pavement and shoulder reconstruction" is included as an HMA project. The other seven projects considered, of the 14 total available from the MTU data, seem correct. 2) Why is the emission factor 12.9 kgCO2/t applied to all calculations now for reconstruction of material amounts, whereas different emission factors are stated in the MTU study (1.14, 1.12, and 1.23 tCO2/100 MT asphaltic pavement materials)? 3) In the methodology text, update Table 5 also, in addition to Table 4 and Table A4.	factors shown on the project main page. Take US-131 for example, the material query shows the emission for NO.904 Asphaltic Materials is 45.4 MT, and asphalt emission factor is reported as 1.14 MT of CO2/100 MT. The asphaltic material weight is 45.4/1.14*100=3982.5 MT. Details about the calculation for all other projects are described in Note 5. 2) All project names have been updated to full names. 3rd Response: As discussed in the conference call, we used Asphalt Mix (material query list NO. 924) to determine equipment emissions. NO 924 Asphalt Mix is HMA, while No 904 represents microsurfacing and other prepreventive treatment. We followed the suggestion and revised all emission values and roadway performance benchmark. Please see the changes in the performance benchmark table in Section 7 on page 13. 4th Response: 1) I-69 Project contains approximately 300 tonne HMA pavement (item No. 924). HMA was used for some section of pavement, ramp, etc. In our analysis, only HMA was included in the calculation. 2) The emission factors published online are asphaltic materials emission factors, which represents all pavement materials and components, for example, HMA, binder, bond coat and microsurfacing materials. HMA emission factor, 12.9 kgCO2/t, was published in Table 4-8 of the MTU report on PE-2 technical details (page 44). This report is available at https://www.michigan.gov/documents/mdot/MDOT_Research__Report_RC-1553_363800_7.pdf 3) Table 5 has been updated.
15	Section 8, Appendix A: The directly surveyed data are from 2013, which is	Emission factors for construction equipment are obtained from EPA's Engine Certification

	adequate. The PE-2 data are from 2011; however, the intensity of emissions sources are not likely to have changed much since that time so the time period is considered adequate. The emission factors from The Climate Registry are also acceptable. However, the source of the emission factors for construction equipment in Appendix B is not clear. Clarify the source and year of the emission factors for construction equipment in Appendix B. 2nd Response: Accepted, but please add reference to the source (EPA 2012) to the Appendix B.	Database for Heavy Truck, Buses, and Engines in 2010. The original data has been provided in the Dropbox folder (EPA has reorganized the website so the original link has not been accessible anymore). EPA has stopped release equipment manufacture information since 2011, so they are the most recent data we could find. 2nd Response: The reference EPA (2012) has been added to the Appendix B. Please see the change on page 37.
16	Section 8, Appendix A: The data examples provided in the Appendix are not transparent and do not permit reconstruction of the GHG estimates. 1) Table A1 seems to show calculation errors. 2) The results shown in Table A3 cannot be replicated. 1) Correct errors in Table A1. 2) Explain and provide excel worksheet to show how the data in Table A3 permit one to calculate the GHG intensities in the final row of the table. 2nd Response: Response regarding Table A3, accepted. 1) In Table A1, please add a column showing the amounts of raw materials in metric tonnes. 2) Please demonstrate calculation of "Raw material delivery" amounts, as this also cannot be replicated with the information provided.	1) In Table A1, the unit of HMA output is US ton instead of metric ton, so a conversion factor of 1.1 is applied when calculating its emission intensity. The unit has been clarified in this table. Calculations for this table have been checked. 2) The sheet "Note 3" has been provided to show the calculation process. 2nd Response: 1) The amounts of raw materials have been shown in metric tonnes in Table A1. 2) The calculation of raw material delivery emission is demonstrated in Note 6.
17	Section 8, Appendix A: It is not clear how the default correction factors in Section 8.4 have been determined. 1) Provide detailed calculations of the correction factors, including excel worksheets. 2) Consider providing an equation to	1) The sheet "Note 4" has been provided to explain detailed calculation. 2) An equation to calculate project specific correction factors has been provided as Equation 14 in Section 8.4. 3) Correction factors reflect the difference in structural performance between baseline and project materials. They should be used when

	calculate project-specific correction factors, rather than default correction factors, taking into account density and thickness requirements for the application of FSB in the specific project activity. 3) Correction factors should be incorporated in the project emissions section (8.3). 2nd Response: 1) Provide the source of the values "The structural layer coefficient for a 19mm HMA base mix is 0.40." 2) Add a guide to the parameters used in the new equation 14 ("Where…") , and add these parameters to section 9. 3) Now that the meaning of coefficient is clear, it appears the equations 15-26 could be improved. It seems that a more accurate representation of emission reductions from a project would be, using the example of equation 15, [CB * Project amount / correction factor - CCPR_EI * Project amount], which simplifies to [(CB/correction factor - CCPR_EI) * Project amount].	quantify project emission reductions as compared to baseline scenario. They are not a part of project emission. 2nd Response: 1) Federal Highway Administration gives the range of HMA layer coefficient to be 0.40-0.50. The data can be found at http://www.pavementinteractive.org/the-aashto-reliability-concept/. As the increase use of RAP (lower structural strength) in HMA production in recent years, 0.40 is used to represent HMA layer coefficient in this methodology. The reference has been added to page 30. 2) A parameter guide has been added below Equation 14. Tables of parameter descriptions have been added to Sections 9.2.1 and 9.2.2. 3) Equations 15-26 have been revised based on your advice. Please see the changes on page 20.
18	Section 8.1: The baseline emissions section does not describe the equation to calculate baseline emissions. Provide the calculation for baseline emissions in section 8.1	Based on the email response on 4/18, we didn't change the Appendix A that contains the calculation of the baseline emissions intensity. We added some explanations on the calculation of baseline emissions based on emission intensities, and made reference to the method in Section 8.4.
19	Section 8.4: A calculation for net emission reductions is included; however, it is not quantified as the difference between the GHG emissions relevant for the project and baseline scenario. Provide the calculation of net emission reductions as the difference between the GHG emissions in the baseline scenario and project, in section 8.4.	Based on the email response on 4/18, our proposed method is acceptable. The net emission reduction is calculated by "difference in emission intensity * project quantity"