Greenhouse Gas Reduction Fund Investments: Project Outcome Reporting Data Collection and Assessment

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About the UC Davis Policy Institute for Energy, Environment, and the Economy

The University of California, Davis Policy Institute for Energy, Environment, and the Economy (Policy Institute) was the contractor for this project. The Policy Institute leverages university expertise and engages directly with decision-makers to deliver credible, relevant, and timely information to inform better energy and environmental policy.

The primary members of the project team were principal investigator Austin L. Brown, Brian Harold, and Colin Murphy, of the Policy Institute.

Disclaimer

The statements, conclusions, and recommendations in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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Executive Summary

Study Goal

California Climate Investments is the portfolio of energy, transportation, natural resources, and related programs that are funded through Cap-and-Trade auction proceeds from the Greenhouse Gas Reduction Fund (GGRF). California Climate Investments programs fund projects that seek to reduce greenhouse gas (GHG) emissions and achieve environmental and socioeconomic benefits within the state of California.

California Climate Investments programs are administered by a wide range of state agencies. The California Air Resources Board (CARB) is responsible for issuing program guidelines, developing Quantification Methodologies (QMs) and calculators which serve as the source of GHG benefits estimates, and conducting other activities related to the administration and oversight of California Climate Investments.

CARB developed a Project Outcome Reporting (POR) phase for California Climate Investments which is intended to collect primary data from grantees and program administering agencies during the period following project implementation to gain insights into project results. In its efforts to implement POR as a reporting phase, CARB determined that there may be opportunities to improve the data collection processes and information obtained through POR and enhance its effectiveness as an evaluation tool.

The University of California, Davis Policy Institute for Energy, Environment, and the Economy (Policy Institute, herein referred to as "the Project Team") was tasked with reviewing the current set of POR requirements and recommending additional or alternative metrics and methods based on best practices in data collection and analysis. The Project Team then sampled 40 California Climate Investments projects and conducted POR data collection to demonstrate these metrics and methods and identify additional data collection and analysis considerations. The primary objective of these efforts was to develop findings and recommendations to support improved data collection, analysis, transparency, and evaluation for individual programs and the California Climate Investments portfolio.

The project involved the collection of a wide range of quantitative data. However, in accordance with CARB objectives for this project, much of the analysis effort focused on developing qualitative findings regarding the strengths and limitations of POR as a reporting phase.

Approach

Each California Climate Investments program was reviewed to identify those that should be assessed for additional or revised POR metrics and selected for POR data collection.

The existing and draft POR metrics and stipulated data collection methods were then reviewed for each program that was selected for metrics and methods assessment. The purpose of these assessments was to recommend additional and refined metrics and methods. These preliminary recommendations were developed prior to the data collection process to allow the Project Team to demonstrate data collection of both original POR metrics and newly recommended metrics.

Following initial metrics recommendations, the Project Team analyzed the list of implemented California Climate Investments projects that were eligible for POR to sample 40 projects for POR data collection. The following table displays the number of sampled projects by program.

Table EX-1. Sampled Projects by Program

Program Name	Sampled Projects
Low Carbon Transit Operations Program	4
Transit and Intercity Rail Capital Program	5
Affordable Housing and Sustainable Communities	5
State Water Efficiency Enhancement Program	6
Low-Income Weatherization	4
Forest Health Program	7
Urban and Community Forestry	3
Urban Greening	1
Car Sharing and Mobility Options Pilot	1
Zero-Emission Truck and Bus Pilot	1
Off-Road Advanced Technology Demonstrations Pilot	1
On-Road Advanced Technology Demonstrations Pilot	1
Advanced Technology Freight Demonstration	1
Total	**40**

The data collection and project assessments focused on collecting all available data to calculate the applicable POR metrics per program, assessing barriers to data collection, and considering opportunities to recommend additional or revised metrics. Assessment activities varied by program and project type, but generally included:

- Administering Agency Interviews and Documentation Requests;
- Project Documentation Reviews;
- Grantee and Project Partner Interviews and Data Requests;
- Survey Data Collection;
- Analysis of Data Records;
- Remote Observation of Project Sites with Aerial Imagery (if applicable); and
- Assessment of Barriers and Evaluation Considerations.

Results

Through the course of the data collection and assessment process, the Project Team identified additional and revised metrics to recommend for POR within sampled programs. Several existing metrics were identified as unlikely to provide insight into project outcomes due to data collection barriers, analytical challenges, or administering agency and grantee resource limitations.

The assessment resulted in a wide range of findings related to data collection and analysis opportunities and challenges. In addition to recommending the addition or revision of POR metrics, recommendations

were developed to improve program data collection procedures, enhance the potential of POR as a reporting phase, and support improved evaluation of California Climate Investments programs overall.

Challenges and Limitations of POR

The assessment identified a series of data collection challenges, analytical barriers, and other issues which present limitations to the use of POR as an evaluation tool for California Climate Investments programs.

The scope and depth of POR is dependent on the existing resources and expertise available to grantees and administering agencies.

As agencies and grantees may not have the funding to contract with third-party evaluators or subject matter experts for POR, CARB has specified that data collection and analysis methods must be accessible to individuals who may not have expertise in topics such as statistics, survey research, technical data monitoring, or experimental design. This reduces the level of rigor that can be required, and limits the extent to which POR can align with evaluation best practices or provide insight into metrics such as changes in ridership or energy use resulting from funded activities.

Insight into project benefits and outcomes is somewhat dependent on whether additional measurement and verification occurs outside of the POR phase.

POR is not designed to serve as a final inspection of implemented projects, and projects may or may not receive inspections at the time of closeout to verify that measures or treatments were implemented as planned. Clear records indicating the status of projects at closeout would serve as a reference point of final scope and characteristics that could later be compared to data collected during the outcome period. In the absence of this information, it may be difficult to use POR data to develop conclusions about changes in projects between the point of closeout and the outcome period.

Projects with low evaluability may not be selected for POR, which may limit the representativeness of POR data.

During the project sampling task, administering agencies indicated that several sampled projects may not be suitable candidates for POR due to project complexity or data collection barriers. In their past selection of POR projects, some administering agencies have used a random sampling approach, while others have selected projects that are likely to allow for sufficient data collection and have excluded projects that may be difficult to measure. If a significant portion of California Climate Investments projects are systematically excluded from POR due to these evaluability issues, the subset of projects that complete outcome reporting may not be representative of programs.

There is not yet a formally defined process for using POR data as an evaluation tool, which creates challenges in determining an appropriate set of metrics and may discourage participation in reporting.

While POR was designed to focus on collecting metrics that are linked to project GHG emission reductions, it is not necessarily intended to formally compare project measurements to initial expectations, calculate revised GHG estimates, or assess the cost-effectiveness of funded projects. Additionally, limitations and challenges associated with POR have created barriers to achieving the overall POR purpose of supporting accountability and transparency in communicating program successes.

Without a precise and achievable POR goal for each program, it is difficult to determine what data should be collected. Administering agencies have expressed concerns about increased reporting requirements and may be adverse to collecting POR data or asking grantees to participate unless there is a clear process for applying the collected data toward a specific purpose.

Recommended Program Specific Purposes of POR

The effective purpose of POR may vary by program due to differences between program components, procedures, limitations, and opportunities. In addition to recommending POR metrics and improved data collection procedures, the assessment resulted in recommended POR purposes for each sampled program.

Low Carbon Transit Operations Program (LCTOP), Transit and Intercity Rail Capital Program (TIRCP), and other transit projects

In its current form, POR stipulates a uniform set of metrics and data collection approaches for all capital transit improvement projects and is not designed to provide customized guidance for specific projects. Due to this, the extent to which POR can provide insight into project benefits is somewhat dependent on the complexity of each project and the uniformity of projects within a program. With transit agencies using a wide variety of methods for estimating the ridership increases that will result from California Climate Investments funding, and the many factors which affect ridership for a transit system or individual service line, the level of complexity for transit projects is high and the level of uniformity across transit projects is low. POR is unlikely to serve as a method of quantifying the ridership impacts that are attributable to funded projects. However, POR may serve to verify the ongoing status of projects, collect data that could be used to validate ridership or trip length inputs that were initially used within program QM calculators, and potentially inform future updates to QM assumptions and calculations.

Affordable Housing and Sustainable Communities (AHSC)

For affordable housing developments, POR data collected through resident surveying with high response rates could provide insight into transportation behavior changes over time at a single site, as well as differences in mode share across multiple sites. Administering agencies may be able to use survey results and occupancy data as a quality assurance tool, such as to identify opportunities for improving transportation access at a site where residents report that their access to transportation is low.

In-depth analysis such as using survey results to assess GHG outcomes and other quantitative program benefits is likely outside the scope and resources of the current POR framework and would require enhancements such as dedicated resources or staff to conduct uniform, statistically representative data collection.

State Water Efficiency and Enhancement Program (SWEEP) and other water efficiency projects

POR can serve as a method for conducting basic measurement and verification of project status, obtaining water and energy usage records for possible future comprehensive assessment, and tracking overall energy and water use of participating sites. However, based on the variety and complexity of SWEEP projects and sites, evaluation activities such as estimating the changes in water or energy use that can be attributed to SWEEP treatments or recalculating project GHG benefits should only be completed through more advanced billing data analyses or monitoring studies that are likely beyond the scope of the current POR framework and its associated resources.

Low-Income Weatherization Program

POR can serve as a method for conducting basic measurement and verification of project status, obtaining energy usage records for possible future comprehensive assessment, and tracking overall energy use of participating sites. Activities such as analyzing bills to estimate changes in energy use attributed to LIWP treatments should only be completed through more resource-intensive, rigorous evaluation efforts outside of POR that include best practices such as weather-normalizing usage data and incorporating a comparison group.

Forest Health and other land management and conservation projects

POR can serve as a valuable monitoring tool to assess the status of project sites over time and identify issues such as disturbances resulting from fire or other ecological distress. Assuming that CAL FIRE and other administering agencies are able to conduct consistent in-depth monitoring of sites, POR can also be used to collect key metrics that relate to project GHG benefits such as tree mortality rates from fire, mortality of planted trees, and annual biomass utilization. If there are persistent barriers to this level of data collection for treated sites, POR may be limited to tracking disturbances and identifying major issues that conflict with expectations for individual projects or project types.

Urban and Community Forestry (UCF) and Urban Greening (UG), and other urban forestry projects

Aerial imagery monitoring or on-site visits conducted as part of POR can serve as a method of tracking project status and general tree health over time. Additionally, the detailed narratives collected by administering agencies during the implementation period suggest that grantees may be willing to provide ongoing qualitative information regarding project successes and impacts upon request.

If collected, quantitative metrics such as tree mortality rates and biomass generation could be used to validate QM assumptions and develop revised GHG estimates during the outcome period for comparison to initial estimates. The ability of POR to consistently collect information on tree mortality rates likely depends on the abilities and resources of urban foresters and administering agencies. Further discussions among CARB, administering agencies, and grantees are likely needed, as well as possible pilot data collection efforts, in order to determine the feasibility of implementing one or more of these methods in support of POR.

Low Carbon Transportation: Clean/Shared Mobility Options

POR may be used as a method of validating project QM estimates and as a broader evaluation tool, depending on the metrics collected. As Clean/Shared Mobility Options quarterly reports include revised GHG reductions estimates based on operational data such as vehicle miles traveled, POR could be used as a method of validating those estimates if GHG assessment were to be added as a component of POR.

In contrast, survey-based metrics cannot be directly linked to specific QM inputs but may provide insight into project effects on mode share and improved mobility for priority populations. With robust data collection efforts, these metrics could be compared across projects to identify outliers for further analysis. However, obtaining reliable and representative survey results would require additional data collection resources and active involvement from individuals with expertise in research design and statistical analysis.

Finally, assessments of operational objectives such as financial sustainability and scalability of Clean/Shared Mobility Options are likely beyond the scope of the prescriptive metrics-based POR format.

These assessments would be best completed as part of separate in-depth studies, several of which are currently being conducted by academic and industry researchers to characterize and evaluate shared mobility business models.

Low Carbon Transportation: Advanced Technology Demonstrations

As these projects currently receive in-depth evaluations as part of their grant requirements, POR can be used as a method of aggregating metrics across multiple projects and ensuring that grantees are reporting a standardized set of relevant metrics. It may be difficult to use POR to gain insights at the program level due to the distinct structure and objectives of different demonstration projects. POR data collection may also be limited to the duration of the demonstration period, depending on the status of continued operation and monitoring of vehicles and equipment.

Rather than relying on individual POR metrics to interpret results, the in-depth final reports completed for each of these grants are likely the best source of information on project outcomes due to the additional context and data that they provide. The final reports also provide revised estimates of project GHG reductions and other benefits using primary data collected during the demonstration period, which is a step beyond the current scope of POR. In combination with these reports, POR can continue to serve as a quality assurance tool by collecting key metrics that can be compared to initial project expectations and potentially identify issues that require further assessment or review.

Overall Recommendations

Based on the findings from the metrics assessment, sample data collection, and analysis, the key recommendations provided for CARB consideration are as follows.

Consider opportunities for enhanced evaluation of California Climate Investments programs, including appropriating or allocating additional resources to primary data collection.

CARB has expressed interest in obtaining actionable insights into California Climate Investments programs from primary project data. Program evaluations can measure the success of programs in meeting their goals, inform investment decisions, and improve performance with respect to the effectiveness of treatments, measures, and program resources. While POR may be further developed to provide valuable information in assessing outcomes of California Climate Investments programs, it faces challenges in serving as a comprehensive or reliable program evaluation tool, due in part to limitations in the resources and evaluation expertise available to administering agencies and grantees. There may be opportunities to improve upon the current level of rigor used to evaluate program processes, GHG benefits, and other impacts of GGRF investments. Specific opportunities for enhanced evaluation of California Climate Investments programs may include:

- **Conducting in-depth evaluations for a small sample of projects:** As a first step in improving evaluation procedures within California Climate Investments, a small sample of in-depth third-party evaluations could serve as case studies of how verified and measured project results compare to QM-based expectations. These targeted evaluations would use best practices in data collection and analysis and would allow for the development and refinement of evaluation methods for selected project types. Evaluation efforts would then be expanded to larger samples of projects based on the availability of funds and key issues identified through the initial case studies.

- **Allocating dedicated evaluation funding based on a percentage of grant funds:** Evaluation funding equal to a small percentage of total grant dollars would allow agencies or grantees to contract with third-party evaluators with subject matter expertise in each program and in data collection and analysis. CARB Advanced Technology Demonstrations projects serve as an example of incorporating evaluation, measurement, and verification (EM&V) into the grant structure. Efforts at this scale would use primary data to obtain measured and verified GHG benefits estimates for comparison with project expectations. As CARB does not have the authority to allocate California Climate Investments funding to program evaluation, implementing this framework would require another dedicated funding source or a legislative modification to funding allocations. If this approach would result in funds being shifted from project implementation towards evaluation, it would be necessary to carefully balance the potential benefits of evaluation against the benefits of implementation by determining the appropriate evaluation resources for each program depending on program size, evaluation research questions, and uncertainty in GHG benefits estimates.
- **Conducting expanded evaluation through contract dollars:** Developing a formal framework for issuing contracts to third-party evaluators would allow California Climate Investments to conduct periodic in-depth evaluations of programs. The evaluation types present within other program portfolios such as the Regional Greenhouse Gas Initiative, including impact evaluations, process evaluations, market evaluations, and evaluability assessments, may serve as examples for California Climate Investments. The frequency of these evaluations could be annual, biannual, or determined for each program based on the availability of funds and identification of program-specific issues that may benefit from evaluation.
- **Developing internal evaluation resources:** As the agency responsible for developing funding and data collection requirements, it may be appropriate for CARB to increase its role in the evaluation of California Climate Investments programs. This could involve establishing a work group that is responsible for assisting agencies and grantees with primary data collection and analysis, either as part of POR or to assess verified GHG reductions and co-benefits. Direct involvement from staff with expertise in program evaluation may improve the success of data collection efforts and the reliability of results. Development of internal evaluation expertise may be achievable to some extent with existing CARB resources, or may be more formally and widely implemented depending on legislative guidance.
- **Conducting increased measurement and verification (M&V) during closeout for operational projects:** Currently, the data collected upon project closeout for some programs exclusively involves verifying that funds have been expended or that the grantee indicates that the work was completed. For projects that are operational by the time of grant closeout, conducting a thorough verification of project components at closeout and adjusting QM inputs as needed would improve the reliability of reported benefits. Additionally, thorough documentation of final project characteristics at the point of closeout would facilitate successful data collection and assessment during the outcome period.

Conduct POR sampling on behalf of agencies, or advise agencies to use a statistical sampling method that can be reviewed.

Current POR guidelines specify that a subset of projects must be selected for outcome reporting, but do not include guidance for how to conduct project selection. It would be useful for CARB use a statistical sampling method such as random sampling to select projects within each program for POR, to better

ensure objectivity and allow CARB to identify evaluability issues if agencies indicate that a sampled project cannot comply with POR requirements. While it may still be necessary to re-sample a portion of projects due to evaluability issues, this approach would improve the visibility of these issues and potentially lead to strategies to overcome them.

If California Climate Investments has a goal of using POR to make program-level generalizations, CARB should also ensure that POR samples are statistically representative of programs in terms of project types, amount of funding, and GHG benefits included in the sample. Otherwise, POR findings should be viewed as reflective of individual projects rather than programs as a whole.

Facilitate improvements in communications and program materials to ensure that administering agencies and grantees have a clear understanding of data collection requirements, metrics definitions, and reporting expectations.

Many grantees of sampled projects were unaware that they may be asked to provide data to support the assessment of POR metrics, and several administering agencies were not familiar with POR guidelines. Additionally, grantees of sampled projects had different interpretations of certain POR metrics and QM inputs. Further communication with agencies and grantees to clarify the definitions of QM inputs and POR metrics would help to improve the consistency of reported data. Administering agencies should also notify grant applicants that they may be expected to provide outcome-related data for their projects and ensure that grantees understand these requirements prior to the outcome period.

Clarify how POR data will be used for each program and ensure data are collected and retained in a manner that is sufficient for necessary analyses and interpretations.

Developing a clear process for using data collected through POR, either by project type or for California Climate Investments as a whole, would help to guide data collection efforts and make improvements to the POR phase. This would involve determining whether and how metrics will be used to inform QM calculations, make quality assurance improvements, track and report co-benefits, or serve other evaluation purposes. Upon defining how each metric will be used within each program, it will be important to develop a data template for each program that clearly organizes metrics and contains all fields that are necessary to reliably interpret collected outcomes.

Explore opportunities to strengthen the link between research studies and reported program results.

In-depth research studies have been conducted through GGRF and non-GGRF funds to assess the impacts and processes of individual California Climate Investments projects and program components. Some of these studies may provide insight into project-specific GHG impacts or co-benefits, and may thereby fulfill certain evaluation needs that are not currently met with POR. As California Climate Investments primarily relies on QM calculator estimates to assess and communicate the results of projects, there may be opportunities for CARB to incorporate results of relevant analytical research into its publicly presented materials that describe the impacts of GGRF as a funding mechanism.

Introduction

The UC Davis Policy Institute for Energy, Environment, and the Economy (herein referred to as the "Project Team") was contracted by the California Air Resources Board (CARB) to evaluate the current Project Outcome Reporting (POR) guidance for California Climate Investments programs receiving funding through the Greenhouse Gas Reduction Fund (GGRF). The purpose of this contract was to refine existing data collection methods and metrics, collect and analyze POR data for a sample of projects, and develop conclusions and recommendations in support of improved evaluation of California Climate Investments programs.

California Climate Investments

California Climate Investments is the portfolio of energy, transportation, natural resources, and related programs that are funded through Cap-and-Trade auction proceeds from the Greenhouse Gas Reduction Fund (GGRF). California Climate Investments programs fund projects that seek to reduce or facilitate the reduction of greenhouse gas (GHG) emissions and achieve environmental and socioeconomic benefits within the state of California.[1] As per Senate Bill (SB) 535 and Assembly Bill (AB) 1550, a minimum of 35% of Cap-and-Trade proceeds must directly benefit low-income populations and environmentally disadvantaged communities, referred to by California Climate Investments as priority populations.[2]

California Climate Investments programs are administered by a wide range of state agencies such as the California Air Resources Board (CARB), the California Department of Forestry and Fire Protection (CAL FIRE), the California Department of Transportation (Caltrans), and the California Department of Food and Agriculture (CDFA), and the California Strategic Growth Council (SGC), among others. CARB is responsible for developing program guidelines, issuing benefits quantification and reporting requirements, preparing the annual report to the legislature, and conducting other activities related to the administration and oversight of programs.

Administering agencies are responsible for designing and implementing programs in compliance with California Climate Investments Funding Guidelines that are issued by CARB. The Funding Guidelines are designed to ensure that programs meet the legislative requirements of California Climate Investments programs including facilitating GHG emission reductions, maximizing benefits to priority populations, and allowing for sufficient accountability and transparency. Administering agencies also develop their own guidelines to provide more program-specific guidance to grant applicants and program staff.

California Climate Investments Quantification Methodologies

With support and insight from academic researchers and industry professionals, CARB develops and periodically updates Quantification Methodologies (QM) and QM calculator tools, which are used by administering agencies and grant applicants to estimate the benefits that can be expected from a proposed California Climate Investments project and assist in project funding determinations.

QMs are specific to each program and define a series of inputs that must be provided by the user, incorporate these inputs into a series of equations, and provide outputs of expected GHG emission

[1] "California Climate Investments," California Climate Investments, accessed June 12, 2021, http://www.caclimateinvestments.ca.gov.

[2] "Priority Populations," California Climate Investments, accessed June 12, 2021, http://www.caclimateinvestments.ca.gov/priority-populations.

reductions, relevant co-benefits, and basic cost-effectiveness in terms of dollars per metric ton of carbon dioxide equivalent (MTCO2e) emissions expected to be reduced by the project. Grantees typically complete QM calculations as part of the application process prior to project implementation. Inputs are determined based on static project characteristics (e.g. project location), planned project scope (e.g. number of trees to be planted), modeled values (e.g. forecasted energy use), or default assumptions (e.g. the average passenger trip length associated with intercity commuter bus travel).

QM results are the source of the GHG emission reductions that are reported by CARB in its Annual Report to the Legislature and publicly available California Climate Investments Reporting and Tracking System (CCIRTS) database exports of project information.[3] While QMs are not the primary focus of this project, they are a core component of California Climate Investments and provide important context for how program benefits are calculated and reported.

Project Outcome Reporting

Whereas QMs are primarily used prior to project implementation to estimate the benefits that can be expected from funded projects, Project Outcome Reporting (POR) is intended to collect primary data during the period following implementation to gain insights into project results. POR is not formally linked to QMs and is not currently incorporated into the reported quantitative benefits of programs.

The objectives of POR as defined by the California Climate Investments Funding Guidelines are to support "accountability and transparency in communicating program successes in facilitating the achievement of GHG reductions and maximizing economic, environmental, and public health benefits to the State".[4] Collecting information on project outcomes is intended to allow CARB and administering agencies to observe changes over time and also encourages ongoing compliance with program funding guidelines, some of which stipulate continued expectations for the operation of projects following the grant period.

As per CARB guidance, POR is intended to involve data collection that can be completed using existing agency and grantee resources and expertise. Activities such as obtaining updated GHG calculations or cost-effectiveness metrics, or conducting in-depth technical analyses, are outside of the current POR scope. However, POR prioritizes the collection of metrics that are linked to GHG impacts and could potentially be used as part of separate analyses to calculate these benefits.

POR is required for a subset of projects, as selected by CARB or administering agencies, and the duration of reporting depends on the type of project and its components. In coordination with administering agencies, CARB stipulated a set of POR metrics to be reported for each project type based on the key outcomes that are linked to GHG reductions and other benefits. CARB developed Reporting Templates which specify the POR metrics, sample size, and duration of reporting for each program.[5] POR guidance

[3] CCIRTS data can be accessed from the California Climate Investments map website: https://webmaps.arb.ca.gov/ccimap/.

[4] California Air Resources Board, "Cap and Trade Auction Proceeds Funding Guidelines for Agencies That Administer California Climate Investments," 2018, https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/2018-funding-guidelines.pdf

[5] Reporting Templates also contain guidance for data to be reported during other project phases, such as the Awarded stage, Implemented stage, and Closeout stage. Reporting Templates are found on the CARB website: "California Climate Investments Quantification, Benefits, and Reporting Materials | California Air Resources Board," accessed June 12, 2021, https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials.

for individual programs has been developed over time and guidance for some programs has not been finalized. Additionally, the extent to which POR has been introduced as a requirement varies by program and many administering agencies had not yet begun collecting POR data as of the time of this report.

Initiation of POR Assessment Project

In its efforts to implement POR as a reporting phase, CARB determined that there may be opportunities to improve the data collection processes and information obtained through POR and to enhance its effectiveness as an evaluation tool. For this contract, the Project Team was tasked with reviewing the current set of POR requirements and recommending additional or alternative metrics and methods based on best practices in data collection.

A primary component of this project was the sampling of 40 California Climate Investments projects to conduct POR data collection in demonstration of these metrics and methods, and to identify additional data collection and analysis considerations. This included characterizing potential barriers to data collection, analytical limitations of available data, and opportunities for enhancing existing program data collection and project verification processes. These efforts resulted in findings and recommendations to support improved data collection, analysis, transparency, and evaluation for individual programs and the California Climate Investments portfolio.

Report Structure

This remainder of this report is separated into 12 chapters. Chapter 1 summarizes the approach of selecting project types and programs for initial POR metrics assessment and data collection. Chapter 2 presents the results of the initial POR metrics and methods assessment that was conducted prior to the sample data collection process. Chapter 3 summarizes the approach and results of sampling 40 California Climate Investments projects for POR data collection and analysis.

Chapters 4 through 11 present the approach and results of data collection for these projects as well as findings and recommendations for each program or group of programs included in the sample, organized as follows:

- Chapter 4 presents the approach and findings for transit projects within the Transit and Intercity Rail Capital Program (TIRCP) and Low Carbon Transit Operations Program (LCTOP).
- Chapter 5 presents the approach and findings for the Affordable Housing and Sustainable Communities (AHSC) Program.
- Chapter 6 presents the approach and findings for water efficiency projects within the State Water Efficiency and Enhancement Program (SWEEP).
- Chapter 7 presents the approach and findings for the Low-Income Weatherization Program (LIWP).
- Chapter 8 presents the approach and findings for the Forest Health Program.
- Chapter 9 presents the approach and findings for urban tree planting and forestry projects within the Urban and Community Forestry (UCF) and Urban Greening (UG) programs.
- Chapter 10 presents the approach and findings for the Clean/Shared Mobility Options sub-program group of Low Carbon Transportation projects.
- Chapter 11 presents the approach and findings for the Advanced Technology Demonstrations sub-program group of Low Carbon Transportation projects.

Chapter 12 presents key discussion items and conclusions resulting from the data collection and analysis effort and provides recommendations related to the broader scope of California Climate Investments and program evaluation. This includes an overarching assessment of the value and limitations of the current POR framework as an evaluation tool, and recommendations for possible future data collection and analysis efforts.

The report includes three appendices:

- Appendix A presents the final list of recommended POR metrics and methods for California Climate Investments programs.
- Appendix B presents descriptions and methods for collecting and reporting the additional metrics that were developed by the Project Team for inclusion in POR.
- Appendix C presents instruments that were used to collect survey and interview data from grantees and project participants in support of assessing POR metrics for sampled projects.

All collected data, analyses, and supporting records used for this project were provided to CARB for review and future reference.

1. Selection of Programs for Assessment and Data Collection

The Project Team reviewed each of the California Climate Investments project types defined by CARB to identify and recommend the project types that should receive an assessment to identify additional or revised POR metrics, and the programs that should be sampled for POR data collection. This chapter describes the approach used to review each project type and presents the list of project types and programs selected for metrics assessment and data collection.

1.1. Selection Approach

CARB provided a list of project types funded through California Climate Investments, and information indicating which programs were associated with each project type. Assignments of project types to programs were based on the end uses, treatments, and equipment or vehicles associated with funded program components. The list of project types provided by CARB included the following:

- Energy Efficiency Measures
- Land Restoration/Management
- Low-Carbon Transportation Zero-Emission Vehicles & Equipment / Clean Mobility Strategies
- Transit & Transit-Oriented Development
- Water Efficiency Measures
- Urban Tree Planting
- Climate Smart Agriculture
- Energy Generation
- Land Conservation
- Active Transportation
- Waste Reduction/Diversion
- Wetlands
- Agricultural Land Management
- Technical Assistance & Workforce Training

Individual programs can be associated with one or more of these project types. For example, the Forest Health Program is associated with the Land Restoration/Management, Energy Generation, Land Conservation, and Waste Reduction/Diversion project types; and the Low-Income Weatherization Program is associated with both the Energy Efficiency Measures and Energy Generation project types.

CARB provided a CCIRTS database export containing project-level data for all California Climate Investments projects that had received funding to date.[6] The Project Team used the list of project types and respective programs to assign project types to each California Climate Investments project within the CCIRTS database export for organizational purposes. This resulted in each individual project being labeled with one or more project types, depending on the project types applicable to its funding program.

[6] CCIRTS data exports can be downloaded from the California Climate Investments Project Map website: "CA GGRF Map," accessed June 15, 2021, https://webmaps.arb.ca.gov/ccimap/.

The Project Team then reviewed the resulting project type assignments and made adjustments based on which project type(s) appeared to be relevant to individual projects based on data available within CCIRTS. For example, the Energy Generation project type was assigned only to Low-Income Weatherization Program projects that had nonzero values for energy generation in the CCIRTS project database.

Several factors were considered in the selection of project types for metrics assessment and data collection:

- **Impact Ranking:** The selection process assessed the relative impact of project types within the California Climate Investments program portfolio by comparing total GHG reductions, funding level, and priority population benefits as reported within CCIRTS. The Project Team ranked each project type by these factors and developed an average Impact Ranking based on these three factors for each project type. This allowed for the classification of each project type as High Impact (upper 50% of Impact Rankings) or Low Impact (lower 50% of Impact Rankings) for comparison purposes. These rankings were based on CCIRTS data as of October 2019.
- **Priority:** In its list of project types, CARB indicated whether it viewed each project type as a High Priority or Low Priority for metrics assessment or POR data collection based on identified evaluation issues or uncertainties. The Project Team considered these categorizations in the selection process.
- **Overall Need:** The selection process included qualitative consideration of the overall need for metrics assessment by project type based on additional available information regarding the quality, consistency, and efficiency of existing methods. This included reviewing existing POR guidance documentation, readily available program materials, and information from CARB regarding the context and history of California Climate Investments programs.

1.2. Selection Results

Table 1-1 lists each project type along with whether it was selected for metrics assessment or data collection, and the programs within each project type that were selected for data collection.

Programs were selected for data collection based on the availability of eligible projects under each program and the expected degree to which data collection within the program would inform one or more of the project types recommended for metrics assessment. The Project Team prioritized data collection for programs whose projects included multiple components and provided the potential to inform multiple prioritized project types.

When designing the POR phase, CARB determined that it would not be appropriate or beneficial to monitor outcomes related to consumer incentive or financing programs, and exempted these programs from POR. Exempt programs include the Clean Vehicle Rebate Project (CVRP), Hybrid and Zero Emission Truck and Bus Voucher Incentive Project, Enhanced Fleet Modernization Program Plus-Up/Clean Cars 4 All, Financing Assistance Program, and Rural School Bus Pilot Project incentives.

Table 1-1. Project Type Selection Summary

Project Type	Impact Level	CARB Priority	Selected for Metrics Assessment	Selected for Data Collection	Program(s) for Project Data Collection
Energy Efficiency Measures	High	High	Yes	Yes	Low-Income Weatherization
Land Restoration/Management	High	High	Yes	Yes	Forest Health Program
Low-Carbon Transportation Zero-Emission Vehicles & Equipment / Clean Mobility Strategies	High	High	Yes	Yes	Low Carbon Transportation (Clean/Shared Mobility Options and Advanced Technology Demonstrations)
Transit & Transit-Oriented Development	High	High	Yes	Yes	Low Carbon Transit Operations Program, Transit and Intercity Rail Capital Program, Affordable Housing and Sustainable Communities Program
Water Efficiency Measures	Low	High	Yes	Yes	State Water Efficiency and Enhancement Program
Urban Tree Planting	Low	High	Yes	Yes	Urban Greening, Urban and Community Forestry
Climate Smart Agriculture	Low	High	Yes	No	N/A
Energy Generation	High	Low	No	Yes	Low-Income Weatherization, Forest Health Program
Land Conservation	High	Low	No	Yes	Forest Health Program
Active Transportation	Low	Low	No	Yes	Urban Greening, Affordable Housing and Sustainable Communities
Waste Reduction/Diversion	High	Low	No	Yes	Urban and Community Forestry
Wetlands	Low	Low	No	No	N/A
Agricultural Land Management	Low	Low	No	No	N/A
Technical Assistance & Workforce Training	High	Low	No	No	N/A

Additional information is provided below regarding the reasons that individual project types were or were not selected for metrics assessment or data collection.

1.2.1. Project Types Selected for Metrics Assessment and Data Collection

- **Energy Efficiency Measures:** This was categorized as high-impact, high-priority project type that presented opportunities for considering best practices in the collection of energy usage data and calculation of energy savings. The Low-Income Weatherization Program provided a wide range of candidate projects to allow for the exploration of billing data collection and analysis.
- **Land Restoration/Management:** This was categorized as a high-impact, high-priority project type that presented an opportunity to explore methods of assessing tree mortality, disturbances, and other land restoration metrics. The Forest Health Program provided a variety of candidate land restoration projects to allow for consideration of current and possible methods.
- **Low-Carbon Transportation Zero-Emission Vehicles & Equipment/Clean Mobility Strategies:** This was categorized as a high-impact, high-priority project type with a variety of innovative components. This project type included a range of recent pilot and demonstration programs with operational projects.
- **Transit & Transit-Oriented Development:** This is a high-impact, high-priority project type that provided opportunities to assess metrics such as ridership, VMT, fuel reduction, and other key inputs within program QM tools. This project type included a wide range of operational projects under the Low Carbon Transit Operations Program, Transit and Intercity Rail Capital Program, and Affordable Housing and Sustainable Communities Program.
- **Water Efficiency Measures:** While this project type was categorized as low-impact based on GHG benefits and expenditures, it was classified as high-priority as the water savings co-benefits generated from these projects were considered by CARB to be an essential component of California Climate Investments.
- **Urban Tree Planting:** This was categorized as a high-priority project type and was associated with a relatively lower level of impacts in the California Climate Investments portfolio. CARB emphasized the importance of developing remote sensing methods of assessing tree mortality and other metrics, and this project type along with Land Restoration/Management provided an opportunity to explore this topic.

1.2.2. Project Types Selected for Metrics Assessment Only

- **Climate Smart Agriculture:** This was categorized as a low-impact project type but was identified by CARB as a high priority for methods standardization and evaluation. This project type provided opportunities to assess soil sampling protocols and best practices related to soil health outcomes in the Healthy Soils Program.

1.2.3. Project Types Selected for Data Collection Only

- **Energy Generation:** This was categorized as a high-impact project type and represented a major portion of GGRF funding and GHG reductions from the installation of solar arrays and biomass generation. The Low-Income Weatherization and Forest Health programs provided a variety of candidate projects.
- **Land Conservation:** This was categorized as a high-impact project type and was a low priority for methods evaluation according to CARB guidance. The Project Team determined that Land Conservation data collection could be included as part of evaluation activities for the Land

Restoration/Management project type, as the Forest Health Program included operational projects that were categorized as both Land Restoration/Management and Land Conservation.

- **Active Transportation:** This was categorized as a low-impact, low-priority project type. However, the Project Team determined that Active Transportation data collection could be included as part of evaluation activities for the Urban Tree Planting and Transit & Transit-Oriented Development project types, as the Urban Greening and Affordable Housing and Sustainable Communities programs included operational projects with active transportation components.
- **Waste Reduction/Diversion:** This was categorized as a high-impact, low-priority project type. The Project Team determined that Waste Reduction/Diversion data collection could be included as part of evaluation activities for the Urban Tree Planting project type, as the Urban and Community Forestry Program included operational projects that were categorized as both Urban Tree Planting and Waste Reduction/Diversion.

1.2.4. Project Types Not Selected for Metrics Assessment or Data Collection

- **Wetlands:** This was categorized as a low-impact and low-priority project type. The Project Team did not identify significant opportunities for methods evaluation or data collection given that the existing monitoring approaches appeared to be sufficient in meeting program objectives.
- **Agricultural Land Management:** This was categorized as a relatively lower-impact and low-priority project type. Feedback from CARB suggested that sampling projects from this project type would be inadvisable due to issues surrounding grantee sensitivity to data collection requirements.
- **Technical Assistance & Workforce Training:** This was categorized as a high-impact project type in terms of GGRF funding and priority population funding, but was categorized as a low-priority project type due to straightforward methods of tracking training participation and completion.

2. Initial Assessment of POR Metrics

The Project Team reviewed the existing and draft metrics and stipulated data collection methods under CARB POR guidance for each program associated with a project type that was selected for metrics and methods assessment. The purpose of these assessments was to identify opportunities for additional and refined data collection metrics and methods, and make initial recommendations to revise POR guidance.

These preliminary recommendations were developed prior to the data collection process to allow the Project Team to demonstrate data collection of both original POR metrics and newly recommended metrics. For programs selected for data collection, the Project Team continued to consider the need to add, modify, or remove POR metrics throughout the data collection process, and developed final recommendations based on lessons learned. For programs selected for metrics assessment only, the Project Team provided initial metrics recommendations and made revisions as appropriate based on administering agency feedback.

This chapter describes the approach used to assess the set of original POR metrics and summarizes the initial recommendations resulting from these assessments. For programs selected for data collection, further revisions and additional POR metrics recommendations are described in the individual program chapters.

2.1. Initial Metrics Assessment Approach

CARB provided POR guidance documents and POR template workbooks for each eligible program within the California Climate Investments portfolio.[7] CARB also provided a set of draft guidance documents for California Climate Investments programs that were expected to become eligible for POR in the future but did not yet have eligible operational projects.

Table 2-1 lists each of the project types selected for metrics and methods assessment and identifies the California Climate Investments programs for which existing or draft outcome guidance was provided by CARB. The status of POR guidance shown is based on information provided by CARB in late 2019 when this assessment was conducted. Programs associated with multiple project types (e.g. State Water Efficiency and Enhancement Program) appear under each applicable project type.

[7] POR requirements and workbooks can be downloaded from the California Climate Investments website: "California Climate Investments Quantification, Benefits, and Reporting Materials | California Air Resources Board," accessed June 15, 2021, https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials.

Table 2-1. Status of POR Guidance by Project Type

Project Type	Programs with Existing Guidance	Programs with Draft Guidance
Energy Efficiency Measures	• Low-Income Weatherization • Woodsmoke Reduction • Water-Energy Grants • State Water Efficiency and Enhancement Program	• Food Production Investment Program
Land Restoration/Management	• Forest Health • Regional Forest and Fire Capacity • Fire Prevention Grants • Prescribed Fire • California Conservation Corps	• CA State Coastal Conservancy Climate Ready Program • Climate Adaptation and Resiliency Program
Low-Carbon Transportation Zero-Emission Vehicles & Equipment / Clean Mobility Strategies	• Low Carbon Transportation (Clean/Shared Mobility Options and Advanced Technology Demonstrations) • Community Air Protection Funds • Funding Agricultural Replacement Measures for Emission reductions (FARMER)	• Low Carbon Transportation (various pilots) • Low Carbon Fuel Production
Transit & Transit-Oriented Development	• Low Carbon Transit Operations Program • Transit and Intercity Rail Capital Program • High Speed Rail Project • Affordable Housing and Sustainable Communities	
Water Efficiency Measures	• Water-Energy Grants • State Water Efficiency Enhancement Program	
Urban Tree Planting	• Urban and Community Forestry • Urban Greening • California Conservation Corps	
Climate Smart Agriculture	• Healthy Soils Program	

The Project Team considered the extent to which the existing POR guidance for each of the above programs aligned with methodological best practices and accounted for the range of possible outcome metrics. Guidance from CARB indicated that POR prioritizes the inclusion of metrics that are linked to GHG benefits, but that recommendations should also be made to include metrics that highlight other types of project benefits. Each project type was assessed according to the following factors:

- **Inclusion of Greenhouse Gas (GHG) Reduction Metrics:** The extent to which existing metrics captured key variables to inform the assessment of GHG reductions resulting from the project.

- **Inclusion of Benefit Metrics:** The extent to which existing metrics allowed for quantitative or qualitative tracking of additional benefits or outcomes aside from, or indirectly related to, GHG reductions.
- **Method Appropriateness:** Whether the set of original POR metrics involved appropriate methods with respect to resource requirements, level of rigor, and clarity.

In order to make informed assessments and subsequent recommendations, the Project Team conducted a variety of activities and referenced various sources in consideration of the above factors. This included the following types of evaluation activities:

- **Program Documentation Reviews:** Reviews of available program-specific materials including QM guidelines, calculator tools, CCIRTS project data, and program funding guidelines in order to gain an understanding of the full range of key variables and benefits applicable to each project type.
- **Subject Matter Expert Interviews:** The Project Team conducted interviews and other correspondence with subject matter experts including industry professionals and academic researchers in order to obtain feedback on POR guidance for individual project types, identify existing literature relevant to key variables, and gain insight into relevant best practices.
- **Agency Meetings:** The Project Team met with administering agencies representing programs within each selected project type in order to gain an understanding of their experiences with outcome reporting, consider potential challenges with specific metrics and methods, identify opportunities for improvements to existing guidance, and discuss data collection recommendations.

Although POR guidance was developed and organized by program, many programs that shared a project type had similar or identical POR requirements. The Project Team considered similarities between programs within each project type but also assessed programs individually.

2.2. Initial Metrics Assessment Results by Project Type

This section summarizes the initial metrics recommendations related to each project type, organized by recommendation category. The recommendation categories are labeled as follows:

- **Additional/Revised GHG Metric:** The Project Team recommended adding or revising one or more metrics to further inform the assessment of GHG reductions resulting from projects.
- **Additional/Revised Benefit Metric:** The Project Team recommended adding or revising one or more metrics to further capture additional benefits or impacts resulting from projects.

The metrics and justifications included in Sections 2.2.1 through 2.2.6 below represent preliminary recommendations prior to the sample project data collection effort, and the Project Team identified the need to add to, revise, or remove these recommended metrics as a result of data collection findings. These preliminary recommendations are included to provide context for the subsequent data collection and analysis effort and final recommendations. Decisions to modify these lists of metrics are described in the individual program chapters.

2.2.1. Transit & Transit-Oriented Development

Additional GHG Metric (Capital Improvements, Expanded/Upgraded Service Projects): Average trip length

The GHG reduction calculations within the QMs for transit projects are based on an estimate of avoided vehicle miles traveled, which relies on average trip length for the relevant transit type as taken from

historical data within the National Transit Database (NTD). To the extent that transit agencies are able to collect trip length data and number of trips along with ridership, reporting average trip length for specific project sites as part of POR would further inform the GHG estimates for completed transit projects.

Revised GHG/Benefit Metric (Affordable Housing Projects): Mode share, by mode

The original POR metric of "Mode share of residents, in aggregate and by income" was developed as a single field in the POR reporting template, which limits the level of detail that can be reported for this metric. Revising this metric to capture the share of various transportation methods used by residents (transit, ridesharing, active transportation, personal vehicles) would allow for a more complete understanding of the mode share of project populations, further informing GHG estimates and other project benefits.

2.2.2. Water Efficiency

Additional GHG Metric (Water-Energy Grants): Quantity of buildings or residences selected for project outcome reporting with gas vs. electric water heating

Original POR guidelines for Water-Energy Grants required information on the specific locations selected for outcome reporting, as individual Project IDs for these two programs can contain multiple sites. As measures installed through this program may achieve either gas or electric energy savings depending on the water heating fuel type, reporting water heating information would provide a more complete depiction of hot water-based energy savings per home.

Additional Benefit Metric (SWEEP): Change in SWEEP project on-farm water use

Water use is a key component of SWEEP and CDFA assesses this metric for internal use, but original SWEEP POR guidance did not include change in water use as an outcome metric. CARB feedback suggested that this metric may have been omitted from initial guidelines unintentionally or due to past grantee sensitivities surrounding water usage.

Additional Benefit Metric (SWEEP): Confirmation that soil health practices are still being implemented (if applicable)

Some SWEEP projects result in funding recipients implementing new practices that contribute to improved soil health (cover cropping, reduced tillage, etc.), and the benefits of these practices are considered in the program funding decision for individual projects. These practices are co-benefits under the Soil Health and Conservation co-benefits assessment methodologies, and are currently tracked as part of outcome reporting under the Healthy Soils Program. Tracking the continuation of these practices for SWEEP would capture and attribute an additional established benefit that is not currently addressed in POR guidance for this project type.

2.2.3. Low-Income Weatherization

Additional GHG Metric (Low-Income Weatherization, Water-Energy Grants): Quantity of each type of measure represented in project outcome sample

Individual Project IDs for these programs can contain multiple sites, where each site may have received a different set of energy efficiency measures. Reporting the quantity of each type of measure represented

by the project outcome sample in the reporting template would provide a more complete depiction of the relationship between measure mix and energy savings.

Additional GHG Metric (Low-Income Weatherization): Quantity of buildings or residences selected for project outcome reporting with gas vs. electric heating

Similar to above, POR guidance for Low-Income Weatherization requires the administering agency to provide information on the specific locations selected for outcome reporting, as individual Project IDs for this program can contain multiple sites. Measures installed through these projects may achieve both gas and electric energy savings depending on the heating fuel type of the building, and reporting heating type would provide a more complete depiction of gas and electric energy savings per home.

2.2.4. Forest Health

Additional Benefit Metric (Reforestation, Pest Management, Forest Fuels Treatment Projects): Fuel load

GHG benefits from these types of forestry projects rely on increased carbon sequestration either due to planting new trees (reforestation) or reducing tree mortality risk (pest management, fuels treatment). In each of these cases, projects may have direct or indirect impacts on surface fuel load, both initially (such as through burning or removing biomass) and during the years following the intervention.

Tracking and reporting fuel load provides a sense of long-term project impacts, allowing for comparison to baseline values and untreated sites. This may also help to identify sites that need to be re-treated or maintained during the outcome period.

Additional Benefit Metric: Qualitative assessment of project impacts on ecological factors

POR guidance for the CA State Coastal Conservancy Climate Ready Program and Climate Adaptation and Resiliency Program specifies including a qualitative assessment of project impacts on various ecological factors. While a descriptive assessment of project ecological impacts may provide useful information related to project outcomes, it may be difficult to compare these assessments across projects or within a single project over time. Additionally, using a single field to describe all types of ecological impacts may create difficulties in identifying specific impacts related to individual factors.

This recommendation involves revising this metric to specify a set of qualitative criteria that can be used in assessing whether the status of ecological factors such as biodiversity, population, erosion, etc. have improved, remained constant, or have otherwise changed since project implementation.[8] This would involve separating the ecological factors into individual outcome metric categories, with funding recipients completing fields that are relevant to the specific project.

As other land restoration/management programs report ecological objectives and benefits as part of project applications and planning, this recommendation also applies to POR for other programs such as Forest Health. Tracking these ecological impacts in a standardized fashion would allow these programs to capture and report benefits that are not currently included in the POR phase.

[8] David A. Pyke et al., "Rangeland Health Attributes and Indicators for Qualitative Assessment," *Journal of Range Management* 55, no. 6 (2002): 584–97, https://doi.org/10.2458/azu_jrm_v55i6_pyke.

2.2.5. Urban Tree Planting

Additional GHG Metric: Quantity of re-plantings (trees planted to replace dead or unhealthy project trees)

The original POR metric for tree mortality rates called for dividing the total number of trees alive at present by the total number of trees originally planted. This would not account for cases where dead trees are replaced by new trees, such as part of a maintenance agreement with the administering agency. Tracking the number of trees used as replacements for dead or unhealthy original project trees would allow for a more complete understanding of the total number of trees (original plantings and replacement plantings) needed to achieve and maintain program benefits throughout the outcome period.

2.2.6. Low-Carbon Transportation Zero-Emission Vehicles & Equipment / Clean Mobility Strategies

Additional GHG Metric/Additional Method (Clean/Shared Mobility Options): Avoided internal combustion engine vehicle miles traveled

Clean/Shared Mobility Options initiatives achieve GHG reductions by encouraging the use of low-carbon options such as electric vehicles (EVs) as a substitute to conventional options such as internal combustion engine (ICE) vehicles. Original POR guidance did not include metrics to capture what method of transportation would have been used in the absence of Clean/Shared Mobility Options projects. This recommendation involves collecting data from users as part of a self-report survey and reporting the percentage of users who indicate that they would choose a conventional vehicle if the Clean/Shared Mobility Options service were not available, and assessing the mileage associated with these trips to estimate the quantity of miles that would have been traveled using an ICE vehicle in the absence of the service.

Additional Benefit Metric/Additional Method (Clean/Shared Mobility Options): Improved mobility vehicle miles traveled

As Clean/Shared Mobility Options services in disadvantaged and low-income communities are designed to assist individuals who may otherwise be unable to effectively meet their transportation needs, tracking improved mobility would more fully capture the qualitative benefits of these programs to individuals and communities. This recommendation involves collecting data on whether users would have made trips in the absence of the Clean/Shared Mobility Options service, and assessing the mileage associated with Clean/Shared Mobility Options travel for these trips to estimate the miles associated with improved mobility (e.g. miles associated with trips that participants would not have been able to take in the absence of the service).

2.2.7. Results for Project Types Selected for Metrics Assessment Only

The following project types were selected for metrics assessment only and were not included in the data collection sample. While the above metrics recommendations were preliminary and were updated as needed based on findings from the data collection process, the metrics presented below represent final metrics recommendations for these project types.

2.2.7.1. Low Carbon Fuels

Additional GHG Metric (Low Carbon Fuel Production): Indication of whether a Low Carbon Fuel Standard Certified Pathway has been obtained, and if so, Carbon Intensity score and ID

As Low Carbon Fuel Production funding recipients are likely to register the funded fuel under the Low Carbon Fuel Standard (LCFS), they would be able to report whether the fuel has received a provisional or final certified LCFS pathway during the outcome reporting period. Tracking the status of this certification and identifying the associated Carbon Intensity (CI) score and ID would link the California Climate Investments program with an industry standard form of measurement for low carbon fuels.

Additional Benefit Metric (Low Carbon Fuel Production): Non-fuel coproducts generated (if applicable)

The original POR guidelines for this program included metrics for quantity of fuel produced, but did not account for non-fuel coproducts that may be created during the fuel production process. This would include products such as distiller's grains, corn oil, biochar, or other bio products. Reporting the quantity of non-fuel coproducts (in gallons or tons per year) produced would capture an additional benefit that can be attributed to this program.

2.2.7.2. Climate Smart Agriculture

Additional GHG Metric (Healthy Soils Program): Soil organic matter

Soil samples are collected prior to project implementation, and annually for 2 years following project operation. CDFA currently tracks soil organic matter through this process and reporting it within project outcomes over time would further link project results to prospective program GHG estimates.

In addition to soil organic matter, the Project Team initially recommended collecting soil health indicators such as bulk density, pH, electrical conductivity, and other metrics that are typically included in soil health assessments as specified by National Resources Conservation Service (NRCS) guidelines.[9] However, based on feedback from CDFA regarding cost and technical barriers to requiring these metrics for incentive recipients, the Project Team removed the soil health indicators metric from its list of recommendations and defers to CARB as to whether these or other indicators are needed and can be effectively implemented for this program.

2.3. Summary of Metrics Assessment Results

Table 2-2 organizes each of the above metrics recommendations by program for reference. Recommendations that apply to multiple programs are repeated across each relevant program.

[9] USDA Natural Resources Conservation Service. "Guidelines for Soil Quality Assessment in Conservation Planning," 2001. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051259.pdf

Table 2-2. Initial Metrics Recommendations by Program

Program	Recommended Metrics
Low-Income Weatherization	Measure mix of sampled sites
	Distribution of primary heating types of sampled sites
Water-Energy Grants	Measure mix of sampled sites
	Distribution of primary water heating fuel types of sampled sites
State Water Efficiency and Enhancement Program	Change in SWEEP project on-farm water use
	Confirmation of continued soil health practices (if applicable)
Forest Health	Qualitative assessment of project impacts on ecological factors
	Fuel load
Regional Forest and Fire Capacity	Qualitative assessment of project impacts on ecological factors
	Fuel load
Fire Prevention Grants	Fuel load
CA State Coastal Conservancy Climate Ready Program	Qualitative assessment of project impacts on ecological factors (Revision)
Climate Adaptation and Resiliency Program	Qualitative assessment of project impacts on ecological factors (Revision)
Low Carbon Transportation	(Clean Mobility) Avoided internal combustion engine vehicle miles traveled
	(Clean Mobility) Improved mobility vehicle miles traveled
Low Carbon Fuel Production	Indication of Low Carbon Fuel Standard (LCFS) Carbon Intensity Score
	Non-fuel coproducts generated (if applicable)
Low Carbon Transit Operations Program	(Capital Improvements, Expanded/Upgraded Service Projects) Average trip length
Transit and Intercity Rail Capital Program	(Capital Improvements, Expanded/Upgraded Service Projects) Average trip length
Affordable Housing and Sustainable Communities	Mode share, by mode (Revision)
	(Capital Improvements, Expanded/Upgraded Service Projects) Average trip length
Urban and Community Forestry	Quantity of replacement trees planted
Urban Greening	Quantity of replacement trees planted
Healthy Soils Program	Soil organic matter

2.4. Final Metrics Recommendations

For programs selected for data collection, the Project Team continued to assess the appropriateness of these metrics throughout the data collection process and made additional recommendations to remove, revise, or add POR metrics based on the findings from the data collection for sampled projects, which are described in the following chapters.

As the project sample did not include projects from all of the above programs, the Project Team determined whether the need to add, revise, or remove POR metrics as a result of the data collection process should be applied to other similar programs which did not receive sample data collection. These determinations were made based on the similarity of program components and the similarity of existing POR metrics among programs.

The complete set of recommended POR metrics based on findings from the entirety of the project, including metrics that were in place prior to the project and that the Project Team recommended retaining, is provided in Appendix A. Detailed descriptions of metrics that were developed by the Project Team and were not in place within POR at the start of this project are provided in Appendix B.

3. Project Data Collection and Assessment

This chapter describes the approach for sampling projects from selected programs and summarizes the types of data collection and evaluation activities conducted. The subsequent individual program chapters describe the data collection approach, assessment results, and recommendations specific to each program.

3.1. Sampling of Projects for Data Collection

The Project Team analyzed the CCIRTS database export of GGRF projects provided by CARB to select and recommend a sample of projects for POR data collection. Based on the findings from the project type and program selection process described in Chapter 1, projects were sampled from the following California Climate Investments programs:

- Forest Health Program
- State Water Efficiency Enhancement Program
- Affordable Housing and Sustainable Communities
- Low Carbon Transit Operations Program
- Transit and Intercity Rail Capital Program
- Low-Income Weatherization (Single-family and Multi-family Energy Efficiency and Solar)
- Urban and Community Forestry
- Urban Greening
- Low Carbon Transportation: Car Sharing and Mobility Options Pilot
- Low Carbon Transportation: Zero-Emission Truck and Bus Pilot
- Low Carbon Transportation: Off-Road Advanced Technology Demonstrations Pilot
- Low Carbon Transportation: On-Road Advanced Technology Demonstrations Pilot
- Low Carbon Transportation: Advanced Technology Freight Demonstration

To focus the evaluation on projects where data collection would provide the greatest value and opportunity for insight into project outcomes, the Project Team identified key characteristics to prioritize and assist in this selection process. These characteristics varied by program but generally included:

- **Funding level:** For programs where funding level varied substantially across projects, the Project Team made efforts to ensure that some portion of the sample included projects receiving a high level of GGRF dollars proportional to other projects in the program.
- **Cost per GHG outliers:** For programs where dollars per ton of GHG reduction varied substantially across projects, the Project Team made efforts to ensure that some portion of the sample included projects whose cost per ton were particularly high or particularly low proportional to other projects in the program.
- **Priority Population benefit:** The Project Team made efforts to ensure that some portion of the sample for each program included projects contributing to priority population benefits, with the objective that the proportion of priority population benefits among the overall sample would at

least meet the statutory investment minimums required for the California Climate Investments portfolio.[10]

- **Other major benefits:** For programs with a major benefit other than GHG reduction (e.g. gallons of water saved for water efficiency projects), the Project Team made efforts to ensure the sample included projects with a high level of these benefits relative to other projects in the program.
- **Grant type representation:** For programs with a variety of grant types (e.g. conservation easements, reforestation, and fuels reduction for the Forest Health Program), the Project Team made efforts to ensure that the sample included projects from multiple grant types.
- **Project Type representation:** For programs containing projects that are associated with multiple project types that were of interest in the evaluation (e.g. Energy Efficiency Measures and Energy Generation for Low-Income Weatherization), the Project Team made efforts to select projects belonging to more than one prioritized project type.

Whenever possible, including all cases where multiple projects met the relevant priority characteristics for a given program, the Project Team conducted random sampling to select individual projects. Common reasons that a project was not selected for data collection include:

- **Project timing:** Projects with operational or completion dates after June 2020, or with unverified operational or completion dates, were excluded from sampling as per CARB guidelines due to the time frame of the data collection task.
- **Project size:** Projects with particularly low funding levels relative to other projects in a program (e.g. lowest 1% or 5% depending on the program) were not prioritized and typically were not selected for data collection, except in cases where programs contained many similarly sized small projects and random sampling resulted in the selection of these smaller projects.
- **Geographic distribution:** The Project Team conducted a qualitative review of the initial sample set and re-sampled geographically clustered projects when necessary in order to maintain a sample that had a high degree of geographic distribution.
- **Outdated projects:** In certain cases, the Project Team received feedback from administering agencies indicating that an initially sampled project had been completed under an outdated iteration of the program and would not be representative of current program structure or scope. The Project Team reviewed each of these projects and re-sampled in some instances.

Table 3-1 lists the number of sampled projects by program and the total number of candidate projects eligible for POR by program. The table also displays the GGRF funding and GHG reductions reported for each program and for the project sample as per CCIRTS records. The Project Team conducted this sampling process in October 2019, and the displayed total program GGRF funding values and GHG reductions are based on data from a 2019 version of the CCIRTS database and do not represent current totals.

[10] CARB indicated that CCIRTS reporting fields for disadvantaged community and low-income community benefits changed over time in alignment with statutory requirements and that older projects may not have data for specific priority population benefits fields that were not yet in place at the time of project implementation. Due to this, the sampling analysis did not include assessing the low-income and disadvantaged community benefits represented by the set of sampled projects as a portion of all CCIRTS projects.

Table 3-1. Characteristics of Sampled Projects by Program

Program Name[1]	Sampled Projects	Total Candidates Eligible for POR	Sampled Projects GGRF Funding	Total Program Implemented GGRF Funding	% of GGRF Funding Represented by Sample	Sampled Projects GHG Reductions	Total Program GHG Reductions	% of GHG Reductions Represented by Sample
Low Carbon Transit Operations Program	4	42	$26,388,083	$249,180,069	11%	939,465	3,198,700	29%
Transit and Intercity Rail Capital Program	5	16	$91,057,000	$338,919,000	27%	146,784	2,340,127	6%
Affordable Housing and Sustainable Communities	5	35	$53,681,459	$311,392,872	17%	52,324	836,718	6%
State Water Efficiency Enhancement Program	6	600	$826,213	$61,541,123	1%	8,615	745,636	1%
Low-Income Weatherization	4	5,566	$803,932	$119,829,319	1%	3,123	418,618	1%
Forest Health Program	7	43	$13,385,342	$110,066,342	12%	783,591	5,199,816	15%
Urban and Community Forestry	3	56	$1,866,017	$38,272,327	5%	9,059	260,587	3%
Urban Greening	1	4	$1,200,000	$6,832,200	18%	859	2,100	41%
LCT - Car Sharing and Mobility Options Pilot	1	5	$1,363,847	$9,551,209	14%	192	3,235	6%
LCT - Zero-Emission Truck and Bus Pilot	1	8	$22,347,502	$82,822,315	27%	9,760	106,514	9%
LCT - Off-Road Advanced Technology Demonstrations Pilot	1	6	$5,339,820	$19,864,635	27%	694	2,527	27%
LCT - On-Road Advanced Technology Demonstrations Pilot	1	2	$6,994,600	$12,076,078	58%	30	430	7%
LCT - Advanced Technology Freight Demonstration	1	3	$9,100,800	$47,269,700	19%	5,235	13,082	40%
Total	**40**	**6,386**	**$234,354,615**	**$1,407,617,189**	**17%**	**1,959,731**	**13,128,090**	**15%**

[1]Program data in this table are based on a CCIRTS project database export received from CARB in October 2019.

3.2. Key Project Data Collection and Assessment Objectives

The objectives of the project data collection and assessment task were as follows:

- **Collect data:** Use stipulated POR methods to collect the data necessary to calculate POR metrics for each sampled project.
- **Analyze collected data:** Use stipulated POR methods to calculate outcome metrics for each sampled project.
- **Assess barriers to data collection:** Identify instances where data were not available or could not be collected due to issues with a stipulated data collection method, lack of access to project sites or documentation, or other issues. Characterize barriers that may serve as challenges for future POR data collection efforts.
- **Identify the need to add, modify, or remove POR metrics or methods:** Based on findings from the data collection and analysis activities, determine whether additional modifications to POR guidelines, such as revised metrics or methods, would improve collected data and results.
- **Identify broader evaluation considerations:** Based on findings from the data collection and analysis activities, and with consideration of the background and context surrounding evaluation of California Climate Investments programs, develop conclusions and recommendations designed to support improved evaluation of individual programs or California Climate Investments as a whole.

3.2.1. Overall Goal of Project Data Collection and Analysis

The project involved the collection of a wide range of quantitative data. However, due to the small sample size per program, and data quality and methodological differences among sampled projects, the collected project data cannot be generalized to represent programs as a whole. Additionally, POR is not currently designed to calculate GHG benefits or cost-effectiveness for individual projects.

For these reasons, and in accordance with CARB objectives for this project, much of the analysis effort focused on using the data collection process to develop qualitative findings regarding the strengths and limitations of POR as a reporting phase. This included considering possible improvements in data collection and reporting that could allow for generalization of findings or in-depth analysis of GHG benefits at a higher level of rigor than current QM calculator procedures.

3.3. Types of Activities Conducted

To accomplish the above objectives, the Project Team conducted the following types of evaluation activities. Specific approaches and activities are described in each program chapter, but generally included:

- **Administering Agency Interviews and Documentation Requests:** The Project Team met with staff of program administering agencies to gain an understanding of program structure, existing data collection and reporting procedures, and sampled project characteristics. This included requesting available documentation for sampled projects.
- **Project Documentation Reviews:** The Project Team reviewed publicly available project documentation or documentation provided by administering agencies for sampled projects to understand project details such as the timing and scope of project components, QM inputs that were used to calculate GHG emission reductions, and co-benefits associated with projects. Project documentation also served as the source for certain POR metrics.

- **Grantee and Project Partner Interviews and Data Requests:** The Project Team met with grantees and project partners such as contractors to gain insight into the availability of POR metrics, identify barriers to data collection, and gain feedback on POR as a reporting phase. Additionally, the Project Team requested project baseline and post-project data records as needed to support the calculation of POR metrics.
- **Survey Data Collection:** For programs with POR metrics that could be assessed through participant surveying, the Project Team coordinated with grantees or project partners to develop or refine survey instruments, initiate data collection, and request collected survey data in support of calculating POR metrics.
- **Analysis of Data Records:** Upon collecting project documentation, operational data records, survey data, or other data types, the Project Team analyzed these data to calculate POR metrics for sampled projects. This involved using the analysis methods that were prescribed by POR, replicating methods currently used by administering agencies to report POR metrics, or developing analysis methods that could be replicated by administering agencies or grantees.
- **Remote Observation of Project Sites:** For programs with projects that may benefit from a form of remote sensing, the Project Team observed sites with remote sensing imagery and tools to explore the possible use of these methods for POR, and to characterize related barriers and opportunities.
- **Assessment of Barriers and Evaluation Considerations:** Throughout the data collection and analysis process, the Project Team considered barriers, challenges, limitations, and opportunities for improvement to POR and evaluation within individual programs and the broader California Climate Investments portfolio. This included consideration of the background and context of evaluation surrounding California Climate Investments and related programs. Additional contextual and background information related to this aspect of the data collection effort is described below in Section 3.4.

3.4. Review of Evaluation Background and Context

When reviewing the existing data collection, analysis, and overall evaluation procedures in place for the project sample, the Project Team considered the background and context of program evaluation within California Climate Investments and other energy and GHG reduction programs. This included reviewing past efforts to implement outcome reporting within California Climate Investments; California evaluation, measurement, and verification (EM&V) guidelines and resources; program evaluation efforts within the Regional Greenhouse Gas Initiative (RGGI); and in-depth studies of California Climate Investments programs that have been conducted by academic and industry researchers.

3.4.1. California Climate Investments Phase 2 Reporting

The initial concept for evaluating the impacts of California Climate Investments projects after implementation was referred to as Phase 2 data collection and reporting, which is described in the 2015 California Climate Investments Funding Guidelines.[11] Based on this description, Phase 2 was intended to require grantees and administering agencies to collect primary data on project performance to demonstrate that expected GHG emission reductions and other benefits were being achieved. Within Phase 2, a subset of projects would be selected to provide metrics to support GHG quantification in the

[11] California Air Resources Board, "Cap and Trade Auction Proceeds Funding Guidelines for Agencies That Administer California Climate Investments," 2015, https://ww2.arb.ca.gov/sites/default/files/classic/cc/capandtrade/auctionproceeds/arb-funding-guidelines-for-ca-climate-investments.pdf.

years following implementation, and administering agencies would be responsible for determining the appropriate approach for meeting Phase 2 requirements.

The 2015 California Climate Investments Funding Guidelines provide several suggestions to agencies for how to implement Phase 2 requirements in their programs, such as including data collection requirements in the grant agreement, issuing a contract to a third-party evaluator using administrative funds, or having agency staff conduct the data collection and reporting process. In discussions with the Project Team, CARB indicated that Phase 2 reporting was not successfully implemented due to barriers associated with data collection costs, logistics, and concerns surrounding the recalculation of GHG benefits after project implementation once funding had already been expended. POR was derived from the overall intent of Phase 2 reporting as a form of collecting information about projects in the period after implementation, but was more limited in scope and expressly did not seek to calculate GHG benefits or measure program cost-effectiveness.

3.4.2. California Energy and Resource Acquisition Program Evaluation Guidelines

The state of California has developed several resources and standards related to program EM&V. Many of these are intended for use in energy efficiency programs such as those implemented with utility ratepayer funds, but the general evaluation concepts and guidelines may have relevance to the broad portfolio of projects funded through California Climate Investments. The California Evaluation Framework establishes a uniform approach for evaluating the processes, impacts, and cost-effectiveness of energy efficiency and resource acquisition programs implemented in the state of California.[12] Development of this framework was mandated by the California Public Utilities Commission (CPUC) to provide a standard set of evaluation guidelines for use by utilities, policymakers, program implementers, and evaluators.

The California Standard Practice Manual outlines the core inputs and tests that are used to assess program cost-effectiveness for energy programs, including the Total Resource Cost (TRC) test which considers costs incurred by both the program provider and participant, and the Societal Test which also incorporates externalities such as environmental effects.[13]

The California Energy Efficiency Evaluation Protocols provide detailed guidance for program evaluators and policy makers in their design and implementation of program evaluations. This includes information on the importance and process for conducting benefits impact evaluations, measurement and verification of measures and treatments, process evaluations to support program improvements, and the appropriate level of rigor to use in evaluation activities based on factors such the magnitude of expected program benefits and the degree of uncertainty associated with these expected benefits.[14]

[12] Nick Hall et al., "The California Evaluation Framework," 2004, https://doi.org/10.13140/RG.2.1.5142.1680.

[13] Woodrow W. Clark, Arnie Sowell, and Don Schultz, "California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects," in *Sustainable Communities Design Handbook* (Elsevier, 2010), 277–312, https://doi.org/10.1016/B978-1-85617-804-4.00018-5.

[14] The CA Energy Efficiency Evaluation Protocols and other CA evaluation standards and guidelines can be found on the CPUC website:

"Energy Efficiency Evaluation, Measurement, and Verification," accessed June 14, 2021, https://www.cpuc.ca.gov/General.aspx?id=5399.

3.4.3. Regional Greenhouse Gas Initiative (RGGI) Evaluation

The Regional Greenhouse Gas Initiative (RGGI) is a multi-state Cap-and-Trade program of Northeast and Mid-Atlantic states that seeks to reduce CO_2 emissions through auctioning limited emissions allowances to qualified bidders in each participating state. Similar to California Climate Investments, auction proceeds are reinvested in a variety of energy and GHG reduction and abatement programs.[15] Each state is responsible for developing programs to reinvest auction proceeds and for reporting the impacts of these programs. Program evaluation methods are also determined at the state level.

The New York State Energy Research and Development Authority (NYSERDA) produces status reports summarizing the allocation and impact of RGGI funds for New York State, and these reports indicate that NYSERDA has funded several evaluation studies for RGGI consumer-based energy efficiency programs to assess the impacts, processes, and other components. Specifically, NYSERDA describes studies using the following categories:[16]

- **Impact Evaluations:** Measure the outcomes and cost-effectiveness of programs and compare these results to initial program expectations and goals. NYSERDA reports expected program impacts in its required RGGI expenditure status updates, and then later reports the results of any impact evaluations as supplementary material.
- **Market Evaluations:** Characterize the market and context of programs to support effective program design and delivery.
- **Process Evaluations:** Assess the effectiveness of program design and delivery and provide recommendations for program improvement.
- **Logic Model Reports:** Identify the characteristics and relationships of program components and objectives.
- **Evaluation Readiness Reviews:** Also referred to as evaluability assessments, these studies determine whether programs are designed in a manner that allows evaluations to yield informative results.

These categories of evaluation are common to the broader EM&V landscape and California evaluation standards. The California Energy Efficiency Evaluation Protocols adopted by CPUC denote and provide guidelines for impact evaluation, process evaluation, and market evaluation, and the descriptions within NYSERDA reporting are consistent with CPUC stated objectives and approaches.

3.4.4. Evaluation Research and Impact Studies Conducted for California Climate Investments Programs

Academic and industry researchers have conducted in-depth studies on subsets of California Climate Investments programs and projects using primary data to assess GHG impacts, co-benefits, program processes, and equity and environmental justice (EJ) considerations. These studies have been funded through matching funds provided by California Climate Investments grantees or project partners, third-

[15] "Investments of Proceeds | RGGI, Inc.," accessed June 14, 2021, https://www.rggi.org/investments/proceeds-investments.

[16] "New York State Regional Greenhouse Gas Initiative-Funded Programs: Semiannual Status Report through June 30, 2020" (NYSERDA, December 2020), https://www.nyserda.ny.gov/-/media/Files/Publications/Energy-Analysis/RGGI/2020-06-EEA-RGGI-2020-H1.pdf.

party evaluation contracts issued by program administering agencies, and other grants and funding from organizations that are not directly associated with California Climate Investments. Examples include:

- Surveys and modeling studies to assess the impacts of California Climate Investments incentives and equity focused rebates for electric vehicles (EVs), such as those provided through the California Clean Vehicle Rebate Project (CVRP) and Clean Cars 4 All;[17]
- Monitoring of urban tree planting sites, including sites funded by the Urban and Community Forestry (UCF) Program, to assess mortality rates and collect baseline characteristics;[18]
- Equity evaluations of clean mobility programs, including carsharing programs funded by California Climate Investments Clean Mobility Options (CMO);[19] and
- Grantee partnerships with academic institutions and to analyze the impacts of California Climate Investments funded projects such as transit and forestry improvements.[20]

California Climate Investments also includes programs with the specific objective of conducting research or evaluation, such as CAL FIRE Forest Health Research Program and the SGC Climate Change Research Program, though these grants do not necessarily involve EM&V of California Climate Investments-funded treatments, vehicles, or equipment.[21]

As California Climate Investments does not uniformly require grants to receive EM&V, the presence or absence of in-depth studies varies by program. Additionally, results of these research studies typically do not inform the GHG benefits that are publicly reported by CARB for individual programs or projects, as these reported benefits are based on outputs from CARB-developed QM calculator tools.[22]

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[17] Alan Jenn et al., "An Examination of the Impact That Electric Vehicle Incentives Have on Consumer Purchase Decisions Over Time," May 1, 2019, https://doi.org/10.7922/G2S46Q51.;

Gil Tal et al., "Electric Cars in California: Policy and Behavior Perspectives," 2020, 11–25, https://doi.org/10.1007/978-3-030-38382-4_2.;

[18] Natalie van Doorn and Erika Teach, "Sacramento Tree Foundation Shade Tree Program: 2015-2018 Tree Mortality and Baseline for Long-Term Monitoring" (USDA Forest Service, September 2018).;

Yekang Ko et al., "Long-Term Monitoring of Sacramento Shade Program Trees: Tree Survival, Growth and Energy-Saving Performance," *Landscape and Urban Planning* 143 (November 2015): 183–91, https://doi.org/10.1016/j.landurbplan.2015.07.017.

[19] "Clean Mobility Equity: A Playbook Lessons from California's Clean Transportation Programs," The Greenlining Institute, March 25, 2021, https://greenlining.org/publications/reports/2021/clean-mobility-transportation-equity-report/.

[20] LCTOP grantee Santa Clara Valley Transportation Authority partnered with Lehigh University to analyze the impacts and performance of its electric bus fleet: "Convergence by Design | P.C. Rossin College of Engineering & Applied Science," accessed June 14, 2021, https://engineering.lehigh.edu/research/resolve/volume-1-2019/convergence-design.;

Documentation for some CAL FIRE Forest Health grants indicates the involvement of academic researchers, such as Cambria Forest Health (8GG14601) which states that researchers from California Polytechnic State University (Cal Poly) will establish research plots to monitor baseline and post-project conditions.

[21] CARB provides resources for universities and research institutions to access funding opportunities: "Grants for Universities/ Research Institutions," California Climate Investments, accessed June 14, 2021, http://www.caclimateinvestments.ca.gov/funding-for-universities-research-institutions.

[22] "Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds" (California Climate Investments, April 2021), https://ww2.arb.ca.gov/sites/default/files/classic//cc/capandtrade/auctionproceeds/2021_cci_annual_report.pdf.

3.4.5. Overall Review Findings

This review suggests that detailed and comprehensive guidelines are in place for EM&V of energy efficiency programs, and that in-depth evaluations are regularly conducted for energy programs such as those funded through RGGI. The reviewed resources did not provide industry standard evaluation guidelines specific to transportation, natural resources, and other project types that are funded through California Climate Investments, though concepts related to project verification, data collection, and analysis may be relevant to a wide range of project types. EM&V of California Climate Investments programs occurs to some extent based on the availability of funding for targeted studies, but is not formally required across programs by California Climate Investments Funding Guidelines or incorporated into public reporting of program impacts.

Overall, the Project Team found that these resources provided valuable context related to the range of evaluation activities that have been or could potentially be conducted for GHG reduction programs. Additionally, this review provided insight into the potential evaluation challenges and limitations in relation to available resources, the extent of program evaluability, and overall evaluation rigor.

The individual program chapters provide findings and recommendations related to evaluation potential and associated challenges based on the data collection and assessment of sampled projects.

3.5. Organization of Sampled Projects and Reported Results

Although CARB initially organized programs by project type, the Project Team found that references to the project types used internally by CARB were not clearly understood by administering agencies. Additionally, organizing the sample in terms of project type resulted in challenges due to programs containing multiple project types, project types being relevant to multiple programs, and projects within programs not necessarily sharing the same set of project types as each other.

To minimize confusion when communicating with CARB and administering agencies and to simplify the process of presenting results, the Project Team discontinued references to CARB-defined project types during the data collection effort and instead referred to projects by their California Climate Investments program. For reporting purposes, this included combining some programs into program groups based on the similarity of POR metrics and funded projects.

The following chapters present the approach, results, and recommendations from the data collection effort for each of these programs and program groups:

- Transit (LCTOP and TIRCP)
- Affordable Housing and Sustainable Communities
- Water Efficiency (SWEEP)
- Low-Income Weatherization
- Forest Health
- Urban Forestry and Tree Planting (UCF and UG)
- Low Carbon Transportation: Clean/Shared Mobility Options
- Low Carbon Transportation: Advanced Technology Demonstrations

As some California Climate Investments programs contain similar components, such as capital transit improvements existing as a component within both LCTOP/TIRCP and AHSC, the Project Team considered certain findings for sampled projects to be relevant to multiple programs and added these findings and associated recommendations to each applicable program chapter. These cross-program findings are denoted within the program chapters, and Chapter 12 presents overarching findings and recommendations that are applicable to the broader California Climate Investments portfolio.

4. Transit

California Climate Investments includes programs which fund the purchase of transit vehicles or equipment and support the expansion of transit services and facilities. The data collection sample included transit projects within the Transit and Intercity Rail Capital Program (TIRCP) and Low Carbon Transit Operations Program (LCTOP). For the purposes of POR assessment and reporting, the Project Team combined TIRCP and LCTOP into a single Transit program group.

- TIRCP is administered by Caltrans on behalf of the California State Transportation Agency (CalSTA) and provides funding for capital improvements such as the purchase of transit vehicles and the expansion of bus, rail, and ferry transit systems.[23]
- LCTOP is administered by the California Department of Transportation (Caltrans) and provides funding to transit agencies to support the purchase of transit vehicles and equipment, the development or expansion of bus and rail services, and the operation of new services and facilities.[24]

While programs such as the Affordable Housing and Sustainable Communities (AHSC) Program also contain transit-related components, the Project Team categorized AHSC into a separate program chapter due to the distinct data collection and evaluation considerations associated with affordable housing and transit-oriented development.[25] This chapter focuses on the sampled TIRCP and LCTOP projects.

4.1. Project Sample

At the time of project sampling in October 2019, there were 16 TIRCP projects and 42 LCTOP projects eligible for POR based on information received from CARB. The final data collection sample included five projects from TIRCP and four projects from LCTOP. The projects in the data collection sample have the following main components.

4.1.1. TIRCP Sampled Projects

- **TIRCP Project 1: Expanding the San Francisco Municipal Transportation Agency (SFMTA) Light Rail Vehicle Fleet. Grantee: SFMTA; CCIRTS Project ID 0016000121.** This TIRCP funding is allocated to the purchase of eight light rail vehicles (LRVs) to expand the SFMTA LRV fleet.
- **TIRCP Project 2: San Diego Metropolitan Transit System (SDMTS) Trolley Capacity Improvements Project. Grantee: SDMTS; CCIRTS Project ID 0016000188; 0017000040.** This project consists of adding a new courthouse terminal station in downtown San Diego for the Blue and Orange SDMTS trolley lines as well as purchasing nine Siemens S70 light rail vehicles to expand Blue line and Orange line service capacity and total number of trips. TIRCP funding was allocated to the construction costs of the courthouse terminal and the purchase of light rail vehicles.
- **TIRCP Project 3: Sonoma-Marin Area Rail Transit (SMART) Rail Car Capacity Project. Grantee: SMART; CCIRTS Project ID 0016000237.** The TIRCP funding for this project is allocated towards the purchase of four additional rail cars which are intended to expand the capacity of the SMART rail

[23] TIRCP program website: https://dot.ca.gov/programs/rail-and-mass-transportation/transit-and-intercity-rail-capital-program

[24] LCTOP program website: dot.ca.gov/programs/rail-and-mass-transportation/low-carbon-transit-operations-program-lctop

[25] The approach and findings for the AHSC program are presented in Chapter 5.

fleet and are part of a larger expansion project involving the construction of a 70-mile commuter rail and parallel bicycle and pedestrian pathway project.

- **TIRCP Project 4: Bravo! Route 560 Rapid Buses. Grantee: Orange County Transportation Authority; CCIRTS Project ID 0016000041.** This project consists of the purchase of four compressed natural gas (CNG) buses to enable the implementation of a new service line that provides rapid bus service along an existing Orange County Transportation Authority (OCTA) route.
- **TIRCP Project 5: Travel Time Reduction Project. Grantee: Capitol Corridor Joint Powers Authority; CCIRTS Project ID 0016000276.** This project consists of implementing track and curve improvements on the Capitol Corridor rail line to reduce the travel time of trains by up to 10 minutes for each trip. This is intended to improve the reliability and quality of service and encourage increased ridership by making the Capitol Corridor a more competitive mode as compared to other travel options.

4.1.2. LCTOP Sampled Projects

- **LCTOP Project 1: Battery Electric Zero Emission Bus and Infrastructure Project. Grantee: Santa Clara Valley Transportation Authority; CCIRTS Project ID 15-16-D4-54.** This project consists of the purchase of five forty-foot zero emission electric transit buses and three fast-speed electric vehicle charging stations, as well as the implementation of related connectivity improvements for this expansion of transit service.
- **LCTOP Project 2: Capital Costs for the Express Bus Pilot Project. Grantee: Alameda-Contra Costa Transit District; CCIRTS Project ID 16-17-D04-037.** This project consists of the construction of a rapid bus corridor along a 9.52-mile service route providing intercity service for the Alameda Contra-Costa Transit District (AC Transit). The LCTOP funding was allocated to a portion of the construction cost which included the implementation of dedicated bus lanes, signal priority, fare collection, and other passenger amenities.
- **LCTOP Project 3: Capital Costs for the Express Bus Pilot. Grantee: SamTrans; CCIRTS Project ID 16-17-D05-063.** This project involves the development of an Express Bus Pilot within the San Mateo County Transit District (SamTrans), consisting of four limited-stop bus routes using 37 new electric buses. LCTOP funding was allocated to the purchase of a portion of the battery electric buses and chargers for these new routes.
- **LCTOP Project 4: Mission Bay Loop. Grantee: SFMTA, CCIRTS Project ID 17-18-D04-057.** This project consists of the construction of a segment of light rail trackway that allows vehicles on the San Francisco Municipal Transportation Agency (SFMTA) T Third Street line to turn around, particularly during special events and peak periods. The project is designed to increase the efficiency and reliability of SFMTA light rail service. LCTOP funds were allocated to pay for a portion of the construction cost associated with implementing this infrastructure improvement.

The initial LCTOP sample consisted of five projects including the four projects above and a fifth project (CCIRTS Project ID 15-16-D8-107). However, upon requesting documentation for this project, the Project Team learned from Caltrans that the project had not moved forward and that the LCTOP funds had instead been transferred to a different project. The Project Team notified CARB that the CCIRTS database showed the project as operational when it had been cancelled. CARB acknowledged that this was an error in the database and that the project would be removed or re-categorized as cancelled, and as a result the Project Team removed Project ID 15-16-D8-107 from the data collection sample.

4.2. Activities Conducted

The data collection and analysis process for the sampled TIRCP and LCTOP projects consisted of the following activities.

4.2.1. Administering Agency Interviews and Documentation Requests

At the start of the data collection process the Project Team completed interviews with Caltrans staff representing TIRCP and LCTOP to gain an understanding of program procedures, existing data collection processes, and the extent of available project data. As part of these interviews the Project Team requested documentation associated with each sampled project.

4.2.2. Project Documentation Reviews

The Project Team reviewed project documentation including initial applications, allocation request documents and workbooks, and supporting documentation such as project maps and funding plans. These reviews focused on identifying key project components, project timelines, and applicable POR data to be collected, as well as characterizing possible evaluation-related issues and questions associated with data collection or analysis.

4.2.3. Transit Agency Interviews and Data Requests

Following the documentation reviews, the Project Team held interviews with representatives of the grantee transit agencies associated with each sampled project. The purpose of these interviews was to verify the operational status of each project, gain a greater understanding of project background and characteristics, and request POR data for the period since the project became operational.

4.2.4. Analysis of Data Records

Upon receiving the requested data for each project, the Project Team reviewed and analyzed these records to develop POR metrics for the defined outcome periods associated with each sampled project. Current TIRCP and LCTOP POR guidelines define the first outcome reporting period as beginning once the new or expanded transit service or purchased vehicles and equipment are operational. Unless otherwise noted within the individual project findings sections, outcome reporting periods were defined for each project as beginning on the operational date and extending one year forward to represent the first round of POR. For projects that had two or more years of data following the operational date at the time of the data request, the Project Team defined subsequent rounds of POR as beginning immediately after the most recent round and extending one year forward.

Table 4-1 displays the list of TIRCP and LCTOP POR metrics approved by CARB at the start of this data collection task following the initial metrics and methods assessment. During the analysis process, the Project Team also identified opportunities for additional or alternative metrics to recommend for inclusion in future rounds of POR.

Table 4-1. Initially Approved LCTOP and TIRCP POR Metrics

	Sub-Program Component	Metrics
Low Carbon Transit Operations Program (LCTOP) Transit and Intercity Capital Rail Program (TIRCP)	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)
		Days of operation per year
		Average daily ridership
		Average trip length
	New Vehicle(s) for Existing Transit Service	Vehicle miles traveled or fuel/energy consumption
		Change in fuel/energy consumption or vehicle miles traveled

4.2.5. Assessment of Barriers and Evaluation Considerations

Throughout the data collection and analysis process, the Project Team took note of data collection challenges and other significant issues that may serve as barriers to effective POR procedures and may present opportunities for improved data collection strategies or relate to overall evaluation recommendations for TIRCP and LCTOP projects.

4.3. Results by Sampled Project

This section summarizes the results of the data collection effort by sampled project.

4.3.1. TIRCP Project 1: Expanding the San Francisco Municipal Transportation Agency (SFMTA) Light Rail Vehicle Fleet, CCIRTS Project ID 0016000121

This TIRCP funding is allocated to the purchase of eight light rail vehicles (LRVs) to expand the SFMTA LRV fleet. This purchase is part of a larger LRV expansion plan, and at the time of the project application SFMTA planned to purchase a total of 64 LRVs by the year 2020 to meet growing system demands.

4.3.1.1. Data Collected

Data collected for this project included:

1. A summary of outcome-related metrics obtained from SFMTA including days of operation per year, average daily ridership, energy consumption, and VMT for the period of October 1, 2019 through September 30, 2020;
2. A memo describing the method of calculating the above metrics; and
3. Supporting documentation consisting of the TIRCP project application.

SFMTA had already provided Caltrans with outcome-related metrics for this project as part of the official POR process. Rather than requesting additional data from SFMTA the Project Team focused on reviewing the available POR data and identifying considerations for future POR periods.

4.3.1.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission: October 1, 2019 – September 30, 2020

This is the outcome tracking period defined by SFMTA in the workbook of outcome-related metrics that was provided to the Project Team in response to the data request. The operational date for the project is listed as November 17, 2017, meaning that the above dates represent the third annual outcome period associated with this project.

Days of operation for the reported outcome period: 181

SFMTA typically operates 365 days per year, but the outcome period October 1, 2019 through September 30, 2020 coincides with the COVID-19 pandemic during which operations were partially or fully suspended. The 181 days shown above represent the actual days of operation during this specific period.

Average daily ridership: 11,033

SFMTA reports systemwide light rail ridership values to the FTA and is currently unable to report the ridership specific to an individual vehicle. Therefore, the ridership shown above is based on average systemwide weekday ridership (164,119) divided by the average number of weekday vehicles (119), to determine an average ridership per vehicle value of approximately 1,379. Multiplying this value by 8, the number of vehicles represented by this grant, results in the average daily ridership value of 11,033 above.

Average trip length: Not available

SFMTA reports systemwide average trip length values to the FTA but did not provide average trip length as part of its previous POR submission for this project. This is because average trip length was added to the POR framework as a result of the initial metrics and methods assessment conducted by the Project Team, and was not a required POR metric at the time of this previous submission. SFMTA indicated that it is not currently able to calculate average trip length per individual vehicle and would need to develop a custom approach for estimating the average trip length for vehicles funded through this grant.

Vehicle miles traveled or fuel/energy consumption: 213,756 miles

This metric was not originally required for the TIRCP sub-program component involving projects that result in expansion of transit service, but during the data collection effort it was determined that VMT is a relevant metric for these types of projects and the Project Team was able to collect it for this SFMTA project. Similar to the ridership approach above, SFMTA provided VMT based on systemwide averages. The above value represents the FY2019 average weekday VMT (17,567) divided by the average number of weekday vehicles (119) and then multiplied by the number of vehicles represented by the TIRCP grant (8) and the actual days of operation during this outcome period (181).

Table 4-2 summarizes the above metrics for this project.

Table 4-2. TIRCP Project 1 Outcome Metrics

Sub-Program Component	Metric	Result
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)	10/1/2019 – 9/30/2020
	Days of operation for the reported outcome period	181
	Average daily ridership	11,033
	Average trip length	Not available
	Vehicle miles traveled or fuel/energy consumption	*213,756*

4.3.1.3. Additional Discussion

The following items are presented discussion based on the data collection and analysis findings for this project.

Ridership impacts and limited days of operation

The listed outcome period coincided with the COVID-19 pandemic and light rail operations were partially or fully suspended starting in March 2020. The typical operational schedule is 365 days per year, and would result in higher average daily ridership and annual ridership values than shown above. External effects such as those presented by the COVID-19 pandemic are not currently controlled for in transit QM tools and estimating the impact of these types of effects on transit ridership is outside the current scope of the POR framework.

Data reporting limitations

SFMTA staff indicated that they are unable to provide outcome-related metrics specific to the individual vehicles associated with the TIRCP funding, for multiple reasons. First, while the TIRCP funds were allocated towards the purchase of vehicles, the vehicle procurement process for SFMTA involves six milestone payments over time rather than a single payment per vehicle, and at the time of this TIRCP award SFMTA planned to purchase 32 new light rail vehicles by the year 2020 in addition to those funded through this allocation. This means that the TIRCP funds were not directly used for the purchase of eight light rail vehicles, but were allocated as needed during the procurement process. For the purposes of reporting, SFMTA has confirmed that the TIRCP funds represent the cost of eight vehicles, but no individual vehicle can be identified as purchased solely through TIRCP funds.

Secondly, SFMTA collects and reports systemwide light rail ridership and VMT to the FTA, and does not report individual vehicle activity. Due to this, SFMTA has calculated and reported metrics for this project by referencing systemwide data and dividing by the total number of light rail vehicles in the system to determine per-vehicle estimates. SFMTA then multiplied the per-vehicle estimates by eight, the number of vehicles represented by the TIRCP grant, to determine the ridership, VMT, and energy consumption associated with these funds. With the quantity of vehicles being the only changing variable, this approach has resulted in SFMTA reporting the same ridership, VMT, and energy consumption outcomes to Caltrans for two separate grants from different funding years, as both grants were associated with the purchase of eight vehicles. While this approach is reasonable given the data limitations, the reason for these duplicate values across grants was not clear to the Project Team or administering agency contacts until

SFMTA explained the approach during a data request interview. Additionally this approach is distinct from the reporting approach used by other transit agencies, some of which are able to provide vehicle-specific data.

With grantee agencies using different methods to calculate outcome metrics, it is important for administering agencies to oversee the reporting process to ensure that data obtained across the range of TIRCP projects are as comparable and consistent as possible. The Project Team recommends that administering agencies work with grantees to determine whether vehicle-specific data or systemwide data will be used for POR purposes, and if the latter, to request a description for how each metric was calculated based on systemwide totals. This will improve CARB and administering agencies' ability to conduct quality assurance on project QM calculations and the POR metrics provided for each project.

Feedback on POR scope and requirements

During a data request interview with SFMTA, project staff suggested that to the extent possible, project outcome reporting requirements should align with the information that is already required by FTA. SFMTA noted that smaller transit agencies may have difficulty fulfilling custom data requests if they differ from what those agencies have already prepared to report for FTA purposes. All of the currently recommended POR metrics for Transit projects are within the scope of current public agency reporting requirements. Agency feedback suggests that if POR were to be expanded to serve as a more comprehensive evaluation phase, this may require third-party evaluator expertise or additional evaluation resources directed towards grantee transit agencies.

4.3.2. TIRCP Project 2: San Diego Metropolitan Transit System (SDMTS) Trolley Capacity Improvements Project, CCIRTS Project ID 0016000188; 0017000040)

This project consists of adding a new courthouse terminal station in downtown San Diego for the Blue and Orange SDMTS trolley lines as well as purchasing nine Siemens S70 light rail vehicles (LRVs) to expand Blue line and Orange line service capacity and number of total trips. TIRCP funding was allocated to the construction costs of the courthouse terminal and the purchase of the LRVs.

4.3.2.1. Data Collected

Data collected for this project included:

1. Ridership data for the extra Blue Line and Orange Line trips that were enabled by the purchase of additional trolley vehicles, for the period of June 9, 2019 through June 8, 2020;
2. VMT data for the extra Blue Line and Orange Line trips that were enabled by the purchase of additional trolley vehicles, for the period of June 9, 2019 through June 8, 2020;
3. Days of operation for the Blue and Orange lines for the period June 9, 2019 through June 8, 2020;
4. Average trip length metrics for the Blue Line and Orange Line extra trips for the period of June 9, 2019 through June 8, 2020;
5. Ridership data for trips serving the courthouse station for the period of April 29, 2018 through April 28, 2019;
6. Average trip length for Orange Line trips serving the courthouse stations from April 29, 2018 through April 28, 2019; and
7. Supporting documentation consisting of the TIRCP project application.

4.3.2.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below. SDMTS received TIRCP funding for two components of the trolley system: 1) Development of a courthouse station to allow for expanded trolley service, and 2) The purchase of additional trolley vehicles as part of capacity expansion. The below metrics separate these two components as they have separate ridership, trip length, and days of operation outcomes, and are distinct in terms of project type (infrastructure vs. capital vehicle purchase).

Tracking dates of data submission:

- Courthouse Station: April 29, 2018 – April 28, 2019
- Blue Line and Orange Line Vehicles: June 9, 2019 – June 8, 2020

These dates are based on the listed operational date for the courthouse station and vehicles purchased through TIRCP and extending one year forward.

Days of operation for the reported outcome period:

- Courthouse Station: 365
- Blue Line and Orange Line Vehicles: 254

SDMTS indicated that the courthouse station operates 365 days per year. For the additional LRVs purchased, the stated outcome period coincides with the COVID-19 pandemic and SDMTS noted that the extra Orange Line trips were not operated from April 13, 2020 through June 8, 2020 for this reason. The value of 254 days of operation shown above is based on data received for the Blue Line, which is consistent with a typical operating schedule.

Average daily ridership:

- Courthouse Station: 792
- Blue Line and Orange Line Vehicles: 1,165

Data provided by SDMTS shows total passengers on the extra Orange Line and Blue Line trips for each quarter of FY2019 and FY2020 within the stated outcome period. SDMTS noted that these extra trips were enabled by the purchase of nine new LRVs.

Average trip length:

- Courthouse Station: 4.8 miles
- Blue Line and Orange Line Vehicles: 5.8 miles

SDMTS provided an estimate of average passenger trip length for both the courthouse station and extra Orange and Blue Line trips for the stated outcome periods.[26]

Vehicle miles traveled or fuel/energy consumption: 76,248 miles (Blue Line and Orange Line Vehicles)

This metric was not originally required for the TIRCP sub-program component involving projects that result in expansion of transit service, but during the data collection effort it was determined that VMT is a relevant metric for these types of projects and the Project Team was able to collect it for this SDMTS project. SDMTS provided data for trolley vehicle miles traveled during the extra Orange and Blue Line trips for the stated outcome period. The value shown above is based on total car miles rather than total train miles (3 cars per train).

Table 4-3 summarizes the above metrics for this project.

[26] The grantee did not provide data or respond to a request for clarification regarding the basis for these average trip length estimates.

Table 4-3. TIRCP Project 2 Outcome Metrics

Sub-Program Component	Metric	Courthouse Station	Blue Line and Orange Line Vehicles
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)	4/29/2018 – 4/28/2019	6/9/2019 – 6/8/2020
	Days of operation for the reported outcome period	365	254
	Average daily ridership	792	1,165
	Average trip length	4.8	5.8
	Vehicle miles traveled or fuel/energy consumption	*N/A*	*76,248 miles*

4.3.2.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Comparison to expected days of operation

The days of operation during the outcome period for the additional Blue Line vehicles is consistent with the 254 days of operation input used in the project application, though Orange Line vehicles were not operational for a two-month portion of this 254-day period. Courthouse station days of operation were not included as an input in the project application.

Comparison to expected average trip length

The Average Trip Length values displayed above (4.8 miles for the courthouse station trips and 5.8 miles for the additional vehicles) is shorter than the 6.5-mile Average Trip Length estimated for this project as part of the TIRCP application. As the trip length value is a key variable in the QM calculations for TIRCP projects, this difference between expected and actual trip length would result in a meaningful reduction in expected GHG benefits for this project if the QM were to be updated with the POR metric.

Limited comparison to expected ridership levels

Data collected for the outcome period show 1,165 daily riders on average for the additional vehicles purchased. In contrast, the ridership ("R") value used in the project application was 3,207. While the observed ridership levels are much lower than anticipated, it should be emphasized that the period for which SDMTS provided ridership data coincides with the COVID-19 pandemic, during which transit ridership levels have decreased dramatically across transit systems in the state.

Ridership estimation methodologies

Based on a review of the project application, SDMTS used a ridership modeling method to estimate the additional ridership that would be achieved by expanding the number of Blue and Orange Line trips. This method referenced the forecasted ridership value for the 2020 year, applied a factor based on peak ridership for each line, and applied a growth factor for each subsequent year. SDMTS projected the total ridership gains that would be achieved by these additional trips by calculating the portion of demand that could be met under the pre-project capacity and estimating the portion of the additional capacity that

would be filled by new transit riders who would otherwise have chosen different travel modes (or not traveled at all). As the TIRCP QM includes an Adjustment Factor to account for transit dependency, it is possible that this estimation approach would result in partially double counting and redundantly excluding riders who would be riding transit in the absence of the project.

The SDMTS approach is one of many different methodologies used by transit agencies to calculate the additional ridership achieved by California Climate Investments projects. Based on discussions with Caltrans, this and other TIRCP projects from this period were funded prior to the development of program QM tools, and therefore grantees were responsible for developing their own estimation methodologies. These older projects likely had greater variation in the approach used to estimate project benefits than do the newer projects, though guidance within QM tools is limited and there may still be an opportunity for improved consistency within estimation approaches. While this variation in approaches applies directly to the QM phase of the funding process rather than the POR phase, inconsistency within QM estimates can act as a barrier to implementing a consistent and informative POR phase or other evaluation framework.

Limited availability of project documentation

The Project Team requested all available project documentation from Caltrans for the sampled TIRCP grants, though only the project applications were provided. Caltrans indicated that this older TIRCP project pre-dated the existence of QM calculators and that the application is the main source of project data, but the application does not appear to match the final benefits estimates for the project that are shown within CCIRTS or other documentation.

For example, the SDMTS project application notes that the project will generate an expected 26.9 million trips over its useful life, resulting in GHG reduction of 11,001 MTCO2. However, a revision summary document provided to the Project Team by Caltrans indicates that this estimate was changed to 13,500 MTCO2e due to an issue with the project life input as well as incorrect quantification inputs. Further supporting documentation was not provided, and it is not clear whether this revision involved an adjustment to the ridership input, trip length input, or multiple different inputs.

While project applications provide information related to initial plans and preliminary metrics, many projects receive revisions or corrections as part of the funding process and it appears that the applications cannot necessarily be viewed as a reliable source for final project calculations and other details.

4.3.3. TIRCP Project 3: Sonoma-Marin Area Rail Transit (SMART) Rail Car Capacity Project, CCIRTS Project ID 0016000237

The TIRCP funding for this project is allocated towards the purchase of four additional rail cars which are intended to expand the capacity of the SMART rail fleet. The original project application indicated that TIRCP funding would be used to purchase three "C" cars, which serve as the middle car of a three-car train, but SMART later changed this plan and used the TIRCP funding towards the purchase of two "A" cars and two "B" cars. The purchase of these cars is part of a larger expansion project involving the construction of a 70-mile commuter rail and parallel bicycle and pedestrian pathway project between Marin County and Sonoma County.[27]

4.3.3.1. Data Collected

Data collected for this project included:

1. Systemwide ridership averages for the period of October 1, 2019 through September 30, 2020;
2. Fueling records for the four vehicles (2 "A" cars and 2 "B" cars) funded through this project for the period of October 1, 2019 through September 30, 2020;
3. Mileage records for the four vehicles funded through this project for the period of October 1, 2019 through September 30, 2020;
4. Average systemwide trip length for Fiscal Year 2020 (July 1, 2019 through June 30, 2020); and
5. Supporting documentation consisting of the original TIRCP project application.

4.3.3.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission: October 1, 2019 – September 30, 2020

These dates are based on the start and end dates of fuel, VMT, and ridership records provided by SMART for the four funded vehicles. Two of the vehicles began service in August 2019 and the other two vehicles began service in September 2019. All vehicles were operational by October 1, 2019 and the Project Team selected this as the start date for the data request. The end date of data provided for all vehicles was September 30, 2020.

Days of operation for the reported outcome period: 365

This value is based on SMART operational records. Some vehicles operated for fewer than 365 days during the specified outcome period, which is shown in the vehicle-level outcomes table below. The above value represents the maximum operational days among the TIRCP-funded vehicles for this period.

Average daily ridership: 1,418

This value represents average systemwide ridership provided by SMART rather than an analysis of vehicle-specific ridership data. SMART staff indicated that they are unable to provide vehicle-specific ridership data.

[27] This project description can be found in the SMART Rail Car Capacity Project TIRCP application.

Average trip length: 23.8 miles

This value represents the average systemwide trip length provided by SMART rather than an analysis of vehicle-specific trip length data. SMART staff indicated that they are unable to provide vehicle-specific trip length data.

Vehicle miles traveled or fuel/energy consumption: 114,029 miles; 39,824 diesel gallons

This metric was not originally required for the TIRCP sub-program component involving projects that result in expansion of transit service, but during the data collection effort it was determined that VMT is a relevant metric for these types of projects and the Project Team was able to collect it for this SMART project. These values are based on the sum of fueling records and mileage service records provided by SMART for each of the 4 vehicles for the period of October 1, 2019 through September 30, 2020.

Table 4-4 summarizes the above metrics for this project.

Table 4-4. TIRCP Project 3 Outcome Metrics – Project Level

Sub-Program Component	Metric	Result
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)	10/1/2019 – 9/30/2020
	Days of operation for the reported outcome period	365
	Average daily ridership	1,418
	Average trip length	23.8 miles
	Vehicle miles traveled or fuel/energy consumption	*114,029 miles; 39,824 diesel gallons*

The current POR framework for TIRCP requests outcomes at the project level but for additional detail Table 4-5 provides days of operation, fuel consumption, and VMT at the vehicle level for each of the four TIRCP-funded vehicles. Presenting these vehicle-specific metrics for is intended to provide insight into the level of detail available from this agency.

The days of operation values are based on information received from SMART regarding the operational status of each vehicle. One of the vehicles (Vehicle ID 116) was taken out of operation from November 13, 2019 through August 5, 2020 due to a collision, and the 99 days of operation shown below represents this unexpected service limitation rather than a scheduled service level.

Table 4-5. TIRCP Project 3 Outcome Metrics – Vehicle Level

Metric	Vehicle ID 115	Vehicle ID 116	Vehicle ID 117	Vehicle ID 118
Days of operation for the reported outcome period	365	99	357	357
Vehicle miles traveled	29,086 miles	5,136 miles	38,627 miles	41,180 miles
Fuel/energy consumption	10,016 diesel gallons	2,555 diesel gallons	13,068 diesel gallons	14,185 diesel gallons

4.3.3.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Comparison to expected average trip length and days of operation

The average trip length value of 23.8 miles shown above is close to the estimated trip length value provided by SMART in the TIRCP application for this grant (19.84 miles for the first year of operation, 25.95 miles for the final year of project quantification). Similarly, the days of operation per year values are close to the value of 365 days submitted in the TIRCP application, aside from Vehicle ID 116 which was limited to 99 days of operation due to a collision.

Project documentation discrepancies

The TIRCP application initially calculated GHG benefits resulting from new service but program guidelines indicate that this project should be categorized as a capacity expansion project. In response to this, CARB ultimately revised the expected benefits for this project from 1,266,293 MTCO2e to 82,630 MTCO2e as a corrective action. Updated inputs and calculations representing this change were not provided, and this creates a barrier to comparing observed POR metrics to original project estimates.

Overall, the extent to which POR can provide insight into this type of project is limited by the level of detail of data provided by the transit agency as well as the reliability and consistency of project documentation. For this project it appears that there were issues in the initial benefits calculations and differences between the planned project and implemented project (e.g. number and types of cars) which adds difficulty to the process of comparing post-project outcomes with pre-project assumptions. This may be resolved with improved quality assurance and close working relationships with grantees during the application process, as well as retaining updated project documentation for the duration of the POR period and providing this information as needed for evaluation purposes.

Feedback on POR and evaluation of project benefits

SMART staff noted that the individual outcome metrics available for the four vehicles associated with this project do not provide a comprehensive understanding of the service improvements and effects on land use enabled by this capacity expansion. For example, SMART indicated that its ability to continually meet service needs is encouraging the development of additional housing along the rail line, providing transit access to additional local residents. SMART staff explained that a third-party analysis of the region estimated that SMART enhancements such as the current expansion project would encourage transit-oriented development, thereby reducing VMT and generating a variety of co-benefits such as reduced

health care costs due to reduced pollution.[28] Assessment of these indirect or long-term effects and benefits is outside the scope of the current POR framework but these comments provide an example of the types of impacts that may be included in a more comprehensive cost-benefit analysis or modeling effort.[29]

Another contextual consideration that applies to many California Climate Investments projects for the 2020 year is related to service interruptions and external effects resulting from the COVID-19 pandemic. SMART staff indicated that their systemwide ridership was down by approximately 85% for the specified outcome period, but that prior to the pandemic they had seen an increase in ridership of 26% in January 2020 as compared to January 2019, and an increase of 40% in February 2020 as compared to February 2019. As the TIRCP QM calculator assumes typical operating conditions, it is not feasible to assess the effectiveness of a project by comparing expected ridership with observed ridership in the outcome period under these circumstances.

The SMART project provides an opportunity to consider certain limitations of standardized outcome reporting and how an in-depth evaluation approach may greatly improve insights into individual project results. While POR is currently intended to provide a snapshot of projects on an annual basis, a more rigorous evaluation of outcomes and impacts could account for unique circumstances that may affect ridership and service operation, either on a broad scale or specific to individual agencies and service areas.

[28] "Sonoma County Scenarios and Analysis". PowerPoint presentation prepared by Calthorpe Analytics for Sonoma County Agricultural Preservation and Open Space District. November 2016. http://scta.ca.gov/wp-content/uploads/2017/12/Sonoma-County-Scenarios-Presentation-11-Dec-2017.pdf.

[29] Todd Litman, "Evaluating Public Transit Benefits and Costs: Best Practices Guidebook.," *World Transit Research*, February 1, 2010, https://www.worldtransitresearch.info/research/2707.

4.3.4. TIRCP Project 4: Bravo! Route 560 Rapid Buses, CCIRTS Project ID 0016000041

This project consists of the purchase of four compressed natural gas (CNG) buses to enable the implementation of a new service line that provides rapid bus service along an existing Orange County Transportation Authority (OCTA) route. The rapid service required the purchase of five buses total, four of which were funded through TIRCP. The remaining bus was purchased using local funds.

4.3.4.1. Data Collected

Data collected for this project included:

1. Ridership by month for the rapid bus service (Route 560) for the period of June 2016 through December 2019;
2. Ridership by month for the standard bus service (Route 60) operating on the same route as the rapid bus service for the period of January 2016 through December 2019;
3. Systemwide ridership for the grantee agency for the period of January 2016 through February 2019;
4. Average passenger trip length estimates for the period of January 2016 through December 2019;
5. Supplementary metrics obtained from the grantee agency regarding the estimated ridership changes that are directly attributable to the rapid bus route project; and
6. Supporting documentation consisting of the TIRCP project application.

4.3.4.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission:

- Period 1: June 1, 2016 – May 31, 2017
- Period 2: June 1, 2017 – May 31, 2018
- Period 3: June 1, 2018 – May 31, 2019

The rapid service buses first became operational in June 2016. The data provided by OCTA represents the first three annual outcome reporting periods for the project (Period 1: June 2016 - May 2017; Period 2: June 2017 - May 2018; Period 3: June 2018 - May 2019).

Days of operation for the reported outcome period: 255 (all periods)

This value was provided by OCTA staff and represents the standard schedule of annual operating days for this service line.

Average daily ridership:

- Period 1: 2,961
- Period 2: 3,126
- Period 3: 3,050

Average Daily Ridership for each of these periods was calculated as total ridership divided by operational days within the outcome period.

Average trip length: 4.6 miles (all periods)

The above value is an estimate provided by OCTA. The Project Team was not able to validate this estimate as data provided by the agency did not include passenger miles records or vehicle-specific estimates of average trip length.

Vehicle miles traveled or fuel/energy consumption: Not available

At the time of the data request for this project, VMT and fuel/energy consumption metrics were applicable to projects involving the purchase of replacement vehicles only. As this is an expanded service project, the Project Team did not seek this information from OCTA part of the data collection effort.

Table 4-6 summarizes the above metrics for this project.

Table 4-6. TIRCP Project 4 Outcome Metrics

Sub-Program Component	Metric	Period 1	Period 2	Period 3
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)	6/1/2016 – 5/31/2017	6/1/2017 – 5/31/2018	6/1/2018 – 5/31/2019
	Days of operation for the reported outcome period	255	255	255
	Average daily ridership	2,961	3,126	3,050
	Average trip length	4.6 miles	4.6 miles	4.6 miles
	Vehicle miles traveled or fuel/energy consumption	Not available	Not available	Not available

In addition to the approved POR metrics, OCTA provided a methodology for estimating the changes in ridership that are attributable to the TIRCP project. This methodology involves using systemwide ridership changes to estimate the counterfactual ridership that would have occurred on the existing standard service line (Route 60) that operates along this route in the absence of the rapid service line (Route 560) expansion project.

While these estimates are not currently required by the TIRCP POR framework, for discussion purposes the Project Team applied this estimation approach to each of the three selected outcome periods to reflect the grantee agency's proposed approach of quantifying project induced ridership effects. Table 4-7 displays these estimates.

Table 4-7. TIRCP Project 4 Ridership Change Attributable to Project (Estimated by Grantee)

Metric	Period 1	Period 2	Period 3
Annual ridership change attributable to project	-13,233	34,676	41,261
Average daily ridership change attributable to project	-52	136	178

4.3.4.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Average trip length

The TIRCP application for this grant used an average trip length of 8.63 miles in its VMT and GHG reduction estimates based on the agency's regional transportation plan. However, this value represents linked trips rather than unlinked trips, and the TIRCP QM specifies using unlinked trip length to calculate avoided VMT and resulting project benefits. Thus the average trip length metric presented above uses the unlinked trip value of 4.6 miles, cited by grantee agency staff. If applied to the QM calculations, this would result in a decrease in avoided VMT for the project.

Ridership and grantee counterfactual estimation

The average daily ridership metrics shown above of approximately 3,000 riders per day for the rapid bus service line in each outcome period are much greater than the estimate of 870 riders per day used in the TIRCP grant application. However, OCTA noted that it may not be appropriate to compare observed ridership to expected ridership in this case as the Route 560 rapid bus service line is used to provide an extension and expansion of service provided to passengers of the existing Route 60 service line. Because of this, much of the new Route 560 ridership consists of existing Route 60 ridership that has been transferred to the new buses. OCTA therefore tracks the combined ridership of Route 560 and Route 60, rather than Route 560 alone, in order to monitor changes in ridership over time.

In order to conduct an informative comparison of initial Route 560 ridership forecasts to actual ridership outcomes, OCTA made efforts to estimate the ridership that is attributable to the addition of Route 560 and that would not have occurred on Route 60 in the absence of this project. Using the estimation approach provided by the grantee agency that considers systemwide ridership changes, the average daily ridership attributable to the rapid service line is -51.89 riders for Period 1, 135.99 riders for Period 2, and 177.85 riders for Period 3. These values are much lower than the forecasted 870 riders per day noted in the grant application, though this approach is presented for exploratory purposes and is not intended to validate or invalidate that initial estimate. Additionally, the current TIRCP QM calculator incorporates an Adjustment Factor to account for transit dependency, and combining this novel estimation approach with the use of the Adjustment Factor may redundantly exclude ridership that could be attributed to the Route 560 expansion.

Overall, this project provides an example of how projects have unique components which may affect the degree to which service expansion affects changes in ridership. Rather than creating a new transit service in an area that was not previously served by the transit agency, this project enhances the transit service

for a specific route an expands capacity between the rapid and standard services. While observing changes in systemwide ridership and using to compare ridership in the pre-project and post-project period may be a reasonable approach in this case, this type of counterfactual estimation is outside the scope of the current POR framework and would need to be tailored to account for the particular features of individual projects and transit systems. If implemented, these efforts would likely require in-depth involvement from CARB, administering agencies, or third-party evaluators in order to develop approaches and maintain consistency in the quality of results across agencies and projects.

4.3.5. TIRCP Project 5: Travel Time Reduction Project, CCIRTS Project ID 0016000276)

This project consists of implementing track and curve improvements on the Capitol Corridor rail line in order to reduce the travel time of trains by up to 10 minutes for each trip. This is intended to improve the reliability and quality of service and encourage increased ridership by making the Capitol Corridor a more competitive mode as compared to other travel options.[30]

4.3.5.1. Data Collected

Data collected for this project included:

1. Ridership data for the Capitol Corridor (Route 37) for Fiscal Year 2018 (FY18) and Fiscal Year 2019 (FY19);
2. Passenger miles traveled for the Capitol Corridor for FY18 and FY19;
3. Information on days of operation, provided by CCJPA staff; and
4. Supporting documentation consisting of the TIRCP project application.

4.3.5.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission: June 30, 2018 – June 29, 2019

This is based on the operational date of the project as listed within the CCIRTS database and extending one year forward to represent the first annual outcome period for this project.

Days of operation for the reported outcome period: 365

This value is based on feedback from CCJPA staff, who confirmed that the service operates 365 days per year.

Average daily ridership: 4,820; **Average trip length:** 67 miles

Data received from CCJPA included ridership and passenger miles by Fiscal Year (FY) rather than by calendar year or month. In order to align the FY data with the specific period of outcome reporting, the Project Team applied a proration approach to FY18 and FY19 based on the portion of the outcome reporting period overlapping with each FY period. In this case 25% of the outcome period (93 days) falls within FY18, and 75% of the outcome period (272 days) falls within FY19. Following this, the Project Team summed the prorated ridership and passenger miles respectively to obtain estimated total ridership and passenger miles for the outcome period. The Project Team then calculated Average Daily Ridership as total ridership divided by the number of operational days within the outcome period. The Project Team calculated Average Trip Length as total passenger miles divided by total ridership.

[30] A description of the project and characterization of the expected benefits resulting from this project are provided in the initial TIRCP application.

Vehicle miles traveled or fuel/energy consumption: Not available

At the time of the data request for this project, VMT and fuel/energy consumption metrics were applicable to projects involving the purchase of replacement vehicles only. As this is an expanded service project, the Project Team did not obtain this information from CCJPA part of the data collection effort.

Table 4-8 summarizes the above metrics for this project.

Table 4-8. TIRCP Project 5 Outcome Metrics

Sub-Program Component	Metric	Result
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)	6/30/2018 – 6/29/2019
	Days of operation for the reported outcome period	365
	Average daily ridership	4,820
	Average trip length	67 miles
	Vehicle miles traveled or fuel/energy consumption	*Not available*

4.3.5.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Prorated ridership and trip length metrics

As noted above, the Project Team used a proration approach with the FY18 and FY19 data provided by CCJPA to estimate average daily ridership and average trip length for the specified outcome period. While the current estimates are likely close approximations to the outcome period, a data set organized by individual month or day rather than FY would allow for more precise calculations.

Comparison to expected average trip length

The average trip length determined for this outcome period is very close to the average trip length estimate for this TIRCP grant: 68 miles estimated in project documentation as compared to 67 miles calculated as part of this data collection effort.

Limited comparison to expected ridership levels

The average daily ridership of 4,820 calculated above cannot be directly compared to initial estimates shown in the project application, as these appear in terms of average weekday ridership (10,311 estimated in project documentation) and average weekend and holiday ridership (2,320 estimated in project documentation). However, the above calculated result for the outcome period appears to be lower than the initial estimate overall. As part of the recommendations for Transit POR metrics the Project Team suggests requesting ridership separated by weekdays, Saturdays, and Sundays, as this provides a more granular view of service and several of the interviewed transit agencies indicated that they already separate ridership data into these categories.

Evaluation considerations related to project complexity

This project involves infrastructure improvements that are intended to improve the reliability and competitiveness of rail service, thereby resulting in increased ridership and avoided personal vehicle VMT. CCJPA obtained the estimated ridership increases for this project through a modeling effort using the California Ridership Model. While the concept of how this project achieves GHG reductions has been reviewed and approved by TIRCP, measuring these effects and attributing any changes in ridership to these improvements would be very challenging due to the scale of these improvements and expected ridership compared to the magnitude of total CCJPA ridership and the many factors that affect mode choice.

Ridership data collected through POR is unlikely to provide insight into the effects of the track and rail improvements funded by TIRCP and a full evaluation of this project may require an updated modeling effort or other in-depth study. Overall, the evaluability of this type of project is very limited under the current POR framework and it may be necessary for CARB and Caltrans to consider assessing project evaluability as part of the funding process if California Climate Investments has an eventual goal of measuring project effectiveness and impacts during the outcome period.

4.3.6. LCTOP Project 1: Battery Electric Zero Emission Bus and Infrastructure Project, CCIRTS Project ID 15-16-D4-54

This project consists of the purchase of five forty-foot zero emission electric transit buses and three fast-speed electric vehicle charging stations, as well as the implementation of related connectivity improvements for this expansion of transit service.

Since project implementation, Santa Clara Valley Transportation Authority (Santa Clara VTA) has partnered with Lehigh University, which is providing data collection and analysis support to evaluate the efficiency and impacts of the agency's transit service. Lehigh University assisted in fulfilling the data requests that the Project Team issued to Santa Clara VTA.

4.3.6.1. Data Collected

Data collected for this project included:

1. Project documentation including the LCTOP allocation request, QM calculator tool workbook, and close out report;
2. Individual vehicle ridership data for the period of June 2019 through May 2020;
3. Days of operation for 2019, 2020, and the June 2019 through May 2020 period;
4. Energy consumption for the five electric buses for 2019, 2020, and the June 2019 through May 2020 period;
5. VMT information for the five electric buses for 2019, 2020, and the June 2019 through May 2020 period; and
6. Average operator trip length data for the five buses for 2019, 2020, and the June 2019 through May 2020 period.

4.3.6.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission: June 1, 2019 – May 31, 2020

This is based on the date that the vehicles began operating their normal service routes (June 2019) and extending one year forward to represent this outcome reporting period.

Days of operation per year: 154

This is based on operational data provided by Lehigh University, though as noted above service was interrupted due to the COVID-19 pandemic as of March 27, 2020.

Average daily ridership: 599

This represents the total ridership for all five buses for the period of June 2019 - May 2020, divided by the operational days for the period (154 days). It should be noted that as the outcome period coincided with the COVID-19 pandemic, the transit agency halted bus service on March 27, 2020, and the buses did not operate at all during April or May 2020.

Average trip length: Not available

This metric was requested but was not provided by the grantee, though total and average operator miles were provided.

Vehicle miles traveled or fuel/energy consumption: 93,933 kWh; 47,211 miles

This metric was not originally required for the LCTOP sub-program component involving projects that result in expansion of transit service, but during the data collection effort it was determined that VMT is a relevant metric for these types of projects and the Project Team was able to collect it for this Santa Clara VTA project. These values represent the total recorded energy usage and vehicle miles traveled during normal weekday operation for all five buses during the listed outcome period, as provided by Lehigh University.

Table 4-9 summarizes the above metrics for this project.

Table 4-9. LCTOP Project 1 Outcome Metrics

Sub-Program Component	Metric	Result
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)	6/1/2019 – 5/31/2020
	Days of operation per year	154
	Average daily ridership	599
	Average trip length	Not available
	Vehicle miles traveled or fuel/energy consumption	*93,933 kWh, 47,211 miles*

4.3.6.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Limited comparison to expected ridership

The total ridership for the five electric buses during the above outcome period is 92,270. In contrast, the first year ridership estimated as part of the LCTOP application was 564,600, meaning that observed ridership for the 12 month outcome period is approximately 16% of expected ridership. While observed ridership levels are much lower than anticipated based on project documentation, it should be noted that the above outcome period includes 2 months (April 2020 and May 2020) during which these buses were not operated at all due to the COVID-19 pandemic. Additionally, the buses are now operating on a normal service route rather than the airport shuttle route that was identified during the project planning process.

This creates challenges in comparing expected and actual ridership levels, and in order to understand how the buses have affected ridership it would be necessary to compare pre-project ridership levels on the current route to post-project ridership levels on that route, while controlling for factors such as reduced transit ridership due to the COVID-19 pandemic. This issue also applies to metrics such as energy consumption and average trip length, which were requested but not provided by the grantee agency. This type of analysis was not conducted as part of the current POR exercise, as it is outside the intended scope of POR and would require a more extensive evaluation and modeling effort.

Changes in vehicle service since project implementation

Santa Clara VTA noted that while the five buses began operating on routes providing airport shuttle service (Line 10, Airport Flyer) in mid-2018 as planned within the project application, the buses were shifted to a different route and now provide normal operating service as of June 2019. According to Santa Clara VTA, Caltrans guidance states that as long as the vehicles are continuing to meet their designated disadvantaged community service level, the grantee does not need to submit a project scope change or notify Caltrans of the change in operation. Santa Clara VTA staff explained that it is possible for a region to be classified as a DAC at the time of implementation, but then to be later reclassified during a CalEnviroScreen update. Although a change in service may continue to meet the same DAC requirements, different service lines are associated with different trip lengths, ridership levels, and other characteristics that are key components of program QM and relevant to potential program impact evaluations. It may be useful for Caltrans to be notified of any major service changes for the purposes of POR or other evaluation efforts which may compare these metrics over time. If a change of service is not accounted for, comparison of metrics for different types of service may lead to incorrect conclusions regarding changes in ridership or vehicle operation from year to year.

The Project Team recommends that as part of POR, Caltrans verifies whether funded vehicles are continuing to provide service as specified within final project documents, and if not, requests a description of the change. Additionally as part of this verification it would be possible to verify whether the new service continues to meet the same level of DAC service according to CalEnviroScreen. While CARB has indicated that verification of the extent to which projects continue to generate benefits to DACs is outside the current scope of POR, periodic monitoring of changes in DAC designations and how this may affect DAC benefits generated in the long term should be considered as a component to potentially include in any expansion of evaluation efforts for California Climate Investments.

Advanced analysis and data collection partnerships

Santa Clara VTA noted that there were many early challenges in obtaining data for this project and that it initially relied on manual data collection such as driver self-reports of ridership and charge use. However, Santa Clara VTA has since established a partnership with Lehigh University who facilitated daily data collection through the use of telematics software and is conducting a thorough analysis of vehicle service, energy use, VMT, and other metrics. Santa Clara VTA reported that this partnership has been instrumental in helping the grantee agency better understand the effects of transit electrification and meet its reporting needs. In addition to the POR metrics currently in place, Lehigh University is conducting an extensive modeling effort and evaluation of the grantee agency's electric fleet that will help to optimize service and plan for expanded fleet electrification in the future. This type of project support and comprehensive analysis may be highly useful in understanding the impacts of California Climate Investments transit projects, but is not available to many grantee agencies and is not well suited to the current metrics-based and uniform POR framework.

While some agencies may be able to provide the resources for a full evaluation of their projects or establish partnerships with researchers, the Project Team suggest that CARB reporting requirements should be limited to a level of data collection and associated resources that will be available across all or nearly all grantee agencies. If there is an interest in fully evaluating the short- and long-term benefits (e.g. verified GHG reductions) of a representative sample of funded projects, most grantee agencies would likely need additional support for data collection and analysis.

4.3.7. LCTOP Project 2: Capital Costs for the Express Bus Pilot Project, CCIRTS Project ID 16-17-D04-037

This project consists of the construction of a rapid bus corridor along a 9.52-mile service route that provides intercity service for the Alameda Contra-Costa Transit District (AC Transit). The LCTOP funding was allocated to a portion of the construction cost which included the implementation of dedicated bus lanes, signal priority, fare collection, and other passenger amenities. AC Transit reported that there are 27 hybrid diesel-electric buses currently dedicated to providing service on the constructed corridor.

4.3.7.1. Data Collected

Data collected for this project included:

1. Project documentation including the LCTOP allocation request and closeout report;
2. Monthly ridership for the constructed bus corridor for August 2020 through January 2021;
3. Average Trip Length for the constructed bus corridor for August 2020 through January 2021;
4. On-time performance metrics for the constructed bus corridor for August 2020 through January 2021; and
5. Monthly average weekday ridership for the constructed bus corridor for August 2020 through January 2021.

4.3.7.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission: August 9, 2020 – January 31, 2021

At the time of project sampling, the CCIRTS database indicated that this project had a completion date of December 31, 2019. However in discussions with AC Transit, the Project Team found that the constructed bus corridor became operational on August 9, 2020. As less than one year had passed since the operational date at the time of the data request, AC Transit provided data for the period of August 2020 through January 2021 as a sample for demonstrative purposes. For official POR purposes, data requests to local transit agencies would be postponed until at least one year after the operational date as per current POR guidelines.

Days of operation for the reported outcome period: 176

AC Transit operates 365 days per year. As the data provided represent the period of August 2020 through January 2021, the value above represents the 176 operational days that occurred during the August 2020 through December 2020 period.

Average daily ridership: 7,031

AC Transit provided both average monthly weekday ridership and total monthly weekday and weekend ridership data for the period of August through January 2021. The ridership value above represents the average combined weekday and weekend ridership for all 27 dedicated buses in the corridor for this period.

Average trip length: 3.1 miles

This value is based on the passenger miles and total unlinked trips on the 27 buses serving the constructed bus corridor for the period of August 2020 through January 2021.

Vehicle miles traveled or fuel/energy consumption: Not available

At the time of the data request for this project, VMT and fuel/energy consumption metrics were applicable to projects involving the purchase of replacement vehicles only. As this is an expanded service project, the Project Team did not seek this information from the grantee as part of the data collection effort.

Table 4-10 summarizes the above metrics for this project.

Table 4-10. LCTOP Project 2 Outcome Metrics

Sub-Program Component	Metric	Result
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)	8/9/2020 – 1/31/2021
	Days of operation for the reported outcome period	176
	Average daily ridership	7,031
	Average trip length	3.1 miles
	Vehicle miles traveled or fuel/energy consumption	*Not available*

4.3.7.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Comparison to expected average trip length

The average trip length value displayed above (3.1 miles) is shorter than the average trip length estimated for this project as part of the LCTOP application (6.3 miles). As the average trip length value is a key variable in the QM calculations for LCTOP projects, this difference in expected and actual trip length would result in a meaningful reduction in expected GHG benefits for this project if the QM were to be updated with a value of 3.1 miles.

Limited comparison to expected ridership

The annualized ridership for the bus rapid transit (BRT) corridor based on multiplying the 7,031 average daily riders and the 365 days of operation is 2,566,315 riders. In contrast, the "YR1 Ridership" value used in the final QM calculations was 5,861,098 riders. While current ridership levels are much lower than anticipated, it should be emphasized that the period for which AC Transit provided ridership data coincides with the COVID-19 pandemic, during which transit ridership levels have decreased dramatically across transit systems. As with other sampled projects, this represents an external variable that would significantly impact baseline ridership in the absence of the project (i.e. the counterfactual scenario).

The LCTOP QM does not estimate the counterfactual ridership levels that would occur in a non-project scenario aside from using an Adjustment Factor, which is intended to account for the portion of riders

who are dependent on transit for travel and would still take transit in the absence of the California Climate Investments transit project. A more comprehensive post-project evaluation such as one that controls for systemwide ridership changes resulting from the COVID-19 pandemic, or an enhanced quantification method that uses systemwide or control group ridership to estimate a counterfactual scenario, would be needed in order to use outcome data to reliably quantify the benefits directly resulting from this and other projects during this period.

California Climate Investments funding as a component of large projects

The LCTOP funding provided to AC Transit was one of multiple funding sources used for the construction phase of the BRT corridor and was not allocated for the direct purchase of vehicles. In the absence of a comprehensive impact evaluation or modeling effort to assess the pre- and post-project travel behaviors of individuals within the AC Transit service area, it is challenging to determine the specific ridership effects and GHG benefits resulting from California Climate Investments as a funding source. For this and other transit projects, the Project Team suggests that individual POR metrics are not sufficient to fully evaluate the benefits that are attributable to projects, but that POR may be used to validate and revise inputs that were estimated for QM calculations as part of the project application and planning phase.

While certain QM inputs such as the Adjustment Factor to account for transit dependency are difficult to collect and validate during the POR phase, metrics such as actual ridership and trip length could be used to validate or revise the QM calculator inputs that grantees initially estimated. GHG benefits were not directly recalculated using the QM tool as part of this exercise as this is beyond the scope of the current POR framework.

Level of ridership reporting

AC Transit was able to provide ridership in terms of weekday averages and total combined weekday and weekend ridership. The combined weekday and weekend ridership value was selected for reporting above for the purposes of aligning with the current LCTOP POR framework, which requests total average daily ridership. For future rounds of POR, CARB and administering agencies should consider requesting separate weekday and Saturday/Sunday averages. This aligns with the data requirements currently in place by the Federal Transit Administration (FTA) and may reduce the need for grantee agencies to conduct a custom ridership analysis for POR purposes.

On-time performance as a key performance indicator (KPI)

AC Transit indicated that in addition to ridership and trip metrics, on-time performance is a key variable for its planning and monitoring procedures. AC Transit has a key performance indicator (KPI) of 72% on-time performance, and staff noted that the BRT corridor had lower levels of on-time performance in its first months of operation but improved over time and is now above this 72% target (achieving 75% for November 2020 and 77% for December 2020). As on-time performance is not a QM input and LCTOP does not currently have a stated objective of improving this KPI as a result of California Climate Investments funding, on-time performance is not currently recommended as a POR metric. If improvements in service quality or reliability resulting from California Climate Investments-funded expansions become a focus of later rounds of LCTOP funding, this and other KPI metrics (such as increased safety) could be considered for inclusion as part of future evaluations.

4.3.8. LCTOP Project 3: Capital Costs for the Express Bus Pilot, CCIRTS Project ID 16-17-D05-063

This project involves the development of an Express Bus Pilot within the San Mateo County Transit District (SamTrans), consisting of four limited-stop bus routes using 37 new electric buses. LCTOP funding is allocated to the purchase of a portion of the battery electric buses and chargers for these new routes. The project ID 16-17-D05-063 is associated with funding from the 2016-2017 fiscal year (FY16-17), though SamTrans has submitted multiple LCTOP allocation requests associated with this service expansion and funds were rolled over into subsequent fiscal years.[31]

4.3.8.1. Data Collected

Data collected for this project included:

1. Project documentation consisting of the LCTOP allocation request workbook for the FY19-20 round of funding associated with this service expansion.

At the time of project sampling, the CCIRTS database indicated that project 16-17-D05-063 had a completion date of June 30, 2019. However in discussions with Caltrans and SamTrans, the Project Team learned that the physical project has been extended through June 30, 2023, and that the express bus routes and associated vehicles have not yet been launched. As the buses were not yet operational at the time of the data request, it was not possible to collect data related to the outcomes of this project. Instead, the grantee interview and review of project documentation focused on identifying any evaluation-related considerations or recommendations for this project or the Transit program group.

As part of this assessment the Project Team also requested and reviewed copies of the passenger survey instruments that SamTrans has administered to passengers of its shuttle and general fixed route services.

4.3.8.2. Discussion

The Project Team presents the following findings for discussion based on the information collected and reviewed for this project.

Multiple funding allocations to a single physical project

Development of the Express Bus Pilot is a multi-year process and the grantee agency has submitted multiple LCTOP allocation requests for funding to purchase battery electric buses that will serve the new routes. As LCTOP project IDs are linked to individual allocation requests rather than grouped by physical project, the SamTrans Express Bus Pilot is associated with multiple LCTOP project IDs. Additionally, rather than each allocation request being associated with a specific project component and separate operational date, all LCTOP funds are being used for the purchase of vehicles and equipment that will not be operational until the launch of the pilot.

For this type of project, it is more practical and efficient to consider the capital costs of the project as a whole rather than limit POR to a single project ID that is linked to one of several allocation requests. If a project ID associated with the Express Bus Pilot is sampled for POR once the pilot becomes operational,

[31] For example, project ID 19-20-D04-052 represents a separate round of LCTOP funding allocated towards this service expansion and is the project ID for which Caltrans provided an allocation request workbook. As the Project Team sampled by project ID, and project IDs within the CCIRTS database are associated with individual allocation requests rather than grouped by physical project or transit agency, the FY16-17 project ID is displayed above.

the Project Team suggests that Caltrans determines the total number of vehicles purchased with LCTOP funding across all project IDs associated with the pilot to use as the basis for POR data requests. POR results could then be separated by project ID and respective funding amounts for reporting purposes. This approach should also be considered for similar projects in future rounds of POR.

Multiple funding sources and POR metrics

As is the case for many transit projects within California Climate Investments, this project received funding from multiple sources including LCTOP, TIRCP, the Affordable Housing and Sustainable Communities (AHSC) program, the SB1 Local Partnership Program, and local sales tax proceeds. The presence of multiple funding sources can create challenges in isolating the specific project components and resulting benefits which are attributable to LCTOP funding and which should be measured as part of tracking project outcomes. As this project involves the purchase of new transit vehicles, the grantee transit agency would need to confirm the number of vehicles purchased using LCTOP dollars such as by dividing the total LCTOP funding by the cost of one vehicle. This is an approach that other agencies have used for POR when they are unable to link funding to a specific vehicle. POR metrics such as ridership could then be reported for this quantity of vehicles to represent the outcomes associated with LCTOP funding.

Passenger surveys and counterfactual travel

SamTrans staff noted that they had previously administered surveys to passengers of their shuttle and fixed route services, most recently in 2018, in order to collect passenger characteristics and feedback on the quality of service. Surveys were developed by a third-party consultant and administered in person onboard the transit vehicles. The Project Team requested and reviewed these survey instruments as examples of existing data collection processes to identify possible opportunities for POR data collection moving forward. In addition to collecting information regarding passenger demographics, travel patterns, and satisfaction, the SamTrans shuttle service survey included questions related to counterfactual travel, such as:

- "If the shuttle service wasn't available, how would you get from your home/starting location to your work/final destination?" and
- "If you were to drive from your home/starting location to your work/final destination, because the shuttle service wasn't available, how many days per week would you drive?"

While the assessment of counterfactual travel scenarios is outside the scope of the current POR framework for Transit projects, these are similar to the questions that the Project Team recommended asking of carsharing users as part of POR for the Clean Mobility Options (CMO) program in order to assess the portion of trips that represent improved mobility or avoided internal combustion engine (ICE) travel. Based on information gathered from agencies throughout this data collection effort, the resources available for administering passenger surveys vary widely among transit agencies and as a result the Project Team does not recommend requiring survey data collection for transit projects within the current POR framework. For more in-depth evaluation studies which include sufficient resources to conduct reliable passenger surveying, this type of data collection could be used to further validate project GHG estimates over time.

For example, asking counterfactual travel questions similar to those above could serve as a method for validating the Adjustment Factor input which is currently used to factor ridership and resulting GHG benefits within the TIRCP and LCTOP QM approaches. The Adjustment Factor is intended to account for

the portion of riders who are transit-dependent and would not travel by other modes in the absence of the service or vehicle associated with the California Climate Investments project, but this variable is typically included in the form of a CARB default value or a pre-project estimate provided by the grantee agency rather than on primary data collected for the specific service being implemented. The default Adjustment Factor values are based on transportation research studies and CARB seeks to periodically revise them using updated research.[32] As with other QM inputs, a measured project-specific value would allow for a more precise evaluation of impacts for sampled projects.

In addition to the validation of GHG inputs, passenger surveying could also be used as part of an in-depth evaluation to collect and report various socioeconomic outcomes associated with transit projects such as improved access to jobs and essential services, reduced transportation costs, and avoided vehicle purchases.

[32] Elisa Barbour et al., "Updated Default Values for Transit Dependency and Average Length of Unlinked Transit Passenger Trips," 2019, 32, https://ww2.arb.ca.gov/sites/default/files/classic//cc/capandtrade/auctionproceeds/transit_factors_technical_081319.pdf.

4.3.9. LCTOP Project 4: Mission Bay Loop, CCIRTS Project ID 17-18-D04-057

This project consists of the construction of a segment of light rail trackway that allows vehicles on the San Francisco Municipal Transportation Agency (SFMTA) T Third Street line to turn around, particularly during special events and peak periods. The project is designed to increase the efficiency and reliability of SFMTA light rail service. LCTOP funds were allocated to pay for a portion of the construction cost associated with implementing this infrastructure improvement.

4.3.9.1. Data Collected

Data collected for this project included project documentation consisting of the LCTOP allocation request.

At the time of project sampling, the CCIRTS database indicated that this project had an operational date of February 28, 2019, which the Project Team expected would allow for a full year of outcome-related data. However in discussions with SFMTA, the Project Team learned that the Mission Bay Loop became operational in October 2019 and that SFMTA had halted rail service beginning in March 2020 due to the COVID-19 pandemic.

Due to this limited outcome period and service interruption, the Project Team did not request outcome data such as ridership for this project and instead focused on identifying any evaluation-related considerations or recommendations for this project or the Transit program group.

4.3.9.2. Discussion

The Project Team presents the following findings for discussion based on the information collected and reviewed for this project.

Basis of ridership estimates and importance to POR

The Mission Bay Loop is an infrastructure improvement project that does not result in a new service line or direct expansion of transit capacity, but is intended to allow for increased service frequency of SFMTA's N and T lines. Additionally, SFMTA noted that the Mission Bay Loop will be crucial during special events such as sporting events, and that it will be a key supportive component for the Central Subway project that is currently in development. With these characteristics, the Mission Bay Loop serves as an example of a project that presents evaluation challenges in relation to both POR and overall project impact estimates.

The allocation request and included QM tool for this project estimate that the Mission Bay Loop will result in GHG reductions of 213,248 MTCO2e by increasing ridership by 752,368 passengers in the first year of operation and by 12,794,219 passengers in the final year of quantification using a 30-year project useful life. For the first year of operation, SFMTA calculated this ridership increase by factoring the forecasted inbound ridership of the N line by the expected percentage of passengers who would use the N line for special events, estimated as 10% of the total. For the final year of quantification, SFMTA used a similar estimation approach but also included a portion of forecasted ridership for the T line, as both the N and T lines are expected to eventually use the loop. For the T line portion of added ridership, SFMTA estimated that 40% of T line service and associated ridership would be attributable to the loop.[33]

Quantifying the growth in ridership associated with the Mission Bay Loop or the counterfactual ridership in the absence of this type of infrastructure project is not straightforward. Although in-depth evaluations

[33] This is based on a review of the allocation request and clarification received from SFMTA staff.

may provide a solution to this challenge in the future, program QM tools are currently the best resource available to CARB for quantifying project impacts. As the ridership inputs for this project are based on factors of forecasts, the same factors would need to be applied to any collected POR ridership data to obtain a like comparison to the initial estimates and potentially update the QM calculation with data collected during the outcome period. For this reason, it is important that grantees provide thorough information regarding any factors or assumptions that they applied to ridership forecasts when estimating ridership increases associated with a funded transit project.

Availability of information from grantee

In order to gain a more thorough understanding of this project, the Project Team asked SFMTA staff for additional details regarding the assumptions and calculations that were initially used in the project application for inputs such as expected ridership increases. While the current SFMTA project contacts were able to review these calculations and provide feedback based on their understanding of how SFMTA forecasts ridership and project characteristics, they noted that the original project staff that had submitted the application no longer worked for the transit agency. This somewhat limited the level of detail and certainty of feedback that SFMTA was able to provide in relation to the basis for the values within the Mission Bay Loop allocation request.

As POR can occur several years after a project's initial QM calculations are completed, it may be difficult to gain clarification on the original project concept or specific assumptions especially if they were developed by project staff who are no longer available. Collection of thorough documentation and clarification from grantees at the time of project submission and approval would support improved quality assurance of projects during the funding process, and would also ensure that any collected POR metrics can be assessed in the context of the original calculations.

Potential limitations in data availability

SFMTA halted light rail service in March 2020 due to the COVID-19 pandemic and the Project Team therefore did not collect POR metrics for the outcome period. In the data collection interview with SFMTA, the Project Team discussed the currently required metrics and asked whether SFMTA would be able to provide this information under typical operating circumstances. For ridership, SFMTA staff indicated that they currently use manual load monitoring and onboard counts to determine rail ridership, as only about one third of the light rail vehicles have onboard automatic passenger counters (APCs). SFMTA staff noted that they are in the process of adding APCs to additional light rail vehicles and are requesting approval from FTA to shift to an APC-based ridership counting methodology. This approach would allow for more precise tracking of ridership for the lines that will be supported by the Mission Bay Loop.

For average trip length, SFMTA staff explained that they are not able to track passenger miles traveled and unlinked passenger trips for individual vehicles or lines, and that they would have to either use a modeling approach to determine these values or report a systemwide average trip length value. The average trip length input provided within the allocation request is based on a modeled value from the San Francisco Chained Activity Modeling Process. POR is intended to gather primary project data rather than rely on modeled values. However, if a grantee agency is unable to collect project-specific trip length data for POR purposes, the Project Team recommends that Caltrans request an update to the modeled value if one is available based on more recent data that the agency has obtained since the original project planning process.

4.4. Key Data Collection Findings

This section summarizes overall findings from the process of reviewing project documentation and collecting data from grantees for each of the above projects.

- **Grantee transit agencies appear willing to provide the requested POR metrics but data limitations and the level of detail available varies widely across agencies.**
    - Some agencies are limited to quantifying ridership at the systemwide level and are not able to provide metrics for individual vehicles or services.
    - Some agencies indicated difficulties with reporting data for a precise period that does not coincide with a calendar year or fiscal year.
    - Agencies that are working with third parties to conduct data collection and analysis may be able to provide much more detail and additional metrics, but most agencies do not have this support.
- **Grantees may need additional training regarding reporting and documentation of POR metrics and QM inputs.**
    - In previous rounds of POR, some agencies have reported VMT in terms of avoided ICE vehicle VMT rather than reporting the VMT of the funded transit vehicles. Additionally, when the Project Team requested average trip length data from grantees, there were cases where the grantee provided the trip lengths of transit vehicles rather than passenger trip lengths.
    - Grantees do not consistently provide detailed information regarding the approach that they used to estimate individual QM inputs and may be unable to provide clarification during the outcome period if the original project staff are no longer part of the agency.
- **For TIRCP, the project documentation available to Caltrans and provided to the Project Team for review was limited to initial project applications, though this is likely due to these projects pre-dating CARB QM calculators.** Due to the lead time between initial project applications and project completion, the TIRCP projects eligible for POR at the time of the sampling process were funded prior to the development of transit QM calculators. For these older projects, grantees were responsible for developing a custom methodology for estimating ridership and other project inputs. Based on discussions with Caltrans, documentation such as allocation requests and QM calculators should be available for all projects funded since the implementation of these program components.

  The Project Team was not able to directly verify whether Caltrans collects and retains all iterations and updates to project calculations throughout the funding and implementation process, and this documentation would be an important resource in comparing outcome-related data to final pre-outcome estimates.

4.5. Key Analysis Findings

This section summarizes overall findings from the process of assessing the collected data records for the outcome periods and assessing the analytical methods currently used by agencies to estimate project metrics.

- **Based on the projects sampled as part of this data collection exercise, it appears that transit agencies have used a wide range of approaches for estimating ridership gains from funded projects.**
    - The current TIRCP and LCTOP QM tools ask agencies to input anticipated ridership increases associated with the funded project, denoted as *"The increase in unlinked passenger trips directly*

associated *with the proposed project in the first year (Yr1)"*, and *"The increase in unlinked passenger trips associated with the proposed project in the final year (YrF)"*. However, there appears to be limited guidance within program QM calculators regarding how agencies should be estimating these values.

  - Some agencies have made efforts to use a net ridership gain value in this field by quantifying and excluding the portion of riders on the expanded service lines who would still have been able to ride transit in the absence of the project. In contrast, other agencies have estimated and applied the total, gross ridership that they expect to observe on the expanded service lines or from the expanded capacity of additional vehicles. The extent to which each approach is validated during the project selection process is also unclear.
  - The current POR phase does not ask agencies to use outcome period ridership data to re-run any ridership gain models or forecasts that they may have used during the program QM process. Thus, raw ridership data collected as part of POR cannot easily be compared to the values within program QM calculators without additional analysis conducted on the part of grantee agencies or thorough documentation explaining the modeling or forecasting approach that was used.

- **POR may have a role in validating initial project inputs, but is limited in its ability to evaluate outcomes that are attributable to projects.**
  - One of the ways in which POR metrics can provide insight into project impacts is to validate or revise the inputs that grantee agencies used to generate project GHG reductions and other benefits estimates within program QM calculators.
  - While relying on program QM calculators as the basis for impact estimates and replacing assumed metrics with available POR metrics does provide an update on project effects within the established QM framework, this is a lower level of evaluation rigor than could be achieved with more in-depth monitoring or modeling research. Past studies have made efforts to assess the effects of specific interventions and external variables on transit ridership.[34] In-depth studies that are tailored to each selected project may allow for greater insight into how the increased capacity or expanded service implemented through California Climate Investments funding is affecting transportation in grantee agency service areas, though this is beyond the current scope and available resources of POR.

4.6. POR Metrics Recommendations

Based on the above data collection and analysis activities, the Project Team identified opportunities for modifications to the set of approved LCTOP and TIRCP POR metrics. This section summarizes these recommendations and presents an updated table of POR metrics for consideration.

[34] Michael Kyte, James Stoner, and Jonathan Cryer, "A Time-Series Analysis of Public Transit Ridership in Portland, Oregon, 1971–1982," *Transportation Research Part A: General* 22, no. 5 (September 1, 1988): 345–59, https://doi.org/10.1016/0191-2607(88)90012-X.

Cynthia Chen, Don Varley, and Jason Chen, "What Affects Transit Ridership? A Dynamic Analysis Involving Multiple Factors, Lags and Asymmetric Behaviour," *Urban Studies* 48, no. 9 (2011): 1893–1908, http://www.jstor.org/stable/43081823.

4.6.1. Recommended Additional or Modified Metrics

The Project Team recommends the following additions or modifications to metrics within the LCTOP and TIRCP POR requirements:

Indication of whether vehicle or service continues to be operated as stated within project close-out documentation (if not, provide description of change)

Some grantees indicated that they have modified the service routes of purchased vehicles since the project closeout phase or that certain vehicles were not in operation due to unforeseen circumstances. Verifying that the status of purchased vehicles or expanded service continues to align with project documentation is a form of basic M&V that can be completed during the outcome period for selected projects. While transit agencies are not required to continue operating vehicles or service in the manner that was initially estimated, gathering information about these changes can provide context to any transit-related data that are collected during POR.

Average daily ridership (separated into weekday, Saturday, and Sunday ridership)

This is a modification of the original "Average daily ridership" metric and involves the separation of ridership data into weekday, Saturday, and Sunday fields. Some transit agencies were only able to provide average weekday ridership, while other agencies provided overall ridership that included weekdays and weekends. Using separate fields to report this information provides additional context for the ridership data that is received from transit agencies.

Average passenger trip length

This is a minor clarification of the "Average trip length" metric to specify that it is referring to passenger trip length rather than transit vehicle trip length.

Vehicle miles traveled or fuel/energy consumption

Though this metric is already included in the "New Vehicle(s) for Existing Transit Service" sub-program component, the Project Team recommends adding it to the "Capital Improvements that Result in New or Expanded Transit Service" sub-program component as well, as it is an input within TIRCP and LCTOP QM tools for these project types.

4.6.2. Deferred Metrics

In addition to recommending additional POR metrics, the Project Team identified one metric that is unlikely to provide insight into projects under the current scope of POR. This metric is categorized as deferred, and the Project Team does not recommend it for inclusion in LCTOP and TIRCP POR unless determined to be useful by CARB and Caltrans:

Change in fuel/energy consumption or annual vehicle miles traveled

Based on discussions with program staff, this metric appears to be misunderstood by transit agencies. In reviewing previously reported POR data, the Project Team found that some agencies reported 1) Change in energy use as compared to a baseline vehicle; while other agencies reported 2) Change in energy use for funded vehicles as compared to the previous outcome period.

As the former metric is estimated as part of program QM and the latter metric could be derived by subtracting the fuel/energy consumption or VMT provided for one outcome period from the respective fuel/energy consumption or VMT provided for another outcome period, the Project Team does not recommend including this metric in future POR requirements.

4.6.3. Final Recommended POR Metrics

Table 4-11 summarizes the recommended and deferred metrics described above, with the additional recommended or modified metrics highlighted.

Table 4-11. Final Transit POR Metrics Recommendations

	Sub-Program Component	Recommended Metrics
Low Carbon Transit Operations Program (LCTOP) Transit and Intercity Capital Rail Program (TIRCP)	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Tracking dates of data submission (i.e. time period represented by reported metrics)
		Days of operation per year
		Average daily ridership (separated into Saturday, Sunday, and weekday ridership if possible)
		Average passenger trip length
		Vehicle miles traveled or fuel/energy consumption of the transit service
		Indication of whether the capital improvements continue to operate as stated within project closeout documentation (if not, provide description of change)
	New Vehicle(s) for Existing Transit Service	Vehicle miles traveled or fuel/energy consumption of the purchased vehicles
		Indication of whether the purchased vehicles continue to be operated as stated within project close-out documentation (if not, provide description of change)
		Deferred Metrics
		Change in fuel/energy consumption or vehicle miles traveled

4.7. Additional Recommendations

In addition to the POR metrics recommendations summarized above, The following recommendations are presented for CARB and Caltrans consideration. These recommendations are designed to support improved evaluability and evaluation of the programs moving forward:

- **In the absence of increased evaluation and reporting resources, continue requiring metrics that are consistent with what agencies are already providing under FTA requirements.**[35] Otherwise, smaller agencies may not have the resources to comply with special requests. For example, this

[35] Federal Transit Administration, *National Transit Database 2020 Policy Manual*, 2020, https://www.transit.dot.gov/sites/fta.dot.gov/files/2020-10/2020%20NTD%20Reporting%20Policy%20Manual_1.pdf.

would include requesting data in terms of average weekday, average Saturday, and average Sunday ridership as recommended in the above POR metrics modifications.

- **Maintain engagement with grantees to ensure that they understand the QM tools and POR metrics, improve consistency across data provided for TIRCP and LCTOP projects, and minimize the presence of errors or incomplete data within project documentation and reports.**
    - Similarly, it may be useful for CARB to provide additional guidance to grantee transit agencies regarding how to estimate the ridership increases that will result from funded projects in order to improve consistency in approaches across agencies. If possible, CARB and administering agencies should consider implementing this guidance in the form of a calculator to include in program QM tools which would allow agencies to estimate ridership gains in a consistent manner that can be referenced during any subsequent evaluation efforts. If such a calculation uses a forecast of gross ridership as an input, POR could collect actual gross ridership and use the QM to obtain a post-project ridership gain estimate for comparison to the pre-project expectation. This is one possible approach for improving the consistency of grantee calculations; CARB and administering agencies may be able to identify other viable options.
    - Administering agencies should also work with grantees to collect more detailed documentation regarding claimed ridership, trip length, and other inputs during the QM phase and should consider conducting additional quality assurance to assess the reasonableness of these estimates. Based on a review of project applications, there are a wide variety of approaches used to estimate these values across agencies; some are more specifically tailored to the individual agency and others rely on industry defaults.
- **Collect and retain project documents such as final QM workbooks and other documentation containing final project details for at least the duration of the POR phase for each project.** The usefulness of the POR phase an evaluation tool relies somewhat on the ability to link post-project data to pre-project estimates, and without sufficient details related to expected benefits and associated calculations it is not feasible to use post-project data to validate or revise those values. Although POR does not currently contain the objective of recalculating project GHG reductions or other benefits, thorough recordkeeping and records retention is needed in order to provide context and a basis of comparison for data collected as part of the outcome period.
- **Continue to validate the data reported in the CCIRTS database and correct instances of cancelled projects appearing to be complete as well as other potential discrepancies.** One of the LCTOP projects that the Project Team initially sampled for data collection had been cancelled and did not move forward but was listed as complete within CCIRTS. Additionally for several projects the listed operational or project completion date did not align with the timeline of physical projects, and the Project Team identified one case where a project ID number was incorrect. Maintaining the accuracy of this publicly available database increases the transparency of California Climate Investments expenditures and estimated benefits.
- **Recommended POR purpose for Transit projects:** In its current form, POR stipulates a uniform set of metrics and data collection approaches for all capital transit improvement projects and is not designed to provide customized guidance for specific projects. Due to this, the extent to which POR can provide insight into project benefits is somewhat dependent on the complexity of each project and the uniformity of projects within a program. With transit agencies using a wide variety of methods for estimating the ridership increases that will result from California Climate Investments funding, and the many factors which affect ridership for a transit system or individual line, the level of complexity for transit projects is high and the level of uniformity across transit projects is low.

POR is unlikely to serve as a method of quantifying the ridership impacts that are attributable to funded projects. Additionally, measuring the GHG benefits attributable to individual transit projects in a way that uses primary data and does not rely on program QM tools would be resource intensive, as evidenced by past in-depth transit studies that have attempted to measure these effects.[36] These activities would likely need to be completed as part of custom evaluation studies that extend beyond the current scope of POR.

However, POR may serve to verify the ongoing status of projects, collect data that could be used to validate inputs that were initially used within program QM calculators, and potentially inform future updates to QM assumptions and calculations. Metrics such as expected ridership and average trip length are key inputs within program QM calculators and most agencies appear to be prepared to provide primary post-project data for these metrics during the outcome period. Program QM tools also appear to be the primary means with which many transit agencies track the GHG benefits from their implemented projects.[37] POR may be a useful way to improve the reliability of information contained in these calculators.

[36] Susan Handy et al., "Impacts of Transit Service Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions," 2013, https://ww2.arb.ca.gov/sites/default/files/2020-06/Impacts_of_Transit_Service_Strategies_on_Passenger_Vehicle_Use_and_Greenhouse_Gas_Emissions_Policy_Brief.pdf.

[37] Based on discussions with transit agencies for projects sampled as part of this data collection effort, and existing research on this topic:
CTC & Associates LLC, "Quantifying the Results of Key Transit Investments" (Caltrans Division of Research, Innovation and System Information, March 16, 2018), dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/preliminary-investigations/quantifying-the-results-of-key-transit-investments-pi-a11y.pdf.

5. Affordable Housing and Sustainable Communities

California Climate Investments provides grants and loans allocated to the development of affordable housing and housing-related infrastructure, with the primary goal of benefiting disadvantaged communities and providing improved access to transportation such as transit. Within the California Climate Investments portfolio of programs, these projects are implemented through the Affordable Housing and Sustainable Communities (AHSC) program.

AHSC is administered by the Strategic Growth Council (SGC) and is implemented by the Department of Housing and Community Development (HCD). In addition to funding affordable housing improvements, AHSC funds can be allocated to the development of land use, land preservation, sustainable transportation infrastructure, and transit improvements.[38] AHSC achieves GHG reductions in part by reducing VMT through improved access to key destinations and encouraging mode shift from single occupancy vehicles to modes such as transit or active transportation.[39]

5.1. Project Sample

At the time of project sampling in October 2019, there were 35 AHSC projects eligible for POR based on information received from CARB. The Project Team sampled five projects from AHSC for POR data collection. Brief descriptions of these sampled projects are as follows:

- **AHSC Project 1: Palm Terrace, CCIRTS Project ID 35378.** This project is categorized as a Rural Innovation Project Area (RIPA) recipient and involves the development of a 50-unit affordable housing community and implementation of a vanpool service in Lindsay, CA.
- **AHSC Project 2: 455 Fell Street, CCIRTS Project ID 35254.** This project is categorized as a Transit Oriented Development (TOD) Project Area recipient and involves new construction of a 108-unit affordable housing development in San Francisco, CA.
- **AHSC Project 3: Wasco Farmworkers Housing Relocation Project, CCIRTS Project ID 34791.** This project is categorized as a Rural Innovation Project Area (RIPA) recipient and involves the construction of a 226-residence affordable housing community and shuttle service in Wasco, CA.
- **AHSC Project 4: Civic Center 14 TOD Apartments, CCIRTS Project ID 30300.** This project is categorized as a Transit Oriented Development (TOD) Project Area recipient and involves new construction of a 40-unit affordable housing development with 477 feet of commercial space in Oakland, CA with the implementation of a smart bicycle rack at a nearby transit station to support active transportation.
- **AHSC Project 5: Jordan Downs Phase 1B, CCIRTS Project ID 34835.** This is categorized as an Integrated Connectivity Project (ICP) Project Area recipient and involves new construction of a 135-unit affordable housing site in Los Angeles, CA.

[38] As AHSC includes projects that involve capital transit improvements, certain POR metrics, as well as findings from the assessment of the Transit program group, are also applicable to the transit components within AHSC. This report refers to those findings and recommendations within this chapter as applicable.

[39] AHSC program description: https://www.hcd.ca.gov/grants-funding/active-funding/ahsc.shtml

5.2. Activities Conducted

The data collection and analysis process for the sampled AHSC projects consisted of the following activities.

5.2.1. Administering Agency Interviews and Documentation Requests

At the start of the data collection process the Project Team completed interviews with SGC and HCD staff in late 2019 to gain an understanding of AHSC program procedures, existing data collection processes, and the extent of available project data. As part of these interviews the Project Team requested documentation associated with each sampled project.

5.2.2. Project Documentation Reviews

Beginning in late 2019, the Project Team reviewed project documentation including initial applications, QM calculators, and grant disbursement agreements, as well as any supporting documentation such as project maps that were available on the Financial Assistance Application Submittal Tool (FAAST) website using the public search function.[40] These reviews focused on identifying key project components such as the characteristics of housing sites and the specific transportation-related improvements associated with each project, identifying the applicable POR data to be collected, and characterizing evaluation-related issues and questions associated with data collection or analysis.

5.2.3. Project Staff Interviews

Following the documentation reviews, the Project Team held interviews with key contacts that were involved in project implementation for each AHSC site including local housing authority staff, developer staff, on-site managers, and transit agencies associated with funded transit improvements. These interviews occurred between early 2020 and early 2021, concurrent with the COVID-19 pandemic. The purpose of these interviews was to gain a greater understanding of the details of each project, request any applicable data related to transit improvements such as ridership, and to discuss the process of developing and administering resident surveys to collect resident-reported POR metrics.

5.2.4. Resident Survey Development and Coordination

Following the initial interviews, the Project Team coordinated with HCD and project staff to develop survey instruments for distribution to residents at each AHSC site. Surveys were distributed between mid-2020 and early 2021, concurrent with the COVID-19 pandemic. Upon finalizing these survey instruments, site staff distributed one survey per resident household and provided the response data to the Project Team for analysis. Section 5.4 provides details regarding the survey development and administration process.

5.2.5. Analysis of Data Records

The Project Team received survey response data and any applicable transit data for each site in early 2021. Upon receiving this information, the Project Team reviewed and analyzed these records to develop POR metrics for the defined outcome periods associated with each project. During the analysis process the

[40] FAAST public search tool: https://faast.waterboards.ca.gov/Public_Interface/PublicSearch.aspx

Project Team also identified opportunities for additional or alternative metrics to recommend including in future rounds of AHSC outcome reporting.

Current AHSC POR guidance specifies that project outcome tracking begins when housing development construction is complete and available for occupancy, or transit improvement construction is complete or transit vehicles are operational. Unless otherwise specified within the individual project findings sections below, the Project Team defined outcome reporting periods for each project as beginning on the opening date of the housing site and extending one year forward to represent the first round of POR.

These reporting periods overlapped with the COVID-19 pandemic and with its resulting effects on transportation and other activities. Although this may have affected the data collection and analysis results, the Project Team proceeded with these analyses because the primary purpose of this work was to develop POR methods for use in the future.

5.2.6. Assessment of Barriers and Evaluation Considerations

Throughout the data collection and analysis process, the Project Team took note of data collection challenges and other significant issues that may serve as barriers to effective POR procedures and may present opportunities for improved data collection strategies or relate to overall evaluation recommendations for AHSC projects.

5.3. Additional POR Metrics Recommendations

Table 5-1 displays the list of AHSC POR metrics approved by CARB at the start of this data collection task following the initial metrics and methods assessment conducted by the Project Team.

Table 5-1. Initially Approved AHSC POR Metrics

	Sub-Program Component	Metrics
Affordable Housing and Sustainable Communities (AHSC)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Affordable Housing	Housing unit occupancy rate
		Income-restricted housing units occupancy rate
		Mode share of residents, by mode
		Residents using transit passes, as applicable
		For mixed-use projects, occupancy of commercial space
	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year
		Average daily ridership
		Average passenger trip length
	Active Transportation	Average traffic of bicycle and pedestrian facilities

During the process of working with HCD and site staff to develop resident survey instruments, the Project Team identified several opportunities for modifications to these approved metrics to improve the clarity and detail of reported data. These modifications included assessing the percentage of households that

have access to one or more personal vehicles, expanding the mode share metric to identify household primary commuting modes and primary non-commuting modes, and developing a metric to assess reliability of transportation access for households. Descriptions of these metrics are as follows:

- **Percentage of households with access to one or more owned, leased, or regularly borrowed cars:** This metric provides additional context to information collected on resident mode share and reliable access to transportation. Households without access to personal vehicles likely need to rely on the alternative transportation modes that are prioritized by AHSC including transit and active transportation, while households with access to personal vehicles may shift their choice in modes due to increased access to these transportation alternatives.
- **Primary commuting and non-commuting modes:** These metrics are a refinement of the "Mode Share" metric that was in place at the start of the data collection effort. This refinement distinguishes between commuting and non-commuting mode choice to provide a more detailed understanding of resident travel patterns.
- **Percentage of households with reliable access to transportation:** This metric was developed using a survey question regarding how often residents are able to travel to where they need to go, and is intended as a general representation of transportation access that could be compared across AHSC sites.

Table 5-2 displays the list of metrics that the Project Team referenced during the data collection effort, with additions and modifications highlighted. These metrics and the results for each sampled site are presented within the subsequent individual project findings sections. A final list of recommended metrics based on findings and lessons learned from the data collection effort is presented in Section 5.7.

Table 5-2. Updated List of AHSC POR Metrics Used for Sample Project Data Collection

	Sub-Program Component	Metrics
Affordable Housing and Sustainable Communities (AHSC)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Affordable Housing	Housing unit occupancy rate
		Income-restricted housing units occupancy rate
		For mixed-use projects, occupancy of commercial space
		Residents using transit passes, as applicable
		Percentage of households with access to one or more owned, leased, or regularly borrowed cars
		Primary commuting and non-commuting modes (percentage of households by primary mode)
		Percentage of households with reliable access to transportation
	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year
		Average daily ridership
		Average passenger trip length
	Active Transportation	Average traffic of bicycle and pedestrian facilities

In addition to the above POR metrics, the Project Team assessed and reported survey summary metrics including the total number of responses and the survey response rate.

5.4. Resident Survey Approach

The Project Team coordinated with HCD and AHSC project staff to develop resident survey instruments for each sampled project. These surveys were designed to collect information about resident households, forms of travel, and access to transportation in support of developing the required POR metrics for each site. Project staff for one of the sampled sites, Jordan Downs, indicated that they would be unable to administer a POR survey to their residents, as they were already administering another survey as part of a separate data collection effort and wanted to avoid the potential confusion or burden of a concurrent survey. The Project Team was therefore able to coordinate survey administration and obtain resident responses for four of the sampled AHSC sites.

There were minor differences in the survey instruments across the sampled sites due to specific site characteristics or feedback from project staff, but the surveys generally requested the following types of information from residents:

1. How long the resident has lived at the housing development;
2. The number of individuals in resident households;
3. Number of personal motor vehicles (owned, leased, or borrowed) available to the household;
4. Number of household members who regularly leave home to go to work (i.e. regularly commute);
5. Transportation mode(s) used for commuting purposes (if applicable);
6. Transportation mode(s) used for non-commuting purposes;
7. Whether households are able to travel to where they need to go (i.e. access to transportation); and
8. Whether the household has used any transportation modes more or less than one year ago.

The objective of this survey effort was to collect the necessary data to report the following project outcome metrics for each sampled site:

1. Percentage of households with access to one or more owned, leased, or borrowed cars;
2. Percentage of households that primarily use a personally owned or leased private car for commuting and non-commuting purposes;
3. Percentage of households that primarily use ride-hailing for commuting and non-commuting purposes;
4. Percentage of households that primarily use transit for commuting and non-commuting purposes;
5. Percentage of households that primarily use an active transportation mode for commuting and non-commuting purposes;
6. Percentage of households that primarily use a transportation mode that is part of an AHSC project-specific component, such as vanpooling, for commuting and non-commuting purposes (if applicable);

7. Percentage of households with reliable access to transportation; and
8. Percentage of residents using transit passes (not applicable for any of the sampled sites, but would typically be collected through the resident survey process).

In order to encourage resident participation, the Project Team coordinated with on-site staff to determine an appropriate incentive to offer to residents for completing these surveys. All sites decided to offer incentives in the form of raffles for retail gift cards, with the quantity and gift card value varying depending on the number of residences in the housing development and the incentive strategy determined through discussions with on-site staff. For an individual site, the number of gift cards ranged from two to eight cards and gift cards were in the amount of either $25 or $50. The survey instruments did not ask for any personal or identifying information from residents. The Project Team asked site staff to complete the gift card lottery process and distribute incentives to randomly selected residences.

All sites requested survey instruments to be available in both English and Spanish languages, and one site requested a Cantonese language version. Staff from UC Davis translated the instrument into these languages and provided all requested versions to each site for final comment. Upon finalization, the Project Team asked site staff to distribute the surveys to resident households and provide the results when available.

Each site distributed paper copies of the survey instruments to each of its residences, and asked that they complete the survey and return it to the front desk, on-site manager, or other site contact. Surveys were administered at the household level, with each respondent being asked to provide information about their household characteristics and household transportation behaviors. Project staff distributed one survey instrument per household.

Upon collecting the completed surveys, site staff scanned each document and emailed them to the Project Team for review and analysis. A sample copy of the resident household survey instrument that site contacts administered for this data collection effort can be found in Appendix C.

5.4.1. Description of Survey Metrics

This section describes each of the AHSC POR metrics that the Project Team developed using resident household survey responses. These metrics appear in the subsequent individual project sections.

5.4.1.1. Percentage of households with access to one or more owned, leased, or regularly borrowed cars

This metric was based on responses to the following survey question:

> ***"How many motor vehicles (cars, trucks, motorcycles), if any, are available to your household? This includes vehicles you own, lease, or regularly borrow."***

The percentage of households with access to one or more cars was calculated by dividing the number of survey respondents indicating that their household has access to 1 or more cars by the total number of respondents. Respondents who stated "don't know" or "prefer not to answer" were excluded from this calculation.

5.4.1.2. Percentage of households with reliable access to transportation

This metric was based on responses to the following survey question:

"Thinking about the transportation available to you, how often are you and the members of your household able to travel to where you need to go (such as commuting, doing errands, traveling to other activities, etc.)?"

The Project Team defined a response of "Always" or "Usually" as indicative of reliable access to transportation. The quantity of respondents selecting either of these responses was divided by the total number of respondents to calculate the percentage of households with reliable access to transportation.

5.4.1.3. Primary commuting and non-commuting modes

These metrics were calculated based on responses to survey questions about which mode(s) respondents use for travel to and from work ("commuting"), and for other types of trips ("non-commuting").

The survey first presented respondents with a matrix table of travel modes and travel frequencies, and asked respondents to indicate how frequently they use each travel mode to travel to and from work:

"For each row in the following table, please fill in a circle to indicate how often your household uses the listed form of transportation to go to and from work."

Following this, the survey presented respondents with a second, identical table, and asked respondents to indicate how frequently they use each travel mode for other types of trips:

"For each row in the following table, please fill in a circle to indicate how often your household uses the following forms of transportation for other types of trips such as social activities, appointments, and errands."

Figure 5-1 provides an example of the matrix table that appeared in the resident survey instruments:

	How does your household get to and from work?	Do not use at all	Use about one day per month	Use a few days per month	Use 5-10 days per month	Use 10-20 days per month	Use on a daily basis
1.	Driving a motor vehicle alone	○	○	○	○	○	○
2.	Carpooling in a private vehicle	○	○	○	○	○	○
3.	Taking a bus or shuttle	○	○	○	○	○	○
4.	Taking a train, light rail, or trolley	○	○	○	○	○	○
5.	Taking a taxi, Uber, Lyft, or similar service	○	○	○	○	○	○
6.	Walking	○	○	○	○	○	○
7.	Using a bicycle	○	○	○	○	○	○
8.	Using a scooter	○	○	○	○	○	○
9.	Other: _____	○	○	○	○	○	○

Figure 5-1. AHSC Resident Survey: Matrix of Travel Modes and Frequencies

For the purposes of reporting POR metrics the Project Team grouped individual travel modes into travel mode categories as follows:

- Responses "driving a motor vehicle alone" and "carpooling in a private vehicle" were grouped into the "Personal or private car" travel mode category;
- Responses of “bus or shuttle” and “train, light rail, or trolley” were grouped into the “Transit" travel mode category;
- Responses of "taking a taxi, Uber, Lyft, or similar service" were grouped into the “Ride-hailing” travel mode category; and
- Responses of "walking", "using a bicycle", and "using a scooter" were grouped into the “Active transportation” travel mode category.

Respondents were able to select multiple travel modes and indicated the number of days per month that they use each mode for commuting and non-commuting purposes.

The Project Team defined the primary commuting mode as the travel mode that a respondent indicated using most frequently. If a respondent indicated more than one mode as their most frequently used travel mode, the Project Team counted each of these travel modes as the respondent's primary travel mode. Thus, the sum of percentages within the commuting mode categories and non-commuting mode categories may exceed 100%.

The survey also asked respondents to indicate how many members of their household regularly travel to and from work; if a respondent indicated "0" for this question, the Project Team excluded their responses regarding commuting modes from these calculations.

Proposed simplified methods for calculating the above metrics, for potential use in future rounds of POR, are provided within Appendix B.

5.4.1.4. Residents using transit passes

As none of the sampled AHSC projects involved the distribution of transit passes to residents, the use of transit passes was not assessed with the resident survey instruments. However, the percentage of residents using program-funded transit passes is an existing POR metric specified by CARB, and could be assessed using this survey approach. This could involve including questions such as:

> ***“Did you receive a [Name of Transit Pass Distributed by ASHC]?”***
>
> ***(If Yes to above) “How often, if at all, do you or other members of your household use [Name of Transit Pass Distributed by AHSC]?” (With response options equal to the frequency of use options in the mode share matrix such as shown in Figure 5-1)***

Transit pass use could then be calculated as a percentage of pass users as compared to non-users, or presented in terms of frequency of use, depending on the quality of data obtained.

5.5. Results by Sampled Project

This section summarizes the results of the data collection effort by sampled project. The survey results presented in this section are based on the pilot data collection activities described above and are not intended to be representative of the resident population within each housing site or representative of AHSC overall. Additionally, surveys were distributed at the household level, and respondents were asked to provide information about their household characteristics and transportation patterns. Because of this,

responses may not reflect individual resident transportation behaviors or potential differences in transportation behaviors among individuals within a residence.

This data collection process coincided with the COVID-19 pandemic, and mode share metrics and other transportation-related data reported for sampled projects may not represent typical travel patterns for residents at these AHSC sites.

5.5.1. AHSC Project 1: Palm Terrace, CCIRTS Project ID 35378

This project is categorized as a Rural Innovation Project Area (RIPA) recipient and involves the development of a 50-unit affordable housing community in Lindsay, CA. This project includes active transportation improvements such as sidewalks providing connection to transit and school facilities, bicycle lanes, and traffic calming measures at a nearby major intersection. Additionally, the project contains a transit capital improvement in the form of a vanpool service that is to be operated by two vans purchased through project funds.

This project also incorporates a variety of energy- and water-related measures such as the installation of solar photovoltaic (PV) equipment, the use of energy efficient lighting and controls, and water-efficient irrigation and landscaping.

This project was funded through 2015-2016 FY funding and the site became operational in November 2018.

5.5.1.1. Data Collected

Data collected for this project included:

1. Responses to the POR residential transportation survey;
2. Information regarding the total number of surveys distributed and completed;
3. Occupancy rate information for the outcome period;
4. Ridership and trip length information for the vanpool vehicles purchased as part of this AHSC project; and
5. Supporting documentation including the project application and grant agreement.

5.5.1.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission: November 13, 2019 – November 12, 2020

The grand opening date for the housing site was November 13, 2018 and the first outcome period would have been November 13, 2018 through November 12, 2019. However, surveys were not administered during that period, and for the purposes of this exercise, the Project Team defined the outcome period of analysis as November 13, 2019 through November 12, 2020. This represents the second one-year outcome period for the site.

Site staff administered surveys in early 2021 after the end of this outcome period due to the timing of finalizing the pilot survey instrument.

Total surveys completed and survey response rate: 25 responses; 51% response rate

Site staff reported the number of survey instruments distributed to residences and the total number of completed surveys. For this site, staff distributed surveys to all 49 residences and received 25 responses. This equals a response rate of 51% at the household level.

Housing unit occupancy rate and income-restricted housing units occupancy rate: 100%

This is based on information from site staff regarding total residents and total occupied units during the outcome period. Staff indicated that the site maintains a 100% occupancy rate for its 49 units, and that all units are income-restricted. This does not include the single onsite manager's unit, which is also occupied.

For mixed-use projects, occupancy of commercial space: N/A

This site does not include a commercial space.

Residents using transit passes, as applicable: N/A

Transit passes were not included as a component of this AHSC project.

Percentage of households with access to one or more owned, leased, or regularly borrowed cars: 84%

A majority of respondents (84%) indicated that their household has access to one or more owned, leased, or regularly borrowed cars. Of these, five respondents (24%) stated that their household has access to two cars, while the remaining 16 respondents (76%) stated that their household has access to one car.

Percentage of households with reliable access to transportation: 92%

Ninety-two percent of respondents indicated that they are "Always" (68%) or "Usually" (24%) able to travel to where they need to go and therefore meet the proposed definition of "Reliable access to transportation". The remaining 8% of respondents indicated that they are "Sometimes" able to travel to where they need to go. This suggests a fairly high level of transportation access for residents at this AHSC site.

Days of operation for the reported outcome period: 195

This AHSC project included the purchase of two vans that are operated as part of CalVans vanpool service in the surrounding region. Data received from CalVans showed ridership and months of operation for the two vans but did not show the exact days of operation during the outcome period. The value above is a prorated estimate based on the expected number of days of vanpool service per 12 months as shown in project documentation (260 days), and the actual number of operational months during the outcome period for each van.

The data showed that Van ID 5162 operated for 10 months and Van ID 5163 operated for 8 months during this outcome period. CalVans reports showed no activity for March or April 2020 as a result of the ongoing COVID-19 pandemic. This approach resulted in an estimated 217 operational days for Van ID 5162, and 173 operational days for Van ID 5163 (an average of 195 days during the outcome period).

Average daily ridership: 36

Average daily ridership is based on the total ridership for the two vans during the outcome period (6,976 riders), divided by the estimated number of operational days (195 days).

Average trip length: 65 miles

This value is based on the total number of passenger miles traveled for both vans during the outcome period (453,404 miles), divided by total ridership for this period (6,976 riders).

Average traffic of bicycle and pedestrian facilities: Not available

The AHSC project at this site contained active transportation improvements including bicycle lanes and traffic calming. However, the active transportation improvements associated with this project are not currently monitored, and the Project Team did not conduct demonstrative on-site active transportation data collection due to issues presented by the COVID-19 pandemic.

Table 5-3 summarizes the above POR metrics for this project.

Table 5-3. AHSC Project 1 Outcome Metrics Summary

Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	11/13/2019 – 11/12/2020 (Surveys administered in early 2021)
Affordable Housing	Housing unit occupancy rate	100%
	Income-restricted housing units occupancy rate	100%
	For mixed-use projects, occupancy of commercial space	N/A
	Residents using transit passes, as applicable	N/A
	Percentage of households with access to one or more owned, leased, or regularly borrowed cars	84%
	Primary commuting and non-commuting modes (percentage of households by primary mode)	(See detail table below)
	Percentage of households with reliable access to transportation	92%
	Total surveys completed (households)	25
	Survey response rate (household level)	51%
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year	195
	Average daily ridership	36
	Average passenger trip length	58 miles
Active Transportation	Average traffic of bicycle and pedestrian facilities	Not available

Primary commuting and non-commuting modes:

Eight respondents indicated that none of their household members regularly travel to and from work. The remaining 17 respondents who provided information about commuting travel indicated that they most frequently use a personal vehicle for commuting purposes. Specifically, 15 respondents (88%) stated that this personal vehicle commuting travel involves driving a car alone, and two respondents (12%) stated that this personal vehicle commuting travel involves carpooling. One respondent also stated that they primarily use a form of active transportation (walking) for commuting purposes.

A majority of respondents (84%) indicated that they primarily use a personal vehicle for non-commuting purposes, while 28% of respondents indicated that they most frequently use a form of active transportation. Of the respondents who indicated that they most frequently use a personal vehicle for non-commuting purposes, 17 respondents (68%) stated that this personal vehicle non-commuting travel involves driving a car alone, and 4 respondents (16%) stated that this personal vehicle non-commuting travel involves carpooling.

Mode choice may have been affected by changes in travel patterns caused by COVID-19, as surveys were administered in early 2021.

Table 5-4 provides the results for household primary commuting and non-commuting modes for this project.

Table 5-4. AHSC Project 1 Outcome Metrics: Primary Commuting and Non-Commuting Mode

Primary commuting mode (percentage of responses, n = 17)	
Personal or private car (driving alone or carpooling)	100%
Transit (bus, shuttle, train, light rail)	0%
Ride-hailing	0%
Active transportation (walking, biking, scooter)	6%
AHSC-specific transportation mode (e.g. funded vanpool)	0%
Primary non-commuting mode (percentage of responses, n = 25)	
Personal or private car (driving alone or carpooling)	84%
Transit (bus, shuttle, train, light rail)	0%
Ride-hailing	0%
Active transportation (walking, biking, scooter)	28%
AHSC-specific transportation mode (e.g. funded vanpool)	0%

5.5.1.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Lack of active transportation data

Current POR requirements request the average traffic of active transportation facilities, but the improvements made in the project area do not appear to be monitored for traffic by local transit agencies, automated counters, or housing development staff. QM tools currently calculate GHG reductions from bicycle and pedestrian improvements based on estimates provided by applicants for average daily traffic and auto trips eliminated, but there does not appear to be a prescribed process for verifying these estimates. It may be useful for future rounds of AHSC funding to incorporate the development of an active transportation monitoring plan into the project application process, either for ongoing use during POR or as a one-time M&V activity during project implementation or closeout.

Vanpool service area discrepancy

Project documentation indicated that two vans would be purchased as part of this AHSC site and operated as a vanpool for residents. Based on this the Project Team recommended that the POR survey for this site include questions related to residents' use of this vanpool. However during later discussions, it was determined that these vans have not been operating at the AHSC site and are instead deployed in other surrounding regions. The Project Team held an interview with CalVans, who operates vanpool services on behalf of the California Vanpool Authority and purchased the two vans through funds provided by this AHSC grant. CalVans staff explained that while the original plan was to operate a vanpool at this AHSC site, CalVans assessed demand for this service in 2019 and determined that the vans would be more

effectively used in other areas. Transit agencies conduct ongoing assessments of service needs and regularly reallocate vehicles to other areas as part of typical operational procedures.

While there is not a particular obligation for these vans to serve the particular AHSC site through which grant funds were received, and the resulting GHG benefits may not be significantly affected, for the purposes of accurate POR data collection it is important to maintain records of project components that vary from what is outlined within project planning documents. For example, residents should not be asked about their use of a vanpool service that is not currently operating at their site. Additionally, updated records regarding service location may help to explain any observed differences in operational metrics such as average trip length or VMT between the project planning period and outcome period.

Limited comparison to expected vanpool activity

CalVans staff provided detailed ridership and trip length information for the two vans for each month of the outcome period which was used to calculate the transit-related outcome metrics above. The total ridership for these two vans was 6,976 passengers; dividing this by the average 195 operational days equals an average daily ridership value of 36 passengers. This is lower than the average daily ridership of 52 passengers that is specified within project planning documents, but it should be noted that this outcome period coincides with the COVID-19 pandemic and that the vans did not operate during two months of the year. Due to the external variables involved it was not feasible to compare expected ridership with actual ridership as part of this POR exercise to gain insight into the performance of this project component.

Survey response rate and site engagement

Site staff distributed paper survey instruments to all 49 residences at this site and received 25 responses, translating to a 51% response rate at the household level. This was the highest response rate of all sampled AHSC sites. Through the data collection effort the Project Team found that on-site staff were generally willing to assist in the data collection effort and that their direct knowledge and relationship to the sites were important factors in the data collection process. Staff at this site provided examples of past successful survey instruments that had been administered to residents and recommended using a gift card to a popular local restaurant as the incentive for the survey completion raffle.

Another key distinction in the data collection approach for this site is that the administration of surveys coincided with the income recertification process that site staff conduct on an annual basis for all residents. Income recertifications are conducted in order to verify that residents continue to meet the income restrictions of the affordable housing site, and involve communicating directly with residents to collect documentation and related information. Site staff were able to explain and distribute surveys during these meetings, which may have improved resident engagement and response rates.

The Project Team recommends that administering agencies begin future surveying efforts by seeking involvement from on-site managers, property owners, community partners, or others who have strong relationships to the site and its residents. Similarly, if administering agencies are able to take on an engagement role with site staff to explain the survey and assist in coordinating the distribution of surveys, this would likely help to maintain consistency in data collection procedures across surveyed sites. Finally, whenever it is possible to distribute surveys at the same time as the annual income recertification, this may improve future response rates. It would be important to ensure that residents understand that the survey is completely voluntary, that it is not linked to their income or personal information, and that it will in no way affect their eligibility as a resident.

5.5.2. AHSC Project 2: 455 Fell Street, CCIRTS Project ID 35254

This project is categorized as a Transit Oriented Development (TOD) Project Area recipient and involves new construction of a 108-unit affordable housing development in San Francisco, CA. This project includes a variety of active transportation improvements such as the installation of median islands on nearby streets, accessibility upgrades including curb ramps and signal improvements, and sidewalk extensions on nearby streets.

The housing development includes energy related measures such as the installation of a solar thermal system, energy efficient water heating, lighting, and building envelope characteristics. The site plan also includes water related measures such as drought-resistant landscaping and water-efficient fixtures in all units. According to project documentation the site is constructed in alignment with GreenPoint Rated standards and exceeds the San Francisco Green Building Ordinance by at least 10%.[41]

This project was funded through 2015-2016 FY funding and the site became operational in September 2019.

5.5.2.1. Data Collected

Data collected for this project included:

1. Responses to the POR residential transportation survey;
2. Information regarding the total number of surveys distributed and completed;
3. Occupancy rate information for the outcome period; and
4. Supporting documentation including the project application and grant agreement.

5.5.2.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below. This site did not include the capital purchase of transit improvements to expand service, and the POR metrics associated with that AHSC sub-program component are not applicable for this project.

Total surveys completed and survey response rate: 32 responses, 30% response rate

Site staff reported the number of survey instruments distributed to residents and the total number of completed surveys. For this site, staff distributed surveys to all 107 residences and received 30 responses. This equals a response rate of 30% at the household level.

Tracking dates of data submission: September 16, 2019 – September 15, 2020

This is based on the initial move-in date for the housing development and extending one year forward to represent the first applicable outcome reporting period. Site staff administered surveys in early 2021 after the end of this outcome period due to the timing of finalizing the pilot survey instrument.

Housing unit occupancy rate and income-restricted housing units occupancy rate: 100%

This is based on information from site staff regarding total residents and total occupied units during the outcome period. Staff indicated that the site maintains a 100% occupancy rate of its 107 units, and that

[41] GreenPoint Rated: https://greenpointrated.com/about/

all units are income-restricted. This does not include the single on-site manager's unit, which is also occupied.

For mixed-use projects, occupancy of commercial space: N/A

This site does not include a commercial space.

Residents using transit passes, as applicable: N/A

Transit passes were not included as a component of this AHSC project.

Percentage of households with access to one or more owned, leased, or regularly borrowed cars: 57%

A majority of respondents (57%) indicated that their household has access to one or more owned, leased, or regularly borrowed cars. Of these, two respondents stated that their household has access to two cars, while the remaining 15 respondents stated that their household has access to one car.

Percentage of households with reliable access to transportation: 90%

Ninety percent of respondents indicated that they are "Always" (48%) or "Usually" (42%) able to travel to where they need to go and meet the proposed definition of "Reliable access to transportation". The remaining 10% of respondents indicated that they are "Sometimes" able to travel to where they need to go. This suggests a fairly high level of transportation access for residents at this AHSC site.

Average traffic of bicycle and pedestrian facilities: Not available

The AHSC project at this site contained active transportation improvements including sidewalk and street improvements such as pedestrian bulbouts. Project staff confirmed that these improvements had been installed and were being actively used. However, the active transportation improvements associated with this project are not currently monitored, and the Project Team did not conduct demonstrative on-site active transportation data collection due to issues presented by the COVID-19 pandemic.

Table 5-5 summarizes the above metrics for this project.

Table 5-5. AHSC Project 2 Outcome Metrics Summary

Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	9/16/2019 – 9/15/2020 (Surveys administered in early 2021)
Affordable Housing	Housing unit occupancy rate	100%
	Income-restricted housing units occupancy rate	100%
	For mixed-use projects, occupancy of commercial space	N/A
	Residents using transit passes, as applicable	N/A
	Percentage of households with access to one or more owned, leased, or regularly borrowed cars	57%
	Primary commuting and non-commuting modes (percentage of households by primary mode)	(See detail table below)
	Percentage of households with reliable access to transportation	90%
	Total surveys completed (households)	32
	Survey response rate (household level)	30%
Active Transportation	Average traffic of bicycle and pedestrian facilities	Not available

Primary commuting and non-commuting modes:

A majority of respondents (61%) indicated that they most frequently use a personal vehicle for commuting purposes, while 22% of respondents indicated that they most frequently use a form of active transportation, 17% stated that they most frequently use transit, and 11% stated that they most frequently use ride-hailing. Of the respondents who indicated that they most frequently use a personal vehicle for commuting purposes, 100% stated that this personal vehicle travel involves driving a car alone rather than carpooling.

A majority of respondents (56%) indicated that they primarily use a personal vehicle for non-commuting purposes, while 41% of respondents indicated that they most frequently use a form of active transportation, 16% stated that they most frequently use transit, and 13% stated that they most frequently use ride-hailing. Of the respondents who indicated that they most frequently use a personal vehicle for non-commuting purposes, 88% stated that this personal vehicle travel involves driving a car alone, and 13% stated that this travel involves carpooling.

Mode choice may have been affected by changes in travel patterns caused by COVID-19 as surveys were administered in early 2021.

Table 5-6 provides the results for household primary commuting and non-commuting modes for this project.

Table 5-6. AHSC Project 2 Outcome Metrics: Primary Commuting and Non-Commuting Mode

Primary commuting mode (percentage of responses, n = 18)	
Personal or private car (driving alone or carpooling)	61%
Transit (bus, shuttle, train, light rail)	17%
Ride-hailing	11%
Active transportation (walking, biking, scooter)	22%
AHSC-specific transportation mode (e.g. funded vanpool)	N/A
Primary non-commuting mode (percentage of responses, n = 32)	
Personal or private car (driving alone or carpooling)	56%
Transit (bus, shuttle, train, light rail)	16%
Ride-hailing	13%
Active transportation (walking, biking, scooter)	41%
AHSC-specific transportation mode (e.g. funded vanpool)	N/A

5.5.2.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Timing of surveys

Due to delays in survey development and implementation on the part of the Project Team, site staff were not able to distribute surveys during the stated outcome period of September 16, 2019 through September 15, 2020 and instead began collecting responses in February 2021. Though site staff indicated that resident turnover during the intervening months was low, delays in survey implementation could create challenges in comparing POR results across specifically defined annual periods. Formal POR data collection efforts should begin to collect survey data towards the end of each outcome period, or if necessary, immediately after the end of each outcome period.

Survey response rate and site engagement

Site staff distributed paper survey instruments to all 107 residences at this site and received 32 responses, translating to a 30% response rate at the household level. While this was one of the highest response rates of all sampled AHSC sites, there are likely opportunities for further increasing response rates in future rounds of formal POR data collection. For example, the AHSC POR requirements were not in place when this project was initiated, and site staff and residents were not initially aware that a survey effort would be taking place. For future projects, providing advance notice of the annual survey to residents and site staff may help to improve overall engagement in the data collection effort and increase response rates.

The data also suggest that language barriers may have affected the response rates for this project. Site staff requested that the survey instrument be provided in English, Spanish, and Cantonese, as these are the three most common languages spoken by residents of 455 Fell Street Apartments. Of the 32 complete

survey responses received, 31 are from the English version, 1 is from the Cantonese version, and none are from the Spanish version. While the Project Team did not receive detailed information on the distribution of languages at this site, staff indicated that Cantonese is the preferred language of a large portion of residents which suggests that the response rate for this version of the survey is disproportionately low. As a result, the survey findings above may not represent the site travel patterns accurately if those who did not respond have, on average, different travel or vehicle ownership patterns from those who did.

The survey instrument was first translated into Cantonese by UC Davis staff and was then reviewed by an on-site manager who is fluent in the language. This manager also participated in the distribution of surveys to resident households. It is unclear whether the lower response rate for non-English surveys is due to the translated survey content, the survey administration strategy, bilingual residents opting to respond to the English version, or a combination of factors. The results suggest that additional consideration of language requirements and potential language barriers for individual sites may be necessary to improve the representativeness of collected data.

5.5.3. AHSC Project 3: Wasco Farmworkers Housing Relocation Project, CCIRTS Project ID 34791

This project is categorized as a Rural Innovation Project Area (RIPA) recipient and involves the construction of 226 residences as an affordable housing community in Wasco, CA. This project is designed to provide improved and relocated housing to agricultural workers and their families as an alternative to existing, industrially-zoned farm labor housing.

This project includes active transportation improvements such as the installation of curbs, sidewalks, and bicycle lanes. Additionally, the project includes a transit capital improvement in the form of a purchased shuttle that is to provide connectivity to the local Amtrak station and retail destinations.

The housing development includes water related measures such as drought-resistant landscaping and a water-efficient irrigation system, and according to project documents the construction meets GreenPoint Rated standards.

This project was funded through 2015-2016 FY funding and the site became operational in January 2019.

5.5.3.1. Data Collected

Data collected for this project included:

1. Responses to the POR residential transportation survey;
2. Information regarding the total number of surveys distributed and completed;
3. Occupancy rate information for the outcome period; and
4. Supporting documentation including the project application and grant agreement.

5.5.3.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Total surveys completed and survey response rate: 14 responses, 6% response rate

Site staff reported the number of survey instruments distributed to residents and the total number of completed surveys. For this site, staff handed out or posted 217 surveys and received 14 responses. This equals a response rate of 6% at the household level.

Tracking dates of data submission: January 10, 2020 – January 9, 2021

The grand opening date for the housing site was January 10, 2019, and the first outcome period would have been January 10, 2019 through January 9, 2020. However, surveys were not administered during that period, and for the purposes of this exercise, the Project Team defined the outcome period of analysis as January 10, 2020 – January 9, 2021. This represents the second one-year outcome period for the site.

Site staff administered surveys in early 2021 after the end of this outcome period due to the timing of finalizing the pilot survey instrument.

Housing unit occupancy rate and income-restricted housing units occupancy rate: 95%

This is based on information from site staff regarding total residents and total occupied units during the outcome period. Staff indicated that the site contains 226 units and that 11 units are vacant (95% occupancy). All units are income-restricted.

For mixed-use projects, occupancy of commercial space: N/A

This site does not include a commercial space.

Residents using transit passes, as applicable: N/A

Transit passes were not included as a component of this AHSC project.

Percentage of households with access to one or more owned, leased, or regularly borrowed cars: 57%

A majority of respondents (57%) indicated that their household has access to one or more owned, leased, or regularly borrowed cars. Of the eight respondents who indicated that they have access to a personal car, three respondents stated that their household has access to two cars, while the remaining five respondents stated that their household has access to one car.

Percentage of households with reliable access to transportation: 55%

A majority of respondents (54%) indicated that they are "Always" (45%) or "Usually" (9%) able to travel to where they need to go and therefore meet the proposed definition of "Reliable access to transportation". The remaining respondents indicated that they are "Sometimes" (27%) or "Rarely" (18%) able to travel to where they need to go. Compared to the other AHSC sites sampled as part of this data collection exercise, this suggests that there may be an opportunity to improve transportation access for residents at this AHSC site.

Days of operation for the reported outcome period; Average daily ridership; Average trip length: Not available

While project documentation indicated that a shuttle would be purchased as part of this AHSC site and operated as a service to residents, site contacts were not able to confirm the operational status of the shuttle or provide associated data.

Average traffic of bicycle and pedestrian facilities: Not available

The AHSC project at this site contained active transportation improvements including bicycle lanes and sidewalk improvements. Site staff confirmed that these had been completed and were being actively used. However, these improvements associated with this project are not currently monitored, and the Project Team did not conduct demonstrative on-site active transportation data collection due to issues presented by the COVID-19 pandemic.

Table 5-7 summarizes the above metrics for this project.

Table 5-7. AHSC Project 3 Outcome Metrics Summary

Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	1/10/2020 – 1/9/2021 (Surveys administered in early 2021)
Affordable Housing	Housing unit occupancy rate	95%
	Income-restricted housing units occupancy rate	95%
	For mixed-use projects, occupancy of commercial space	N/A
	Residents using transit passes, as applicable	N/A
	Percentage of households with access to one or more owned, leased, or regularly borrowed cars	57%
	Primary commuting and non-commuting modes (percentage of households by primary mode)	(See detail table below)
	Percentage of households with reliable access to transportation	55%
	Total surveys completed (households)	14
	Survey response rate (household level)	6%
Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year	Not available
	Average daily ridership	Not available
	Average passenger trip length	Not available
Active Transportation	Average traffic of bicycle and pedestrian facilities	Not available

Primary commuting and non-commuting modes:

Six of the fourteen respondents indicated that their households regularly travel to and from work. Of these, four respondents indicated that they most frequently use a personal vehicle by driving a car alone for commuting purposes. One respondent indicated that they primarily walk when traveling for commuting purposes, and the remaining respondent selected "Other" as a response option for their most frequent commuting mode and indicated that they primarily use a wheelchair for commuting.

Twelve respondents provided information about their non-commuting travel modes. Seven respondents (54%) indicated that they most frequently use a personal vehicle for non-commuting purposes. Of the seven respondents who indicated that they most frequently use a personal vehicle for non-commuting purposes, five respondents stated that this personal vehicle non-commuting travel primarily involves driving a car alone, and one respondent stated that this personal vehicle non-commuting travel primarily involves carpooling. The remaining respondent indicated that they use both private vehicle travel and carpooling equally for non-commuting purposes.

Aside from personal vehicle travel, three respondents indicated that they most frequently use a form of active transportation. Finally, three respondents selected "Other" as a response option for their most frequent non-commuting mode; two of these respondents specific that their primarily use a wheelchair when traveling for non-commuting purposes, and the third respondent, who completed the Spanish

language version of the survey, wrote an open-ended response of "raite". This can be translated to "ride" and may refer to the site's shuttle, riding in a private vehicle, or another mode.

Mode choice may have been affected by changes in travel patterns caused by COVID-19 as surveys were administered in early 2021. The small sample size suggests that these figures may not accurately represent the travel patterns of the site as a whole.

Table 5-8 provides the results for household primary commuting and non-commuting modes for this project. This table presents results in terms of percentages to maintain consistency with the POR metrics reported for other sampled sites, though the Project Team emphasizes that the commuting mode results are based on a limited sample size of six respondents.

Table 5-8. AHSC Project 3 Outcome Metrics: Primary Commuting and Non-Commuting Mode

Primary commuting mode (percentage of responses, n = 6)	
Personal or private car (driving alone or carpooling)	67% (4 respondents)
Transit (bus, shuttle, train, light rail)	0%
Ride-hailing	0%
Active transportation (walking, biking, scooter)	17% (1 respondent)
AHSC-specific transportation mode (e.g. funded vanpool)	N/A
Primary non-commuting mode (percentage of responses, n = 13)	
Personal or private car (driving alone or carpooling)	54%
Transit (bus, shuttle, train, light rail)	0%
Ride-hailing	0%
Active transportation (walking, biking, scooter)	23%
AHSC-specific transportation mode (e.g. funded vanpool)	N/A

5.5.3.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Presence of carsharing service

As shown above, a majority of respondents (57%) indicated that their household has access to one or more owned, leased, or regularly borrowed cars. However, site staff also noted that this location contains an electric vehicle carsharing hub, and one respondent indicated that their household has access to two electric vehicles. It is possible that some respondents who indicated that they have access to a personal vehicle were referring to these electric carsharing vehicles rather than their own vehicles. This detail was not captured as part of the current survey effort but should be addressed in future formal rounds of POR. If site contacts indicate that this type of service is available to residents, it should be included as a separate mode option within the commuting and non-commuting mode questions.

Lack of information regarding shuttle purchase and operations

Site contacts were not able to confirm the operational status of the shuttle that was to be purchased using AHSC funds for this site or provide data associated with the shuttle's operation. The Project Team issued several requests for clarification but did not receive a final response regarding the shuttle status. This suggests that there is an opportunity to improve the availability of this type of information by informing grantees that ridership and trip information will be requested following the completion of the AHSC grant, and potentially developing a plan with grantees early in the project to prepare for reporting this information.

Survey response rate and site engagement

Site staff distributed 217 paper survey instruments at this site and received 14 responses, translating to a 6% response rate. This is the lowest response rate across all sampled AHSC sites and suggests that there is a significant opportunity for further increasing response rates in future rounds of formal POR data collection. Only six of those respondents answered questions about commuting travel mode. This low response rate and small sample size present difficulties in developing actionable findings from POR data.

Staff at this site distributed surveys directly to residents when possible, but posted surveys on residence doors if they were not available. As a posted survey does not allow for staff to explain the purpose of data collection or directly engage with residents, response rates may be much lower than if surveys are provided directly to residents or if residents are asked to collect surveys at a front desk or from the on-site manager. It will likely be necessary to work with staff on-site to determine the most effective method of distributing surveys to resident households. For example, converting the surveys to an online format may also improve response rates for sites where residents have sufficient internet and computer access.

Additionally, based on findings from the overall data collection effort, it may be useful to distribute surveys during the annual income recertification process when site staff are already engaging with residents. It would be important to ensure that residents understand the completely optional nature of the survey and to emphasize that it will not affect the result of the income recertification.

5.5.4. AHSC Project 4: Civic Center 14 TOD Apartments, CCIRTS Project ID 30300

This project is categorized as a Transit Oriented Development (TOD) Project Area recipient and involves new construction of a 40-unit affordable housing development with 477 feet of commercial space in Oakland, CA.

This project includes active transportation improvements through the implementation of a 12-dock high-security smart bicycle rack at a nearby Bay Area Rapid Transit (BART) station and the construction of bicycle pathways on station stairways. The housing development was constructed to receive LEED Gold Certification.[42]

This project was funded through 2014-2015 FY funding and the site became operational in May 2018.

5.5.4.1. Data Collected

Data collected for this project included:

1. Responses to the POR residential transportation survey;
2. Information regarding the total number of surveys distributed and completed;
3. Occupancy rate information for the outcome period; and
4. Supporting documentation including the project application and grant agreement.

5.5.4.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below. This site did not include the capital purchase of transit improvements to expand service, and the POR metrics associated with that AHSC sub-program component are not applicable for this project.

POR metrics are provided as percentages for the purposes of maintaining consistency with other AHSC POR results, but as the resident household survey for this project received only 5 responses, narrative descriptions of survey results in this section refer to the number of respondents rather than the percentage of respondents.

Total surveys completed and survey response rate: 5 responses; 13% response rate

Site staff reported the number of survey instruments distributed to residents and the total number of completed surveys. For this site, staff distributed surveys to all 40 residences and received 5 responses. This equals a response rate of 13% at the household level.

Tracking dates of data submission: May 30, 2020 – May 29, 2021

This housing site opened to residents in May 2018 and the first two outcome periods would have been May 30, 2018 through May 29, 2019; and May 29, 2019 through May 30, 2020. However, surveys were not administered during or near that period, and for the purposes of this exercise, the Project Team defined the outcome period of analysis as May 30, 2020 through May 29, 2021. This represents the third one-year outcome period for the site.

[42] Meta Housing Corporation: https://www.metahousing.com/location/civic-center-14-tod/

Site staff administered surveys in early 2021 during the latter portion of this outcome period due to the timing of finalizing the pilot survey instrument.

Housing unit occupancy rate and income-restricted housing units occupancy rate: 98%

This is based on information from site staff regarding total residents and total occupied units during the outcome period. Staff indicated that the site currently has a 98% occupancy rate for its 40 units and that all units are income-restricted.

For mixed-use projects, occupancy of commercial space: 0%

The site includes a commercial space but it has not yet been occupied and therefore has an occupancy rate of 0%.

Residents using transit passes, as applicable: N/A

Transit passes were not included as a component of this AHSC project.

Percentage of households with access to one or more owned, leased, or regularly borrowed cars: 50%

Two of four respondents to this question indicated that their household has access to one or more owned, leased, or regularly borrowed cars. Both of these respondents indicated that their household has access to one car.

Percentage of households with reliable access to transportation: 60%

Three of five respondents indicated that they are "Always" able to travel to where they need to go and therefore meet the proposed definition of "Reliable access to transportation". The remaining respondents indicated that they are "Sometimes" (1 respondent) or "Rarely" (1 respondent) able to travel to where they need to go. Compared to the other AHSC sites sampled as part of this data collection exercise, this suggests that there may be an opportunity to improve transportation access for residents at this AHSC site.

Average traffic of bicycle and pedestrian facilities: Not available

The AHSC project at this site included the installation of a smart bicycle rack, but this had not yet been completed at the time of this data collection exercise and was planned for implementation in late 2021.

Table 5-9 summarizes the above metrics for this project.

Table 5-9. AHSC Project 4 Outcome Metrics Summary

Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	5/30/2020 – 5/29/2021 (Surveys administered in early 2021)
Affordable Housing	Housing unit occupancy rate	98%
	Income-restricted housing units occupancy rate	98%
	For mixed-use projects, occupancy of commercial space	0%
	Residents using transit passes, as applicable	N/A
	Percentage of households with access to one or more owned, leased, or regularly borrowed cars (four respondents)	50%
	Primary commuting and non-commuting modes (percentage of households by primary mode)	(See narrative below)
	Percentage of households with reliable access to transportation (five respondents)	60%
	Total surveys completed (households)	5
	Survey response rate (household level)	13%
Active Transportation	Average traffic of bicycle and pedestrian facilities	Not available

Primary commuting and non-commuting modes:

As the results to the commuting and non-commuting modes for this site reflect five or fewer respondents, responses are not tabulated and are instead summarized narratively below.

Two of the five respondents indicated that their households regularly travel to and from work. Both of these respondents indicated that they most frequently use a personal vehicle for commuting purposes and that this primarily involves driving a car alone rather than carpooling. One of these two respondents also stated that they primarily use active transportation (walking) when traveling to and from work.

Two of five respondents indicated that they primarily use active transportation for non-commuting purposes. Specifically, one of these respondents primarily walks and the other primarily uses a bicycle. One respondent indicated that they primarily use ride-hailing for non-commuting purposes, and another respondent indicated that they primarily drive a car alone when traveling for non-commuting purposes. The remaining respondent indicated that they primarily use transit when traveling for non-commuting purposes.

Mode choice may have been affected by changes in travel patterns caused by COVID-19 as surveys were administered in early 2021. The small sample size suggests that these figures may not accurately represent the travel patterns of the site as a whole.

5.5.4.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Active transportation data availability

The smart bicycle rack that was funded by this AHSC project had not yet been completed at the time of this data collection exercise. Transit agency staff noted that once it is implemented, the smart bike rack will be able to provide data regarding daily usage, which would satisfy the current POR requirement for average traffic of active transportation facilities. These types of facility and equipment installations which include an embedded data collection mechanism are ideal candidates for outcome reporting, as no manual data collection or installation of automatic counters is necessary.

Commercial space vacancy

Site staff explained that the commercial space has not yet been leased at this site and that there are currently no plans to move forward with leasing the space. In discussions with site staff, this did not appear to be related to the COVID-19 pandemic but due to an unspecified management decision or property issue. As the AHSC program QM incorporates a land use index based on the square footage of mixed-use (e.g. commercial or social services) space when calculating VMT reductions, 0% occupancy of the commercial space at this site may be in conflict with the original commercial space assumptions that were used in the GHG calculations for this project.

Survey response rate and site engagement

Site staff distributed paper survey instruments to all 40 residences at this site and received 5 responses, translating to a 13% response rate at the household level. This is a fairly low response rate and a very limited sample size, which presents difficulties in developing actionable findings from POR data. As is the case with all AHSC sites that were sampled as part of this exercise, there are likely opportunities for further increasing response rates in future rounds of formal POR data collection.

5.5.5. AHSC Project 5: Jordan Downs Phase 1B, CCIRTS Project ID 34835

This project is categorized as an Integrated Connectivity Project (ICP) Project Area recipient and involves new construction of a 135-unit affordable housing site in Los Angeles, CA. This project includes active transportation improvements in the form of a half-mile street extension that runs through the site and contains sidewalks, bike lanes, curb ramps, and signal improvements.

The housing development includes energy and water related measures such energy efficient building envelope characteristics and stormwater capture and filtering equipment. The Jordan Downs 1B phase that was sampled for this POR data collection effort is part of a larger Jordan Downs housing community with residences that existed prior to this new construction, and at the time of this data collection effort developers were in the process of constructing additional residences onsite.

This project was funded through 2015-2016 FY funding and the site became operational in December 2020.

5.5.5.1. Data Collected

Data collected for this project included:

1. Responses to a transportation survey question that was administered as part of a data collection effort conducted by the Housing Authority of the City of Los Angeles (HACLA) and EJP consulting;
2. Information regarding the total number of surveys distributed and completed; and
3. Occupancy rate information for the outcome period.

5.5.5.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below. This site did not include the capital purchase of transit improvements to expand service, and the POR metrics associated with that AHSC sub-program component are not applicable for this project.

Total surveys completed and survey response rate: 21 responses; 17% response rate

Site staff reported the number of survey instruments distributed to residents and the total number of completed surveys. For this site, staff distributed surveys to all 122 residences and received 21 responses. This equals a response rate of 17% at the household level.

It should be noted that Jordan Downs 1B is one component of the site and that there are a total of 584 households across all residential components of the housing community and 351 total survey responses (a response rate of 60% at the household level). As the current data collection exercise focused on the Jordan Downs 1B component which was funded in association with Project ID 34835, the above metric is based on 21 respondents out of the 122 Jordan Downs 1B households living at this site. The broader Jordan Downs housing community includes residences that have been in place for several years and were not part of this specific project.

Tracking dates of data submission: December 1, 2020 – March 31, 2021

This is based on the initial move-in date for the housing development (December 1, 2020) and extending through the first quarter of 2021. At the time of this data collection exercise, less than one year had

elapsed since the site opened for occupancy. Surveys were administered in early 2021 during this outcome period.

Housing unit occupancy rate and income-restricted housing units occupancy rate: 92%

These are based on information from site staff regarding total residents and total occupied units during the outcome period. The data above represent occupancy rates for the first quarter (January - March) of 2021. Currently, 122 of 133 units are occupied and all of these units are income-restricted. The site began leasing its units in December 2020 and the management company is still in the process of leasing up its remaining units. The occupancy rate is expected to increase to full occupancy in the second quarter of 2021. The site includes two managers units and the above values exclude those units.

For mixed-use projects, occupancy of commercial space: N/A

The site does not include a commercial space.

Residents using transit passes, as applicable: N/A

Transit passes were not included as a component of this AHSC project.

Percentage of households with access to one or more owned, leased, or regularly borrowed cars: Not available

This question was not included in the survey administered through the housing authority.

Percentage of households with reliable access to transportation: Not available

This question was not included in the survey administered through the housing authority.

Average traffic of bicycle and pedestrian facilities: Not available

The AHSC project at this site included active transportation improvements such as sidewalk improvements and bicycle lanes but these improvements are not currently monitored and the Project Team did not conduct on-site monitoring of active transportation due to issues presented by the COVID-19 pandemic.

Table 5-10 summarizes the above metrics for this project.

Table 5-10. AHSC Project 5 Outcome Metrics Summary

Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	12/1/2020 – 3/31/2021 (Surveys administered in early 2021)
Affordable Housing	Housing unit occupancy rate	92%
	Income-restricted housing units occupancy rate	92%
	For mixed-use projects, occupancy of commercial space	N/A
	Residents using transit passes, as applicable	N/A
	Percentage of households with access to one or more owned, leased, or regularly borrowed cars	Not available
	Primary commuting and non-commuting modes (percentage of households by primary mode)	(See detail table below)
	Percentage of households with reliable access to transportation	Not available
	Total surveys completed (households)	21
	Survey response rate (household level)	17%
Active Transportation	Average traffic of bicycle and pedestrian facilities	Not available

The survey administered by the housing authority and its consultant included a single transportation-related question ("What's your primary form of transportation?"). This question did not separate commuting travel from non-commuting travel, and therefore the below values represent the overall primary transportation mode of resident households rather than commuting or non-commuting modes.

A majority of respondents (67%) indicated that they most frequently use a personal vehicle for transportation, while 24% of respondents indicated that they primarily use transit, 17% indicated that they primarily use transit, 5% indicated that they primarily walk or bike, and 5% indicated that they primarily use a taxi or car share service.

Mode choice may have been affected by changes in travel patterns caused by COVID-19 as surveys were administered in early 2021.

Table 5-11 provides the results for this transportation question that was asked of Jordan Downs 1B resident households.

Table 5-11. AHSC Project 5 Outcome Metrics: Primary Transportation Mode

Primary transportation mode (percentage of responses, n = 21)	
Personal or private car (driving alone or carpooling)	67%
Transit (bus, shuttle, train, light rail)	24%
Ride-hailing	5%
Active transportation (walking, biking, scooter)	5%
AHSC-specific transportation mode (e.g. funded vanpool)	N/A

5.5.5.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Concurrent Survey Efforts

This site was unable to administer the pilot AHSC POR survey, as the housing authority and its consultant were already administering another survey as part of a separate data collection effort. In order to avoid the potential confusion or burden of a concurrent survey, the Project Team requested any available transportation-related results from this separate survey effort. The survey administered through the housing authority included one transportation-related question, which provided sufficient information to complete several of the mode share POR metrics currently in place for AHSC projects. The survey did not include separate questions about commuting travel and non-commuting travel, and used slightly different response options for some modes.

The Project Team suggests that ideally, each AHSC site would use a uniform set of survey questions to collect POR metrics, which would require that the full survey instruments or individual questions are provided by administering agencies. While there was not an opportunity to revise the housing authority survey to add specific POR questions as part of the current data collection exercise, the existence of this separate residential survey suggests that there may be an opportunity for administering agencies to collaborate with site contacts on survey data collection efforts in the future. For sites that are planning to issue a separate survey, administering agencies may be able to coordinate with the site to consolidate efforts and issue a single survey instrument that captures POR information and other data that is of interest to the housing authority or site staff. It would likely be necessary for administering agencies to work with site representatives early on in the project to plan for survey data collection. If site representatives are not able to include POR questions in their own survey instruments, administering agencies should coordinate with the site to ensure that there is a gap in timing, such as several months, between administering POR surveys and any other resident surveys.

If administering agencies determine that the existence of a concurrent survey effort is prohibitive to collecting POR data for an AHSC site, the Project Team recommends that agencies notify CARB of this issue as soon as possible and resample a new site for outcome reporting if necessary.

5.6. Key Data Collection and Analysis Findings

This section summarizes overall findings from the process of reviewing project documentation, collecting data, and analyzing results for each of the above projects:

- **The AHSC data collection effort encountered limitations resulting from the COVID-19 pandemic.** The Project Team initially planned to work directly with housing development staff to administer surveys as part of on-site visits, and to conduct demonstrative on-site data collection for active transportation improvements. Due to travel restrictions and other barriers resulting from the COVID-19 pandemic, it was not feasible to engage in these on-site activities. This limited the ability of the Project Team to coordinate and observe survey administration for each site, which likely reduced the uniformity of data collection procedures and may have affected overall response rates. The Project Team was also unable to conduct sample monitoring of active transportation facilities, which limits the POR findings and recommendations that this assessment is able to provide for those project components.

- **Reported transportation modes and other collected information were likely substantially affected by the COVID-19 pandemic.** As the data collection effort coincided with the COVID-19 pandemic, metrics such as mode share reported through this exercise may not be an accurate representation of typical resident travel behaviors. For example, travel restrictions and social distancing guidelines may have reduced the availability and use of modes such as transit and ride-hailing. Additionally, residents who previously would have regularly traveled to work may have been telecommuting at the time that the survey was administered. Residents may also be selecting retail establishments with better curbside pick-up options, even if those require driving instead of walking or biking.

  When asked whether they use specific modes more or less than one year ago, several respondents provided open-ended comments indicating that their overall travel or use of specific modes has been affected by the pandemic. The magnitude of this external effect is unclear, and additional data collection during periods of typical travel conditions would be needed in order to fully assess the transportation patterns of residents at these AHSC sites.

- **Surveys obtained very limited sample sizes in several cases and may be highly variable in general, which creates difficulties in comparing results or gaining actionable insights.** Survey response rates for the sample of projects ranged from 6% to 51% at the household level, and the average response rate for four sites was 25%, excluding the fifth site that conducted its own separate survey effort. Response rates for specific questions were frequently lower than overall survey response rates, and the household-level response rates do not reflect the number of residents represented by survey responses as compared to the total resident population.

  The variability in response rates may be due to a variety of factors including differences in incentives offered, language or demographic barriers, differences in the data collection approaches used by on-site staff, or differences in resident interest in transportation issues. Additionally, the period of survey administration was generally limited to a few days and the response rate of a specific site during this exercise may not be representative of the response that could be expected as part of a longer term or repeated survey effort.

  The current household response rates suggest that it will be difficult to consistently obtain a statistically representative level of data for the subset of AHSC projects that are sampled for POR. As the current POR framework is not intended to serve as a mechanism for reassessing project GHG reductions and other benefits, this quality of data may be adequate for some qualitative purposes if program staff are able to implement practices to achieve response rates closer to the higher end of what was obtained for the sample sites. Conducting a more rigorous sampling and data collection approach that would yield statistically representative results may require dedicated resources and the involvement of researchers with expertise in survey data collection.

- **Coordination with on-site staff and housing authorities is a key component of survey data collection.** On-site staff often have existing working relationships with residents and are able to provide insight into the engagement and data collection strategies that may be the most effective for their resident population. Additionally, as administering agencies may not have access to sites and the program does not collect contact information from residents, substantial involvement from on-site staff is likely needed in order to communicate with and distribute surveys to resident households. Finally, housing authorities may conduct their own resident surveys with alternate or complementary objectives to the POR survey, and it may be necessary to coordinate with these organizations to avoid conflicting, redundant, or overly frequent surveying of residents.

- **Incentives were important in encouraging resident survey responses.** Based on feedback from on-site staff, residents were interested in the gift card lotteries offered to survey respondents and the existence of incentives was a useful recruitment tool. The number of gift cards and gift card dollar amounts per site were determined based on feedback from housing authority and on-site staff as well as the availability of incentive funding for this data collection effort. Additionally, one site offered to match the survey incentive amount using its own funds, which may be a possibility to explore for future rounds of POR. However, only a few gift cards were allocated to each site and a majority of respondents did not ultimately receive an incentive. Appropriate compensation or incentivization of participants is important from both a data collection and ethics and equity perspective. Continued rounds of data collection and coordination with housing sites would be needed in order to determine the appropriate and most effective incentive strategy.
- **Active transportation data collection can be resource intensive and active transportation improvements are not being monitored at a consistent level for these projects.** As mentioned above, the Project Team was unable to conduct sample active transportation monitoring as part of this exercise due to the COVID-19 pandemic. Based on reviews of existing methodologies and discussions with transit agency and on-site staff, collecting POR data on active transportation improvements may present significant challenges. The current POR framework for AHSC requires agencies to report the average traffic of bicycle and pedestrian facilities and improvements that were funded through the program. Active transportation monitoring can be conducted using a variety of manual or automated approaches, with the recommended approach varying depending on the facility or area being monitored and the availability of count technologies.[43] According to transit agency and housing development staff, none of the active transportation improvements associated with the sites sampled for this data collection effort were actively being monitored for bicycle or pedestrian traffic.

  Implementing manual monitoring for these sites would require involvement and training of on-site staff or site visits conducted by administering agencies, and implementing automated counts would require funds for the use of equipment or technology such as infrared detectors or intersection video recorders.[44] Either of these methods would be difficult to implement as part of POR unless a monitoring method is designed and prepared early on in the project planning process, such as part of the program application. As daily traffic is a key input in the QM calculation of GHG benefits from active transportation improvements, post-project monitoring of these components could serve as a valuable M&V activity during the outcomes phase or prior to project closeout.

[43] California Department of Transportation, "Interim Count Methodology Guidance for Active Transportation Program (ATP)," June 2021, https://dot.ca.gov/-/media/dot-media/programs/local-assistance/documents/lapg/c25/25y.pdf.

[44] Kittelson & Associates, Inc., Ryan Snyder Associates, and Los Angeles County Bicycle Coalition, "Conducting Bicycle and Pedestrian Counts: A Manual for Jurisdictions in Los Angeles County and Beyond" (The Southern California Association of Governments, Los Angeles County Metropolitan Transportation Authority, June 2013), http://media.metro.net/projects_studies/call_projects/images/metroscag_bikepedcounttrainingmanual.pdf.

- **Metrics collected through POR surveys cannot easily be used to validate affordable housing QM inputs.** The current QM framework for affordable housing improvements calculates GHG emissions benefits by estimating the avoided VMT for residents as compared to a baseline scenario.[45] The VMT reduction calculations rely on a series of inputs related to the net density of housing, destination accessibility, and affordability of housing, and include stipulations as defined in the California Air Pollution Control Officers Association (CAPCOA) manual for Quantifying Greenhouse Gas Mitigation Measures.[46] Unlike some QM calculators such as for active transportation or transit improvements, where data for ridership or average daily traffic could potentially be collected during POR and used to validate initial QM inputs, the affordable housing QM does not directly rely on estimates of resident mode share or access to vehicles.

  Due to this, mode share and other metrics that can be collected through resident surveying may provide qualitative insight into resident transportation patterns as compared to initial expectations, but there is no direct way to make a quantitative comparison to the QM estimates. While modeling approaches or other analyses could potentially estimate GHG reductions using mode share and other transportation metrics collected from residents, these activities are outside the scope of the current POR framework and would require a more in-depth data collection effort.

The following findings are related to data collection and analysis for transit capital improvements. Similar findings are also presented in the LCTOP and TIRCP section of this report. While the transit capital improvements for AHSC projects sampled through this data collection effort were limited to a vanpool and shuttle service, these findings may be useful considerations for those types of services as well as the broader scope of transit components that may be funded through AHSC:

- **Grantee transit agencies appear willing to provide the requested POR metrics but data limitations and the level of detail available varies widely across agencies.**
  - Some agencies are limited to quantifying ridership at the systemwide level and are not able to provide metrics for individual vehicles or services.
  - Some agencies may have difficulties with reporting data for a precise period that does not coincide with a calendar year or fiscal year.
  - Agencies that are working with third parties to conduct data collection and analysis may be able to provide much more detail and additional metrics, but most agencies do not have this support.

[45] California Air Resources Board, "Quantification Methodology: Strategic Growth Council Affordable Housing and Sustainable Communities Program" (California Climate Investments, February 25, 2021), https://ww2.arb.ca.gov/sites/default/files/classic/cc/capandtrade/auctionproceeds/sgc_ahsc_qm_022521.pdf.

[46] California Air Pollution Control Officers Association, "Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures," August 2010, http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf.

- **Grantees may need additional training regarding reporting and documentation of POR metrics and QM inputs.**
    - In previous rounds of POR for transit projects, some agencies have reported VMT in terms of avoided ICE vehicle VMT rather than reporting the VMT of the funded transit vehicles. Additionally, there have been cases where the grantee provided the trip lengths of transit vehicles rather than passenger trip lengths.
    - Grantees do not consistently provide detailed information regarding the approach that was used to estimate individual QM inputs and may be unable to provide clarification during the outcome period if the original project staff are no longer part of the agency.
- **POR may have a role in validating initial project inputs for transit improvements, but is limited in its ability to evaluate outcomes that are attributable to projects.**
    - One of the ways that POR metrics can provide insight into transit project impacts is to validate or revise the inputs that grantee agencies used to generate project GHG reductions and other benefits estimates within program QM calculators.
    - While relying on program QM calculators as the basis for impact estimates and replacing assumed metrics with available POR metrics does provide an update on project effects within the established QM framework, this is a lower level of evaluation rigor than could be achieved with more in-depth monitoring or modeling research. Past studies have made efforts to assess the effects of specific interventions and external variables on transit ridership.[47] In-depth studies that are tailored to each selected project may allow for greater insight into how the increased capacity or expanded service implemented through California Climate Investments funding is affecting transportation in grantee agency service areas, though this is beyond the current scope and available resources of POR.

5.7. Final POR Metrics Recommendations

Based on the above data collection and analysis activities, the Project Team identified additional opportunities for modifications to the set of approved AHSC POR metrics. This section summarizes these recommendations and presents an updated table of POR metrics for consideration.

The Project Team recommends the following additions or modifications to metrics within the AHSC POR framework:

Energy generated by solar PV

As the AHSC program QM calculator includes an input for expected annual solar PV generation, this metric could be collected from AHSC sites during the outcome period to allow for potential validation of these initial estimates. This metric was not in place during the current data collection exercise but is recommended for future formal rounds of POR.

[47] Michael Kyte, James Stoner, and Jonathan Cryer, "A Time-Series Analysis of Public Transit Ridership in Portland, Oregon, 1971–1982," *Transportation Research Part A: General* 22, no. 5 (September 1, 1988): 345–59, https://doi.org/10.1016/0191-2607(88)90012-X.

Cynthia Chen, Don Varley, and Jason Chen, "What Affects Transit Ridership? A Dynamic Analysis Involving Multiple Factors, Lags and Asymmetric Behaviour," *Urban Studies* 48, no. 9 (2011): 1893–1908, http://www.jstor.org/stable/43081823.

Percentage of households with access to one or more owned, leased, or regularly borrowed cars (not including carsharing programs)

The original POR metric for household vehicle access did not account for the existence of carsharing programs, which residents may have reported as their own regularly borrowed vehicles. This metric is intended to capture the percentage of households with access to personal vehicles, and borrowed vehicles in this sense would refer to vehicles borrowed from friends or family rather than electric carsharing vehicles. This revision serves as a minor clarification of the intention for this metric.

The following POR metrics recommendations are applicable to capital transit improvement components of AHSC projects.

Indication of whether service continues to be operated as stated within project close-out documentation (if not, provide description of change)

Verifying that the status of purchased vehicles or expanded service continues to align with project documentation is a form of M&V that can be completed during the outcome period for selected projects. While transit agencies are not required to continue operating vehicles or service in the manner that was initially estimated, gathering information about these changes can provide context to any transit-related data that are collected during POR.

Average daily ridership (separated into weekday, Saturday, and Sunday ridership)

This is a modification of the original "Average daily ridership" metric and involves the separation of ridership data into weekday, Saturday, and Sunday fields. Based on the data collection findings for transit projects, some transit agencies are only able to provide average weekday ridership, while other agencies provided overall ridership that included weekdays and weekends. Using separate fields to report this information provides additional context for the ridership data that is received from transit agencies.

Average passenger trip length

This is a minor clarification of the "Average trip length" metric to specify that it is referring to passenger trip length rather than transit vehicle trip length.

Vehicle miles traveled or fuel/energy consumption

As vehicle miles traveled (VMT) and/or fuel/energy consumption is an input within the AHSC QM tool for transit capital improvements, the Project Team recommends collecting this metric during the outcome period. This is consistent with the POR metrics recommended for transit programs such as LCTOP and TIRCP.

5.7.1. Final Recommended POR Metrics

Table 5-12 summarizes the recommended metrics described above, with the additional recommended or modified metrics highlighted. This list of metrics assumes that POR data collection will include the use of resident surveys.

Table 5-12. Final AHSC POR Metrics Recommendations

	Sub-Program Component	Recommended Metrics
Affordable Housing and Sustainable Communities (AHSC)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Affordable Housing	Housing unit occupancy rate
		Income-restricted housing units occupancy rate
		For mixed-use projects, occupancy of commercial space
		Residents using transit passes, as applicable
		Percentage of households with access to one or more owned, leased, or regularly borrowed cars (not including carsharing programs)
		Primary commuting and non-commuting modes (percentage of households by primary mode)
		Percentage of households with reliable access to transportation
		Energy generated by solar PV, as applicable
	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year
		Average daily ridership (separated into weekday, Saturday, and Sunday ridership)
		Average passenger trip length
		Confirmation that service continues to be operated as stated within project close-out documentation (if not, provide explanation)
		Fuel/energy consumption or vehicle miles traveled
	Active Transportation	Average traffic of bicycle and pedestrian facilities

In addition to the POR metrics listed above, the Project Team recommends that projects provide supplemental summary metrics for completed surveys, including the total number of responses received and the survey response rate as a percentage of total residents invited to complete the survey. Complete survey data should also be made available for California Climate Investments staff review upon request.

5.8. Additional Recommendations

These additional recommendations are presented for CARB, SGC, and HCD consideration. These recommendations are designed to support improved evaluability and evaluation of ASHC moving forward.

The following recommendations are related to best practices in the design and administration of surveys and are only applicable if surveying will be required as part of POR data collection. However, due to the challenges and limitations highlighted in Section 5.6, a preliminary recommendation is for CARB, SGC, and HCD to collaborate on survey methodologies and required resources to determine the feasibility of administering surveys for this purpose. If there are substantial barriers to successful survey

implementation, it may be necessary to temporarily focus on collecting non-survey POR metrics while establishing the resources and procedures for effective survey data collection and analysis.

- **Develop a survey data collection plan with affordable housing sites during project implementation.** If surveys are to be used to collect POR data for AHSC, it will be important to plan for data collection prior to the outcome period. As individuals such as on-site managers and housing authority staff are important stakeholders in the data collection process, administering agencies should notify these and other project staff of the resident survey component as early in the project process as possible such as when funds are awarded. This would allow project staff to acknowledge the data collection effort and identify any considerations that should be addressed prior to data collection, including the timing of surveys, whether the site is planning any separate surveying efforts, any changes that should be made to the survey instruments such as translations or additional mode options, and other details.

  This planning process should also involve determining who will administer the surveys and the mode of administration such as online, in-person, or through the mail and what incentives will be offered to residents. These efforts will help to increase the level of engagement from housing development sites and may improve response rates and the overall efficiency of data collection efforts.

- **Survey data collection should be conducted in a manner that appropriately engages, informs, and protects residents.** Formal research studies that incorporate surveys, such as those completed by academic institutions, take a series of precautions and comply with research standards in order to maintain a high quality of data and protect the privacy and agency of participants.[48] While the current POR framework is not intended to serve as a form of human subjects research, surveying of affordable housing residents should be viewed as a sensitive activity that requires consideration of participant consent, privacy, and overall risk. As residents of these sites are not program grantees and are not under an obligation to provide information on project outcomes, they must be informed that their participation is completely voluntary and that their decision of whether or not to participate will not affect factors such as their resident eligibility status. Additionally, resident surveys should avoid collecting personally identifiable information (PII) unless additional protocols are taken to protect this information. Surveys should make efforts to fully inform residents of the purpose of data collection and how the information will be used. If possible, POR surveying should be conducted or overseen by individuals with expertise in survey administration, data collection protocols, and ideally for AHSC projects, equity considerations related to program evaluation.[49]

- **Resident surveys should be as consistent as possible but tailored to site-specific transportation characteristics if needed based on feedback from site staff.** The types of transportation available to residents and overall resident transportation patterns vary among AHSC sites depending on the surrounding land use characteristics, applicable transit agencies, and other factors. Due to this, it may be necessary to add, remove, or modify transportation mode options within surveys depending on the modes available to specific sites. For example, one of the sampled AHSC sites was located near an electric carsharing hub, and one survey respondent indicated that they have access to two electric vehicles. As the survey instrument did not account for the presence of this carsharing hub, this presents an issue for the analysis of personal vehicle access at this site.

[48] American Association for Public Opinion Research, "AAPOR Guidance for IRBs and Survey Researchers," 2014, https://www.aapor.org/Standards-Ethics/Institutional-Review-Boards/Full-AAPOR-IRB-Statement.aspx.

[49] "Equitable Evaluation Framing Paper," Equitable Evaluation, accessed June 21, 2021, https://www.equitableeval.org/pp-resources/2020/2/13/equitable-evaluation-framing-paper.

The Project Team recommended minor adjustments to each survey instrument for this data collection process based on feedback from site staff, and administering agencies should plan to make similar minor adjustments as part of future POR efforts. While modifications to mode response options may improve the clarity and reliability of survey results, survey questions that are used to calculate POR metrics should otherwise be kept as consistent as possible across sites to maintain comparability of data collected for different projects.

- **As a possible expansion of POR or California Climate Investments evaluation, consider collecting baseline transportation information as part of the resident survey process.** This recommendation would involve changes that occur outside of the POR period and is provided for general consideration in relation to AHSC program evaluation. While administering a survey to residents during the outcome period allows for the reporting of POR metrics, the absence of baseline metrics creates challenges in comparing POR data to conditions prior to the outcome period. The current POR framework generally relies on baselines that are established prior to POR as part of QM calculations or during project implementation. Administering a survey that asks residents about their mode share and access to transportation when living at their previous residence could be used to establish a baseline for comparison with metrics that are later collected during POR. As an example, this initial survey could be administered to residents once per project during the time of initial property lease-up. These baseline metrics could then be reported as part of the project closeout process prior to the beginning of the outcome period. This process would not be linked to program QM tools but would serve as a separate form of analysis for the program.

The following recommendation is related to active transportation improvements:

- **Develop an active transportation monitoring plan during project planning, or prioritize active transportation improvements with embedded data collection features.** Based on the findings from this data collection effort, the level of existing monitoring for active transportation improvements funded through AHSC is low. If grantees or administering agencies are expected to collect data on daily use of active transportation facilities, it would be useful for AHSC to either request a monitoring plan from grantees as part of the project application process or develop a plan for monitoring a sample of sites and whether this will be done with monitoring technology or a manual count process. Alternatively, some active transportation improvements such as the smart bicycle rack funded through one of the sampled AHSC projects include a data collection feature that is able to report daily usage counts which could be compared to initial QM estimates for daily traffic. Improvements such as bicycle lanes can also include automatic traffic detectors that would be installed as part of the construction process. Prioritization of improvements that include a data component would reduce the need to conduct manual monitoring after projects are complete.

  In either case, early planning for active transportation monitoring would improve the availability of this type of data during project closeout, POR, or other potential evaluation activities. If there are barriers to developing monitoring plans or to collecting active transportation data, POR should at least verify that the active transportation improvements were implemented as planned and are continuing to operate as expected.

The following recommendations relate to transit capital improvements. Similar recommendations are also presented in the LCTOP and TIRCP section of this report due to similarities with this component of the AHSC program:

- **In the absence of increased evaluation and reporting resources, continue requiring metrics that are consistent with what transit agencies are already providing under FTA requirements.** Otherwise, smaller agencies may not have the resources to comply with special requests. For

example, this would include requesting data in terms of average weekday, average Saturday, and average Sunday ridership as recommended in the above POR metrics modifications.

- **Maintain appropriate engagement with transit agency grantees to ensure that they understand the QM tools and POR metrics, maintain consistency across data provided for AHSC projects, and minimize the presence of errors or incomplete data within project documentation and reports.**
    - Similarly, it may be useful for CARB to provide additional guidance to grantee transit agencies regarding how to estimate the ridership increases that will result from funded projects in order to improve consistency in approaches across agencies. If possible, CARB and administering agencies should consider implementing this guidance in the form of a calculator to include in program QM tools which would allow agencies to estimate ridership gains in a consistent manner that can be referenced during any subsequent evaluation efforts. If such a calculation uses a forecast of gross ridership as an input, POR could collect actual gross ridership and use the QM to obtain a post-project ridership gain estimate for comparison to the pre-project expectation. This is one possible approach for improving the consistency of calculations completed by grantees, but CARB and administering agencies may be able to identify other viable options.
    - Administering agencies should also work with grantees to collect more detailed documentation regarding claimed ridership, trip length, and other inputs during the QM phase and should consider conducting additional quality assurance to assess the reasonableness of these estimates. Based on a review of project applications, there are a wide variety of approaches used to estimate these values across agencies; some are more specifically tailored to the individual agency and others rely on industry defaults.
- **Recommended POR purpose within AHSC:** For affordable housing developments, POR data collected through resident surveying with high response rates could provide insight into changes in transportation behaviors over time at a single site as well as differences in mode share across multiple sites. Administering agencies may be able to use these survey results as a quality assurance tool, such as to identify opportunities for improving transportation access at a site where residents report that their access to transportation is low. Additionally, CARB, SGC, and HCD may identify other data such as socioeconomic metrics to collect with these surveys based on evolving program goals and reporting requirements.

  In-depth analysis such as using survey results to assess GHG outcomes and other quantitative program benefits is likely outside the scope and resources of the current POR framework and would require enhancements such as dedicated resources or staff to conduct uniform, statistically representative data collection. As affordable housing QM calculations do not incorporate inputs that can be easily collected through resident surveying, POR data collection in its current form is best suited to providing valuable information regarding resident perspectives that can be used to make program improvements over time. Finally, research studies using detailed survey instruments, focus groups, and statistical analysis have been conducted to develop in-depth conclusions and policy recommendations related to affordable housing programs.[50] Whether implemented through

[50] Association of Bay Area Governments, "Transit Oriented Development and Affordable Housing: A Survey of Residents in Five East Bay Properties," 2015, https://abag.ca.gov/sites/default/files/transit-and-affordable-housing-survey.pdf.

Barajas, Jesus, Karen Frick, and Robert Cervero. "Travel of TOD Residents in the San Francisco Bay Area: Examining the Impact of Affordable Housing," June 30, 2020. https://escholarship.org/uc/item/1r20w0tv.

California Climate Investments or conducted by external parties, future efforts of this type may provide a comprehensive source of findings for understanding affordable housing benefits and informing program decision-making.

For transit improvements, the Project Team recommends that POR is used to verify the ongoing status of projects and collect operational data on metrics such as ridership and average trip length that could potentially be used to validate or revise the initial QM inputs provided by grantees. Metrics such as expected ridership and average trip length are key inputs within program QM and transit agencies appear to be prepared to provide primary post-project data for these metrics during the outcome period. This is consistent with the findings and recommendations for POR within transit programs including LCTOP and TIRCP. Similarly, monitoring of active transportation improvements can provide data that could potentially be used to validate initial traffic estimates within QM calculators.

6. Water Efficiency

California Climate Investments programs include projects with the primary objective of optimizing and reducing water usage while also achieving energy reductions and GHG benefits. Within the California Climate Investments portfolio of programs, projects with water efficiency as a primary goal are typically associated with the Water-Energy Efficiency Program or the State Water Efficiency and Enhancement Program (SWEEP).

6.1. Project Sample

At the time of project sampling in October 2019, there were 600 SWEEP projects eligible for POR based on information received from CARB. The final data collection sample included six SWEEP projects.[51]

SWEEP is administered by the California Department of Food and Agriculture (CDFA) and provides grants for primarily agricultural irrigation water and energy end uses including drip systems, moisture monitoring systems, pump retrofits, variable frequency drives (VFDs), and renewable energy systems.

The six projects included in the data collection sample are described below. Due to sensitivities surrounding the confidentiality of grantee utility usage data which were used to calculate POR metrics, these projects are labeled with anonymous identifiers rather than their California Climate Investments program ID numbers. The Project Team provided CARB with a list of these projects and their program ID numbers for internal reference.

- **SWEEP Project 1.** Installation of soil sensors, a VFD, and solar array to replace propane usage on approximately 60 acres of wine grapes. This project also includes the installation of flow meters, and implementation of cover cropping and composting as additional management practices.
- **SWEEP Project 2.** Installation of soil sensors, irrigation management system, and solar array on approximately 170 acres of mixed vegetable crops. This project also includes the implementation of cover cropping and compost application as additional management practices.
- **SWEEP Project 3.** Installation of soil sensors, drip system to replace flood irrigation, and pump retrofit on approximately 75 acres of almond crops (converted from alfalfa during project implementation). This project also includes the installation of flow meters, and compost application as an additional management practice.
- **SWEEP Project 4.** Installation of a solar array, soil sensors, and irrigation management system on 60 acres of wine grapes. This project also includes the installation of a flow meter.
- **SWEEP Project 5.** Installation of pipeline irrigation to replace open ditch flood irrigation. This is designed to enable the use of well pumping for irrigation and eliminate the use of diesel-powered vehicles for open ditch pumping.
- **SWEEP Project 6.** Installation of soil sensors and irrigation management system on 420 acres of wine grapes. This project also includes the installation of flow meters, and implementation of mulching and compost application as additional management practices.

[51] At the time of project sampling, the Water-Energy Grants program was involved in an in-depth M&V study conducted by the UC Davis Center for Water-Energy Efficiency (CWEE) to quantify program impacts. As a result the Project Team determined that SWEEP was associated with a greater outstanding evaluation need and focused on SWEEP for the water efficiency data collection effort.

6.2. Activities Conducted

The data collection process for the sampled SWEEP projects consisted of the following activities:

6.2.1. Administering Agency Interviews and Documentation Requests

At the start of the data collection process the Project Team completed interviews with CDFA staff to gain an understanding of program procedures, existing data collection processes, and the extent of available project data. As part of these interviews the Project Team requested documentation associated with each sampled project.

6.2.2. Project Documentation Reviews

The Project Team reviewed project documentation including initial SWEEP applications, populated QM calculator tools, supporting documents such as baseline pump efficiency tests, and project verification forms for site visits that were conducted by CDFA. The purpose of these reviews was to understand the components of each project, identify the POR data to be collected, and identify any key considerations related to potential evaluation barriers or opportunities that should be investigated as part of the data collection process. CDFA retains project documentation for SWEEP grantees and applicants and provided the above documents for each sampled project to the Project Team upon request.

6.2.3. Grantee Questionnaires and Interviews

The Project Team developed a questionnaire for each sampled project and sent these questionnaires to grantees to collect initial outcome-related information and request relevant data records. Specifically, these questionnaires asked grantees to confirm whether the project components associated with SWEEP continued to be operational and whether the grantee had made any major changes to their equipment, irrigation systems, or land use since the time of project completion. Additionally, the questionnaires asked grantees whether they would be able to provide data such as water usage records, energy usage records, and solar energy generation records for the period since project completion. Finally, the questionnaires asked grantees to confirm whether they had continued to implement any of the soil management practices that they had planned for during the application process, and to provide feedback and recommendations related to how SWEEP should collect this type of information moving forward. A copy of the grantee questionnaire can be found in Appendix C.

The Project Team asked grantees to respond to the questionnaire by either email or telephone. All but one grantee preferred to communicate by phone, and in these instances the Project Team was able to administer the questionnaire in the form of an in-depth interview to gather thorough information about each project and site. As part of either the email or telephone communications with grantees the Project Team then issued requests for all relevant water usage data, energy usage data, solar generation data, and supporting records (such as pump efficiency reports) for the period since project implementation. The Project Team requested that grantees only provide usage data that were relevant to the SWEEP project, rather than to the entire property.

As some data records were not initially available or were incomplete, the Project Team continually coordinated with grantees over the course of the data collection process in an effort to gather the most relevant and complete datasets possible for each site.

6.2.4. Analysis of Data Records

Upon receiving all available data records for each site, the Project Team reviewed and analyzed these records in order to develop the POR metrics associated with SWEEP projects for the defined outcome periods associated with each sampled site. Current SWEEP POR guidelines define the first outcome reporting period as beginning once projects are complete and CDFA has conducted its project verification site visit. Based on this, the Project Team defined outcome reporting periods for each project as beginning on the date that CDFA conducted its verification and extending one year forward to represent the first round of POR. For projects with two years of post-verification data, the Project Team defined the second round of POR as beginning immediately after the first round and extending one year forward.

Table 6-1 displays the list of SWEEP POR metrics approved by CARB at the start of this data collection task. During the data records analysis process, the Project Team also identified opportunities for additional or alternative metrics to recommend for inclusion in future rounds of SWEEP outcome reporting.

Table 6-1. Initially Approved SWEEP POR Metrics

	Sub-Program Component	Metric
State Water Efficiency and Enhancement Program (SWEEP)	All	Tracking dates of data submission (i.e. time period represented by data and reported metrics)
		Confirmation that soil health practices are still being implemented
		For joint SWEEP Prop 1 projects, energy use of distribution system
	Energy Efficiency	Change in SWEEP project on-farm energy use
		Change in SWEEP project on-farm fuel use
	Water Efficiency	Change in SWEEP project on-farm water use
	Solar Photovoltaic (PV)	Energy generated

6.2.5. Assessment of Barriers and Evaluation Considerations

Throughout the data collection and analysis process, the Project Team took note of data collection challenges and other significant issues that may serve as barriers to effective POR procedures and may present opportunities for improved data collection strategies or relate to overall evaluation recommendations for SWEEP projects.

6.3. POR Metrics Recommendations

Based on the above data collection and analysis activities, the Project Team identified opportunities for modifications to the set of approved SWEEP POR metrics. This section summarizes these recommendations and presents an updated table of POR metrics. This updated list of metrics is referenced and used for reporting purposes within the subsequent individual project findings sections.

6.3.1. Recommended Additional Metrics

The Project Team recommends adding the following metrics to the SWEEP POR framework:

Total SWEEP project on-farm energy use; Total SWEEP project on-farm water use

The Project Team recommends these fields as additional outcome metrics to provide basic information on overall usage for project sites, given the challenges in reliably calculating water and energy use for SWEEP projects as part of the current POR framework. Inclusion of these metrics also serves the purpose of continuing to encourage grantees to retain water and energy records if "change in water use" and "change in energy use" are no longer included as POR metrics.

Confirmation that SWEEP measures remain in place and operational; Indication of substantial change to irrigation system, acreage, or land use

The Project Team recommends these fields as additional annual outcome metrics to verify that the project remains operational as described in the project planning and verification phases. This serves as a basic form of M&V for project sites.

6.3.2. Deferred Metrics

In addition to recommending additional POR metrics, the Project Team identified two categories of metrics that are unlikely to provide insight into projects under the current scope of POR or may no longer be relevant to SWEEP projects. These metrics are categorized as "deferred", as the Project Team does not recommend them for inclusion in SWEEP POR unless deemed to be necessary by CARB and CDFA.

Change in SWEEP project on-farm energy and water use

Due to the limitations of the simple difference approach for calculating water and energy use, and in consideration of the technical resources required to implement a more rigorous analytical method that could account for external factors such as weather changes and water availability, the current POR framework is likely unable to obtain reliable estimates of energy and water use changes that can be attributed to funded projects. The Project Team defers to CARB and CDFA for final determinations regarding the inclusion of these metrics but if program staff plan to conduct a simple difference approach for comparing usage data, the Project Team does not recommend using the resulting values to report on project energy or water savings or recalculate project GHG benefits. Ideally, any change in energy or water use that is to be attributed to a specific project would be evaluated through a more rigorous M&V phase that expands upon the scope and resources of POR.

For joint SWEEP Prop 1 projects, energy use of distribution system

Based on discussions with CDFA, this metric is no longer applicable to SWEEP projects.

Confirmation that soil health practices are still being implemented

The Project Team proposed this as an additional metric for SWEEP based on the fact that CDFA considers the implementation of soil health practices when assessing project applications and has prioritized projects that include one or more eligible practices. The intent of including this metric was to provide ongoing insight into how SWEEP has encouraged improved long-term soil health through its prioritization of projects that include these optional practices. However based on CDFA feedback, this metric is not viewed as useful to program decision-making or to understanding project outcomes. The Project Team determined not to include this in the final recommended list of metrics and defers to CARB as to whether this information is valuable at the administrative level.

6.3.3. Final Recommended POR Metrics

Table 6-2 summarizes the recommended and deferred metrics described above, with the additional recommended metrics highlighted.

Table 6-2. Final SWEEP POR Metrics Recommendations

	Sub-Program Component	Recommended Metrics
State Water Efficiency and Enhancement Program (SWEEP)	All	Tracking dates of data submission (i.e. time period represented by data and reported metrics)
		Confirmation that SWEEP measures remain in place and operational
		Indication of substantial change to irrigation system, acreage, or land use (if Yes, describe)
	Energy Efficiency	**Total SWEEP project on-farm energy or fuel use**
	Water Efficiency	**Total SWEEP project on-farm water use**
	Solar Photovoltaic (PV)	Energy generated
	Deferred Metrics	
	Change in SWEEP project on-farm energy use	
	Change in SWEEP project on-farm fuel use	
	Change in SWEEP project on-farm water use	
	Confirmation that soil health practices are still being implemented	
	For joint SWEEP Prop 1 projects, energy use of distribution system	

6.3.4. Potential Future Metrics

These metrics would involve modifications to program requirements and procedures outside of the POR phase, but are provided for CDFA and CARB to consider as part of future rounds of SWEEP funding.

Energy intensity

Energy Intensity (EI) is the ratio of energy consumption over water flow volume for a given period.[52] For projects which are intended to improve the energy efficiency of irrigation, it may be useful to include EI as a metric during the pre-project phase, which could then be compared to the EI for the outcome period and could serve as a metric to assist in comparing the baseline period to the post-project period. EI at the time of implementation could likely be calculated by CDFA using its currently available data, though additional requirements associated with increased costs to grantees would be needed in order to add this as an outcome metric.

Overall pumping plant efficiency (OPPE)

For energy efficiency projects, consider requiring pump tests one year after project implementation in order to compare pump efficiency reports in pre- and post-periods. This could be used to compare overall

[52] Robert Wilkinson et al., "An Analysis of the Energy Intensity of Water in California: Providing a Basis for Quantification of Energy Savings from Water System Improvements," *ACEEE Summer Study on Energy Efficiency in Buildings*, 2006, https://www.aceee.org/files/proceedings/2006/data/papers/SS06_Panel12_Paper14.pdf.;

UC Davis Center for Water-Energy Efficiency, "Energy Intensity Analysis," 2017.

pumping plant efficiency (OPPE) for pre- and post-project periods. As pump tests are associated with a cost to the grantee, it may be appropriate to allocate a small portion of the SWEEP grant towards the completion of a post-project pump test. However, CDFA has indicated challenges with implementation timing and funding these tests, which would need to be resolved prior to adding this as an outcome metric.

6.4. Results by Sampled Project

This section summarizes the results of the data collection effort by project.

6.4.1. SWEEP Project 1

This project includes the installation of soil sensors, a VFD, and solar array to replace propane usage on approximately 60 acres of wine grapes. This project also includes the installation of flow meters, and implementation of cover cropping and composting as additional management practices.

This project was funded through Round 1 of the 2016 SWEEP solicitation. Following project implementation, CDFA conducted its verification of this project on March 9, 2017.

6.4.1.1. Data Collected

Data collected for this project included:

1. Handwritten flow meter records for the period of July 12, 2016 through November 26, 2019;
2. Tule sensor irrigation summaries for 2 of the site's blocks for the period of June 30, 2016 through March 1, 2020 (Block 10) and July 3, 2016 through November 26, 2019 (Block 17);
3. PG&E energy reports for 5 of the site's meters including 3 agricultural pumps (denoted as "AG PUMP" within utility documentation) for the billing periods of June 9, 2015 through November 6, 2015;
4. Utility transaction data (PG&E and propane) for the entire property for the period of 2016 through 2019;
5. PG&E Net Energy Metering Aggregation (NEMA) annual true-up reports for the period of 2017 through 2019; and
6. Responses to the grantee questionnaire, completed through a telephone interview.

6.4.1.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Outcome tracking start and end: March 9, 2017 - March 8, 2018 (Period 1); March 9, 2018 - March 8, 2019 (Period 2)

The project was verified on March 9, 2017, marking the beginning of the first outcome period and extending through March 8, 2018. The second outcome period begins on March 9, 2018 and ends on March 8, 2019. The third outcome reporting period would be defined as March 9, 2019 through March 8, 2020, though the grantee did not provide data for this period.

Change in SWEEP project on-farm energy use: -9,273 kWh (Period 1); -5,117 kWh (Period 2)

These values were calculated based on a simple difference between the baseline energy usage records and outcome period energy records for the single meter for which outcomes data were provided.

Change in SWEEP project on-farm water use: Not available

The water usage data provided for the outcome periods appears to be incomplete and out of alignment with baseline data, and a change value was not calculated.

Total SWEEP project on-farm energy use: 554 kWh (Period 1, Single meter only); 4,710 kWh (Period 2, Single meter only)

These values do not represent all meters at the project site. Energy data for the outcome period were provided for a single meter connected to solar through net metering, and energy usage includes solar reductions.

Total SWEEP project on-farm water use: 6,093,500 gallons (Period 1, Incomplete data); 1,901,800 gallons (Period 2, Incomplete data)

The flow meter records provided by the grantee appeared to be incomplete. These values are based on the information available but may be substantially lower than actual usage, as described below in Section 6.4.1.3.

Energy generated: Not available

This metric is not available as the NEMA true-up reports provide net metering information rather than isolating energy generation for each year, and as the records provided were year-end records the solar allocations listed in each summary only represent solar allocations for the final month of billing in each year rather than monthly allocations throughout the year.

Confirmation that VFDs remain in place and operational; Confirmation that sensors remain in place and operational; Confirmation that solar system remains in place and operational: Yes

This is based on an interview conducted with the grantee in April 2020.

Indication of substantial change to irrigation system, acreage, or land use: No

This is based on an interview conducted with the grantee in April 2020.

Confirmation of continued soil health practices: Yes

This is based on an interview conducted with the grantee in April 2020.

Table 6-3 summarizes the above outcome metrics for this project.

Table 6-3. SWEEP Project 1 Outcome Metrics Results

	Sub-Program Component	Metric	Period 1	Period 2
State Water Efficiency and Enhancement Program (SWEEP)	All	Tracking dates of data submission (i.e. time period represented by data and reported metrics)	3/9/2017 – 3/8/2018	3/9/2018 – 3/8/2019
		Confirmation that SWEEP measures remain in place and operational	Yes	Yes
		Indication of substantial change to irrigation system, acreage, or land use (if Yes, describe)	No	No
	Energy Efficiency	Total SWEEP project on-farm energy or fuel use	554 kWh (solar meter only)	4,710 kWh (solar meter only)
	Water Efficiency	Total SWEEP project on-farm water use	6,093,500 gallons (incomplete data)	1,901,800 gallons (incomplete data)
	Solar Photovoltaic (PV)	Energy generated	Not Available	Not Available
	Deferred Metrics			
	Change in SWEEP project on-farm energy use		-9,273 kWh (solar meter only)	-5,117 kWh (solar meter only)
	Change in SWEEP project on-farm fuel use		N/A	N/A
	Change in SWEEP project on-farm water use		Not Available	Not Available
	Confirmation that soil health practices are still being implemented		Yes	Yes
	For joint SWEEP Prop 1 projects, energy use of distribution system		N/A	N/A

6.4.1.3. Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Incomplete water usage records

The handwritten flow meter records provided by the grantee were very detailed in some areas and showed the estimated gallons of irrigation per watering period, but in many areas the gallons were not provided or the notations were not clear. For these reasons, the total water usage shown above likely does not accurately represent the actual irrigation for this site. If possible, flow meter records should be provided in a digital format that clearly displays the gallons per irrigation block or total gallons for the site. The format of baseline water usage data provided for this project is more readable and informative, and ideally the same format would be used during the outcome reporting period to allow for straightforward comparison of the pre- and post-project irrigation.

Metering issues

Energy usage records received from this grantee for the outcome periods represent a single meter which is connected to the installed solar system through net metering. From the records provided, it is not

possible to extract energy usage from the pump connected to the meter from the solar generation component. If monthly solar allocations were available for this site it would be possible to estimate solar generation as a separate metric, but the records received only include solar allocations for certain months rather than each billing period. Additionally, as the energy generation and energy usage values are combined in these records, the change in energy use field above includes energy reductions from the solar generation component of the project. As this does not allow for individual evaluation of the performance of the VFDs and solar component separately, projects should incorporate separate solar metering tools (such as provided by third-party solar installers) which directly track the generation for the system, if possible.

Incomplete energy usage records

Based on the data available, change in energy usage was calculated using a simple difference method comparing the 2015 baseline with each of the outcome periods. This shows a reduction in energy usage of 9,273 and 5,117 kWh respectively, though this represents only one of the meters on the site and therefore the baseline energy usage is 9,827 kWh rather than the 73,631 kWh baseline reported as part of the application process. It is apparent that the outcomes data collected are not comprehensive and provide limited insight into the project. The grantee did not respond to additional requests for clarification regarding these records.

Unclear fuel conversion component

Although the SWEEP project verification records indicate that the site underwent a fuel conversion from propane to electric irrigation, this is not mentioned in the initial application (which states that "the wells are run on electric grid hookup") and propane records were not received as part of baseline documentation. Outcome data provided by the grantee show propane purchases during the outcome periods, possibly for a use other than irrigation, but in the GHG estimation calculator provided by the grantee during the application process, "current propane use" is listed as zero gallons per year. This suggests that there may be an inconsistency between the project application and actual project implementation and verification. Consistency in program documents and additional contextual information regarding site details would be instrumental in allowing for comprehensive evaluation of project outcomes and benefits particularly for any third-party evaluation efforts that may be implemented during future program years.

6.4.2. SWEEP Project 2

This project includes the installation of soil sensors, irrigation management system, and solar array on approximately 170 acres of mixed vegetable crops. This project also includes the implementation of cover cropping and compost application as additional management practices.

This project was funded through Round 2 of the 2016 SWEEP solicitation. Following project implementation, CDFA conducted its verification of this project on December 10, 2018.

6.4.2.1. Data Collected

Data collected for this project included:

1. Flow meter records for the period of January 2019 through December 2019;
2. PG&E NEMA Statements for April through December 2019;
3. PG&E energy bills for the relevant pump meter for all months in 2019;
4. Solar energy generation records for all months in 2019;
5. SWEEP Reporting worksheet information for 2018 and 2019; and
6. Responses to the grantee questionnaire, completed through a telephone interview.

CDFA provided items 1 through 5 above on behalf of the grantee.

6.4.2.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Outcome tracking start and end: December 10, 2018 – December 9, 2020

Beginning from the verification date of December 10, 2018 and extending one year forward, this 12-month period represents the first annual outcome reporting period.

Change in SWEEP project on-farm energy use: -111,234 kWh

The change in SWEEP project on-farm energy use is based on a simple difference comparison between energy bills for the current outcome period and energy bills for the baseline period. Total energy usage for the outcome period was 112,378 kWh, and total energy usage for the baseline period in 2015 was 223,612 kWh. This does not include energy generation of 364,947 kWh, which is presented as a separate outcome metric.

Change in SWEEP project on-farm water use: Not available

The change in SWEEP project on-farm water use was not calculated, as the baseline water usage data for this site as provided in the project application documentation appear to be based on modeled NRCS estimates rather than direct flow meter records. The Project Team does not recommend comparing modeled data with primary on-site data and did not conduct this type of comparison as part of this exercise.

Total SWEEP project on-farm energy use: 112,378 kWh

This represents the sum of energy usage within records provided for the specified outcome period.

Total SWEEP project on-farm water use: 156,997,293 gallons

This represents the sum of water usage within records provided for the specified outcome period.

Energy generated: 364,947 kWh

This is based on the cumulative generation values provided by the grantee for 2019, starting with April 2019 when the solar system first became operational.

Confirmation that sensors remain in place and operational: No

This is based on an interview conducted with the grantee in April 2020. The grantee indicated that they had replaced the sensors that were installed as part of this project.

Confirmation that solar PV remains in place and operational: Yes

This is based on an interview conducted with the grantee in April 2020.

Indication of substantial change to irrigation system, acreage, or land use: Yes

This is based on an interview conducted with the grantee in April 2020. The grantee indicated that crops change depending on demand, so the crop is not constant and would have varying irrigation needs.

Confirmation of continued soil health practices: Yes

This is based on an interview conducted with the grantee in April 2020.

Table 6-4 summarizes the above metrics for this project.

Table 6-4. SWEEP Project 2 Outcome Metrics Results

	Sub-Program Component	Metric	Result
State Water Efficiency and Enhancement Program (SWEEP)	All	Tracking dates of data submission (i.e. time period represented by data and reported metrics)	12/10/2018 – 12/9/2019
		Confirmation that SWEEP measures remain in place and operational	No (sensors replaced)
		Indication of substantial change to irrigation system, acreage, or land use (if Yes, describe)	Yes, crops change depending on demand, so the crop is not constant
	Energy Efficiency	Total SWEEP project on-farm energy or fuel use	112,378 kWh
	Water Efficiency	Total SWEEP project on-farm water use	156,997,293 gallons
	Solar Photovoltaic (PV)	Energy generated	364,947 kWh
	Deferred Metrics		
	Change in SWEEP project on-farm energy use		-111,234 kWh
	Change in SWEEP project on-farm fuel use		N/A
	Change in SWEEP project on-farm water use		Not available
	Confirmation that soil health practices are still being implemented		Yes
	For joint SWEEP Prop 1 projects, energy use of distribution system		N/A

6.4.2.3. Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Water usage baseline

The grantee was able to provide flow meter records for the outcome period which represent total irrigation for the relevant project area. The total irrigation for the outcome period is 481.8 acre-feet, which the Project Team converted to 156,997,293 gallons above by multiplying by a factor of 325,851. According to the grantee, these flow meters were in place prior to project implementation. However based on documentation obtained from the application period, baseline water usage and expected water savings appear to be based on the NRCS irrigation tool rather than actual flow meter records. As this does not allow for a comparison of similar datasets, total water usage for the outcome period is included above but change in water usage is not reported.

Energy usage baseline

Energy usage records received from this grantee represent all electricity usage from the pump associated with the irrigation of the relevant crops. This is an appropriate data set, as energy usage from other areas

of the property such as buildings or other equipment are not relevant to the treatment provided by the SWEEP project (implementation of soil sensors and a solar array). The baseline records for energy usage available for this site are from the 2015 year, which is four years prior to the outcome period. Ideally the baseline data would represent the most recent year prior to project implementation, though collecting such data would likely require a separate baseline data request as part of project outcome reporting, as the project application phase during which baseline data are first provided may occur a year or more before measures are implemented. Based on the data available, change in energy usage above was calculated using a simple difference method comparing the 2015 baseline with the 2019 outcome period. This shows a reduction in energy usage of 111,234 kWh compared to the baseline, which is approximately a 50% reduction.

Status of project sensors

The grantee indicated that the sensors which were purchased through the project had to be replaced after approximately 2 years based on guidance from the contractor who installed them. While the grantee reported that the new sensors have provided similar information and have continued to allow them to efficiently manage their irrigation practices, this equipment change is an example of an update that should be recorded as part of outcome reporting and basic M&V of the project over time. In cases where equipment is removed and not replaced, or energy efficiency upgrades are replaced with equipment of higher or lower efficiency, capturing this type of status update as an outcome metric would provide context for the findings from water or energy usage analysis.

Status of land use and pre-post considerations

The grantee indicated that crops at this site are not static and that crop changes had been made since the implementation of the SWEEP project. This is likely to be the case for many grantees, who may also make other changes to their land such as modifying the irrigation structure, adding or removing pumps, and changing the irrigated acreage. As these types of changes can affect the watering requirements and resulting energy usage for a site, this creates a challenge in comparing baseline data with project outcome data and further limits the reliability of the simple difference approach currently used for this program.

6.4.3. SWEEP Project 3

This project includes the installation of soil sensors, drip system to replace flood irrigation, and pump retrofit on approximately 75 acres of almond crops (converted from alfalfa during project implementation). This project also includes the installation of flow meters, and implementation of composting as an additional management practice.

This project was funded through Round 2 of the 2016 SWEEP solicitation. Following project implementation, CDFA conducted its verification of this project on February 9, 2018.

6.4.3.1. Data Collected

Data collected for this project included:

1. PG&E energy bills for a single meter for the period of August 2017 through December 2019; and
2. Responses to the grantee questionnaire, completed by email.

6.4.3.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Outcome tracking start and end: March 1, 2018 – August 31, 2019

Baseline records for this project cover a 6-month period of March 2016 through August 2016, and the Project Team aligned the outcome period to these same months in 2018 (following CDFA verification on February 9, 2018) for the purposes of comparison.

Total SWEEP project on-farm energy use: 99,499 kWh

This represents the sum of energy usage within records provided for the specified outcome period. Baseline data cover a 6-month period from March through August 2016, so the outcome period was limited above to allow for a like comparison.

Total SWEEP project on-farm water use: Not available

This metric was not available, as the grantee did not provide flow meter data for the outcome period.

Change in SWEEP project on-farm energy use: 44,870 kWh

The change in SWEEP project on-farm energy use is based on a simple difference comparison between energy bills for the current outcome period and energy bills for the 6-month baseline period (2016, as provided with the project application).

Change in SWEEP project on-farm water use: Not available

This field is not completed, as the grantee did not provide flow meter data for the outcome period.

Confirmation that sensors remain in place and operational: Yes

These fields are filled in based on the questionnaire completed by the grantee in June 2020. The grantee indicated that the sensors which were purchased through the project were still in place.

Indication of substantial change to irrigation system, acreage, or land use: No

These fields are filled in based on the questionnaire completed by the grantee in June 2020. The grantee indicated that there had not been any major changes to acreage or land use since the project was verified.

Confirmation of continued soil health practices: Yes

This is based on the questionnaire completed by the grantee in June 2020. The grantee indicated that they had continued composting efforts in alignment with the SWEEP grant agreement.

Table 6-5 summarizes the above outcome metrics for this project.

Table 6-5. SWEEP Project 3 Outcome Metrics Results

	Sub-Program Component	Metric	Result
State Water Efficiency and Enhancement Program (SWEEP)	All	Tracking dates of data submission (i.e. time period represented by data and reported metrics)	3/1/2018 – 8/31/2019
		Confirmation that SWEEP measures remain in place and operational	Yes
		Indication of substantial change to irrigation system, acreage, or land use (if Yes, describe)	No
	Energy Efficiency	Total SWEEP project on-farm energy or fuel use	99,499 kWh
	Water Efficiency	Total SWEEP project on-farm water use	Not available
	Solar Photovoltaic (PV)	Energy generated	N/A
	Deferred Metrics		
	Change in SWEEP project on-farm energy use		44,870 kWh
	Change in SWEEP project on-farm fuel use		N/A
	Change in SWEEP project on-farm water use		Not available
	Confirmation that soil health practices are still being implemented		Yes
	For joint SWEEP Prop 1 projects, energy use of distribution system		N/A

6.4.3.3. Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Water usage baseline

The NRCS calculations completed as part of the application process estimated that the total pre-project water usage for the existing crop (alfalfa) was 98.1 acre-inches per acre and that the post-project water usage would be 61.7 acre-inches per acre, representing a 37% reduction in water usage. However this grantee also indicated plans for a crop change from alfalfa to almonds and provided the NRCS usage estimates for the new almond crop as well (77.8 acre-inches per acre pre-project and 48.9 acre-inches per acre post-project, also a 37% reduction).

If the change in crop is independent of the SWEEP project, water usage reductions attributed to the project should be based on the almond crop baseline compared to the almond crop water usage during the outcome period, as this would capture the difference between almond irrigation without program intervention and almond irrigation with program intervention.[53] As the grantee did not respond to requests to provide flow meter data for the site, there is insufficient data to make this comparison. The grantee also indicated that they had not obtained a recent pump test, which would be required in order to incorporate metrics such as pump efficiency and total dynamic head with site energy records to estimate water withdrawals.

Energy usage uncertainties

Energy usage records received from this grantee are for a single meter on the site, though the meter number that is present within the outcome data differs from the meter number associated with the baseline period. This may be due to the meter having been replaced since project implementation.

The grantee confirmed that the energy records for the outcome period are associated with the pump that was replaced through SWEEP, but a simple difference comparison between these data sets shows a substantial increase in energy usage. The baseline energy records from 2016 are for a 6-month period ranging from March through August. Comparing this to the same 6-month time frame in the outcome period shows an increase in energy usage of 44,870 kWh, which is approximately an 82% increase. In the absence of supplementary documentation such as water usage or pump data, this increase cannot be reliably attributed to the SWEEP project.

[53] CDFA noted that in some cases, SWEEP may be the cause of crop changes, such as providing funding for grantees to shift from flooded field crops to higher value tree crops and result in water savings.

6.4.4. SWEEP Project 4

This project includes the installation of a solar array, soil sensors, and irrigation management system on 60 acres of wine grapes. This project also includes the installation of a flow meter.

This project was funded through Round 6 of the 2017 SWEEP solicitation. Following project implementation, CDFA conducted its verification of this project on August 22, 2019.

6.4.4.1. Data Collected

Data collected for this project included:

1. Energy records for the vineyard's two well pumps for the period of August 2018 through December 2020;
2. Irrigation records and estimates of total water usage for the 3 irrigation blocks upon which SWEEP project sensors were installed;
3. Energy generation records for the period of January 2020 through December 2020; and
4. Responses to the grantee questionnaire, completed through a telephone interview.

6.4.4.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Outcome tracking start and end: August 22, 2019 – August 21, 2020

Beginning from the verification date of August 22, 2019 and extending one year forward, this 12-month period represents the first annual outcome reporting period.

Total SWEEP project on-farm energy use: 38,358 kWh

This represents the sum of energy usage within records provided for the specified outcome period.

Total SWEEP project on-farm water use: 168,781 gallons (Incomplete data)

This represents the sum of energy usage and water usage within records provided for the specified outcome period. The water usage value is exclusively for the three irrigation blocks with sensors, and does not include the remaining blocks.

Change in SWEEP project on-farm energy use: 548 kWh

The change in SWEEP project on-farm energy use is based on a simple difference comparison between energy bills for the current outcome period and energy bills for the baseline period (2015-2016, as provided with the project application). This calculation does not include the energy generation of 155,647 kWh, which is presented as a separate energy generation outcome metric.

Change in SWEEP project on-farm water use: Not available

The change in SWEEP project on-farm water use was not calculated, as the baseline irrigation documentation available for this site did not include an estimate of volume of irrigation per block.

Energy generated: 155,647 kWh

This is based on the sum of kWh values from the solar records provided by the grantee for the outcome period. All months other than January and July are accounted for in these records, as a system error affected its ability to record energy generation data for those months.

Confirmation that sensors remain in place and operational; Confirmation that solar PV remains in place and operational: Yes

This is based on interviews conducted with the grantee in April 2020 and March 2021.

Indication of substantial change to irrigation system, acreage, or land use: No

This is based on interviews conducted with the grantee in April 2020 and March 2021.

Table 6-6 summarizes the above metrics for this project.

Table 6-6. SWEEP Project 4 Outcome Metrics Results

	Sub-Program Component	Metric	Result
State Water Efficiency and Enhancement Program (SWEEP)	All	Tracking dates of data submission (i.e. time period represented by data and reported metrics)	8/22/2019 – 8/21/2020
		Confirmation that SWEEP measures remain in place and operational	Yes
		Indication of substantial change to irrigation system, acreage, or land use (if Yes, describe)	No
	Energy Efficiency	Total SWEEP project on-farm energy or fuel use	38,358 kWh
	Water Efficiency	Total SWEEP project on-farm water use	168,781 gallons (incomplete data)
	Solar Photovoltaic (PV)	Energy generated	155,647 kWh
	Deferred Metrics		
	Change in SWEEP project on-farm energy use		548 kWh
	Change in SWEEP project on-farm fuel use		N/A
	Change in SWEEP project on-farm water use		Not available
	Confirmation that soil health practices are still being implemented		N/A
	For joint SWEEP Prop 1 projects, energy use of distribution system		N/A

6.4.4.3. Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Energy generation

Although the SWEEP Project Verification documentation indicates that all components of the project were installed and operating properly as of August 22, 2019, the grantee indicated that they did not receive permission to operate until mid-January 2020. Solar records are available beginning in 2020 and are missing for three months during the year due to system crashes that affected the energy generation records but did not affect the system's capacity to generate electricity. Thus, the energy generation value displayed above is likely a conservative estimate; the grantee provided an estimate of the system's actual generation during 2020 that is approximately 10% higher than this value.

As there can be a gap between the time that a solar system is installed and the point at which it is approved by the utility and becomes operational, the Project Team recommends that the SWEEP verification documentation indicate whether the system is operating or awaiting interconnection from utilities, as this would affect the start of the POR period.

Energy usage

There are two vineyard pumps at this site, and the PG&E records for both the baseline period and outcome period include energy usage for two meters, each labeled "Vineyard Pump #1" and "Vineyard Pump #2". However, the meter ID for Pump #2 in the outcomes period does not match the meter ID for Pump #2 in the baseline period. The grantee was unable to confirm whether the meter ID had changed since project implementation, but indicated that as there are only two pumps on this site, these two meter IDs for Pump #2 must refer to the same pump. Based on this, the Project Team compared meter data for Pump #1 and Pump #2 for the baseline period to meter data for Pump #1 and Pump #2 in the outcome period.

A simple difference comparison shows a slight increase in energy use from the baseline period and outcome period for these pumps, but as noted in the overall findings for SWEEP projects, the simple difference approach does not control for the many factors outside of the project that can affect energy and water usage. For example, the grantee indicated that compared to 2016, the overall watering strategy for vineyard grapes has shifted to involve more water per vine and that this could account for an increase in pumping activity. Although the overall water usage for the site may have increased based on this change in procedures, the grantee noted that the soil sensors and evapotranspiration scheduling are allowing them to meet their watering targets in a more efficient way than they would have in the absence of the SWEEP measures. Assessing the counterfactual water usage in this case would be challenging, and may involve development of a baseline using the site's current water stress targets and estimated pre-project watering efficiency to calculate energy use under the current watering strategy in the absence of soil sensors. This would require complete pre-project watering records and a quantitative understanding of the current watering strategy, which were not available for this site.

Water usage

Water usage records provided for the outcome period represent the three irrigation blocks where sensors were installed as part of the SWEEP project. The usage estimates are based on calculations performed by the grantee in response to the outcomes data request; the calculations incorporate total irrigation hours, plants per block, and flow rate to estimate total gallons used. The grantee indicated that they would be

able to replicate these calculations and provide irrigation estimates for all of the blocks at the site, but noted these three blocks are the most representative of the site's irrigation patterns. For formal POR reporting each project should report its total on-site water usage for all irrigation blocks, but for the purposes of this exploratory exercise, the Project Team asked the grantee to demonstrate the ability to provide water usage records for these representative blocks and the usage for this sample of blocks is displayed above.

The total water usage estimate within the SWEEP application for this site is based on the NRCS model rather than on-site irrigation records. The grantee also provided water usage records for the 2016 year, but these records show watering date and hours of watering without an estimate of total gallons per block, number of plants per block, or flow rate. As the post-project watering volume calculations provided by the grantee use number of plants per block and flow rate to compute gallons and these factors may have changed between the 2016 and 2019 periods, the data provided for the baseline period do not allow for reliable estimation of gallons per irrigation block. As a result, the Project Team did not assess change in water use as part of this exercise.

6.4.5. SWEEP Project 5

This project includes the installation of pipeline irrigation to replace open ditch flood irrigation. This is designed to enable the use of well pumping for irrigation and eliminate the use of diesel-powered vehicles for open ditch pumping.

This project was funded through Round 2 of the 2016 SWEEP solicitation. Following project implementation, CDFA conducted its verification of this project on December 6, 2017.

6.4.5.1. Data Collected

Data collected for this project consisted of responses to the grantee questionnaire, completed through a telephone interview.

6.4.5.2. Results

Due to issues outside the scope of the California Climate Investments grant, the grantee was unable to fulfill the request for data related to the energy usage of well pumps and water usage for the site for the period since project implementation. The Project Team was therefore unable to calculate many of the POR metrics for this sampled site.

During a telephone interview completed in April 2020, the grantee provided sufficient information to assess the following metrics:

Confirmation that SWEEP measures remain in place and operational: Yes

The grantee indicated that the irrigation system continued to operate as planned.

Indication of substantial change to irrigation system, acreage, or land use: No

The grantee indicated that they had not made major changes to the property since project verification.

6.4.5.3. Discussion

Based on a review of project documentation and qualitative information received from the grantee, the following discussion items are provided for consideration.

Lack of surface water measurement

During the telephone interview, the grantee explained that the site is located at the end of the district canal and uses surface water from the canal by blending it into its well water irrigation system when it is available. The grantee noted that this surface water is available between 30 and 120 days per year, and that there is currently no meter or other form of measurement to assess how much water is being collected in this way. This would present a significant challenge in estimating baseline water usage or comparing well irrigation for the pre- and post-project period. Without the ability to measure the amount of surface water entering the irrigation system, any measured decrease or increase of water or energy usage between the pre- and post-period may be partially due to fluctuations in surface water availability rather than project treatments performed at the site. While this site did not provide water or energy usage records for the outcome period and current POR practices do not seek to control for this type of external

variable, this is an example of a site characteristic that would present an evaluability issue if a more in-depth evaluation were to be conducted.

Fuel conversion

This project involves converting irrigation from diesel-powered vehicles to electric well pumping and CDFA indicated that it may be difficult to establish baseline GHG emissions using the fuel receipts provided by the grantee. While the Project Team did not conduct comparisons between the diesel usage records in the pre-project period and electricity usage records in the post-project period, it appears that some fuel conversion projects may present an evaluability issue related to establishing an appropriate baseline. This finding, as well as the surface water issue above, suggest that there may be a need to consider the evaluability of projects as part of the project selection process, particularly if California Climate Investments plans to place greater emphasis on validating initial project benefits estimates through enhanced M&V procedures. Collecting complete baseline data and developing a method of comparing baseline diesel use to post-project electricity use may allow for increased evaluability without deprioritizing these types of projects.

Changes in grantee availability

Though this grantee initially indicated that they would be able to provide energy usage and water usage records for this site, circumstances beyond the grantee's control prevented them from being able to fulfill the data request. If similar cases occur during formal rounds of POR, the Project Team recommends that administering agencies resample to select a new project for outcome reporting and provide a description of the data collection issue and resulting need to resample to CARB.

6.4.6. SWEEP Project 6

This project includes the installation of soil sensors and irrigation management system on 420 acres of wine grapes. This project also includes the installation of flow meters, and implementation of mulching and composting as additional management practices.

This project was funded through Round 6 of the 2017 SWEEP solicitation. Following project implementation, CDFA conducted its verification of this project on April 17, 2019.

6.4.6.1. Data Collected

Data collected for this project included:

1. Pump test reports for three well pumps, completed on March 25, 2020; and
2. Responses to the grantee questionnaire, completed by email and through a telephone interview.

6.4.6.2. Results

The grantee was unable to fulfill the request for water and energy usage data at the site for the period since implementation. The Project Team was therefore unable to calculate many of the POR metrics for this site.

The grantee responded to the SWEEP POR questionnaire in June 2020 and spoke with the Project Team by telephone on two occasions. This provided sufficient information to assess the following metrics:

Confirmation of continued soil health practices: Yes

The grantee indicated that they had continued their mulching and composting practices as planned.

Confirmation that SWEEP measures remain in place and operational: Yes

The grantee indicated that the VFDs continue to operate as planned.

Indication of substantial change to irrigation system, acreage, or land use: No

The grantee indicated that they had not made major changes to the property since implementation.

6.4.6.3. Discussion

Based on a review of project documentation and qualitative information received from the grantee, the following discussion item is presented for consideration.

Lack of data records and POR awareness

The Project Team coordinated with several different site contacts for this project throughout the course of this data collection exercise, and most contacts appeared unaware that site records such as water and energy usage may be requested as part of their participation in SWEEP. CDFA provides grantees with a summary of continued expectations that describes these possible data requests, and also includes descriptions of these requirements in the request for grant applications, the grant agreement, the pre-project consultation phase, and in the grant awards procedures manual. However, it appears that the existence or purpose of this project phase is not well understood by individuals at project sites. Additionally, contacts for this site indicated that they had not started recording water usage for the project

area and that they would be unable to provide water or energy records or sensor data due to a variety of on-site issues.

This suggests that in order to allow for a representative sample of SWEEP projects for participation in POR, it may be necessary for CDFA to increase its level of engagement with grantees. Efforts could include explaining the purpose and process of data requests, assisting grantees in establishing sufficient data recording procedures, and remaining in contact with grantees after CARB or CDFA selects them for POR to ensure that they are prepared for any upcoming requests.

6.5. Key Data Collection Findings

This section presents overall findings from the process of collecting data from grantees for each of the above projects and reviewing project documentation.

- **Grantees were generally willing to participate and provide data but may need assistance, preparation, and training moving forward.** For the projects sampled as part of this effort, grantees had limited awareness of the POR phase and the fact that CDFA or CARB may issue requests for data related to funded projects. Additionally within the set of sampled projects, there were sites where data recording procedures had not yet been implemented.
- **There were substantial limitations to the quality of data overall, such as discrepancies between data provided for the outcome period and baseline data that had been provided to CDFA.** This includes different meter IDs or number of meters without clear records to match the pre- and post-meters, different irrigation blocks and IDs, and different data formats and data fields between the baseline period and outcome period. Grantees also provided handwritten water usage records with missing data, which presented barriers to analysis.
- **Based on the data collected and project documentation reviews, the evaluability of some projects appears to be limited.** The sample reviewed by the Project Team included projects with site characteristics such as unmetered water sources that create barriers to baseline or benefits estimation and post-project measurement. Additionally according to CDFA, there may also be data collection barriers associated with grantee consent and responsiveness issues, as later years of POR would take place after the end of the grant period.
- **The CDFA SWEEP Reporting Worksheet appears to be a useful and straightforward POR tool and may serve as a useful example for other programs.** CDFA currently issues a Reporting Worksheet to grantees who are selected for POR which requests data such as energy usage and solar PV generation for the outcome period. The Project Team reviewed example Reporting Worksheets and compared the data provided in the worksheets to raw data provided by the grantee, and found the worksheets to be an accurate representation of site records. For other California Climate Investments programs for which grantees are responsible for reporting POR metrics, this type of standardized form that is issued by the administering agency on an annual basis may be a useful component of the data collection process.

6.6. Key Analysis Findings

This section presents overall findings from the process of assessing the collected data records for the outcome and baseline periods, as well as reviewing analytical best practices for these project types.

- **There are major limitations to using a simple difference comparison approach for energy and water usage data to gain insight into a project.** A simple difference approach does not account for factors outside the project such as weather changes, crop changes, and changes in irrigation strategies that may affect energy or water usage. Analyses would need to account for these and other variables in order to attribute a reliable reduction in energy usage value to the treatment implemented through the SWEEP project. The Project Team does not recommend using a simple difference approach to attribute a change in energy or water usage to program treatments. Industry standards such as the National Renewable Energy Laboratory (NREL) protocol for irrigation M&V and existing research groups such as the UC Davis Center for Water-Energy Efficiency (CWEE) have established guidance on industry best practices in assessing changes in energy and water usage and have provided findings on the benefits and drawbacks of various analytical approaches.[54]
- **Subject matter experts in water and energy analysis advise against comparing actual post-project usage data to deemed or modeled baselines to assess the change (e.g. change in water use) resulting from treatments.** In discussions with the Project Team, researchers at UC Davis CWEE indicated that combining modeled baselines with primary usage data in the outcome period does not allow for a like comparison and is not a reliable method of evaluating a change in energy or water use. For this reason, the Project Team did not compare post-project water usage data to modeled pre-project usage estimates and did not assess the "change in SWEEP project on-farm water use" metric for the sampled projects.
- **Based on the current POR framework and resources available to agencies, there is a gap between the evaluation capabilities of California Climate Investments outcome reporting and what could be accomplished with a more in-depth evaluation phase.** Expanded evaluation efforts such as third-party impact evaluation contracts may be an appropriate method of building upon the outcome reporting phase to quantify first-year or lifetime project benefits for the program, if this is an eventual goal for California Climate Investments programs. CDFA has indicated past challenges with obtaining funding for these types of contracts, which would need to be resolved prior to pursuing this option.

6.7. Recommendations

Based on the above findings, The following recommendations are presented for CARB and CDFA consideration. These recommendations are designed to improve the SWEEP POR process and support improved evaluability and evaluation of the program moving forward:

- **Assess project evaluability and grantee ability to participate in POR as part of the project selection and funding process.** If a project is associated with major data collection challenges or includes components that cannot feasibly be measured, it may be appropriate for CDFA to deprioritize the project within the funding process, conduct more in-depth data collection to assess expected impacts, or make recommendations to the grantee to improve the evaluability of the site.

[54] Charles W. Kurnik, Kate M. Stoughton, and Jorge Figueroa, "Outdoor Irrigation Measurement and Verification Protocol," 2017, https://doi.org/10.2172/1412803.;

UC Davis Center for Water-Energy Efficiency. "Evaluation Methods for Water, Energy, and Greenhouse Gas Emissions Conservations Programs," 2020.

Evaluability should be balanced with the objective of implementing projects at the highest impact sites and meeting program equity objectives.

- **Consider including a data verification step within the CDFA project verification visit.** This data verification could collect a sample of energy and water data and confirm that the format and scope is sufficient to allow for the reporting of POR metrics. Data collected at this phase would not be analyzed to assess project impacts, but would serve to demonstrate that proper data recording and retention procedures are in place. If the appropriate data procedures are in place at the point of verification, this increases the likelihood that records will be accessible at the time of POR.
- **Consider incentivizing the reporting of POR metrics during the term of the grant after projects are implemented.** For projects that complete implementation prior to the end of the grant term, it may be useful to allocate a small amount of grant funds (e.g. less than one percent) to "first-year" POR, and notify grantees that they will receive this portion of funding once they provide the requested POR data. This would encourage grantees to establish sufficient data collection procedures initially and may improve compliance with POR requests in later years.
- **Consider using more on-site data, when available, to establish the baseline water usage for projects.** This could include pump records to estimate groundwater withdrawals, or actual flow meter data, to allow for like comparison with usage during the outcome period.[55]
- **Assess the timing of project baselines and establish new baselines if needed based on the project implementation date.** For projects with out-of-date baseline data due to a long lead time between the initial SWEEP application and measure implementation, it may be appropriate to request updated pre-project data for the period immediately prior to the implementation of SWEEP measures. Baseline data should be requested for at least one full year prior to project implementation in order to establish a baseline for comparison with the outcome period.
- **For solar PV projects, encourage the use of dedicated system monitoring either through separate meters or companion software applications.** This would improve the transparency of solar PV outcomes and minimize the analytical effort required assess solar PV generation kWh in the outcome period. With readily available solar generation records, grantees would benefit from being able to track their generation separately from their energy usage and easily report isolated solar generation kWh values as part of POR upon request.
- **To maximize the representativeness of data provided through SWEEP POR, use a simple random sample or stratified sample by project type to select projects for outcome reporting.** In cases where data are not available for a sampled project, CDFA should plan to resample and provide a description of the data collection issues for the originally sampled projects as part of California Climate Investments reporting.
- **Recommended POR purpose within SWEEP:** POR can serve as a method for conducting basic measurement and verification of project status, obtaining water and energy usage records for possible future comprehensive assessment, and tracking overall energy and water use of participating sites. However, based on the variety and complexity of SWEEP projects and sites, evaluation activities such as estimating the changes in water or energy use that can be attributed to SWEEP treatments or recalculating project GHG benefits should only be completed through more advanced billing data analyses or monitoring studies that are likely beyond the scope of the current POR framework and its associated resources.

[55] John R. Martindill, Robert T. Good, and Frank J. Loge, "Estimating Groundwater Withdrawals with Energy Data," *Journal of Water Resources Planning and Management* 147, no. 5 (May 2021), https://doi.org/10.1061/(ASCE)WR.1943-5452.0001348.

7. Low-Income Weatherization

Low-income weatherization projects have the main objectives of improving energy efficiency, reducing energy costs, and increasing the safety and comfort of low-income households. Within the California Climate Investments portfolio of programs, the Low-Income Weatherization Program (LIWP) is the primary program associated with these types of projects.

7.1. Project Sample

At the time of project sampling in October 2019, there were 5,566 LIWP project IDs eligible for POR based on information received from CARB. The final project sample include four project IDs from LIWP. LIWP is administered by the California Department of Community Services & Development (CSD) and installs a variety of energy efficiency upgrades and solar photovoltaic (PV) systems within low-income single-family and multi-family residences. The Association for Energy Affordability, Inc. (AEA) is the statewide administrator for the multi-family component of the program.

The four projects included in the data collection sample are described below. Due to sensitivities surrounding the confidentiality of grantee utility usage data which were used to calculate POR metrics, these projects are labeled with anonymous identifiers rather than their California Climate Investments program ID numbers. The Project Team provided CARB with a list of these projects and their program ID numbers for internal reference.

- **LIWP Project 1.** Installation of common area and tenant unit energy efficiency measures and a solar PV system for 58 multi-family residential units;
- **LIWP Project 2.** Installation of common area and tenant unit energy efficiency measures and a solar PV system for 56 multi-family residential units;
- **LIWP Project 3.** Installation of energy efficiency measures and solar PV systems in 31 single-family residences; and
- **LIWP Project 4.** Installation of energy efficiency measures and solar PV systems in 16 single-family residences.

7.2. Activities Conducted

The data collection process for the sampled LIWP projects consisted of the following activities:

7.2.1. Administering Agency Interviews and Data Requests

The Project Team conducted interviews with CSD and AEA to gather information related to project implementation, existing data collection processes and challenges, and feedback regarding the types of metrics that should be included as part of POR for Low-Income Weatherization projects. Following these interviews, the Project Team issued requests to CSD and AEA for all available pre-project and post-project electricity and gas utility bills and solar generation data associated with the sampled projects. CSD and AEA provided the requested utility records in February 2020, with usage data dates ranging from early 2017 through late 2019 depending on the sampled project.

7.2.2. Project Documentation Reviews

The Project Team reviewed project documentation including measure-level tracking data and project background summary documents. The purpose of these reviews was to understand the components of each project, identify the POR data to be collected, and identify any key considerations related to potential evaluation barriers or opportunities that should be investigated as part of the data collection process. CSD retains records of project tracking data and associated information and provided the above items upon request.

7.2.3. Analysis of Data Records

Upon receiving all available energy usage and solar generation data for each site, the Project Team reviewed and analyzed these records in order to develop the POR metrics for the defined outcome periods associated with each sampled LIWP project.

Current POR guidelines specify that outcome tracking for LIWP as a program begins when 50% of the LIWP fiscal year appropriation allocated to a subprogram (e.g. single-family and multi-family programs) has been expended. For the purposes of establishing a specific outcome period for each sampled project, the Project Team defined one-year outcome periods for each sampled site as beginning once measures were installed and operational.

Table 7-1 displays the list of LIWP POR metrics approved by CARB at the start of this data collection task. During the analysis process, the Project Team also identified opportunities for additional or alternative metrics to recommend for inclusion in future rounds of LIWP outcome reporting.

Table 7-1. Initially Approved LIWP POR Metrics

	Sub-Program Component	Metric
Low-Income Weatherization Program (LIWP)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
		Information on selected locations
		Measure mix of sampled sites
		Distribution of primary home heating type of sampled sites
	Energy Efficiency and Solar Water Heating	Change in energy use
	Solar Photovoltaic (PV)	Energy generated by solar PV

7.2.4. Assessment of Barriers and Evaluation Considerations

Throughout the data collection and analysis process, the Project Team took note of data collection challenges and other significant issues that may serve as barriers to effective POR procedures and may present opportunities for improved data collection strategies or relate to overall evaluation recommendations for LIWP projects.

7.3. POR Metrics Recommendations

Based on the above data collection and analysis activities, the Project Team identified opportunities for modifications to the set of approved Low-Income Weatherization POR metrics. This section summarizes these recommendations and presents an updated table of POR metrics. This updated list of metrics is referenced and used for reporting purposes within the subsequent individual project findings sections.

7.3.1. Recommended Additional Metrics

The Project Team recommends adding the following metrics to the Low-Income Weatherization POR framework:

Information on selected locations, including program tracking data

Following a review of available project records for each participating site, the Project Team recommends that CSD provide a full export of tracking data for each project that is selected for POR. The tracking data should include information about all measures installed at the site, the expected energy and cost savings, and residence characteristics such as heating type and water heating type. This information provides context for understanding the sources of energy savings at each location and may serve as supporting documentation for any in-depth billing analyses that could be conducted as a potential expansion upon the current POR framework. As the program tracking dataset would include information on the measure mix and heating types, this recommendation replaces the previously recommended metrics of "Measure mix of sampled sites" and "Distribution of primary home heating type of sampled sites".

This dataset provides context that may enhance the analysis of participants' utility bills or lead to findings regarding the share of savings from certain measures between different home configurations, but this information is based on data collected at project completion and would not change between the rounds of POR for a given site. Therefore this data export would only be needed for the first round of POR reporting for a given project.

Confirmation that solar PV remains in place and operational; confirmation that common area measures remain in place and operational

The Project Team recommends these fields as additional outcome metrics to verify that the project remains operational as described in the program tracking data. This would involve contacting building managers to verify that equipment and measures are operating as planned and would serve as a basic form of M&V.

Total energy use

The Project Team recommends including this as an outcome metric primarily to encourage the continued collection and retention of participant utility data, and to provide basic information on participant energy use over time. If CSD and AEA are able to implement a more in-depth billing analysis approach that incorporates weather normalization and the use of a control group for comparison to treatment sites, and CARB expands the intent of POR to require this type of advanced analysis, this metric could be replaced by the original "Change in energy use" metric that is currently categorized as "deferred" in the following section.

7.3.2. Deferred Metrics

In addition to recommending additional POR metrics, the Project Team identified one metric that is unlikely to provide insight into projects under the current scope of POR. This metric is categorized as deferred, and the Project Team does not recommend it for inclusion in Low-Income Weatherization POR unless determined to be necessary by CARB and CSD:

Change in energy use

Due to the limitations of the simple difference approach for assessing changes in energy use, and in consideration of the intended scope of the POR phase and the required resources for conducting a sufficiently rigorous analytical method, the current POR framework is likely unable to obtain reliable estimates of energy use changes or energy cost savings that can be attributed to funded projects. This metric in its current form serves only to track overall increases or decreases in energy usage which may be due to a variety of project or non-project factors.

The Project Team defers to CARB and CSD for final determinations regarding the inclusion of this metric but the Project Team does not recommend using a simple difference bill comparison approach to report on project energy savings or recalculate project GHG benefits. Ideally, the change in energy use that is due to a specific weatherization treatment would be quantified through a more rigorous EM&V phase that expands upon the scope and resources of the current POR framework.

7.3.3. Final Recommended POR Metrics

Table 7-2 summarizes the recommended and deferred metrics described above, with the additional recommended metrics highlighted.

Table 7-2. Final LIWP POR Metrics Recommendations

	Sub-Program Component	Recommended Metrics
Low-Income Weatherization Program (LIWP)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
		Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)
		For multi-family sites, confirmation that common area measures remain in place and operational
	Energy Efficiency and Solar Water Heating	**Total energy use**
	Solar Photovoltaic (PV)	**Confirmation that solar PV remains in place and operational**
		Energy generated by solar PV
	Deferred Metrics	
	Change in energy use	

7.3.4. Potential Future Metrics

These metrics would involve modifications to program requirements and procedures outside of the POR phase and may require resources that are not currently within the scope of POR. They are provided for CARB and CSD to consider as part of future program decision making and in the event that in-depth evaluations are incorporated into LIWP:

Resident-reported benefits

If agency engagement with residents increases and allows for data collection through resident surveys or interviews, various additional socioeconomic benefits and project metrics could be included as part of in-depth evaluation efforts:[56]

- Persistence of single-family or tenant-unit measures
- Improvements in health, safety, and comfort
- Reduced rates of utility bill delinquency, arrearages, and service shutoff

Water usage

If CSD and AEA can more reliably obtain residential water usage data, total water use and change in water use could be estimated as part of possible future in-depth evaluation efforts.

7.4. Results by Sampled Project

This section summarizes the results of the data collection effort by sampled project.

7.4.1. LIWP Project 1 (Multi-family)

This project includes the installation of common area and tenant unit energy efficiency measures and a solar PV system for 58 multi-family residential units within a single census tract. The construction and implementation period for this project began in January 2018 and was completed in May 2018.

7.4.1.1. Data Collected

Data collected for this project included:

1. Information regarding the participating multi-family site (e.g. number of residence units, work conducted for common/owner vs. tenant areas);
2. Monthly electricity and gas utility billing data electricity and gas for 12 months pre-project and 12 months post-project (as well as 5 months of utility data during the construction period for this project);
3. Monthly energy generation records for 12 months post-project for both tenant and owner areas;
4. Information on the primary heating type and water heating type for the site; and

[56] Stefen Samarripas and Dan York, "Closing the Gap in Energy Efficiency Programs for Affordable Multifamily Housing," *American Council for an Energy-Efficient Economy*, April 2019, https://www.aceee.org/sites/default/files/publications/researchreports/u1903.pdf.

5. Measures installed at this site and expected energy, cost, and emissions savings and reductions for each.

7.4.1.2. Results by Metric – Census Tract Level

The POR metrics results for the entire project, referred to as the census tract level, are summarized below.

Tracking dates of data submission: June 1, 2018 – May 31, 2019

This is based on the start and end dates of utility data provided for the 12-month post-project period.

Information on selected locations, including program tracking data: Received

AEA was able to provide this export in fulfillment of the data request.

Confirmation that common area measures remain in place and operational: Not available

The Project Team added this as a recommended metric after completing the data collection for this program and did not conduct verification of common area measures as part of this project.

Confirmation that solar PV remains in place and operational: Yes

This is confirmed based on a review of solar PV generation data for the site.

Energy generated by solar PV: 128,617 kWh

This is the sum of solar energy generation records received for each residence for the 12-month period following project completion.

Total energy use (Electricity and Gas): 185,242 kWh; 308 Therms

These values are based on the sum of post-project utility bills for 12 months following project implementation, exclusive of the months in which improvements were made. The construction period for this project was 5 months, according to records provided by AEA, and the Project Team defined the outcome period as beginning after construction is complete and measures are operational. The kWh values represent total electric energy usage rather than net usage, and therefore do not include solar generation kWh.

Change in energy use (Electricity and Gas): -51,100 kWh; 40 Therms

These values are based on a simple difference comparison by subtracting 12 months of pre-project utility data from the 12 months of post-project utility data for each residence. Thus, a negative value indicates a decrease in energy usage from the pre-period to the post-period and a positive value indicates an increase in usage. This simple difference comparison was conducted in alignment with AEA's existing billing data comparison approach and does not incorporate a control group or normalize for weather changes between the pre- and post-period.

Table 7-3 summarizes the above metrics for this project.

Table 7-3. LIWP Project 1 Outcome Metrics – Census Tract Level

	Sub-Program Component	Metric	Result
Low-Income Weatherization Program (LIWP)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)	6/1/2018 – 5/31/2019
		Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)	Received
		For multi-family sites, confirmation that common area measures remain in place and operational	Not available
	Energy Efficiency and Solar Water Heating	Total energy use (electricity and gas)	185,242 kWh; 308 Therms
	Solar Photovoltaic (PV)	Confirmation that solar PV remains in place and operational	Yes
		Energy generated by solar PV	128,617 kWh
	Deferred Metrics		
	Change in energy use (electricity and gas)		-51,100 kWh; 40 Therms

7.4.1.3. Results by Area Type

The current Low-Income Weatherization POR framework specifies that outcomes are to be reported at the Census Tract Level, but the Project Team also presents outcome metrics separated by building area type in Table 7-4. This table separates results into common/owner area outcomes and tenant unit outcomes. As there is a distinction between the types of measures and relative expected savings for common areas and tenant units, as well as different data collection and analysis challenges for each area, reporting these areas separately allows for a more detailed view of the project.

Table 7-4. LIWP Project 1 Outcome Metrics by Area Type

Recommended Metrics	Common/Owner Area Results	Tenant Unit Area Results
Tracking dates of data submission (i.e. time period represented by reported metrics)	6/1/2018 – 5/31/2019	6/1/2018 – 5/31/2019
Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)	Received	Received
For multi-family sites, confirmation that common area measures remain in place and operational	Not available	N/A
Confirmation that solar PV remains in place and operational	Yes	Yes
Energy generated by solar PV	4,039 kWh	124,579 kWh
Total energy use (Electricity)	9,957 kWh	175,285 kWh
Total energy use (Gas)	308 Therms	N/A
Deferred Metrics		
Change in energy use (Electricity)	-2,005 kWh	-49,095 kWh
Change in energy use (Gas)	40 Therms	N/A

7.4.1.4. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Tenant data challenges

The utility provider for this property, San Diego Gas & Electric (SDG&E), requires data requests to be made based on account number rather than meter number. As account numbers for a meter can change when tenants change residences, approximately 25% of the tenant data requested by AEA was not available from SDG&E. To address this, AEA calculated the average kWh usage by apartment and applied that value to the periods of missing data. While this approach is reasonable given the data available, the information presented for this site is not fully based on primary utility records data and the Project Team suggests that complete utility data should be collected and used for reporting when possible.

Solar PV data challenges

According to AEA, solar monitoring records were not available for this property. AEA addressed this by reviewing each SDG&E bill for the property and using the listed solar allocation kWh to estimate solar production. This is a fairly time consuming process but serves as a reasonable alternative for locations that do not provide solar monitoring data. In order to improve this aspect of the data collection process, AEA has indicated that solar metering has since become a requirement for funded projects.

Limited comparison with expected energy savings

Based on project records, the expected annual savings for this project site are 103,509 kWh, which includes 2,791 kWh for common/owner area lighting. A simple comparison of utility bills for the one-year post project period indicates a decrease in electricity usage of 2,005 kWh in common/owner areas and a

decrease of 49,095 kWh in tenant unit areas, totaling 51,100 kWh for the entire project. A similar comparison of gas utility data for the common/owner area shows an increase in usage of 40 Therms. While this suggests that the project may be achieving energy savings at a lower rate than anticipated, these changes in energy use cannot be attributed to the project with this analysis approach and a more rigorous billing analysis method would be needed in order to reliably compare expected and actual energy savings for this site.

Comparison with expected energy generation

Project records indicate expected energy generation from solar PV of 137,320 kWh annually. Using the solar generation estimate based on AEA's method above, the site generated an estimated 128,617 kWh during the one-year post-project period. Solar generation for this site appears to be close to initial estimates, though complete solar monitoring records would likely provide a more reliable estimate of energy generated.

7.4.2. LIWP Project 2 (Multi-family)

This project includes the installation of common area and tenant unit energy efficiency measures and a solar PV system for 56 multi-family residential units within a single census tract. The construction and implementation period for this project began in January 2017 and was completed in December 2017.

7.4.2.1. Data Collected

Data collected for this project included:

1. Information regarding the participating multi-family building (e.g. number of residence units, work conducted for common vs. tenant areas);
2. Monthly electric utility billing data for 12 months pre-project and 12 months post-project (as well as 12 months of utility data during the construction period for this project);
3. Information on the primary heating type and water heating type for the site; and
4. Measures at this site and expected energy, cost, and emissions savings and reductions for each.

7.4.2.2. Results by Metric – Common/Owner Area

AEA was not able to obtain tenant utility data prior to January 2017 and therefore would not have sufficient data to construct a pre-post comparison for the property's residential units. Therefore only common/owner area data were provided for this site. As a result outcomes metrics are reported below for the common/owner area type only.

Tracking dates of data submission: January 1, 2018 – December 31, 2018

This is based on the start and end dates of utility data provided for the 12-month post-project period.

Information on selected locations, including program tracking data: Received

AEA was able to provide this export in fulfillment of the data request.

Confirmation that common area measures remain in place and operational: Not available

The Project Team added this as a recommended metric after completing the data collection for this program and did not conduct verification of common area measures as part of this project.

Confirmation that solar PV remains in place and operational: No

The solar array was not yet operational during this outcome period.

Energy generated by solar PV: Not available

These records were not available at the time of the data request for this site, as the solar array was not yet operational.

Total energy use (Electricity only): 22,930 kWh

This value is based on the sum of post-project utility bills for 12 months following project implementation, exclusive of months in which the project improvements were made. The construction period for this project was 12 months according to records provided by AEA. This is an all-electric property with no applicable gas usage.

Change in energy use (Electricity only): -16,889 kWh

This value is based on a simple difference comparison by subtracting 12 months of pre-project utility data from the 12 months of post-project utility data for each residence. Thus, this negative value indicates a decrease in energy usage from the pre-period to the post-period. This simple difference comparison was conducted in alignment with AEA's existing billing data comparison approach and does not incorporate a control group or normalize for weather changes between the pre- and post-period.

Table 7-5 summarizes the above metrics for the common/owner area portion of this project.

Table 7-5. LIWP Project 2 Outcome Metrics for Common/Owner Area

	Sub-Program Component	Metric	Result
Low-Income Weatherization Program (LIWP)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)	1/1/2018 – 12/31/2018
		Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)	Received
		For multi-family sites, confirmation that common area measures remain in place and operational	Not available
	Energy Efficiency and Solar Water Heating	Total energy use (electricity)	22,930 kWh
	Solar Photovoltaic (PV)	Confirmation that solar PV remains in place and operational	No
		Energy generated by solar PV	Not available
	Deferred Metrics		
	Change in energy use (electricity)		-16,889 kWh

7.4.2.3. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Tenant data

AEA indicated that the available tenant data for this site were insufficient to create a 12-month pre-project period for comparison with the post-project period. While the absence of pre-project data is a major barrier to billing analysis, program staff indicated that this issue is mainly limited to older projects and that the primary challenge in obtaining tenant data moving forward will likely be related to tenant authorization of data sharing rather than a lack of pre-project records.

Solar PV data

At the time of this data request, CSD indicated that the solar PV system installed as part of this project was not yet operational. Therefore no solar PV generation data were provided for this site. This would

present a barrier to complete outcome reporting for LIWP unless sites are re-sampled for POR based on the availability of utility data. To assist in avoiding sampling issues, it is recommended that CSD verify the operational status of each project site and notify CARB in cases where the recorded operational date should be modified so that sites are not selected for POR until they are fully operational.

Limited comparison with expected energy savings

Based on project records, the expected annual savings for this project site are 271,201 kWh, including 29,678 kWh from owner/common area lighting measures. While tenant utility data were not available, a simple comparison of owner/common area utility bills for the one-year post project period indicates a decrease in common/owner area electricity usage of 16,889 kWh. Due to the limited nature of this approach it is not clear whether this decrease is due to the installed common area measures or other factors.

7.4.3. LIWP Project 3 (Single-family)

This project includes the installation of energy efficiency measures and solar PV systems in 31 single-family residences within a single census tract. The installation and implementation period for residences within this project varied by residence, with completion dates ranging from March 2018 to October 2018.

7.4.3.1. Data Collected

Data collected for this project included:

1. A list of residence IDs participating in LIWP within this census tract;
2. Monthly utility billing data (electricity and gas) for up to 12 months pre-project and 12 months post-project for each participating residence;
3. Monthly energy generation records for up to 12 months post-project as applicable for each residence where solar PV was installed;
4. Primary home heating and water heating types by residence;
5. Measures installed per residence and expected energy, cost, and emissions savings and reductions for each.

7.4.3.2. Results by Metric – Census Tract Level

The POR metrics results for all residences in this project are summarized below.

Tracking dates of data submission: May 28, 2018 – September 5, 2019

Due to the timing of project implementation in individual residences and the start and end dates of utility bills for individual meters, it is not possible to assign a single time period to a census tract that represents the one-year post-project period for each of the participating residences in that census tract. Therefore the tracking dates of data submission value for this project is based on the start date of the earliest available post-project utility bill (May 28, 2018) and end date of the latest available post-project utility bill (September 5, 2019) across all residences within this project.

Information on selected locations, including program tracking data: Received

CSD was able to provide this export in fulfillment of the data request.

Confirmation that solar PV remains in place and operational: Yes

This is confirmed based on a review of solar PV generation data for the site.

Energy generated by solar PV: 2,349 kWh

This is the sum of solar energy generation records received for each residence for up to a 12-month period following project completion. The Census Tract Level table shows the sum of all energy generation for the single residence that had solar PV listed as a measure within the LIWP tracking data. Another residence showed solar generation of 587 kWh in the outcome period, but it appears that the solar array existed prior to the project and was not associated with LIWP. The solar generation kWh from this residence is not included in the outcome metrics assessment.

Total energy use (Electricity and Gas): 502,701 kWh; 475 Therms

These values are based on the sum of post-project utility bills for 12 months following project implementation for each residence, exclusive of the month in which improvements were made. Twelve residences declined to provide electricity energy usage data and are not included in the kWh sum. The Therms value represents a single residence, as twenty-nine residences did not provide gas usage data and one residence is all-electric. The values in the electricity usage field represent total energy usage rather than net usage, and therefore do not include solar generation kWh.

These energy usage values are unusually high and suggest that the billing data provided included residences which were not part of the LIWP project. Program staff were not able to confirm the specific reason for these higher than expected usage values.

Change in energy use (Electricity and Gas): 11,302 kWh; 103 Therms

These values are based on a simple difference comparison by subtracting 12 months of pre-project utility data from the 12 months of post-project utility data for each residence for which utility data were provided. CSD provided electricity usage data for 19 residences and gas usage data for 1 residence. These positive values indicate an increase in energy usage from the pre-period to the post-period. This simple difference comparison was conducted in alignment with CSD's existing billing data comparison approach and does not incorporate a comparison group or normalize for weather changes between the pre-project and post-project period.

Table 7-6 summarizes the above metrics for this project.

Table 7-6. LIWP Project 3 Outcome Metrics – Census Tract Level

	Sub-Program Component	Metric	Result
Low-Income Weatherization Program (LIWP)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)	5/28/2018 – 9/5/2019
		Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)	Received
		For multi-family sites, confirmation that common area measures remain in place and operational	N/A
	Energy Efficiency and Solar Water Heating	Total energy use (electricity and gas)	502,701 kWh; 475 Therms
	Solar Photovoltaic (PV)	Confirmation that solar PV remains in place and operational	Yes
		Energy generated by solar PV	2,349 kWh
	Deferred Metrics		
	Change in energy use (electricity and gas)		11,302 kWh; 103 Therms

7.4.3.3. Results – Residence Level

The current Low-Income Weatherization POR framework specifies that outcomes are to be reported at the Census Tract Level, but the Project Team also presents energy usage and generation outcomes at the residence level in Table 7-7. Due to the timing of project implementation in individual residences and the start and end dates of utility bills for individual meters, reporting at the residence level allows for more precise reporting of energy usage over a specified outcome period.

The residences for which CSD was unable to provide electricity or gas usage data are identified below with "Not available" indicators in each of the energy metrics fields. Residence IDs are labeled as provided within the CSD dataset. The outcome period for these residences is defined as the 12-month period following measure implementation. Seventeen of the residences in this census tract provided electricity usage data for a single shared meter, as the residences are not individually metered in this location. For the purposes of billing analysis, these separate residences would be treated as a single site.

CSD did not receive a response to requests for gas usage data for these 17 residences, and residence ID 59960 is an all-electric residence with no gas utility provider. Therefore gas usage data were available for Residence ID 61224 only.

As noted above with the energy usage POR metric, the data reflect unusually high energy usage for the quantity of 17 residences on a shared meter. It is possible that the usage values also included data from residences that were not part of the LIWP project and therefore do not have a residence ID in the dataset.

Table 7-7. LIWP Project 3 Energy Usage and Generation Metrics – Residence Level

Residence ID	Outcome Tracking Period Start	Outcome Tracking Period End	Total Energy Use (Electricity kWh)	Total Energy Use (Gas Therms)	Change in Energy Use (Electricity kWh)	Change in Energy Use (Gas Therms)	Energy Generated by Solar PV (kWh)
59960	5/28/2018	5/27/2019	6,117	-	-1,166	-	2,349
61224	6/6/2018	6/5/2019	4,211	475	-494	103	-
60212, 60238, 60241, 60243, 61546, 61548, 61552, 61553, 61648, 61649, 61656, 61809, 61810, 61814, 61815, 61816, 61818	9/6/2018	9/5/2019	492,373	Not available	12,962	Not available	-
61140	10/1/2018	9/30/2019	Not available	Not available	Not available	Not available	Not available
61643	8/1/2018	7/31/2019	Not available	Not available	Not available	Not available	Not available
61716	8/1/2018	7/31/2019	Not available	Not available	Not available	Not available	Not available
61717	8/1/2018	7/31/2019	Not available	Not available	Not available	Not available	Not available
61718	9/1/2018	8/31/2019	Not available	Not available	Not available	Not available	Not available
61770	9/1/2018	8/31/2019	Not available	Not available	Not available	Not available	Not available
62198	10/1/2018	9/30/2019	Not available	Not available	Not available	Not available	Not available
62215	9/1/2018	8/31/2019	Not available	Not available	Not available	Not available	Not available
62414	10/1/2018	9/30/2019	Not available	Not available	Not available	Not available	Not available
62531	10/1/2018	9/30/2019	Not available	Not available	Not available	Not available	Not available
62827	10/1/2018	9/30/2019	Not available	Not available	Not available	Not available	Not available
62860	10/1/2018	9/30/2019	Not available	Not available	Not available	Not available	Not available

7.4.3.4. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Separation of energy usage and energy generation

CSD provided an initial estimate of energy savings for these residents based on available utility data, which incorporated energy generated by solar PV in the calculation of post-project energy usage. As energy use and energy generation are separate POR metrics, the Project Team excluded kWh generated by solar PV from the calculation of total post-project energy usage in the above analysis to avoid double-counting of energy generation. The Project Team recommends that total energy usage estimates are reported independently of solar generation for this reason moving forward.

Data access limitations

CSD was unable to obtain utility data for 12 of the 31 residences in this Census Tract. CSD has indicated that there are currently challenges to reliably obtaining utility data for each participant but that these

issues are being addressed for future reporting periods. For future utility billing analysis purposes, sites with missing or inconsistent data should be removed from the analysis as part of an initial data cleaning process (with these removals reported to CARB using the "Not available" indicator as shown in the above Residence Level table). Additionally, in cases where a Census Tract is selected for POR and CSD is unable to obtain utility data for a high portion of residences, it may be necessary to resample.

Based on the intention of energy usage POR metrics in assessing annual usage changes, the Census Tracts selected for POR should be projects for which 12 months of pre-project and post-project utility data are available for all residences. In order to avoid the need to selectively sample sites with sufficient data, the Project Team suggests that CSD continues its efforts to overcome data collection challenges, such as through continued coordination with utilities and properties, so that a random sample of participating projects could be conducted and result in successful collection of POR metrics.

Limited comparison with expected energy savings

Based on project records, the expected annual electricity savings for the entire project are 23,276 kWh and the expected annual gas savings are 2,671 Therms. Excluding the residences for which utility data were not available, the expected annual electricity savings for 19 of 31 residences is 6,691 kWh and the expected annual gas savings for 1 of 30 residences is 134 Therms. These energy savings estimates are exclusive of expected solar generation. A simple difference comparison of common area utility bills for the one-year post project period indicates an increase in electricity usage of 11,302 kWh among the 19 residences with electricity usage data, and an increase in gas usage of 103 Therms for the single residence with gas usage data. While these values suggest that energy usage is increasing among these sites, a more rigorous billing analysis approach and complete usage data across participating residences would be needed in order to determine whether this is the case and whether the change is due to project treatments or other factors.

Comparison with expected energy generation

In the measure level tracking data provided by CSD, residence ID 59960 is the only residence with solar PV listed as an installed measure, accounting for 4,984 kWh in expected annual generation. However in the utility data received for these sites, residence ID 61224 also displays energy generated by solar PV, totaling 587 kWh for the specified outcome period. As the utility data for residence ID 61224 show solar generation kWh for the pre-project period as well as the post-project period, it appears that this solar array was pre-existing and was not installed as part of the LIWP treatments. Using the available solar metering data for residence 59960 only, this site generated an estimated 2,349 kWh during the one-year post project period. In comparing observed energy generation to expected energy generation for a given project, solar generation from a non-LIWP sources should be omitted from the analysis. Measure level tracking data, which the Project Team recommends that agencies provide as part of POR, can serve as a source for determining which residences should report solar generation kWh for this metric.

7.4.4. LIWP Project 4 (Single-family)

This project includes the installation of energy efficiency measures and solar PV systems in 16 single-family residences within a single census tract. The installation and implementation period for residences within this project varied by residence, with completion dates ranging from May 2018 to September 2018.

7.4.4.1. Data Collected

Data collected for this project included:

1. A list of residences participating in LIWP within this census tract;
2. Monthly utility billing data (electricity and gas as applicable) for up to 12 months pre-project and 12 months post-project;
3. Monthly energy generation records for up to 12 months post-project as applicable;
4. Primary home heating and water heating types by residence; and
5. Measures installed per residence and expected energy, cost, and emissions savings and reductions for each.

7.4.4.2. Results by Metric – Census Tract Level

The POR metrics results for all residences in this project are summarized below.

Tracking dates of data submission: May 3, 2018 – September 3, 2019

Due to the timing of project implementation in individual residences and the start and end dates of utility bills for individual meters, it is not possible to assign a single time period to a census tract that represents the one-year post-project period for each of the participating residences in that census tract. Therefore the tracking dates of data submission value for this project is based on the start date of the earliest available post-project utility bill (May 3, 2018) and end date of the latest available post-project utility bill (September 3, 2019) across all residences within this project.

Information on selected locations, including program tracking data: Received

CSD was able to provide this export in fulfillment of the data request.

Confirmation that solar PV remains in place and operational: Yes

This is confirmed based on a review of solar PV generation data for the residences within this project. One of the six residences that received solar PV equipment through LIWP did not provide generation data and the Project Team was not able to verify the status of equipment for this residence.

Energy generated by solar PV: 10,970 kWh

This is the sum of solar energy generation records received for each residence for up to a 12-month period following project completion. One of the six residences that received solar PV equipment through LIWP did not provide solar generation data, and this sum does not include generation kWh for this residence.

Total energy use (Electricity and Gas): 75,652 kWh; 4,190 Therms

These values are based on the sum of post-project utility bills for 12 months following project implementation for each residence, exclusive of the month in which project improvements were made. CSD was unable to obtain gas usage data for seven of the residences in this census tract, and was unable to obtain electricity usage data for two residences. Additionally, one residence had only 5 months of post-project utility data available. Therefore the analyses did not include these residences, and the total gas usage metric for this project is based on 9 of 16 residences while the total electricity usage metric is based on 13 of 16 residences. The values in the electricity usage field represent total energy usage rather than net usage, and therefore do not include solar generation kWh.

Change in energy use (Electricity and Gas): -15,461 kWh; 687 Therms

These fields are based on a simple comparison by subtracting 12 months of pre-project utility data from the 12 months of post-project utility data for each residence. Thus, a negative value indicates a decrease in energy usage from the pre-period to the post-period and a positive value indicates an increase from the pre-period to the post-period. The seven residences for which gas usage data were not available and the three residences for which electricity usage data were not available or represented less than a full year are not included in these totals. This simple difference comparison was conducted in alignment with CSD's existing billing data comparison approach and does not incorporate a control group or normalize for weather changes between the pre- and post-period.

Table 7-8 summarizes the above metrics for this project.

Table 7-8. LIWP Project 4 Outcome Metrics – Census Tract Level

	Sub-Program Component	Metric	Result
Low-Income Weatherization Program (LIWP)	All	Tracking dates of data submission (i.e. time period represented by reported metrics)	5/3/2018 – 9/3/2019
		Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)	Received
		For multi-family sites, confirmation that common area measures remain in place and operational	N/A
	Energy Efficiency and Solar Water Heating	Total energy use (electricity and gas)	75,652 kWh; 4,190 Therms
	Solar Photovoltaic (PV)	Confirmation that solar PV remains in place and operational	Yes
		Energy generated by solar PV	10,970 kWh
	Deferred Metrics		
	Change in energy use (electricity and gas)		-15,461 kWh; 687 Therms

7.4.4.3. Results by Metric – Census Tract Level

The current Low-Income Weatherization POR framework specifies that outcomes are to be reported at the Census Tract Level, but the Project Team also presents energy usage and generation outcomes at the residence level in Table 7-9. Due to the timing of project implementation in individual residences and the start and end dates of utility bills for individual meters, reporting at the residence level allows for more precise reporting of energy usage over a specified outcome period. Residence IDs are labeled as provided within the CSD dataset.

The residences for which utility data were not available are identified below with "Not available" in the gas or electricity usage fields as applicable, and the residence for which only five months of post-project electricity usage data were available is identified below with "Incomplete". These residences are not included in the reported Census Tract Level outcome metrics for this project.

Monthly energy generation values per residence were much lower than expected in project documentation. One residence showed zero generation for some months, but each residence overall showed low generation kWh over the course of the outcome period. The reason for this was not clear within the utility data provided or through information obtained from CSD.

Table 7-9. LIWP Project 4 Energy Usage and Generation Metrics – Residence Level

Residence ID	Outcome Tracking Period Start	Outcome Tracking Period End	Total Energy Use (Electricity kWh)	Total Energy Use (Gas Therms)	Change in Energy Use (Electricity kWh)	Change in Energy Use (Gas Therms)	Energy Generated by Solar PV (kWh)
58753	5/7/2018	5/6/2019	3,643	Not available	(772)	Not available	1,387
58805	7/4/2018	7/3/2019	Incomplete	Not available	Incomplete	Not available	-
58816	8/2/2018	8/1/2019	5,680	Not available	(1,129)	Not available	-
58854	7/1/2018	6/30/2019	Not available	Not available	Not available	Not available	-
58895	8/2/2018	8/1/2019	1,640	193	(242)	32	-
58966	5/7/2018	5/6/2019	5,280	793	(2,864)	187	3,303
59001	5/3/2018	5/2/2019	6,213	345	(627)	37	-
59010	8/1/2018	7/31/2019	9,432	531	(2,607)	110	-
59013	6/6/2018	6/5/2019	6,195	673	(460)	76	-
59032	5/3/2018	5/2/2019	8,135	401	(880)	4	-
59033	9/4/2018	9/3/2019	7,296	Not available	(1,852)	Not available	1,074
59034	8/1/2018	7/31/2019	6,085	530	(932)	78	2,113
59035	9/1/2018	8/31/2019	Not available	Not available	Not available	Not available	Not available
59062	8/6/2018	8/5/2019	6,953	Not available	(584)	Not available	-
59148	5/3/2018	5/2/2019	7,497	461	(1,710)	112	3,093
59242	6/6/2018	6/5/2019	1,603	263	(802)	51	-

7.4.4.4. Additional Discussion

The following items are presented for discussion based on the data collection and analysis findings for this project.

Separation of energy usage and energy generation

As noted for the other sampled single-family project above, the Project Team excluded kWh generated by solar PV from the calculation of post-project energy usage to avoid double-counting. The Project Team recommends that these values are reported separately for this reason moving forward.

Data access limitations

Residents declined to provide electricity usage data for 2 of the 16 residences in this Census Tract, and CSD did not receive responses to requests for gas usage data for seven of the residences. CSD has indicated that there are currently certain challenges to reliably obtaining utility data for each participant but that these issues are being addressed for future reporting periods through additional coordination with residents and utility providers. Additionally, one residence had only 5 of 12 months of post-project utility data available due to the timing of the data request. To ensure that sufficient post-project data are available for each residence during future rounds of POR, the Project Team recommends that POR for a project ID (i.e. census tract) begin after 12 months have elapsed for all residences associated with that project ID.

Limited comparison with expected energy savings

Based on project records, the expected annual electricity savings for the entire project are 29,495 kWh and the expected annual gas savings are 1,911 Therms. Excluding the sites for which utility data were not available or were incomplete, the expected annual electricity savings for 13 of 16 residences is 23,501 kWh and the expected annual gas savings for 9 of 16 residences is 944 Therms. A simple difference comparison of common area utility bills for the one-year post project period indicates a decrease in electricity usage of 15,461 kWh, and an increase in gas usage of 687 Therms for these subsets of residences. As noted previously, a more rigorous billing analysis approach and complete usage data would be needed in order to reliably compare expected and actual energy savings for each residence in this project.

Comparison with expected energy generation

Project records indicate expected solar PV energy generation of 33,460 kWh annually for the six residences that received solar equipment through LIWP. Excluding the residence for which post-project solar generation data were not provided, expected annual energy generation for the remaining five residences is 28,670 kWh. Using the available solar metering data, these five residences generated an estimated 10,970 kWh during the one-year post project period.

7.5. Key Data Collection Findings

This section presents overall findings from the process of reviewing project documentation and collecting data from grantees for each of the above projects:

- **There are currently various challenges and barriers associated with utility data collection for participating sites.**
    - CSD indicated that while it can reliably obtain data from certain investor-owned utilities (IOUs), other utilities such as cooperatives will not necessarily agree to share data. Additionally, CSD reported that while it can submit requests for natural gas usage data, these requests frequently go unfulfilled. Finally, some IOUs require data requests to be directed towards specific account numbers rather than meter numbers, which can lead to gaps in the data if residents move out of a participating residence during the post-project period.
    - CSD indicated that while program staff provide residents with data sharing authorization forms at the time of project completion, resident agreement is optional and some residents decline to sign the authorization form. This excludes these residences from data collection and analysis.
    - CSD and AEA do not currently have close working relationships with individual residents and residents do not agree to be contacted directly following their participation in the program. This limits the potential for collecting resident-reported information such as in-residence measure in-service rates, health and safety metrics, and other socioeconomic outcome metrics that may provide insight into program non-energy benefits.
    - CSD and AEA indicated that access to residential water usage records is very limited, and that they are currently unable to collect information to validate the deemed water usage estimates that are included in program QM documentation.
- **The program does not currently collect information on non-energy benefits such as reduced arrearages or deferred replacement cost for residential equipment.** While these non-energy benefits do not affect program GHG estimates, they would be potential inputs for any advanced cost-benefit testing that could be performed for the program as part of future expanded evaluation efforts.

7.6. Key Analysis Findings

This section presents overall findings from the process of assessing the collected data records for the outcome and baseline periods, as well as reviewing analytical best practices for these types of projects:

- **The savings estimates for LIWP are based on deemed or simulated values, but the program includes a valuable M&V phase during which a sample of sites (e.g. 5-10%) receive detailed inspections.** The deemed values that CSD reports to CARB are based on the actual measures that are implemented at each site, and are recalculated if necessary based on the results of these inspections. This finding does not specifically relate to the POR phase but this practice of conducting project verification visits and calculating and reporting savings estimates upon project completion is recommended and may serve as an example for other California Climate Investments programs whose reported savings are based on initial project planning documentation only.
- **There are major limitations to using a simple difference comparison approach for energy usage data to gain insight into project-induced outcomes.** A utility billing analysis that is aligned with best practices would allow for the quantification of program-induced savings during the post-project period, which could be compared to the expected savings that were calculated during the project

implementation phase. The simple difference comparison approach that is used by program staff and that the Project Team replicated to report the outcome metrics for this data collection exercise does not account for external factors such as differences in heating degree days and cooling degree days between the pre-project and post-project period, which can be incorporated into advanced analyses.[57] Additionally, this approach does not incorporate a comparison group to account for resident turnover or behavioral changes that may be specific to the treatment group. Overall, a simple difference assessment indicates whether a site's energy usage is increasing or decreasing but does not indicate the extent to which these increases or decreases are a result of the program, changes in weather, or other changes within the residences.

7.7. Recommendations

Based on the above findings, The following recommendations are presented for CARB and CSD consideration. These recommendations are designed to improve the Low-Income Weatherization POR process and support improved evaluability and evaluation of the program moving forward:

- **For multi-family weatherization projects, consider recommending common/owner area and tenant unit data to be reported separately.** Reporting POR metrics at the census tract level provides a pooled representation of multi-family buildings, but does not distinguish between common area and tenant unit measures and data. There are distinct data collection and measure verification challenges associated with each area type, and assessing these areas separately increases the transparency of reported results.
- **For single-family weatherization projects, consider requiring outcomes for each residence to be reported separately or require a supplemental report that identifies the outcome period start and end dates for each residence.** As each residence within a census tract of participating sites can have a different project completion date, a single outcome period start and end date will not accurately reflect the start of the post-project period for each residence and may serve as a barrier to potential billing analysis efforts. If a supplemental report is provided, it should list the start and end dates of the outcome period for each residence based on the period represented by post-project billing data.
- **Consider revising the definition of when the POR period begins for LIWP in order to provide clear guidance regarding when CSD should begin tracking and reporting outcome metrics for a specific project.** Current POR guidance states that project outcome tracking for the program begins "when 50 percent of the Low-Income Weatherization Program fiscal year appropriation allocated to a subprogram has been expended", but the Project Team recommends that this be revised to state the following: "Project outcome tracking begins when the project construction is complete and improvements and equipment are operational". This is the definition that the Project Team used when defining the outcome periods for each of the sampled LIWP projects, and this change would align the format of POR guidance for Low-Income Weatherization with that of other California Climate Investments programs that involve the implementation of energy efficiency measures. Reporting would occur once 12 months of post-construction data are available.
- **As part of project implementation, consider whether additional information on residential baseline equipment and home characteristics can be collected and included as part of the energy savings estimates for completed projects.** Details such as existing efficiency levels of baseline equipment, whether energy efficiency measures are early replacements or replace-on-burnout

[57] Margaret F. Fels, "PRISM: An Introduction," *Energy and Buildings* 9 (1986): 5–18.

(ROB), and home characteristics such as pre-project insulation levels and infiltration leakage rates may serve as useful information for any future comprehensive program evaluation efforts.

- **Continue making efforts to improve the reliability of obtaining utility data for participating sites.** This includes coordinating with utilities, encouraging or requiring the use of solar metering, and identifying possible data collection challenges early on in the project timeline to allow for resolution prior to the POR phase. Although residents are not obligated to agree to share their utility data, there may also be opportunities for improved engagement with residents to increase their willingness to participate, such as providing additional information regarding the purpose of the LIWP data requests and assuring residents that their personal information will not be shared with any other individuals or groups.
- **Consider increasing the level of engagement with residents in order to allow for data collection and reporting of additional outcome metrics.** These metrics could include the in-residence measure installation rates and persistence over time as well as various socioeconomic benefits such as improved health and safety and reduced bill delinquency due to decreased energy costs. If residents are included as part of the data collection process, the Project Team recommends that CSD and AEA emphasize that their participation is voluntary rather than required, provide sufficient information as to the purpose of the data collection, and offer incentives for any completed surveys.
- **For potential future in-depth evaluation efforts that may involve a larger sample size, explore whether it is possible to gather 12-24 months of pre-project billing data from future program participants to potentially establish a control group for comparison against post-project billing data for recent participants.** For example, sites that are scheduled to participate in the program in the 2022 year could provide their 2020 and 2021 pre-treatment billing data which could be compared to the 2020 pre-treatment and 2021 post-treatment data of sites that received treatments in early 2021.[58] This could allow CSD, CARB, or other evaluators to estimate the change in energy use that is attributable to LIWP treatments and thereby provide greater insight into participant outcomes over time. These control groups should be as similar as possible to the treatment group in terms of dwelling type (e.g. single-family vs. multi-family), square footage, number of residents, and any other available characteristics. While these activities are outside the scope of POR and are likely better suited to larger scale in-depth evaluations, it may still be useful for CSD to explore whether this pre-treatment data can be collected from participants at the time of their enrollment to support possible third-party evaluations or a future expansion of evaluation procedures within California Climate Investments.
- **Recommended POR purpose within LIWP:** POR can serve as a method for conducting basic M&V of project status, obtaining energy usage records for possible future comprehensive assessment, and tracking overall energy use of participating sites. Activities such as analyzing bills to estimate the changes in energy use that can be attributed to LIWP treatments should only be completed through more rigorous evaluation efforts that include best practices such as weather-normalizing usage data and incorporating a comparison group.

  Rather than a simple difference comparison approach, reliable quantification of program-induced energy reductions would require the application of robust analytical procedures such as described

[58] Michael Blasnik et al., "National Weatherization Assistance Program Impact Evaluation: Energy Impacts for Large Multifamily Buildings" (Oak Ridge National Laboratory, September 2014), https://weatherization.ornl.gov/wp-content/uploads/pdf/WAPRetroEvalFinalReports/ORNL_TM-2014_332.pdf.

in the Uniform Methods Project, existing research studies or national program evaluations.[59] Feedback from CSD and AEA indicates that using a more rigorous billing analysis approach POR would not be feasible due to technical resource constraints, and the Project Team acknowledges that the current scope of POR is not intended to incorporate advanced analytical methodologies.

Based on the resources available to agencies and the present intent and scope of POR, this type of in-depth analysis would likely be more suitably implemented as part of a separately funded and more in-depth evaluation phase rather than as part of POR in its current form. For example, an advanced billing analysis could be completed by third-party evaluators as part of evaluation contracts that are issued for the program.

If CSD and CARB confirm that an advanced billing analysis approach is beyond the scope of POR, and the goal is to assess LIWP-induced energy savings during the post project period, it would likely be beneficial to continue collecting and retaining utility data from the POR sample for use in possible future technical evaluations of the program. In this case, CSD would make utility bills available to CARB as needed for further analysis.

[59] Ken Agnew and Mimi Goldberg, *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol* (National Renewable Energy Laboratory, 2013), https://www1.eere.energy.gov/wip/pdfs/53827-8.pdf.

Joshua Zivin and Kevin Novan, "Upgrading Efficiency and Behavior: Electricity Savings from Residential Weatherization Programs," *The Energy Journal* 37, no. 4 (2016): 1–23, https://doi.org/10.5547/01956574.37.4.jziv.

8. Forest Health

The Forest Health Program is administered by CAL FIRE and provides funding for activities such as fuels reduction, reforestation, pest management, the implementation of conservation easements, and related research. The program is designed to conserve natural resources and improve the resiliency and overall health of forests and other natural lands, and achieves GHG and energy benefits through increased carbon sequestration, avoided emissions from wildfires, and biomass utilization. Other California Climate Investments programs such as Prescribed Fire and Regional Forest and Fire Capacity include similar objectives and treatments.

8.1. Project Sample

At the time of project sampling in October 2019, there were 43 Forest Health Program projects eligible for POR based on information received from CARB. The final project sample included seven projects within the Forest Health Program. Brief descriptions of these sampled projects along with their CCIRTS project IDs are as follows:

- **Forest Health Project 1: Marshall Ranch Conservation Easement, CCIRTS Project ID 8GG17606.** This project involves the implementation of a conservation easement on a 2,942 acre area in Humboldt County.
- **Forest Health Project 2: Pacific Union College, CCIRTS Project ID 8CA03410.** This project involves the implementation of a Conservation easement on 864 acres of forest land at Pacific Union College (PUC) in Angwin, CA.
- **Forest Health Project 3: Cambria Forest Health, CCIRTS Project ID 8GG14601.** This project involves several treatment sites within and near Cambria, CA. The total treatment area is approximately 950 acres and project treatments include fuels reduction and the processing of woody materials for biomass generation.
- **Forest Health Project 4: 2014 Day Fire Restoration, CCIRTS Project ID 8GG14901.** This project involves restoring land affected by the 2014 Day Fire through reforestation on approximately 5,850 acres in Modoc County, CA. The project also includes biomass utilization of heavy tree stand areas on approximately 2,000 acres.
- **Forest Health Project 5: Black Mountain Forest & Watershed Restoration, CCIRTS Project ID 8GG15102.** This project involves the implementation of a fuel break through stand thinning on 1,360 acres, and plantation thinning on 494 acres within the Modoc National Forest and private land managed by Shasta Forests Timberlands.
- **Forest Health Project 6: Mt. Shasta Headwaters Forest Health and Resilience Project: Phase 1 – Black Butte, CCIRTS Project ID 8GG17604.** This project involves fuels reduction, biomass utilization, installation of a fuel break, and the implementation of a conservation easement in Siskiyou County, CA. The project includes fuels reduction through thinning of approximately 450 acres of pine plantation stands.
- **Forest Health Project 7: Circle U Ranch, CCIRTS Project ID 8GG14308.** This project involves restoration of land affected by the 2014 Eiler Fire through by planting approximately 25,000 trees on 99 acres in Shasta County, CA.

8.2. Activities Conducted

Evaluation activities for the sampled Forest Health projects consisted of the following:

8.2.1. Administering Agency Interviews and Documentation Requests

At the start of the data collection task, the Project Team held interviews with CAL FIRE and California Natural Resources Agency (CNRA) staff to discuss California Climate Investments forestry programs and gain an understanding of existing data collection and reporting procedures. As part of communications with CAL FIRE Forest Health staff, the Project Team discussed the projects sampled for data collection and requested project documentation such as applications, grant agreements, monitoring reports, maps, and other records. The Project Team later issued data requests for GIS files including shapefiles for a subset of sampled projects.

8.2.2. Project Documentation Reviews

Upon receiving the available documents from CAL FIRE for the set of sampled projects, the Project Team conducted documentation reviews in order to characterize the components of each project and identify evaluation-related considerations to inform recommendations for the program. For sampled projects that included conservation easements, the Project Team reviewed post-project monitoring reports to verify the status of projects in the outcome period.

8.2.3. POR Monitoring Manual Review

CAL FIRE provided a draft version of the project monitoring manual that Forest Health Program staff developed in preparation for POR data collection and reporting. The Project Team reviewed this manual to gain an understanding of CAL FIRE's proposed monitoring approach and identify opportunities and considerations for POR within Forest Health and other similar programs.

8.2.4. Review of Remote Sensing Resources

As part of the data collection process, the Project Team met with several organizations and subject matter experts to determine the availability of aerial imagery and remote sensing resources that could be used to assess POR metrics for Forest Health projects. This included conducting interviews with staff from Planet, the UC Davis Center for Spatial Technologies and Remote Sensing (CSTARS), the UC Davis Department of Plant Sciences, and CARB.

8.2.5. Remote Sensing Demonstration

The Project Team coordinated with the Dr. Alexander Koltunov, eDaRT lead scientist and developer of the Ecosystem Disturbance and Recovery Tracker (eDaRT), a highly automated Landsat-based disturbance detection system at UC Davis to discuss the system and use it to observe the sampled sites for which CAL FIRE provided GIS files. The objective of this effort was to characterize the process of disturbance detection and explore the potential application of this type of approach in relation to POR and overall project monitoring.

Table 8-1 displays the list of Forest Health POR metrics approved by CARB at the start of this data collection task.

Table 8-1. Forest Health POR Metrics

	Sub-Program Component	Metrics
Forest Health	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Reforestation	Tree mortality of planted trees
		Qualitative assessment of project impacts on ecological factors
		Fuel load
	Pest Management	Tree mortality in treatment and impact boundaries since treatment
		Qualitative assessment of project impacts on ecological factors
		Fuel load
	Forest Fuels Treatment (if wildfire has occurred in treatment or impact boundary)	Wildfire disturbance in treatment boundary (Y/N)
		Wildfire disturbance in impact boundary (Y/N)
		Description of disturbance impacts
		Forestland within treatment and impact boundary impacted
		Tree mortality in treatment and impact boundaries as a result of disturbance
		Fuel load
	Forest Conservation	Verification that the land is being managed in accordance with the terms of the forest conservation easement
		Biomass delivered to a renewable energy facility
		Harvested wood delivered to a mill
		Mill efficiency and wood product classes, if available from mill
		Qualitative assessment of project impacts on ecological factors
	Biomass Utilization	Biomass delivered to a renewable energy facility
		Harvested wood delivered to a mill
		If producing wood products, mill efficiency and wood product classes, if available from mill
		If producing energy or fuel, renewable energy generated
	Research	Quantity of publications resulting from funded research
		Quantity of publications resulting from funded research that are freely available to the public
		Quantity of conferences, panels, etc. where research findings were presented
		Quantity of citations to published works since publication

8.3. Data Collection and Analysis Limitations

Based on the review of available remote sensing resources, the Project Team determined that it would not be feasible in the scope of this project to obtain and analyze high spatial resolution imagery for the outcome period of Forest Health project sites that were sampled as part of this data collection effort. Data such as high resolution multispectral images were not available from CARB or other agencies at the time of the data collection request, and obtaining a license for proprietary imagery was beyond the resources available for this effort. Additionally, the Project Team did not conduct on-site monitoring of sampled sites under the scope of this project.

As a result, the Project Team focused on conducting a qualitative assessment of considerations related to the above POR metrics for forestry projects, rather than collecting data to quantify these metrics for the project sample. Specifically, this assessment is focused on conducting reviews of available project documentation, and for sampled projects for which CAL FIRE provided GIS files, exploring the potential of remote sensing-based disturbance detection for POR and project evaluation.

8.4. Remote Sensing Demonstration Approach

This section describes the tools and approach used by the Project Team to observe sampled sites as an example of remote sensing disturbance detection and its potential applicability to POR.

8.4.1. Disturbance Detection Tool Overview

The Ecosystem Disturbance and Recovery Tracker (eDaRT) is a remote sensing processing system that was developed through a partnership between the UC Davis Center for Spatial Technologies and Remote Sensing (CSTARS) and the United States Forest Service (USFS) Region 5 Remote Sensing Lab (RSL).[60] eDaRT uses remote sensing algorithms to detect disturbances in vegetation cover and health through time series processing of Landsat satellite imagery for geographic regions of interest (ROI), referred to as scenes.

The primary objective of eDaRT is to detect and map the extent, intensity, and timing of disturbances for a given region of interest (ROI). The eDaRT algorithms rely on Landsat imagery and detect disturbances for individual 30-by-30 meter pixels by comparing images over time. eDaRT creates a disturbance history for each pixel in a scene by establishing an initial baseline from a series of training images. When a disturbance is detected that deviates from this baseline, eDaRT uses the images from the disturbance period to establish a new baseline for the specific pixel. In each processed image (typically 10-20 per year), eDaRT compares the data to the most recently established baseline and checks whether a disturbance event has occurred relative to that baseline. As a result, eDaRT detects disturbance event timing to 8-16 day precision, depending on cloud cover.[61]

As part of detecting disturbance events, the eDaRT algorithm calculates a Mortality Magnitude Index (MMI) value associated with the disturbance. This MMI value is a representation of live tree canopy cover loss as a percentage of pixels area (900 square meters). Developers applied a statistical model using residuals from the eDaRT anomaly detection algorithm and trained the model using actual mortality

[60] Alexander Koltunov et al., "eDaRT: The Ecosystem Disturbance and Recovery Tracker System for Monitoring Landscape Disturbances and Their Cumulative Effects," *Remote Sensing of Environment* 238, no. 1 (March 2020), https://doi.org/10.1016/j.rse.2019.111482.

[61] The disturbance timing and information is available in several raster formats, in which a pixel is labeled with the calendar year and also its fractional part (Julian day divided by 365.242). Annual summary raster files are also available.

events. Although both overstory and understory damage are detectable with eDaRT, the MMI model was trained to emphasize detection of overstory canopy damage.

Disturbances and associated MMI values are displayed using a color coding system. Disturbances and MMI can be viewed as opaque layers, or as semi-transparent layers to allow for overlaying detected disturbances on other layers such as basemap imagery. Figure 8-1 presents gradient legends representing the range of MMI percentages and associated color scheme displayed on opaque and semi-transparent layers when viewing eDaRT within a geospatial processing program such as ArcMap.

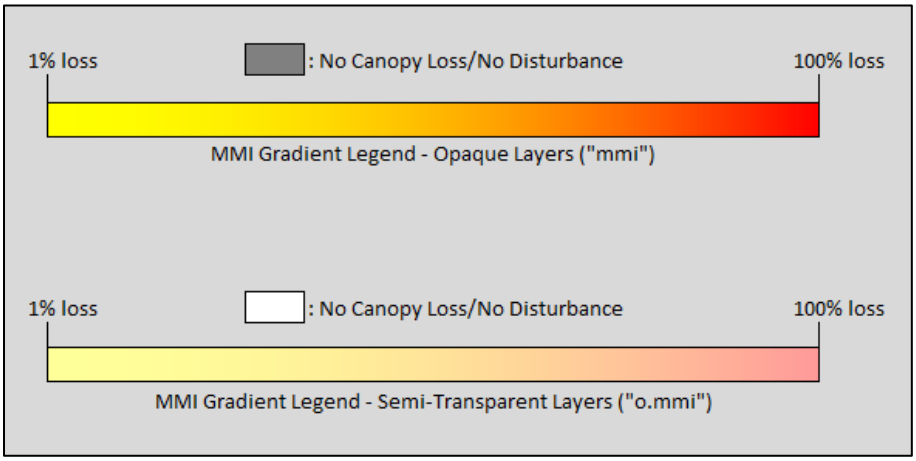

Figure 8-1. Gradient Legends for eDaRT Mortality Magnitude Index (MMI) Disturbance Layers

Figure 8-2 provides an example comparison between MMI color coding as displayed when viewing an opaque disturbance layer and MMI color coding as displayed when viewing a semi-transparent disturbance layer with satellite image basemap.

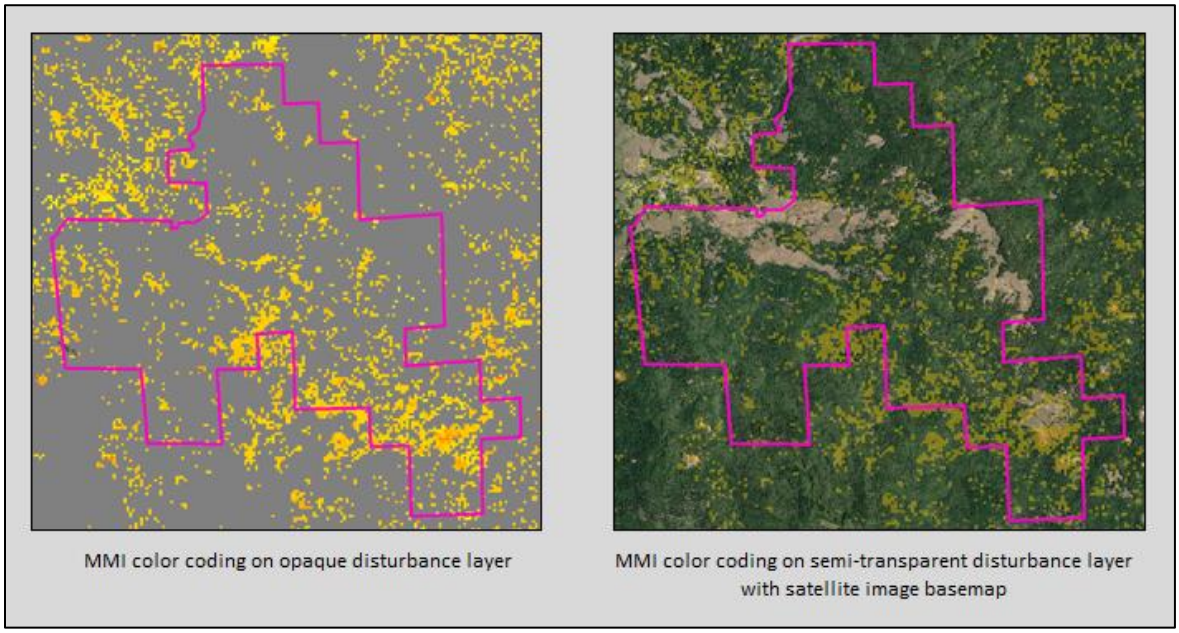

Figure 8-2. Example MMI Color Coding on Opaque and Semi-Transparent Disturbance Layers

The USFS and UC Davis eDaRT teams have used the system to map tree mortality in the Sierra Nevada region and to map canopy cover as part of wildlife habitat research.[62] Currently eDaRT products are generated for the entire land area of California and developers are continuing to improve the system.

8.4.2. Limitations and Considerations

Several limitations and considerations related to the use and reliability of eDaRT as a detection tool are described below.

8.4.2.1. Single Disturbance Classification

The algorithms detect disturbances resulting from a variety of causes such as fuels treatments, fire, drought, and other sources of ecosystem stress, but has a single disturbance classification and does not provide information to distinguish between different disturbance types. eDaRT developers recommend that users of the detection tool reference other data sets or information about a given site to make determinations regarding the specific cause of detected disturbances. The algorithms for disturbance attribution are currently in development.

8.4.2.2. Detection Sensitivity and Accuracy

Past evaluations of eDaRT performance in the Sierra Nevada region found that the algorithm is able to detect mortality levels as low as 1-5% canopy loss. Probability of detection most strongly depends on the magnitude of canopy loss. For example, probability of detection of 5% canopy loss is around 55-60%. Mortality representing 30% of canopy loss, or greater, are detected with practically 100% probability according to eDaRT developers. The false positive rate has been reported at approximately 10-12%. However, eDaRT developers do not specify or guarantee a particular level of accuracy or detection reliability for other regions of California and acknowledge that detection sensitivity is affected by a variety of random and systematic factors. In general, eDaRT developers indicate that the algorithm is most accurate in forested areas but is also effective for a variety of other land cover classes such as shrub areas and grasslands. eDaRT is not optimized for use in urban areas and may display false positive disturbance detections in areas with snow cover or edges of cloud cover.

8.4.2.3. Mortality Magnitude Index (MMI) Reliability

Developers emphasize that the MMI estimates are an experimental feature that is currently in development and is in the process of being validated for a variety of landscape types.[63] Additionally, developers note that MMI results for disturbances such as fire, harvesting, or ecological stress should not

[62] M. Slaton, A. Koltunov, and C. Ramirez, "Application of the Ecosystem Disturbance and Recovery Tracker in Detection of Forest Health Departure from Desired Conditions in Sierra Nevada National Forests," *AGU Fall Meeting Abstracts* 2016 (December 2016): B53A-0508, https://ui.adsabs.harvard.edu/abs/2016AGUFM.B53A0508S/abstract.;

Douglas J. Tempel et al., "Meta-Analysis of California Spotted Owl (Strix Occidentalis Occidentalis) Territory Occupancy in the Sierra Nevada: Habitat Associations and Their Implications for Forest Management," *The Condor: Ornithological Applications* 118, no. 4 (n.d.): 747–65, https://doi.org/10.1650/CONDOR-16-66.1.

[63] The eDaRT Product User Guide notes that initial testing showed a 13% root-mean-square error (RMSE) for MMI estimates.

be viewed as precise estimates at this time. Finally, pixels with multiple events in a short time period may confound MMI calculations.

8.4.2.4. Timing of Disturbance Detection

The manner in which eDaRT processes imagery and identifies disturbances over time is associated with certain limitations affecting the timing of detection estimates. First, eDaRT requires a training period consisting of a series of initial images in order to create the starting baseline for a scene. Disturbances that occur during the training period are not mapped as disturbance events and are instead incorporated into the baseline.

Secondly, in order to establish a revised baseline following a disturbance event, eDaRT must process a period of imagery following the disturbance and cannot identify additional disturbances for an individual pixel during this baseline processing period. As a result, eDaRT can only detect one disturbance per 160 days for an individual pixel. If two disturbances occur within 160 days, the second disturbance, if detected, can show a detection date that is later than the actual disturbance date.

Finally, although eDaRT can detect disturbance year-round, current standard procedures at the USFS Region 5 Remote Sensing Lab define an Inspection Period that excludes cloudy seasons to reduce the occurrence of images with high levels of snow, cloud cover, or other confounding characteristics. Therefore, disturbances which occur outside of or close to the boundaries of the Inspection Period may not be detected until the following Inspection Period. This can result in eDaRT indicating a detection year that is one year later than the actual disturbance year. Much less commonly, it is possible for eDaRT to indicate a disturbance year that is one year earlier than the actual disturbance year.

8.4.2.5. Product End Uses and Customization

Although eDaRT is under continuous development to improve its effectiveness and functionality, it is a remote sensing product that has limitations and may not be appropriate for certain uses. eDaRT developers recommend that users consult with the product team in order to discuss potential limitations and considerations when applying the software to a given end use. Additionally, developers indicate that while the default tool offers standard functionality and outputs, it would be possible to customize eDaRT to improve its effectiveness in detecting disturbances and quantifying MMI as part of a specific monitoring or evaluation objective. For example, combining the disturbance detection outputs with other GIS tools could allow project monitors to calculate an average MMI value for an entire project area, or automatically identify areas with a certain number of disturbances per pixel to flag them for further in-depth inspection.

8.4.3. Observation of Sampled Projects

For this data collection exercise, the Project Team coordinated with Dr. Koltunov, the eDaRT team science lead, to discuss the detection tool and observe the sampled sites for which CAL FIRE provided GIS files. The objective of this effort was to characterize the process of disturbance detection and explore the potential application of this type of approach in relation to POR and overall project monitoring. This activity is not intended to endorse a particular software product but is meant to serve as an example of automated disturbance detection from Landsat imagery and discuss related considerations.

Table 8-2 displays the sampled projects for which CAL FIRE provided GIS files and therefore allowed for demonstrative disturbance detection.

Table 8-2. Projects Monitored with eDaRT

Project ID	Project Name	GIS Files Received
8GG17606	Marshall Ranch Conservation Easement	Yes
8CA03410	Pacific Union College	-
8GG14601	Cambria Forest Health	Yes
8GG14901	2014 Day Fire Restoration	-
8GG15102	Black Mountain Forest & Watershed Restoration	Yes
8GG17604	Mt. Shasta Headwaters Forest Health and Resilience Project (Phase 1-Black Butte)	Yes
8GG14308	Circle U Ranch	-

Table 8-3 displays key parameters of the data used by eDaRT in its disturbance detection for the sampled Forest Health projects.

Table 8-3. Key Parameters of Disturbance Detection for Sampled Sites

Parameter	Value	Note
Satellites used for data processing	Landsat 5, 7, and 8	
Training period	2006 - 2008	Specific dates depend on scene.
Approximate start of detection period	Late 2008	Specific date depends on scene and pixel.
Approximate end of detection period	Black Mountain Forest & Watershed Restoration (8GG15102): October 2019 Cambria Forest Health (8GG14601): September 2020 Marshall Ranch Conservation Easement (8GG17606): November 2020 Mt. Shasta Headwaters Forest Health and Resilience Project, Phase 1-Black Butte (8GG17604): November 2020	Specific date depends on scene and pixel. Detections are reported until 48-64 days before the end of the detection period.
Inspection period per year	May 1 - November 30	

The eDaRT team periodically processes Landsat imagery to update each of its ROIs, or scenes, which currently span the entire area of California. As this processing is done on an ongoing basis and is not limited to a particular shapefile or project, obtaining disturbance detection results for the sample of Forest

Health projects did not require additional image processing. Shapefiles were used as references within pre-processed scenes to observe disturbance detection results for the individual project areas.

8.5. Results by Sampled Project

This section summarizes the results of the data collection and documentation review effort by sampled project.

8.5.1. Forest Health Project 1: Marshall Ranch Conservation Easement, CCIRTS Project ID 8GG17606

This project involves the implementation of a conservation easement on a 2,942 acre area in Humboldt County. The easement is intended to protect habitat for threatened and endangered fish, to increase carbon sequestration, and allow for improved management of forest areas within the project site.

This project was funded through 2016-2017 FY funding and has a project completion date of November 27, 2019. The CCIRTS database lists total Forest Health Program funding as $3,100,000 with total GHG reductions of 178,923 MTCO2e.

8.5.1.1. Data Collected

Data and documentation collected for this project included:

1. Project documentation including an annual monitoring report completed in 2020 by the California Rangeland Trust; and
2. Project GIS files: CAL FIRE provided shapefiles and related GIS files for the conservation easement project area.

8.5.1.2. Activities Conducted

Activities conducted for this project included:

- **Documentation review:** The Project Team reviewed project documentation, including the annual monitoring report, to assess the status of the project site in the outcome period and gain an understanding of project history, components, and results.
- **Remote sensing observation of project site:** The Project Team received GIS files, including a shapefile for this site, and used eDaRT outputs available for the project area to view disturbances over time and demonstrate the capability of disturbance detection with remote sensing.

8.5.1.3. Results

This section presents the findings from the above activities for this project.

Review of Annual Monitoring Report

CAL FIRE confirmed that the completion date for this project was November 27, 2019. Based on the current POR framework for Forest Health, the first annual outcome period for this project would be defined as November 27, 2019 through November 26, 2020. The first annual monitoring report for this project describes the results of the monitoring visit that was conducted by the California Rangeland Trust on September 29, 2020 towards the end of the first POR period.

The monitoring report indicates that no changes in conditions were observed since the baseline site condition, and that the site is being managed in accordance with the Forest Management Plan (FMP) that is in place. Additionally, the report states that no changes to the FMP are needed at the time of this report. In a section regarding wildlife habitat, the report notes that diversity is increasing and that the number of deer in the region has increased.

The monitoring report also indicates that the landowner does not plan to conduct any commercial timber harvesting during the 2020 calendar year, and is not planning any reforestation, prescribed fires, or other fire management activities. The report states that the monitor did not observe the construction of any new facilities such as ranch facilities, recreation facilities, power generation or transmission facilities, billboards, or communication facilities and that any new development such as water resource development had been conducted within the terms of the conservation easement.

The monitoring report includes a series of photos of various areas of the conservation easement and a map showing the route traveled during the visit and location of photos.

Overall Monitoring Report Findings

Overall, the monitoring report indicates that the site continues to be managed in accordance with the terms of the conservation easement and does not suggest that there are any major issues occurring on-site that need to be addressed.

For POR purposes, the metric described as "Verification that the land is being managed in accordance with the terms of the forest conservation easement" should be reported as "Yes" for the current outcome period based on the contents of this monitoring report. The report indicates that wildlife diversity in the area is increasing, and this is an example of a finding that could be used to qualitatively report on the status of ecological factors in the project area as part of POR.

Site Observation and Disturbance Demonstration

As the funding for this project is allocated towards the implementation of a conservation easement, the current POR framework does not require CAL FIRE to track disturbances in the project area or assess metrics such as tree mortality rates during the outcome period. However, as this is one of the projects in the sample for which CAL FIRE was able to provide GIS files, the Project Team observed the site in eDaRT in order to demonstrate the capabilities of this type of disturbance detection tool. This section presents the results of this observational activity.

Figure 8-3 displays the shapefile received for this project from CAL FIRE, overlaid on a satellite imagery base map, also referred to as a service layer.[64] This shapefile matches the project area shown within project documents.

[64] Displaying "World_Imagery" service layer. Service layer credits: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

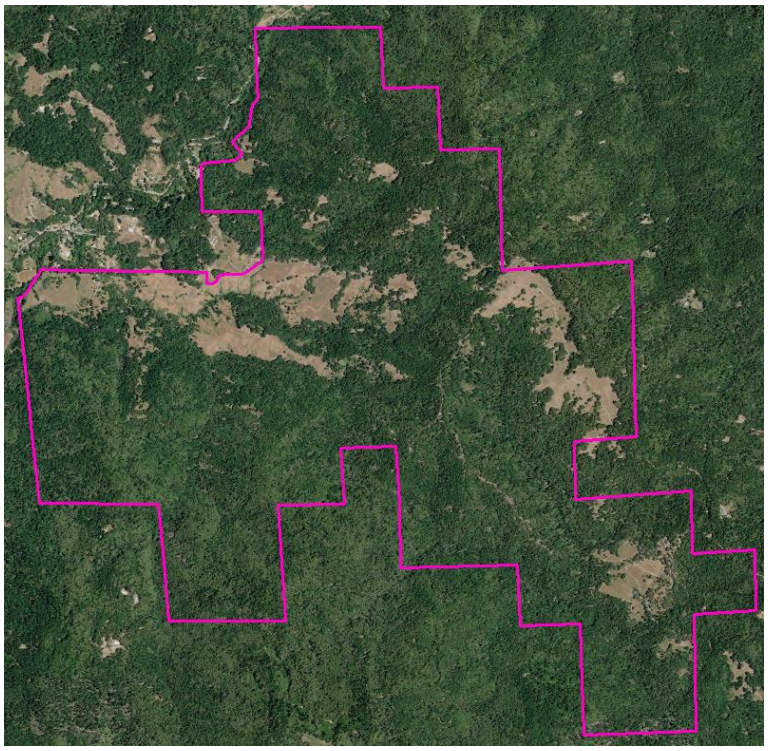

Figure 8-3. Forest Health Project 1 Project Site

One function of the eDaRT tool is to display disturbances on an ordinal basis for a given time period (e.g. showing when the first, second, or third disturbance event occurred for each pixel). The time period of processed data for this site within eDaRT ranges from the year 2008 through the year 2020. Figure 8-4 shows the date of the first disturbance event, second disturbance event, third disturbance event, and fourth disturbance event for each pixel in the site area, with the date of disturbance indicated by the color of the pixel (a black pixel indicates the absence of an event).[65] As shown in this figure, the majority of the project area experienced at least one disturbance between 2008-2020 but very few pixels show more than two events occurring during this period. This suggests a fairly stable site that has not experienced ongoing major developments during the observed period.

[65] Displaying the following layers, as labeled within assessed eDaRT files: "EVYY: event #1: sc106 b=201025-1601" (1st Disturbance Event), "EVYY: event #2: sc106 b=201025-1601" (2nd Disturbance Event), "EVYY: event #3: sc106 b=201025-1601" (3rd Disturbance Event), and "EVYY: event #4: sc106 b=201025-1601" (4th Disturbance Event).

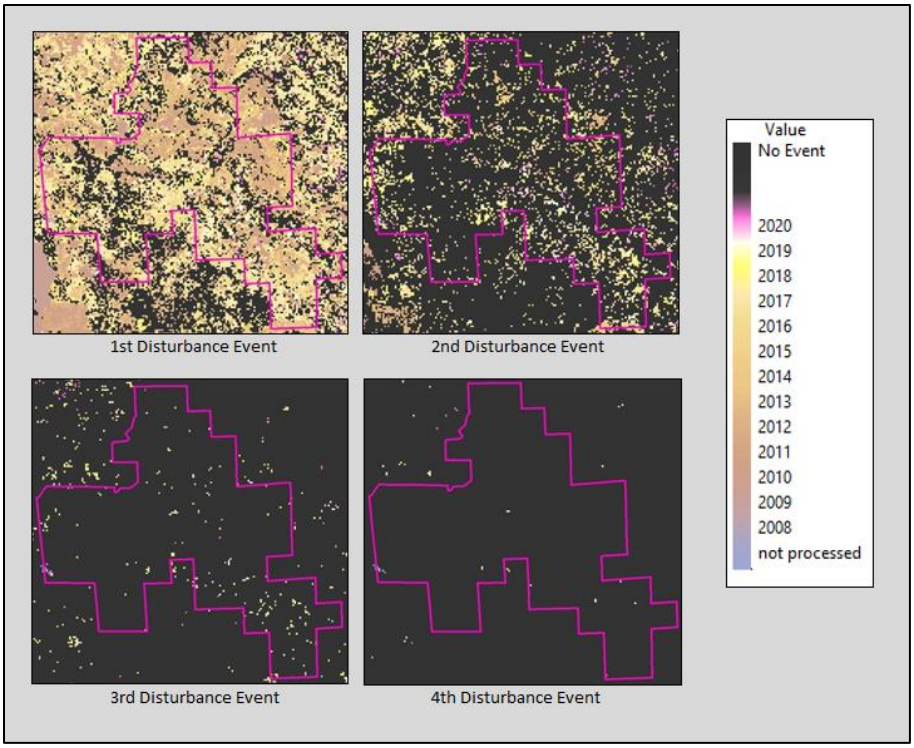

Figure 8-4. Forest Health Project 1 Timing of Disturbance Events by Event Number

The first outcome period for this site is defined as November 2019 through November 2020 based on the closing date of the conservation easement. Figure 8-5 displays disturbances for the years 2019 (left image) and 2020 (right image), overlaid on the satellite service layer, and shows low levels of mortality in a few areas.[66] Overall this indicates very minimal disturbance activity for this time period.

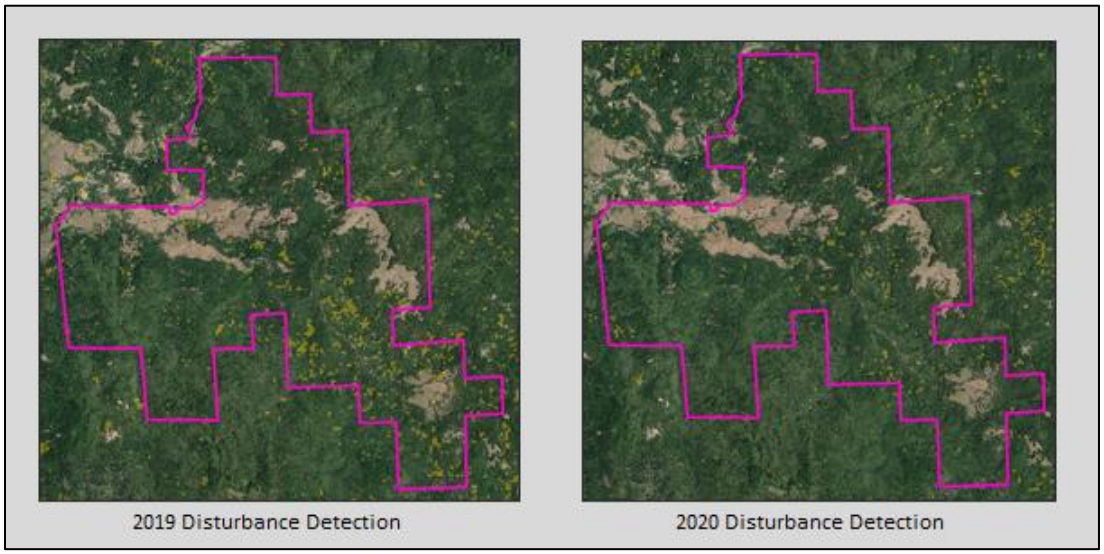

Figure 8-5. Forest Health Project 1 Detected Disturbances, 2019 vs. 2020

[66] Displaying semi-transparent layer "o.mmi_sc106nc_2020.bsq" as labeled within assessed eDaRT files, over "World_Imagery" layer.

As part of this observation, the Project Team viewed detection years that occurred prior to project implementation to gain insight into historical disturbances and assess the detection algorithm outputs over a range of time periods for a single location. Viewing the project site for the 2016 detection year shows greater mortality levels in some areas, including a concentrated site of canopy loss near a location which is marked as "Building Envelope D" on the map that was included with the project application.

Figure 8-6 displays the 2016 disturbance detection results from various views, including using the semi-transparent disturbance layer over satellite service layer, the semi-transparent disturbance layer excluding the service layer, the opaque disturbance layer, and an enlarged view of the opaque disturbance layer to more clearly show the area of concentrated canopy loss.[67]

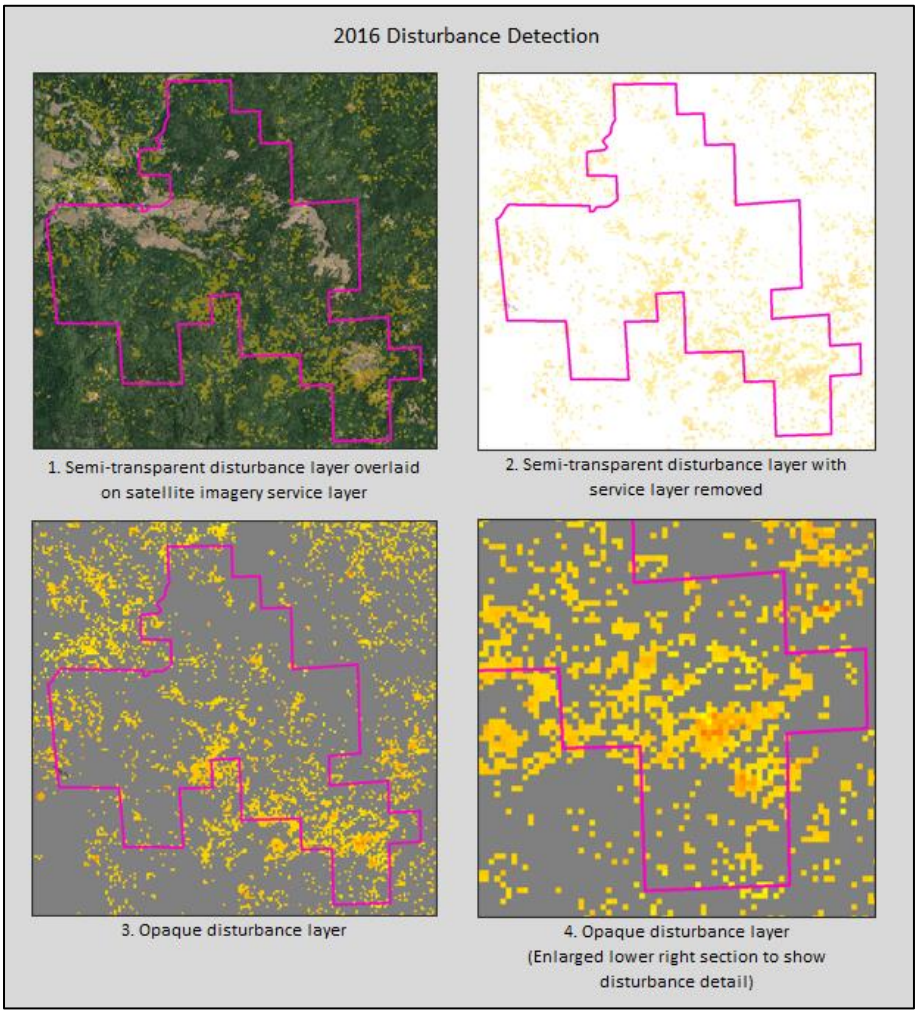

Figure 8-6. Forest Health Project 1 Detected 2016 Disturbances, Various Viewing Modes

[67] Displaying the following layers, as labeled within assessed eDaRT files: Image 1: "World_Imagery" service layer, "o.mmi_sc106nc_2016.bsq" semi-transparent layer; Image 2: "o.mmi_sc106nc_2016.bsq"; Images 3 and 4: "mmi_sc106nc_2016.bsq".

To demonstrate a process for using satellite imagery to conduct further investigation into initially identified disturbances, the Project Team selected an individual point within this section of concentrated canopy loss from the 2016 year as an example. Figure 8-7 shows the enlarged section of the 2016 disturbance layer with an individual point selected, which displays the eDaRT MMI estimate of 51%.[68]

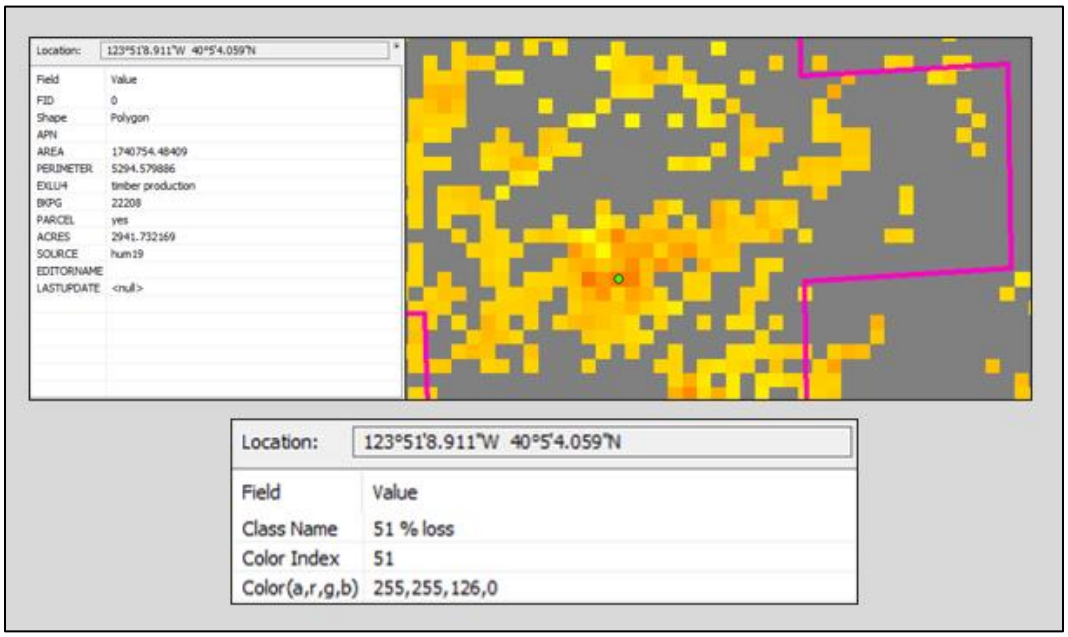

Figure 8-7. Forest Health Project 1 Detected 2016 Disturbances, Enlarged With Selected Point

The satellite image service layer used to assist in viewing sites represented a single point in time and did not allow for comparing satellite imagery of project sites over the course of several years. In order to accomplish this comparison, the Project Team used the latitude and longitude of the example point above to locate the point in Google Earth. The Project Team then used the Historical Imagery feature within Google Earth to first view the location through 2015 imagery (prior to the detected 2016 disturbance), and then through the most recent imagery available through Google Earth, which is from 2019.

Figure 8-8 displays the 2015 imagery (top image) compared to 2019 imagery (bottom image) for this site, with a highlighted selection near the example point to show the difference in canopy cover and indication of timber harvesting activity occurring at this site.[69]

[68] Displaying layer "mmi_sc106nc_2016.bsq" as labeled within assessed eDaRT files.

[69] Selection is approximately 30 meters by 30 meters.

Figure 8-8. Forest Health Project 1 Google Earth Imagery for Area of Interest, 2015 vs. 2019

This type of harvesting is consistent with descriptions within project documentation and the Project Team does not suggest that this represents an ecological concern or other issue. This observation activity is intended as an example of disturbance detection and investigation and to suggest that a similar process could be used to monitor for other types of disturbances or potential concerns during the outcome period.

Overall, this observation shows that automated disturbance detection can be used to verify the absence of disturbances in an area that is expected to remain undeveloped over time and can identify concentrated areas of disturbances resulting from activity such as forest treatments.

8.5.2. Forest Health Project 2: Pacific Union College, CCIRTS Project ID 8CA03410

This project involves the implementation of a conservation easement on 864 acres of forest land at Pacific Union College (PUC) in Angwin, CA. The conservation easement is intended to preserve natural resources and the natural habitats of animal and plant species, protect scenic open spaces, and preserve the use of the land for recreational purposes such as hiking and camping. The easement allows continued timber harvesting and forest thinning activities that comply with a set of requirements specified by the agreement and also provides guidance for activities such as building structures, engaging in recreational activities, and conducting other forest management practices.

This project was funded through 2014-2015 FY funding and CAL FIRE indicated that the project was completed on December 20, 2018. The CCIRTS database lists total Forest Health Program funding as $2,850,000 with total GHG reductions of 75,803 MTCO2e.

8.5.2.1. Data Collected

Documentation provided by CAL FIRE for this project consisted of project records including the project baseline report, conservation easement agreement, monitoring memorandum of understanding (MOU) for the Land Trust of Napa County (LTNC), and the annual monitoring report for the first year of the conservation easement.

8.5.2.2. Activities Conducted

Activities conducted for this project included reviewing the conservation easement agreement, project baseline report, monitoring and management plan, and first annual monitoring report to confirm that the site is being managed in accordance with the agreement and to identify any evaluation-related findings that may serve as considerations for future rounds of POR.

8.5.2.3. Results

This section presents the findings from the above activities for this project.

Review of Baseline Documentation Report

The Project Team reviewed the baseline documentation report that was completed as part of the implementation of this conservation easement to gain a sense for how baselines are assessed and reported for this type of project. Documentation of a project baseline provides valuable information for subsequent evaluation efforts, and a thorough understanding of pre-project conditions allows for comparisons with post-project data. The baseline report for this project was completed by a forester consultant in 2018 and provides detailed information regarding site characteristics, value, timber inventory, ecological considerations such as disease occurrences and invasive species, and the status of air, water, and other resources. The baseline report also includes a description of the recommended monitoring for the site, and states that annual monitoring should be conducted to ensure that the terms of the conservation easement are being met.

Overall Baseline Report Findings

The monitoring recommendations are fairly general and do not specify particular ecological factors that should be assessed as part of ongoing site monitoring, other than referring to the terms of the

conservation easement. The majority of the report is very detailed, and provides a comprehensive assessment of the project site in order to serve as a resource for future monitoring.

Review of Conservation Easement Monitoring Protocols and Monitoring MOU

Under current Forest Health program guidelines, post-project evaluation of conservation easements mainly consists of monitoring visits that are completed each year after the easement is implemented. For this project, the Project Team received the conservation easement agreement and monitoring Memorandum of Understanding (MOU), both of which provide details regarding the required monitoring approach. This section briefly summarizes the findings from a review of these documents as an example to provide an understanding of the conservation easement evaluation scope and to provide context for the review of the annual monitoring report.

The conservation easement agreement includes a section specifying the protocols that are to be followed for annual monitoring of the site. These protocols specify that monitoring must be completed at least once per year and that monitors must inspect and document property conditions and evaluate the conservation values of the land in comparison to the conditions identified in the baseline documentation. Additionally, monitors are to review and analyze documentation provided by the landowner such as timber harvesting documents and compare this documentation to observed conditions and to baseline property conditions. Finally, the protocols state that monitors must document any conservation easement violations and report any other unanticipated occurrences that may affect the conservation easement.

Similarly, the monitoring MOU outlines the responsibilities and activities to be conducted annually by LTNC following the implementation of the conservation easement. The MOU states that LTNC will conduct annual monitoring to verify that the terms of the conservation easement continue to be met and that monitors will follow a standard protocol for indicating whether or not a change was observed for each of a variety of land development, ecological, and other factors. The MOU references the monitoring protocols specified in the conservation easement agreement and states that all such protocols will be followed. The MOU states that in addition to on-site monitoring, LTNC will determine whether it is necessary to obtain updated aerial imagery for the site in order to conduct a remote sensing assessment of changes. If needed, LTNC is to obtain this imagery either from existing imagery providers or by conducting individual aerial flyovers. The MOU states that once LTNC obtains updated imagery, it should be compared to baseline images to determine whether there have been changes in the site that should be further assessed during an upcoming on-site monitoring visit. The MOU also provides guidelines for reporting and includes a sample checklist of findings to be filled out during each monitoring visit.

Overall Monitoring Protocols and MOU Findings

Overall, the monitoring MOU provides a fairly detailed framework and set of requirements for site monitoring that are fairly consistent with the protocols specified by the conservation easement agreement. Additionally, the sections relating to aerial imagery suggest that advancements in remote sensing methodologies may be of interest to monitoring teams for the purposes of efficiently tracking conservation easement site changes over time.

Review of Annual Monitoring Report

CAL FIRE indicated that the completion date for this conservation easement project was December 20, 2018. Based on the current POR framework for Forest Health, the first annual outcome period for this project would be defined as December 20, 2018 through December 19, 2019. The annual monitoring

report provided to the Project Team for this project is based on a monitoring visit conducted by the Land Trust of Napa County on January 31, 2020 after the end of this first POR period.

In a section relating to any reserved rights that have been exercised on the land since the establishment of the conservation easement, the monitoring report indicates that a trail license agreement allowing public access to PUC trails was created in the summer of 2019 and that a fuel break was installed in February 2019, which involved fuels thinning of 32 acres. The monitoring report also states that PUC is planning to conduct further thinning on 46 acres in one area and additional thinning on one portion of the property boundary. All of these activities are within the guidelines of the conservation easement agreement.

The monitoring report states that all restrictions in the conservation easement are being complied with and that there do not appear to be any issues or concerns related to the conservation easement area or neighboring areas. Specifically, the report indicates that there has been no construction or removal of structures in any of the assigned development areas or outside of the designated building envelope areas of the property, and that existing roads and trails are being maintained but that no new roads or trails have been created. Additionally, no activities that are detrimental to water, soil, habitat preservation, native plants, or other ecological factors were observed.

Overall Monitoring Report Findings

Based on this review, the information in this monitoring report is sufficient to verify that the land is being managed in accordance with the terms of the forest conservation easement, and a POR value of “Yes” could be reported for that verification metric for this first outcome period. The monitoring report does not appear to identify any significant ecological changes associated with the project that could be reported as part of POR for this site.

The conservation easement monitoring protocols state that monitors should review and analyze any documentation obtained from the landowner such as inventory reports, timber harvesting documents, and CAL FIRE inspection reports. However, the annual monitoring report does not appear to reference or discuss this type of documentation. The report includes photographs of various forest management practices such as thinning and the installation of a fuel break, but it is not clear whether any applicable documentation such as harvesting records were generated as a result of these activities.

8.5.3. Forest Health Project 3: Cambria Forest Health, CCIRTS Project ID 8GG14601

This project is categorized as a Forest Pest Control project within the CCIRTS database and is located on several treatment sites within and near Cambria, CA in San Luis Obispo County. The total treatment area across the treatment sites is approximately 950 acres according to the project application. Project treatments include fuels reduction through the removal of dead, dying, hazardous, and infected trees and the processing of woody materials for the purposes of biomass generation. The project is designed to implement forest management activities that will mitigate the effects of diseases such as pitch canker and mistletoe, improve forest health in areas affected by bark beetle mortality and invasive species, and reduce fire hazards in the local area.

This project was funded through 2014-2015 FY funding and has a listed project completion date of December 31, 2019. The CCIRTS database lists total Forest Health Program funding as $498,736 with total GHG reductions of 5,235 MTCO2e.

8.5.3.1. Data Collected

Data and documentation collected for this project included:

1. Project documentation including the grant agreement, project application, progress reports, and final project report; and
2. Project GIS files including shapefiles: CAL FIRE provided Keyhole Markup Language (KMZ) files containing shapefiles for each project treatment area.

8.5.3.2. Activities Conducted

Activities conducted for this project included:

- **Documentation review:** The Project Team reviewed project documentation including the Forest Health application, progress report, and final report to gain an understanding of project history, components, and results.
- **Remote sensing observation of project site:** The Project Team received GIS files including a shapefile for this site from CAL FIRE and used eDaRT outputs available for the project area to view disturbances over time and demonstrate the potential of disturbance detection with remote sensing.

8.5.3.3. Results

This section presents the findings from the above activities for this project.

Review of Forest Health Application

CAL FIRE provided the grant agreement that was created for this project which includes a copy of the initial project application. The Project Team reviewed this document in order to gain an understanding of project components, the basis of expected GHG benefits, and information related to evaluation plans for this type of project.

The Forest Health grant agreement includes a section detailing the monitoring and reporting requirements that apply to GGRF projects. The agreement states that grantees are required to monitor and report the direct emissions, avoided emissions, and carbon sequestration resulting from their projects, and that these values are to be based on a comparison of the project baseline to the in-progress

or completed project. The guidelines shown in the grant agreement indicate that Forest Health grantees must report these values annually and at the time of project completion. Specific metrics required for Forest Pest Control project include the increased carbon sequestration through tree growth and timberland management, the GHG emissions from project treatments, the avoided GHG emissions from biomass utilization and prevention of disease spread, and net GHG benefits achieved to date.

The Forest Health application submitted for this project includes a detailed description of the proposed treatment activities and expected benefits, funding requested, and project timeline. Regarding expected GHG benefits, the application summarizes a detailed methodology that was used to calculate sequestration and avoided emissions benefits through on-site data collection and the use of the Climate Action Reserve and COLE carbon calculator. The grantee used the USFS Forest Vegetation Simulator (FVS) to compare the treatment scenario to the counterfactual non-treatment scenario and estimate benefits that would be attributable to project treatments. This description appears to be of sufficient detail to allow CAL FIRE to thoroughly review the methodology for quality assurance purposes, as it cites the sources used, key inputs, and a variety of assumptions and stipulations made during the calculation process.

In addition to providing details regarding the initial calculation of GHG estimates for the project, the application includes a section describing the grantee's proposed post-project evaluation and monitoring activities. This section notes that the grantee has installed permanent monitoring plots on each treatment property to serve as treatment and control groups. The grantee states that these plots will be monitored annually to assess factors such as mortality and tree health and that this will include annual quantification of carbon sequestration and fuel load through collaboration with organizations such as Cal Poly University, The Nature Conservancy, Cambria Community Services District, and the University of California at Santa Barbara.

Overall Grant Agreement and Project Application Findings

Based on the grant agreement and project application review, the Forest Health Program includes detailed requirements for grantee estimation, monitoring, and reporting of project benefits including GHG emission reductions. Additionally, the application asks grantees to consider and plan for post-project monitoring and evaluation prior to project implementation, which likely facilities successful data collection during the outcome period.

Review of Progress Report

CAL FIRE provided a sample progress report that was submitted by the grantee in October 2019 for the period of July 1 through September 30, near the end of project implementation. Grantees are required to submit progress reports each quarter during project implementation or with each submitted invoice for the project. This section summarizes the information requested by the quarterly report template and the content provided by the grantee within this sample report as an example of the type of information received by CAL FIRE from grantees on an ongoing basis.

The quarterly report includes fields for grantees to indicate the total California Climate Investments funding and matching funding expended during the quarterly reporting period as well as the total funding expended to date. The report also includes a field for grantees to state the program income generated during the current period for projects that would generate a form of income from completed activities; this amount is zero for the Cambria Forest Health project. Next, the progress report includes a section for grantees to indicate any status updates on environmental compliance proceedings for the project, such

as for California Environmental Quality Act (CEQA) approvals or exemptions. For this project, the grantee indicated that all environmental compliance had been completed.

The report template then asks grantees to describe progress that has been made since the last progress report, including funding expended for specific treatment activities along with the number of acres treated through each activity. This sample progress report notes that the grantee had completed activities including hazardous tree removal in order to allow crews access to sites for additional tree removal, and that crews had worked to remove dead, dying, and invasive trees and plants from several treatment sites. The progress report also includes sections requesting updates on non-treatment activities such as research, education, and outreach. This sample report describes monitoring activities being conducted for the research plots that were established as part of the project, and notes that the project had coordinated monthly fire safety focus groups and a community town hall as part of its outreach efforts.

Finally, the progress report asks grantees to describe current challenges and goals for the upcoming reporting period and requests that grantees include supplementary documentation such as maps or photographs to convey the current status of the project. In this example, the grantee provided images of two treatment sites and of the Cambria town hall meeting that was held to discuss the project. The quarterly progress report does not appear to include a section for grantees to report estimated emission reductions or sequestration associated with recent project activities, though according to the grant agreement these metrics are to be reported annually and at project completion rather than quarterly.

Overall Progress Report Findings

Based on this review, the Forest Health progress reports request a series of pertinent information from grantees throughout the project and allow for detailed tracking of funding expenditures and the scope and timing of project components. This helps to maintain transparency into funded activities and could serve as a useful supplemental resource for any post-project auditing or evaluation efforts.

Review of Final Report

This section briefly summarizes the findings from a review of the final report for the Cambria Forest Health project as an example to provide an understanding of the documentation and data that CAL FIRE receives at the time of project closeout. Grantees for Forest Health treatments are required to submit a final report to CAL FIRE at the time of their final invoice for the project. The final report summarizes the benefits achieved by the project such as renewable energy generated, acres of land treated or conserved, and the number of trees planted. Final report guidelines specify that grantees are to submit a detailed narrative of project accomplishments, collaboration activities, research, education and outreach, co-benefits, and long-term forest management efforts to sustain the benefits achieved by the treatment. Finally, the reporting template requests a detailed summary of funding expended for each treatment type and asks grantees to submit supporting documentation such as maps, GIS files, outreach and news materials associated with the project, and any scientific publications generated from the project.

The final report for this project states that the grantee completed a variety of activities across the several treatment sites including thinning, biomass removal, pile burns, and establishing research plots. Total California Climate Investments expenditures are listed as $498,736 and total matching expenditures are listed as $243,098, which is consistent with the values listed in the CCIRTS database. The grantee included several metrics associated with completed activities such as stating that the project had treated 983 acres and had planted 1,000 trees. However, the final report does not appear to include an estimate of emission reductions or carbon sequestration. As the grant agreement specifies that these metrics are to be

provided by grantees at the time of project completion, the reason for their absence in this document is unclear.

The narrative included with the final report describes each project component and activity in detail. This includes qualitative information on the types of activities conducted as well as quantitative information such as the number of acres receiving different treatments, the number of stakeholder meetings and education or outreach meetings held, the number of research plots implemented, and other metrics.

Overall Final Report Findings

Overall, the final report contains thorough information indicating the final status of the project, funding expended, and outcomes at the time of closeout. The presence of this type of closeout documentation would likely serve as a valuable resource for any post-project evaluation activities which seek to assess long-term changes and outcomes for the project since its completion. There may be an inconsistency between the contents of the final report and the grant agreement requirements which specify that emissions and sequestration estimates must be reported, unless these are reported by grantees to CAL FIRE through a separate mechanism.

Site Observation and Disturbance Demonstration

CAL FIRE provided GIS files including shapefiles for this project, and the Project Team observed the project site using eDaRT as another example of remote sensing disturbance detection advantages and limitations. Figure 8-9 displays the shapefiles received from CAL FIRE for this project overlaid on a satellite image service layer (left image), along with a map image from project documentation (right image).[70] The shapefiles are somewhat similar to maps of the project sites and treatment areas submitted by the grantee and provided by CAL FIRE, though there are differences in the shape and location of several areas and the reason for this was not clear.

[70] Displaying "World_Imagery" service layer. Service layer credits: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 8-9. Forest Health Project 3 Project Site, GIS Shapefiles vs. Map Documentation

The Cambria Forest Health project involves multiple treatment areas within and surrounding the urban area of Cambria, CA. One limitation of eDaRT is that it is optimized for forests, shrub areas, grasslands, and other natural land areas and is less optimized for use in urban and developed areas. Due to this, the reliability of disturbance detection and resulting MMI estimates is likely lower across treatment areas within this type of project. The following figures present examples of identified disturbances in and around these project areas during the grant period as further exploration of this remote sensing approach and potential limitations.

Figure 8-10 displays the eDaRT disturbance detection layer for 2017 across the entire project area.[71] Minor to moderate canopy loss is shown within the southern Rancho Marino area (outlined in green), and moderate to major canopy loss is shown within and around the northern area identified as Covell Ranch within project documentation (outlined in purple).

[71] Displaying layer "mmi_sc203co_2017.bsq" as labeled within assessed eDaRT files.

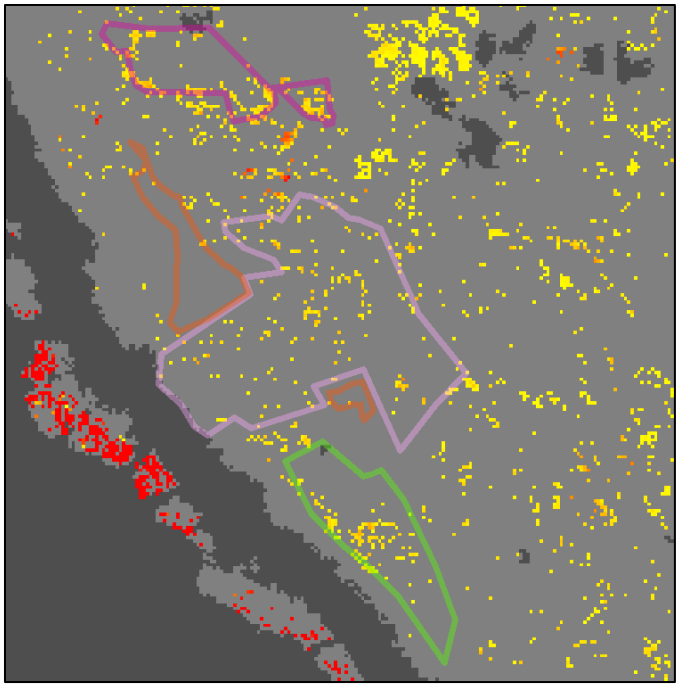

Figure 8-10. Forest Health Project 3 Detected 2017 Disturbances, Full Project Area

Figure 8-11 displays an enlarged segment of the 2017 disturbance layer with a single sample point selected outside of the Covell Ranch project area.[72] The MMI estimate for this selected point is 71% canopy loss which within eDaRT results is typically associated with complete tree death or removal.

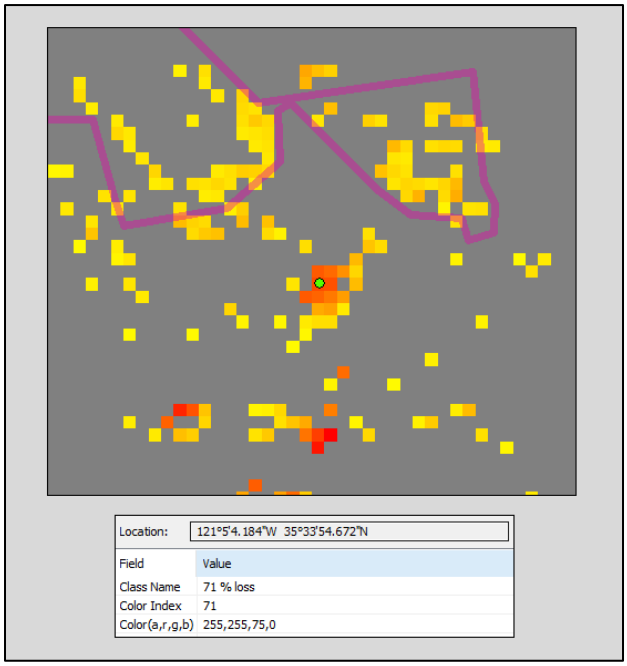

Figure 8-11. Forest Health Project 3 Detected 2017 Disturbances, Enlarged With Selected Point

[72] Displaying layer "mmi.sc203co_2017.bsq" as labeled within assessed eDaRT files.

Using the latitude and longitude of this sample point and viewing the location through historical Google Earth imagery allows for a closer inspection of the detected disturbance. Figure 8-12 displays the selected point as observed through imagery from June 2017 (top image) as well as through imagery from September 2018 (bottom image).[73] These images show a major disturbance that resulted in complete vegetation loss in one area, which does not appear to be related to project activities and may be the result of a fire which occurred in Cambria in July 2017.[74]

Figure 8-12. Forest Health Project 3 Google Earth Imagery for Area of Interest, 2017 vs. 2018

The 2018 disturbance detection layer (Figure 8-13) shows minor moderate disturbances within and around several of the outlined project areas, including a series of disturbances within the project area identified as Lodge Hill in project documentation; this is the center area outlined in light purple.[75] The Lodge Hill segment is a predominantly developed area centering on the town of Cambria, and the eDaRT algorithms are not optimized to distinguish vegetation disturbances from other changes in urban settings.

[73] Selection is approximately 30 meters by 30 meters.

[74] "Cambria gets a scare as brush fire forces evacuations" (July 18, 2017). https://www.sanluisobispo.com/news/local/community/cambrian/article162294613.html

[75] Displaying layer "mmi_sc203co_2018.bsq" as labeled within assessed eDaRT files.

The detected disturbances may therefore be a result of typical urban activity or a variety of factors that are not associated with canopy loss or the hazard tree removal that is listed within project documentation for the Lodge Hill area. On-site monitoring or the analysis of high spatial resolution imagery may be needed to provide detailed and reliable information regarding long-term treatment status and outcomes for treatments conducted in these area types.

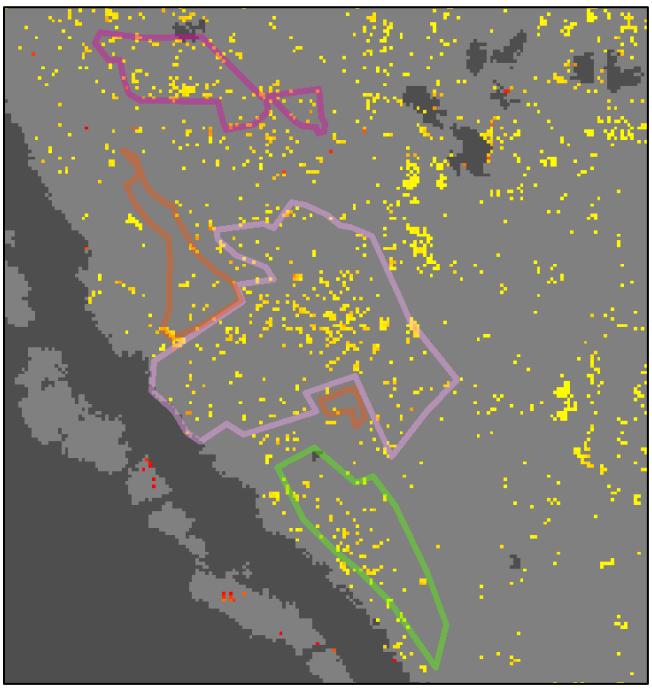

Figure 8-13. Forest Health Project 3 Detected 2018 Disturbances, Full Project Area

The 2019 disturbance detection layer (Figure 8-14) shows increased disturbances within the Rancho Marino treatment area to the south, and moderate to major disturbances between the Fiscalini Ranch Preserve treatment area, outlined in orange, and the Lodge Hill area.[76] Based on the quarterly progress report for July 1, 2019 through September 30, 2019 which was included in the documentation review, project crews removed dead and dying trees and invasive plants in the Fiscalini Ranch Preserve during this period and the disturbances shown near the Fiscalini Ranch Preserve treatment area may be a result of this activity.[77] The progress report also indicates that removal of dead and dying trees and invasive plants was also conducted within additional sites such as 135 acres within the Bridge Street area and Cambria Pines Road, which are along and to the left of the upper border of the Covell Ranch treatment area (outlined in dark purple). The 2019 disturbance layer shows some scattered moderate to major disturbances in this region, though as with the Fiscalini Ranch treatment area it appears that the shapefiles may not fully represent the areas in which treatments were performed.

[76] Displaying the following layers, as labeled within assessed eDaRT files: 2019 Detected Disturbances: "mmi_sc203co_2019.bsq"; 2020 Detected Disturbances: "mmi_sc203co_2020.bsq".

[77] While the GIS shapefiles indicate that these disturbances are outside of the Fiscalini Ranch Preserve treatment area, maps included with project documentation show that the project area and Fiscalini Ranch Preserve property extend into this region.

The 2020 disturbance detection layer shows minimal disturbances in any of the treatment areas other than the Rancho Marino area to the south. As the project was completed at the end of 2019, these disturbances may represent the final salvage and sanitation treatments that were conducted in this region in 2019 but were not identified through eDaRT processing until the 2020 detection year.

The Project Team was unable to use imagery within Google Earth to view pre-project and post-project conditions for this 2020 detection as the most recent available imagery is from 2018. This represents a minor limitation in conducting a detailed investigation of detected disturbances; in formal project monitoring or evaluation another publicly available imagery source such as National Agriculture Imagery Program (NAIP) imagery or other sources available to administering agencies could be accessed in order to make this type of comparison.

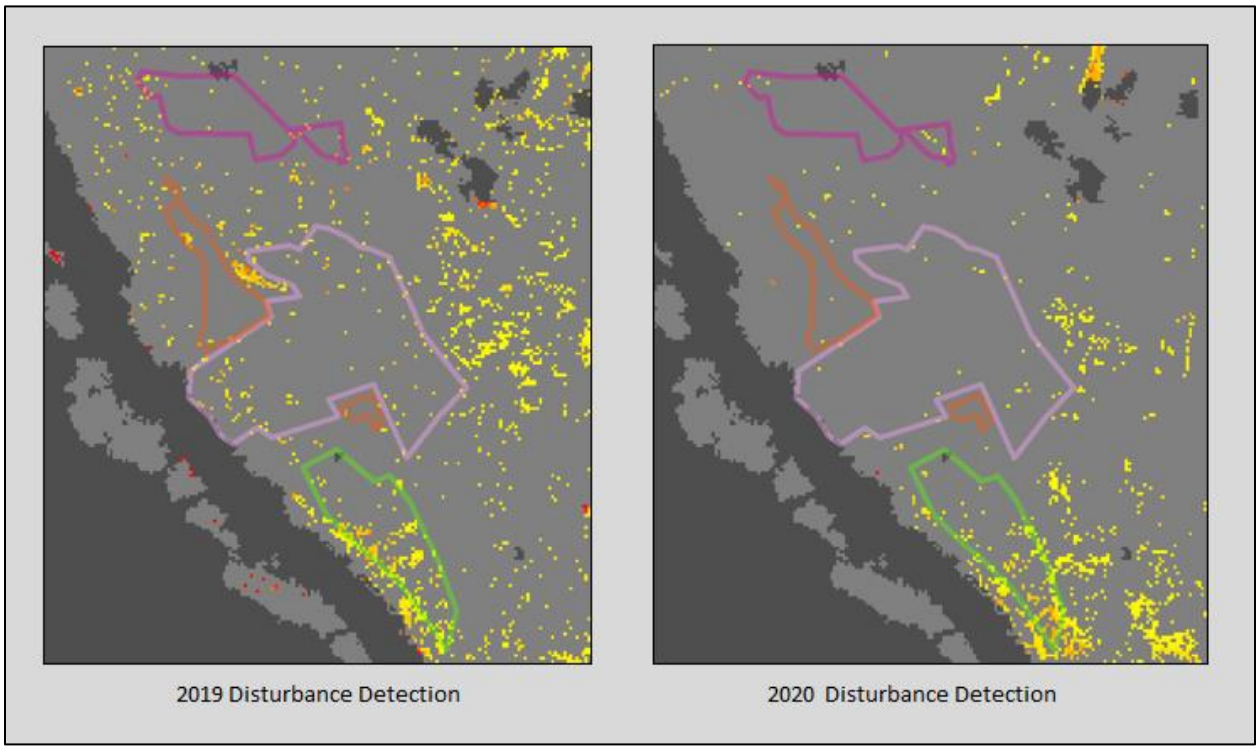

Figure 8-14. Forest Health Project 3 Detected Disturbances, 2019 vs. 2020

Overall, remote observation of this project provided an example of detecting disturbances from both treatment and non-treatment events, but that the presence of urban areas may require alternative disturbance detection approaches. Additionally, complete information regarding the boundaries of treatment sites and the timing and location of treatments would be useful in identifying the specific cause of detected disturbances.

8.5.4. Forest Health Project 4: 2014 Day Fire Restoration, CCIRTS Project ID 8GG14901

This project is categorized as a Watershed Restoration project within the CCIRTS database and involves restoring land affected by the 2014 Day Fire through reforestation on approximately 5,850 acres in Modoc County, CA. The project includes conducting a release treatment in the form of an herbicide spray following reforestation in order to encourage continued growth of seedlings. The project also includes biomass utilization of heavy tree stand areas on approximately 2,000 acres for the purposes of fuels reduction and preparing the area for planting.

This project was funded through 2014-2015 FY funding and CAL FIRE confirmed that the project end date is December 31, 2019. The CCIRTS database lists total Forest Health Program funding as $489,963 with total GHG reductions of 494,969 MTCO2e.

8.5.4.1. Data Collected

Documentation provided by CAL FIRE for this project consisted of the project grant agreement and application document.

8.5.4.2. Activities Conducted

Activities consisted of reviewing the grant agreement and project application to identify any discussion items or considerations for future rounds of POR or Forest Health project evaluation.

8.5.4.3. Results

This section presents the findings from the documentation review for this project.

Review of Forest Health Grant Agreement and Application

The Forest Health application submitted for this project includes a description of the proposed scope of work, details on proposed treatments to be funded by the program, a list of project staff, and an estimated project timeline. The application also includes maps of the project area and supplemental information about the site such as zoning classifications and existing timber harvesting activity.

The scope of work explains that portions of project preparation had already begun at the time of application submission, such as salvage logging in the reforestation areas, purchasing and growing seedlings for planting, and planting a subset of seedlings along watercourse areas in the project sites. The application notes that the project has multiple phases and can be divided into components based on the availability of Forest Health funding.

The application provides a detailed summary of the methodology that was used to calculate carbon sequestration resulting from reforesting efforts. The grantee used a database of site-specific inputs to analyze the area with a Conifers Young Stand Growth Model and assess long-term growth with Forest and Stand Evaluation Environment (FORSEE) software. The description specifies a variety of stipulations and assumptions that were used in these calculations. The GHG calculation methodology also accounts for carbon that would be removed or burned as part of preparing treatment sites using a mobile combustion emissions equation provided by CARB. The grantee subtracted the resulting emissions value from the CO_2 benefits associated with the reforestation effort to estimate the net emission reductions for the project. According to the application, this methodology is in compliance with the CAL FIRE estimation approach that was in place at the time that this project was submitted.

Following the description of the GHG calculation methodology, the application includes a description of proposed post-project evaluation and monitoring of the site. The application indicates that post-planting stocking surveys will be conducted in order to identify any issue areas where additional planting may be needed and to verify the GHG estimates that were calculated at the beginning of the project. According to the project application, these surveys will collect data including seedling counts, live tree characteristics, and information on identified downed wood and snags (dead or dying trees). The application does not specify the length of post-project monitoring.

Overall Grant Agreement and Application Review Findings

Based on the grant agreement and project application review, this project provided detailed information regarding the estimation, monitoring, and reporting of project benefits including GHG emission reductions. The consideration of post-project data collection early in the project planning process suggests that the site will be accessible and receive a form of ongoing evaluation, though the extent to which the grantee would be able and willing to assist with long-term monitoring under specific CARB requirements such as the assessment of POR metrics is not clear based on the information provided.

8.5.5. Forest Health Project 5: Black Mountain Forest & Watershed Restoration, CCIRTS Project ID 8GG15102

This project is categorized as a Fuels Reduction project within the CCIRTS database and involves the implementation of a fuel break through stand thinning on 1,360 acres, and plantation thinning on 494 acres within the Modoc National Forest and private land managed by Shasta Forests Timberlands.[78] The project is intended to reduce the potential mortality effects of wildfires and utilize biomass for electricity generation. The project is also designed to result in co-benefits such as improved forest aesthetics, improved wildlife habitat, improved road access, and improved water quality and availability.

This project was funded through 2014-2015 FY funding and has a completion date of December 31, 2019. The CCIRTS database lists total Forest Health Program funding as $864,780 with total GHG reductions of 13,009 MTCO2e.

8.5.5.1. Data Collected

Data and documentation collected for this project included:

1. Project documentation including the grant agreement and project application, project invoices, and the final project report submitted by the Pit Resource Conservation District; and
2. Project GIS files including shapefiles: CAL FIRE provided shape format (.shp), shape index format (.shx), and attribute format (.dbf) files for the Modoc National Forest and private Shasta Forests Timberlands project areas.

8.5.5.2. Activities Conducted

Activities conducted for this project included:

- **Documentation review:** The Project Team reviewed project documentation including the Forest Health application and final report to gain an understanding of project history, components, and results.
- **Remote sensing observation of project site:** The Project Team received GIS files including a shapefile for this site from CAL FIRE and used eDaRT outputs available for the project area to view disturbances over time and demonstrate the capability of disturbance detection with remote sensing.

8.5.5.3. Results

This section presents the findings from the above activities for this project.

Review of Forest Health Grant Agreement and Application

As with the other sample projects reviewed, the Forest Health application submitted for this project includes a description of the proposed scope of work, details on proposed treatments, and an estimated project timeline. The application also includes supplemental information about the site such as zoning classifications and the certification of the area by the Forest Stewardship Council and notes that these items will not adversely affect project activities.

[78] The project application indicates that stand thinning was to occur on 743 acres and plantation thinning was to occur on 1,228 acres, but these values are updated within the final project report.

The application details the approach used by the grantee to estimate the GHG benefits that will be attributable to the funded fuel reduction activities and utilization of biomass for energy generation purposes. The methodology assesses GHG benefits associated with increased carbon sequestration, avoided wildfire emissions within the treatment area, and avoided wildfire emissions on land adjacent to the treatment area.

For carbon sequestration, the application states that data were used from plots established within each treatment area to model growth within the Forest and Stand Evaluation Environment (FORSEE) software and Forest Vegetation Simulator (FVS) and the methodology specifies various inputs and stipulations that were used in this approach. The application provides a similar level of detail for the approach to calculate avoided wildfire emissions in and adjacent to the treatment area, which also used FVS and simulated fire conditions with FlamMap software. This approach estimates CO_2 emissions in the treatment scenario and counterfactual non-treatment scenario in order to quantify net emission reductions expected for the project.

The GHG estimation methodologies for this project are custom approaches designed by the grantee, which appears to be the case for many projects which occurred prior to the development of Forest Health QM calculators. The availability of QM tools for more recent funding years has reduced the extent to which grantees are responsible for developing their own analysis to estimate project benefits.

The application does not include information regarding a proposed approach for post-project monitoring or evaluation other than stating that both the public and private treatment areas are managed on an ongoing basis for their resource value and that the certification of the Shasta Forest Timberlands area by the Forest Stewardship Council indicates that the property owners are committed to long-term forest management.

Review of Final Report

The final report for this project was prepared by the Pit Resource Conservation District and was completed in December 2019. The report includes narratives detailing the description of the project, accomplishments, and information on the acreage and location of specific project treatments. The report confirms that the project included stand thinning performed on 1,360 acres of private roadways as well as 494 acres of plantation thinning within the Modoc National Forest. These thinning activities were conducted in order to reduce fire hazard and improve growth and health of remaining trees in the area, and the report notes that conducting thinning along private roadways resulted in the creation of a series of fuel breaks in the Shasta Forest Timberlands area. The report provides information on the pre-project and post-project stand conditions in terms of stems per acre as a depiction of the reduction in fuels and overall improvement in stand health.

The report includes a separate section that identifies each of the metrics required by California Climate Investments for fuels reduction projects completed through the Forest Health Program. These metrics include estimates of increased carbon sequestration, GHG emissions resulting from project implementation, avoided GHG emissions from reductions in wildfire risk and from biomass utilization, and an estimate of the overall net GHG benefits achieved by the project.

The report estimates GHG emissions resulting from project activities by applying the CARB mobile combustion emission factor to the total bone dry tons of biomass removed from the site and delivered to local biomass-powered electrical generation facilities. The report also estimates the avoided GHG emissions from the electricity generated with this biomass using the appropriate CARB factor.

For carbon sequestration, the report notes that these are long-term benefits and that they have not yet accrued at the time of reporting. For avoided GHG emissions resulting from wildfires, the report estimates that the removal of forest fuels from treatment sites may have avoided emissions of 34,767.27 MTCO2e if a fire had occurred since these treatments were completed. The report notes that since a fire had not occurred in the area to date, these avoided emissions are not currently included in the net emissions benefit for the project. Overall, the report estimates the net GHG benefit achieved to date as 2,273.61 MTCO2e.

The report also includes a section assessing the project's co-benefits and benefits to disadvantaged communities. The report states that disadvantaged community benefits were accrued as a result of the biomass component of the project which involved the hiring of local contractors and the distribution of wood-energy chips to local power generating facilities. For co-benefits, the report describes a variety of ecological improvements that have resulted from project activities including improved forest aesthetics, wildlife habitat, hunting conditions, air and water quality, protection of existing infrastructure, and improved access to the land for firefighters and recreational use.

In its final narrative section, the report provides an explanation of a change in project scope that resulted from delays in approvals to conduct treatments within the Modoc National Forest project area. Due to these delays, the grantee determined that there was insufficient time to meet the acreage target for thinning treatments within Modoc National Forest and requested an amendment with CAL FIRE to shift the project boundary to include additional acres within the Shasta Forest Timberlands area. Finally, the report notes that a snowstorm which occurred in November 2019 prevented the grantee from completing the chipping of removed trees for biomass utilization. The remaining trees represent 213 acres and the report states that once weather allows, the chipping process will be completed during the 2020 year after the end of the grant period.

The report concludes with a series of maps and photographs depicting the project area and treatments conducted, as well as copies of receipts from the delivery of wood-energy chips to local biomass-powered energy generation facilities. It should be noted that while the quantity of biomass delivered to energy facilities is a required metric under the current POR framework for Forest Health, this requirement currently focuses on long-term biomass infrastructure and is intended to capture biomass utilization that occurs during the outcome period rather than prior to project closeout. The wood-energy chips represented in these receipts would therefore not be reported for the project under the current POR framework.

Overall Final Report Findings

Based on this review, the final report is very detailed and meets the California Climate Investments reporting requirements specified in the grant agreement for this project type. Additionally, the inclusion of details related to changes in project scope assist in providing a complete understanding of the final location and timing of project treatment activities. The report estimates benefits accrued to date at the time of reporting and does not provide a forecast of future benefits that will be attributable to completed project activities. As many of the GHG and ecological benefits resulting from this project would occur over the course of many years, similar analysis and reporting conducted throughout the lifetime of the project could be used to reassess the to-date benefits accrued. However, this would require continued grantee engagement or administering agency resources and is currently outside the scope of project monitoring and POR requirements.

Site Observation and Disturbance Demonstration

CAL FIRE provided GIS shapefiles for this project, and the Project Team observed the Modoc National Forest and Shasta Forest Timberlands treatment areas using eDaRT as further exploration of remote sensing disturbance detection. The shapefiles received from CAL FIRE for this project are displayed overlaid on a satellite image service layer in Figure 8-15.[79] The segments outlined in pink represent the Modoc National Forest treatment area, and the segments outlined in blue represent the Shasta Forest Timberlands treatment area. These shapefiles are in alignment with depictions of the treatment areas within the project application.

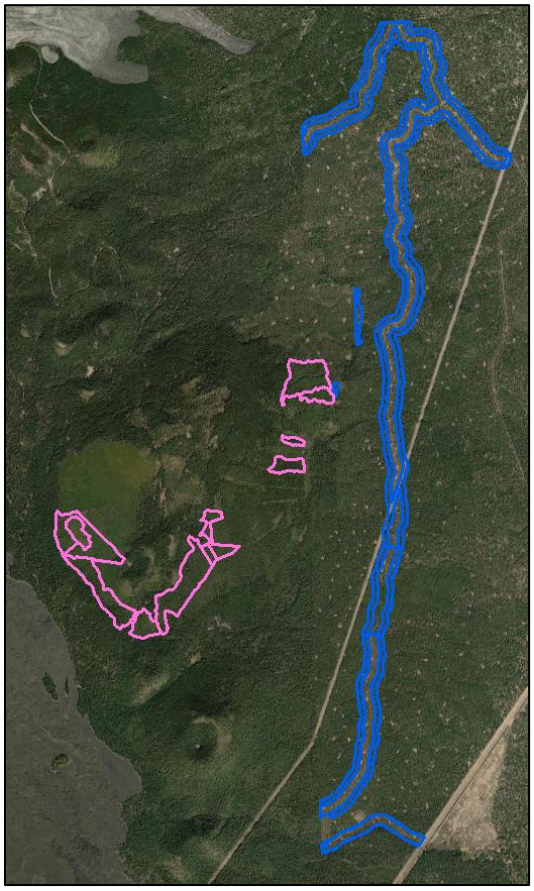

Figure 8-15. Forest Health Project 5 Project Site

Observing the project sites using the yearly eDaRT disturbance layers shows minimal disturbances within these treatment areas for the 2012-2015 detection years prior to project implementation. The project was approved in 2016, and the 2016 disturbance layer shows disturbances that may represent the initial treatment work being conducted in the Shasta Forest Timberlands area. Detected disturbances in the Modoc National Forest for these two years are more minor and scattered, which is consistent with the

[79] Displaying "World_Imagery" service layer. Service layer credits: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

final project report which noted that treatment work was delayed in these areas. Figure 8-16 displays the 2016 year (left image) and 2017 year (right image) disturbance detection layers for all project sites.[80]

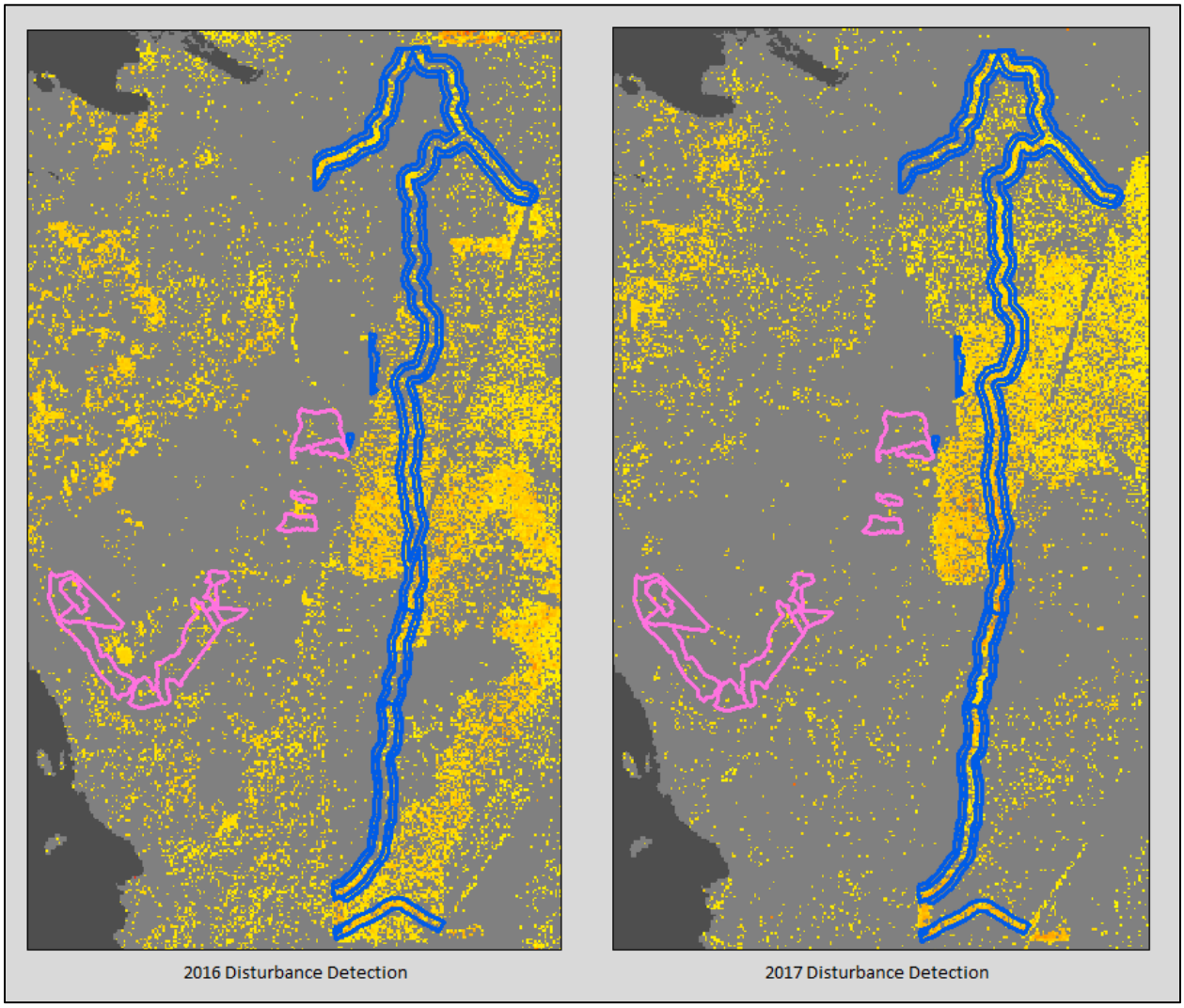

Figure 8-16. Forest Health Project 5 Detected Disturbances, 2016 vs. 2017

To further investigate the disturbances identified for 2017, the Project Team selected a sample treatment area point as displayed in Figure 8-17.[81] This point is located along the network of private roads in the Shasta Forest Timberlands area where project crews conducted fuels thinning, and the MMI estimate for this selected point for 2017 is 33%.

[80] Displaying disturbance layer "mmi_sc301ns_2016.bsq" (left) and "mmi_sc301ns_2017.bsq" (right), as labeled within assessed eDaRT files.

[81] Displaying disturbance layer mmi_sc301ns_2018.bsq.

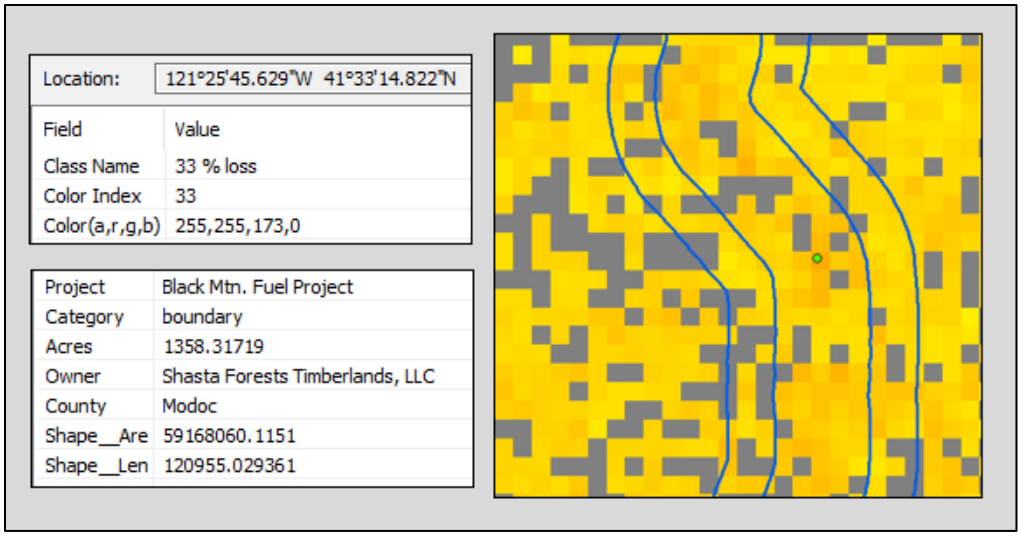

Figure 8-17. Forest Health Project 5 Detected 2017 Disturbances, Enlarged with Selected Point

Viewing the location through historical Google Earth imagery provides insight into the pre-project and post-project conditions that correspond to the detection of a disturbance at this sample site. Figure 8-18 displays the area around this selected point as observed through imagery from 2014 (left image) and 2017 (right image). These images do not clearly show fuels reduction in the surrounding forest area, but the 2017 image shows evidence of timber piles that were not present in 2014, which were presumably a result of the treatment activity during this period.

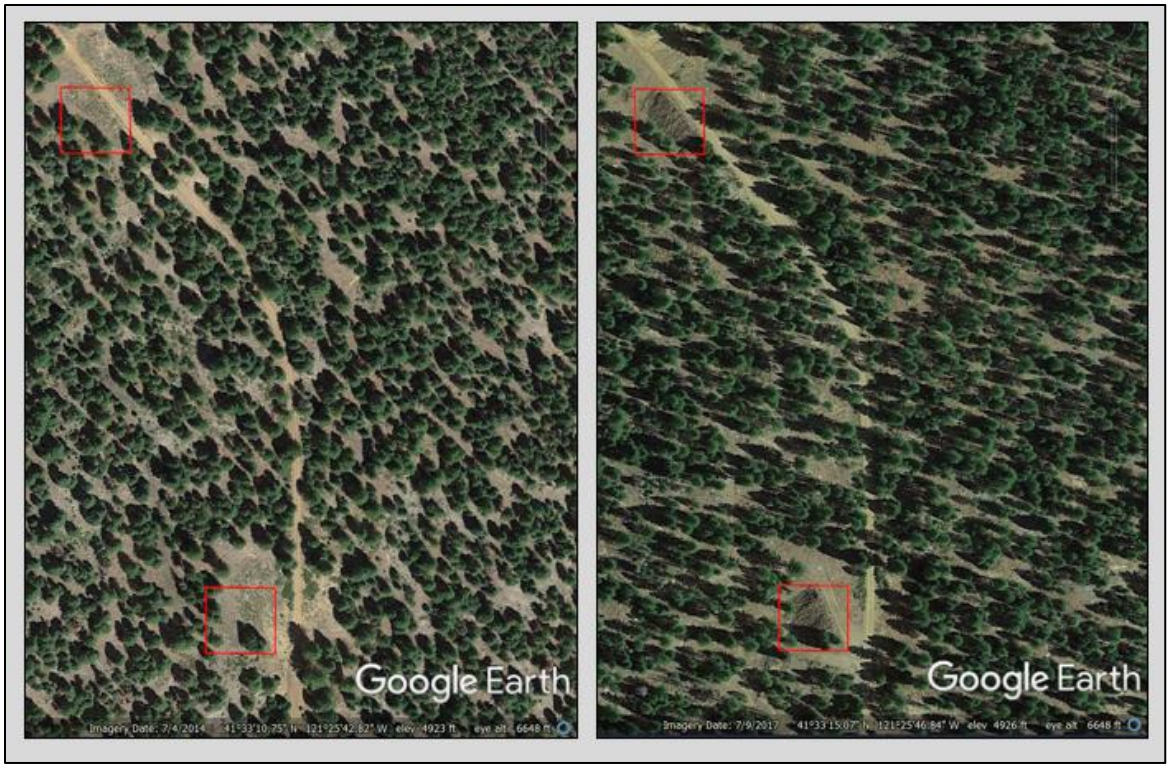

Figure 8-18. Forest Health Project 5 Google Earth Imagery for Area of Interest, 2014 vs. 2017

The 2018 disturbance layer as displayed in Figure 8-19 indicates the greatest level of disturbances in the project sites among all years observed through eDaRT as part of this exercise.[82] This detection year shows substantially increased disturbances within the Modoc National Forest area and continued moderate to major disturbances within the Shasta Forest Timberlands area, likely corresponding to fuels thinning in both locations. The disturbance activity for Modoc National Forest appears to align with treatment area boundaries in some locations but the surrounding land shows similar levels of disturbances, suggesting that treatments may have been extended outside of the perimeter represented by project shapefiles.

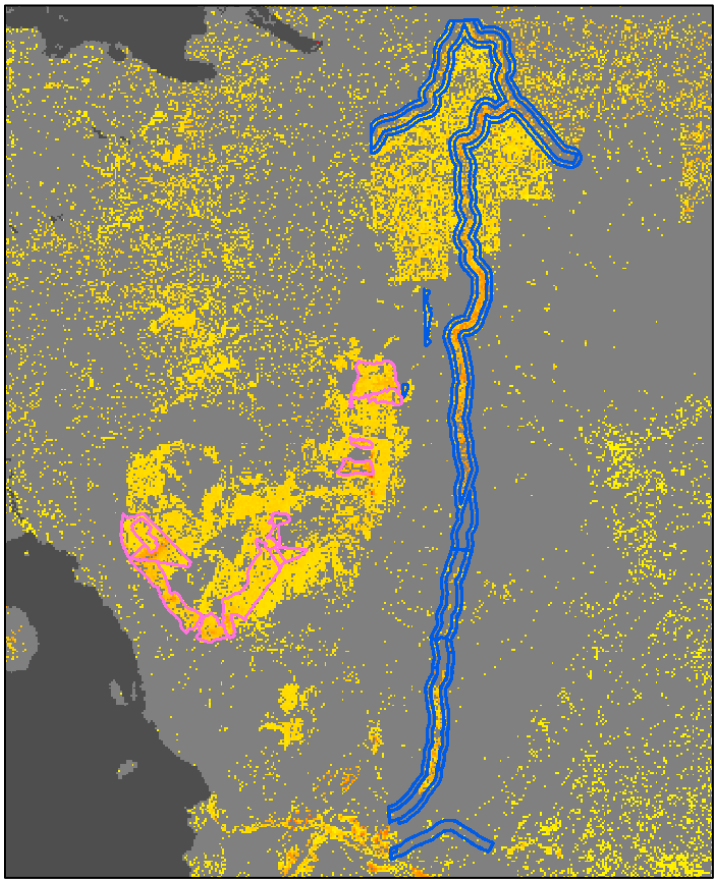

Figure 8-19. Forest Health Project 5 Detected 2018 Disturbances, Full Project Area

The 2019 disturbance layer shows continued activity in both the Modoc National Forest and Shasta Forest Timberlands treatment areas (Figure 8-20).[83] One distinction between the appearance of Shasta Forest Timberlands disturbances for 2018 and 2019 is that the 2019 disturbances align closely with the boundaries of the treatment area on either side of the roadways in this region. This may correspond to final clearing efforts and activities related to establishing the roadside fuel breaks as mentioned within the project description and final report. The 2019 year was the most recent period of imagery processed by eDaRT at the time of this exercise.

[82] Displaying disturbance layer "mmi_sc301ns_2018.bsq" as labeled within assessed eDaRT files.

[83] Displaying disturbance layer "mmi_sc301ns_2019.bsq" as labeled within assessed eDaRT files.

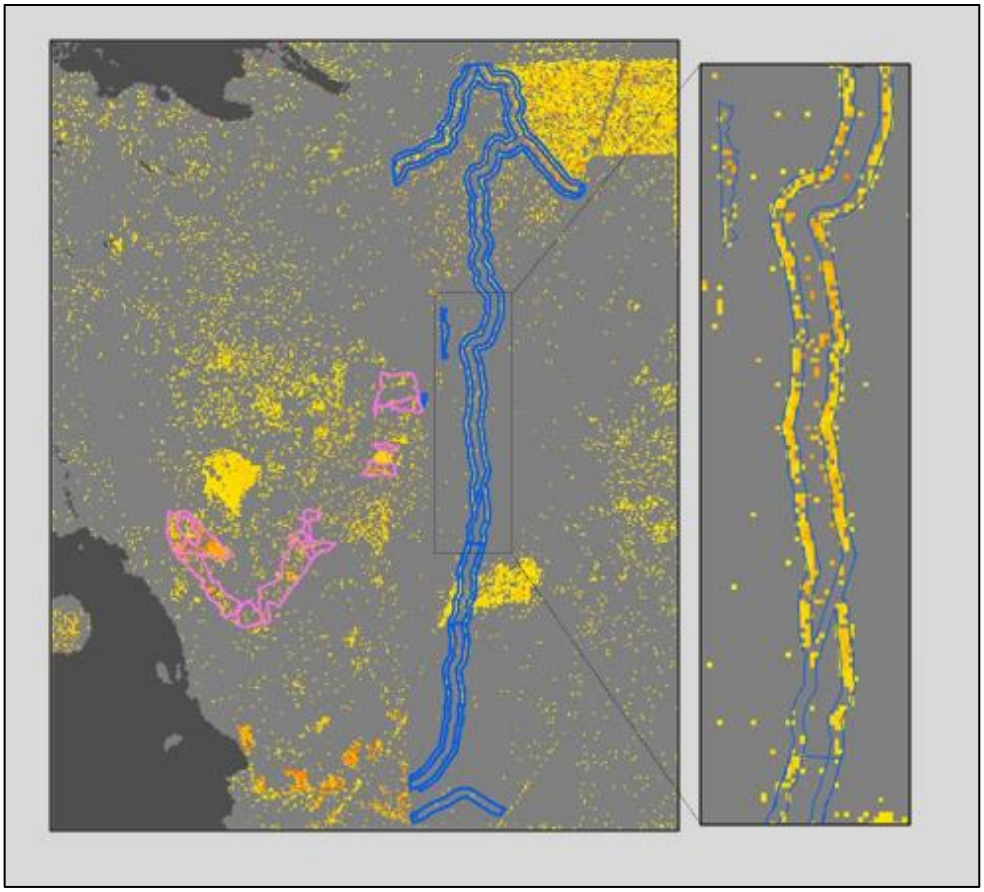

Figure 8-20. Forest Health Project 5 Detected 2019 Disturbances, Fuel Break Treatment Activity

This observation did not include viewing satellite imagery for a sample point within the Modoc National Forest for the pre-project and post-project period, as project treatments in this region began in 2017 or 2018 and the most recent available Google Earth imagery for this site is from 2017. The Project Team was able to use the semi-transparent eDaRT layers to provide an overall depiction of pre-project and post-project activity within this area. Selecting and overlaying semi-transparent disturbance layers for multiple years allows eDaRT to represent the accumulated disturbances for a multi-year period. Figure 8-21 displays the accumulated disturbances in Modoc National Forest for the 2010-2015 pre-project period, as well as for the 2016-2019 period that corresponds with the timing of project treatments.[84]

This shows that the accumulation of disturbances in this area was fairly minimal prior to project treatments, but that disturbances were concentrated within the boundaries of the treatment area throughout the course of the project, as would be expected. As noted previously, the disturbances during the project period align closely with the perimeter of the shapefiles in some areas but there also appear to be consistent disturbances surrounding certain areas of these boundaries which may correspond to additional treatment activity.

[84] Displaying semi-transparent disturbance layers as follows: 2010-2015 Disturbance Detection: "o.mmi_sc301ns_2010", "o.mmi_sc301ns_2011", "o.mmi_sc301ns_2012", "o.mmi_sc301ns_2013", "o.mmi_sc301ns_2014", "o.mmi_sc301ns_2015" as labeled within assessed eDaRT files; 2016-2020 Disturbance Detection: "o.mmi_sc301ns_2016", "o.mmi_sc301ns_2017", "o.mmi_sc301ns_2018", "o.mmi_sc301ns_2019", as labeled within assessed eDaRT files.

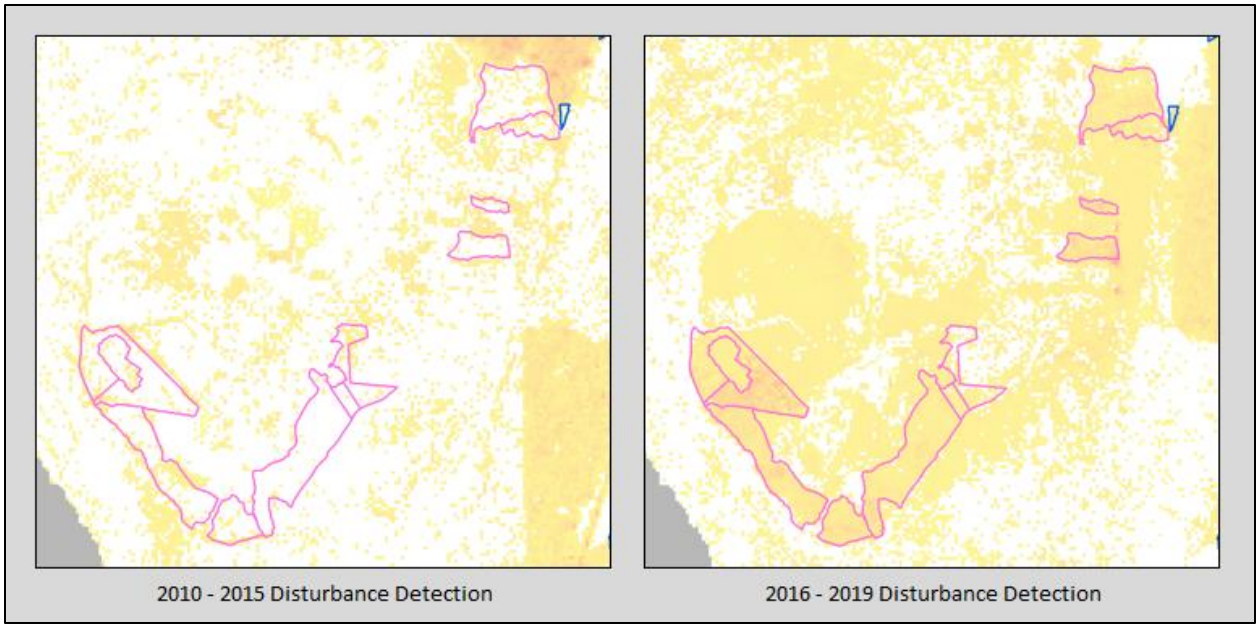

Figure 8-21. Forest Health Project 5 Cumulative Disturbances, 2010-2015 vs. 2016-2020

Based on the remote observation conducted as part of this project review, automated disturbance detection is able to identify patterns of disturbances that can be linked to specific phases of treatment activity and can serve as a method of locating areas of interest within project sites for subsequent inspection or analysis. Additionally, detailed project documentation provides crucial contextual information that assists in explaining the likely origin of detected disturbances.

While the primary focus of this data collection effort is POR and consideration of project evaluation in the outcome period, this assessment encountered limitations due to the timing of project completion and the availability of processed disturbance layers for the period following the project. The observation of project treatment disturbances is intended to provide an example of disturbance detection which could be similarly applied to non-treatment disturbances in the outcome period. Practical application of this approach would be needed in order to determine the effectiveness of automated disturbance detection in collecting information to support the assessment of POR and related metrics.

8.5.6. Forest Health Project 6: Mt. Shasta Headwaters Forest Health and Resilience Project: Phase 1 – Black Butte, CCIRTS Project ID 8GG17604

This project is categorized as a Landscape Scale Health/Forest Legacy project within the CCIRTS database and involves fuels reduction, biomass utilization, installation of a fuel break, and the implementation of a conservation easement in Siskiyou County, CA. The conservation easement covers approximately 5,000 acres and is intended to achieve GHG benefits through avoided residential development and increased carbon sequestration through regulation of timber harvesting. The shaded fuel break is on 40 to 60 acres and connects to an existing fuel break to protect areas outside of the project boundary.[85] The project includes fuels reduction through thinning approximately 450 acres of pine plantation stands.

This project was funded through 2016-2017 FY funding and has an easement closing date of December 27, 2018. Project progress reports indicate that the fuel break and fuels thinning occurred after this date, with treatments continuing through the grant end date of March 30, 2020.

The CCIRTS database lists total Forest Health Program funding as $5,481,904 with total GHG reductions of 4,102 MTCO2e.

8.5.6.1. Data Collected

Data and documentation collected for this project included:

1. Project documentation including the grant agreement, project application, progress reports, and an annual monitoring report completed in 2020 by the Pacific Forest Trust (PFT); and
2. Project GIS files for the conservation easement, fuel break line, and specific management zones within the project area.

8.5.6.2. Activities Conducted

Activities conducted for this project included:

- **Documentation review:** The Project Team reviewed the annual monitoring report to assess the states of the project site in the outcome period, and also reviewed documents including the project application and progress reports to gain an understanding of project history and components.
- **Remote sensing observation of project site:** The Project Team received GIS files including a shapefile for this site from CAL FIRE and used eDaRT outputs available for the project area to view disturbances over time and demonstrate the capability of disturbance detection with remote sensing.

8.5.6.3. Results

This section presents the findings from the above activities for this project.

[85] The project application indicates that the fuel break will be installed on 40 acres, but later communications with CAL FIRE in March of 2019 indicated that the project contractor planned to increase the area of this component by 10 to 20 acres.

Review of Forest Health Grant Agreement and Application

This project involves multiple components including fuels thinning, biomass utilization, and the establishment of a conservation easement. The project application provides detailed qualitative and quantitative information about the project site, proposed treatment activities, and expected GHG reductions and other benefits.

The application includes a complete summary of the inputs used to calculate GHG benefits for the project activities and presents screenshots of all Forest Health QM fields for each project component. The GHG benefits and other QM tool outputs resulting from these calculations match the metrics provided by the grantee in other areas of the project documentation.

Regarding project monitoring, the application states that conservation easement monitoring will be coordinated by the Pacific Forest Trust (PFT) and that PFT will provide monitoring reports on an annual basis, as required. Additionally, the application notes that Michigan-California Timber Co. (MCTC) will conduct ongoing maintenance for the fuel break and fuels thinning components of the project. Maintenance activities to be conducted by MCTC include applying herbicide applications to the fuel break every five years, and managing regulatory compliance, contract administration, and annual monitoring and reporting related to the fuels thinning and biomass utilization project component.

The application concludes with several maps of the project site to depict information such as the property boundaries, proposed conservation easement and fuel break areas, zoning and ownership of surrounding areas, and special habitat management zones.

Overall Grant Agreement and Application Review Findings

As with the other sampled Forest Health projects, this application is thorough and meets the detailed requirements that are in place for this program. The inclusion of QM inputs and results within the project application provides transparency regarding the basis for GHG benefits and other parameters, and language in the application suggests that the grantee provided the full QM workbook to CAL FIRE as part of the project package. Retaining this information and any subsequent updates throughout the duration of POR may provide valuable context during the years following project implementation. Additionally, the QM workbooks could allow for potential comparisons between expected and verified benefits by adjusting QM inputs based on measurements and observations taken during the outcome period. This type of benefits validation is outside the scope of the current POR framework but is noted by the Project Team as an activity that could be included as part of a future expansion of California Climate Investments evaluation protocols.

Review of Progress Report

CAL FIRE provided three sample progress reports submitted by the grantee for this project. The dates of submission for these progress reports are December 19, 2018; May 15, 2019; and July 30, 2019. Each progress report details updates related to the fuels thinning, fuel break, and conservation easement project components, and the latest progress report from July 2019 describes the biomass utilization activities conducted on-site including total thinning acreage and biomass tonnage removed. The progress reports indicate the total California Climate Investments dollars and matching funds expended for the reporting period as required.

Forest Health progress reports include fields for grantees to provide qualitative information on project activities including overall status as well as any setbacks and challenges. The December 2018 report

provides information about the fuel break and fuels thinning planning process and summarizes progress related to the site appraisal and baseline report that were required in order to establish the conservation easement. This report estimates that the conservation easement will be finalized by the end of the 2018 year. The December 2018 progress report also notes that the fuels thinning activities may not be completed by the March 30, 2020 end date of the grant, and copies of accompanying email communications provided by CAL FIRE indicate that CAL FIRE authorized the grantee to complete the thinning work after this date.

The May 2019 progress report states that the fuel break was completed in March 2019 and that project crews conducted plantation thinning on 418 acres. This progress report also provides a copy of the Habitat Enhancement Plan that was developed as part of the conservation easement as well as a press release announcing the establishment of the easement, which was finalized as planned in late 2018.

The July 2019 progress report indicates that the fuel break had been completed and that the thinning activities represented the final task to be completed under the grant and were nearly complete at the time of that report.

Overall Progress Report Findings

As with other Forest Health projects reviewed as part of this assessment, the progress reports submitted by the grantee are fairly thorough and provide information that is useful for verifying the progress and completion of project tasks. Additionally, for monitoring activities such as remote disturbance detection, an understanding of the timing, scope, and any changes related to planned project activities can be essential in distinguishing treatment-related disturbances from non-treatment disturbances.

Review of Annual Monitoring Report

CAL FIRE confirmed that the closing date of the conservation easement was December 27, 2018. Based on the current POR framework for Forest Health, the first annual outcome period for the conservation easement component of the project would be defined as December 26, 2018 through December 25, 2019. The monitoring report provided to the Project Team describes the results of a monitoring visit conducted by PFT on June 19, 2020, which was the first monitoring visit conducted for this project.

The monitoring report contains a section relating to remote sensing of disturbances on the property and indicates that PFT conducted a review of NAIP imagery and did not identify any disturbances or visible changes in the land area. The report also indicates that Pacific Forest Trust conducted an interview with the landowner in February 2020 prior to the site visit but does not specify the purpose or results of this interview.

The monitoring report provides a detailed description of the path traveled during the site visit and references photos that were taken at various points during the visit. This description includes qualitative information about observations that the monitoring group made during the visit. For example, the report states that the monitoring group observed that the removal of conifers and shrubs in one area has increased fire resilience and improved the habitat of a large meadow area, which is consistent with the objectives of the property's Habitat Enhancement Plan (HEP). The monitoring group also observed the status of a thinned plantation stand along the western property line and viewed an untreated portion of the fuel break on the property boundary. Additionally, the monitoring report documents observations of biomass harvesting, other thinning areas, and various characteristics indicating a healthy forest canopy.

The report refers to a planned installation of a headgate structure on a culvert in the Black Butte Springs area of the property that will replace a temporary headgate to allow for improved water withdraws. The report states that while all parties have approved of this installation, PFT staff should conduct a follow-up visit to observe the headgate during the next annual monitoring period.

The monitoring report contains a list of conservation easement restrictions and includes fields to indicate whether a potential violation of any of these restrictions was observed during the monitoring visit. The report shows that no potential violations were observed for any of the listed restrictions and states that there were no additional notable disturbances or observations that would impact the conservation value of the land.

The report contains a photo showing of one of the biomass utilization areas that was funded by the Forest Health program. The monitoring report does not include biomass documentation such as weight receipts but estimates that 26 bone-dry tons per acre were removed from this thinning area.

In its conclusion, the report states that there are no outstanding issues to address during the next monitoring year but encourages the landowner to continue implementing the HEP which includes a prescribed fire component. The report also states that PFT should coordinate with the landowner at the end of the year to assess the extent to which timber harvest volumes have been depleted as a result of the timber harvesting plan (THP) that is currently facilitating logging activity in the easement area.

Overall Monitoring Report Findings

Overall, the monitoring report indicates that no significant issues or concerns were identified during this monitoring visit and suggests that the land continues to be managed in accordance with the terms of the conservation easement. The information in this report would be sufficient to complete this verification metric for conservation easements under the current POR framework. Regarding the status of ecological factors, the monitoring report observations regarding increased resilience and improved meadow habitat could be reported as qualitative POR findings to convey to the effect of project improvements.

Site Observation and Disturbance Demonstration

The Project Team monitored the project site with eDaRT layers as an example of remote sensing disturbance detection. Figure 8-22 displays the shapefiles received from CAL FIRE for this project, overlaid on a satellite image service layer.[86] The shapefiles match the project areas and property boundaries depicted in the application and other project documentation.

[86] Displaying “World_Imagery” service layer. Service layer credits: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

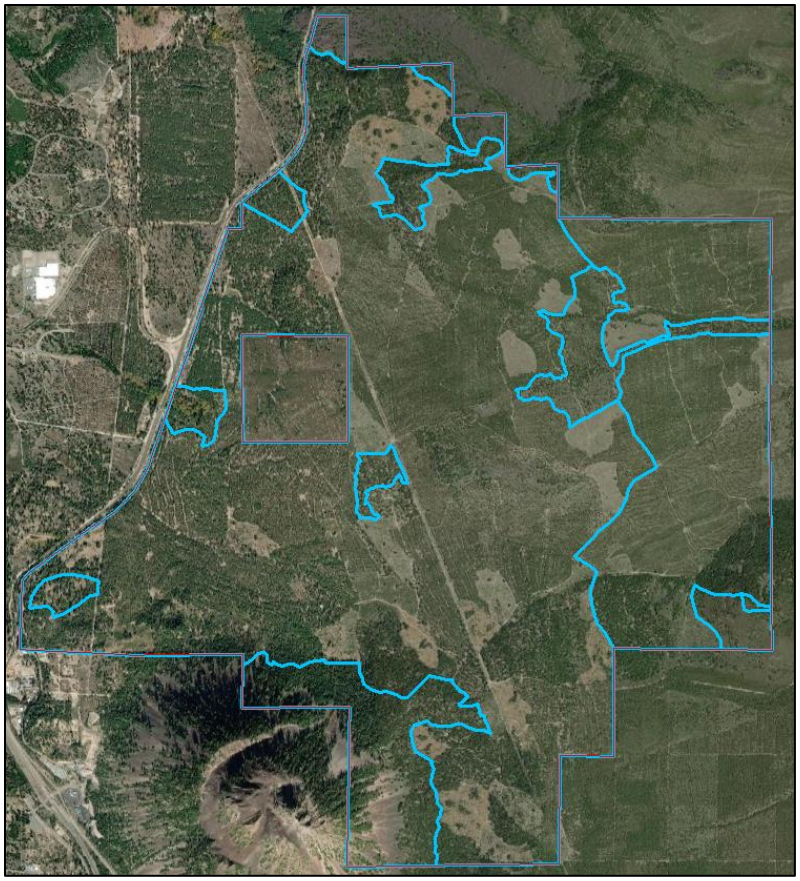

Figure 8-22. Forest Health Project 6 Project Site

As the conservation easement component of this project was finalized in 2018 but the treatment activities such as fuels thinning continued into 2020, the available eDaRT disturbance layers coincide with the project implementation period rather than the outcome period. However, observing the site across multiple annual disturbance layers during this time provides insight into project progress and other possible events.

Figure 8-23 displays the project site as viewed with the 2017, 2018, 2019, and 2020 eDaRT disturbance layers.[87] Based on the timing of reported project activities, the 2017 disturbance layer shows the project site prior to the implementation of treatment efforts. The 2018 disturbance layer shows several concentrated areas of disturbance events which appear to correspond to project activities. The detected events along the upper left boundary of the property align with the planned location for the funded fuel break, and the larger areas of disturbance in the lower right portion of the property align with the planned boundaries for major MCTC forest thinning efforts. The 2019 layer shows continued disturbance events in these areas with higher MMI estimates, coded in red, in some locations. This layer also shows disturbances corresponding to the implementation of the southern fuel break on the lower left boundary of the property.

[87] Displaying the following layers, as labeled within assessed eDaRT files: 2017 Disturbance Detection: "mmi_sc103nc_2017.bsq"; 2018 Disturbance Detection: "mmi_sc103nc_2018.bsq"; 2019 Disturbance Detection: "mmi_sc103nc_2019.bsq"; 2020 Disturbance Detection: "mmi_sc103nc_2020.bsq".

The 2020 disturbance layer shows major disturbance events in many areas of the map, representing the greatest degree of disturbances for all years included in this observation. Some of these disturbances correspond to treatment boundaries depicted on project planning maps, though several areas do not appear to be identified for treatment within the available project documentation.

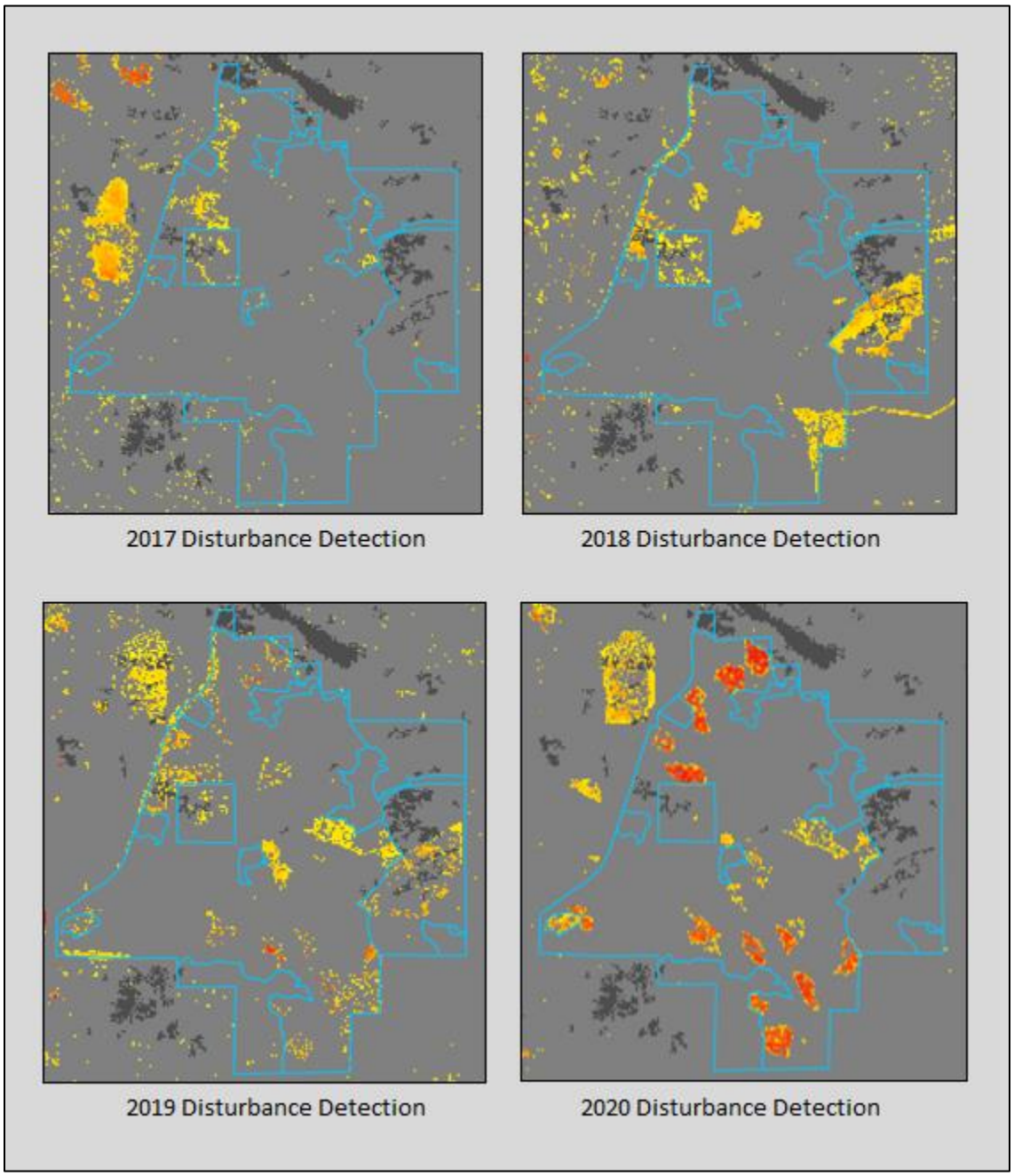

Figure 8-23. Forest Health Project 6 Detected Disturbances, 2017-2020

Figure 8-24 displays an enlarged portion of the 2020 disturbance layer overlaid on a satellite image service layer, with the corresponding eDaRT MMI estimate for a sample point.[88] The MMI estimate for this sample

[88] Displaying semi-transparent layer "o.mmi_sc103nc_2020.bsq" as labeled within assessed eDaRT files, overlaid on "World_Imagery" service layer.

point corresponds to 91% canopy loss, which according to the eDaRT developer typically suggests complete tree removal. The annual monitoring report completed in 2020 provided photos of timber harvesting conditions, pest-related mortality patterns, and forest thinning impacts. The high MMI estimates for various areas in the 2020 disturbance layer suggest that these events are related to complete tree removal through harvesting.

The Project Team was not able to view historical satellite imagery for this site in order to gain further insight into pre- and post- conditions, as the most recent available Google Earth image is from 2017. Specific information about harvesting locations and ongoing treatments would be needed in order to determine which disturbance areas correspond with timber harvesting plans, whether certain regions represent additional fuels thinning conducted by MCTC during 2020, and whether other types of disturbance events are being detected for this period.

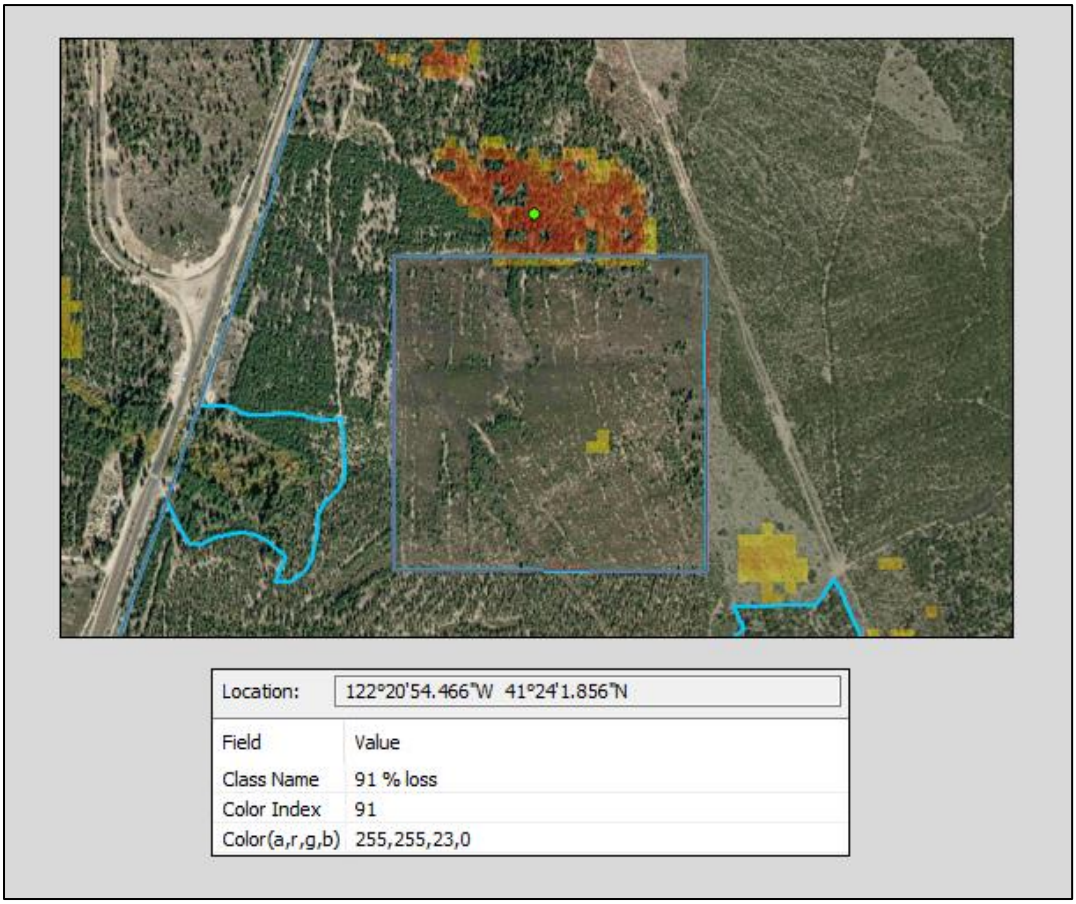

Figure 8-24. Forest Health Project 6 Detected 2020 Disturbances, Enlarged with Selected Point

Overall, remote observation of this site provides an example of disturbance detection for a project with multiple separate components and ongoing activities. Project documentation provides necessary information for distinguishing between different types of disturbance causes, such as fuel breaks compared to fuels thinning or harvesting. More detailed documentation, an in-depth understanding of the site, or high resolution historical imagery would be necessary in order to fully characterize and distinguish disturbances during the project implementation and outcome periods.

8.5.7. Forest Health Project 7: Circle U Ranch, CCIRTS Project ID 8GG14308

This project is categorized as a California Forest Improvement Program (CFIP) Reforestation project within the CCIRTS database and involves restoring land affected by the 2014 Eiler Fire through reforestation by planting approximately 25,000 trees on 118 acres in Shasta County, CA.[89] The project includes treating the area with an herbicide spray both to prepare the site for planting and 1-2 years after planting to control competing vegetation and encourage tree growth.

This project was funded through 2014-2015 FY funding and has a grant end date of December 31, 2019, though the final invoice for the project was submitted on July 17, 2018. The CCIRTS database lists total Forest Health Program funding as $99,959 with total GHG reductions of 11,550 MTCO2e.

8.5.7.1. Data Collected

Documentation received from CAL FIRE for this project consisted of project records including the project grant agreement, application, invoices, and final closeout report submitted to CAL FIRE.

8.5.7.2. Activities Conducted

Activities conducted for this project included a review of documents received from CAL FIRE for this project such as the application and closeout report to gain an understanding of project components and identify any evaluation-related findings that may serve as considerations for future rounds of POR.

8.5.7.3. Results

This section presents the findings from the documentation review for this project.

Review of Grant Agreement and Project Application

This project was funded through the California Forest Improvement Program (CFIP) in the 2014-2015 fiscal year, and program QM calculators were not in place at that time for this project type. The application summarizes the GHG calculation methodology for the project, which used site-specific stand information to create a growth model and assess the site within the USFS CONIFERS growth simulator and USFS FORSEE software. The application notes that this methodology uses equations approved by the CARB Forest Project Protocol. The calculation subtracts biomass removed as part of site preparation in order to estimate net carbon sequestration of 13,702 MTCO2e resulting from the project.

The application provides narrative regarding the overall value of the project and co-benefits associated with reforestation including reduced fire risk and increased species diversity. The application does not specify proposed post-project monitoring or evaluation procedures but indicates that a management plan will be developed as part of project implementation. CFIP guidelines indicate that a management plan must be submitted and approved prior to the beginning of treatments.

Overall Grant Agreement and Project Application Review Findings

Overall, the content and detail in this grant agreement and application are less extensive than that of other reviewed Forest Health projects, but this may be due to this project being part of an older funding

[89] The project application indicates that reforestation will occur on 118 acres, but this value is revised to 99 acres in the final project report that was submitted to CAL FIRE and is shown as 108 acres in the final invoice.

process within CFIP that predated the existence of QM tools and other requirements. The application includes sufficient details to convey the purpose, scope, expected benefits, and other project details.

Review of Final Report and Invoices

The final report was submitted by the grantee on April 1, 2020 after the end of the grant term, which ended on December 31, 2019. This report states that the project treated 99 acres, planted 24,750 trees, and expended $90,351 in CAL FIRE funds. The acreage value varies from the value of 108 treated acres which is indicated in the final project invoice. Additionally, the final report expenditure value of $90,351 does not precisely match the total project cost of $99,959 which is shown in the final invoice.

The final report details the treatments and associated costs for each phase of the project, including developing a land management plan, providing site supervision and preparation, tree planting, and conducting the herbicide release. Several invoices also provide an edited version of the project site map which indicate the specific areas that were treated during the reporting period.

In the final report section outlining co-benefits of the project, the report states that the treatments will help to reduce fire risk, improve wildlife diversification and aesthetics, and contribute to economic benefits as a result of jobs provided to site staff. Regarding long-term management, the report notes that the landowners are committed to forest management and that they will continue to be active in on-site timber management and farming efforts. From this information it is not clear whether any specific data collection activities will take place in the years following project implementation, though a stated commitment to forest management suggests that the landowners may be willing to cooperate with possible subsequent monitoring efforts if the site were to be selected for POR or other evaluation.

This project was from the 2014-2015 funding cycle, and at that time the program did not require grantees to submit GIS files in order to be approved for funding. CAL FIRE staff noted that these projects did typically submit maps of the project site and that these maps could be digitized into shapefiles if needed. The final report for this project includes a PDF map of the project treatment areas and overall property.

Overall Final Report and Invoice Review Findings

Based on this review, the final report for this project appears to meet program requirements and provide information that may be needed for POR purposes, though there appear to be minor discrepancies between the final report and the final project invoice.

8.6. Key Data Collection and Analysis Findings

This section presents overall findings from reviews of CAL FIRE and project documentation, discussions with agency staff and subject matter experts, and assessments of remote sensing data collection and site observation:

- **The CAL FIRE monitoring manual is a valuable resource for POR and may serve as an example for other agencies and programs.** Through discussions with Forest Health program staff and review of the draft CAL FIRE project monitoring manual, the Project Team found that CAL FIRE has a thorough proposed monitoring protocol and plan for assessing the metrics that are required under the current POR framework. The project monitoring manual provides guidelines for project sampling, data collection, and reporting of each metric, and at the time of the agency interviews Forest Health staff indicated that they were preparing to sample their first subset of projects to be monitored using this approach. Overall, the CAL FIRE manual represents an in-depth monitoring approach that incorporates best practices such as representative and random sampling, the use of control areas

for comparison, and collection of a wide range of metrics that provide insight into the status of project areas. CAL FIRE appears to be well positioned to complete the data collection and reporting of required POR metrics.

The approach proposed by CAL FIRE may serve as an example for other California Climate Investments natural resources programs that are developing their monitoring protocols. Additionally, administering agencies for other program types may benefit from a similar process of developing data collection and reporting procedures for the POR metrics applicable to their projects. It should be noted that the expertise and resources required for these approaches may extend beyond the current capabilities of some administering agencies, who may require training and support from CARB in order to develop a similar monitoring process.

- **CAL FIRE currently collects thorough documentation detailing the final status of completed projects and updated GHG estimates.** Forest Health grantees are required to complete progress reports for CAL FIRE which contain information on all activities conducted to date and provide updates on metrics such as the number of trees planted, number of acres treated, and associated GHG estimates. Through this process, CAL FIRE is able to confirm the final status of projects and is notified of any differences between the planned project and implemented project. This level of project verification is informative, improves the ability of POR data to provide insight into project accomplishments, and may serve as an example for other California Climate Investments programs.

  The Project Team found that the content and level of detail within project documentation varied for some older projects. For example, there were instances where a post-project monitoring and evaluation plan was required by the grant agreement but was not included in the project application. This does not appear to be an issue for more recent projects, where the implementation of standard QM tools and updated program guidelines appear to have improved the consistency and completeness of project documentation overall.

- **Annual monitoring reports are sufficient to serve as the primary source of currently required POR metrics for conservation easements.** The annual monitoring reports completed for conservation easement projects appear to be highly detailed and contain a variety of information on the management status and ecological changes occurring within project sites. These reports can be used to verify that the land is being managed in accordance with the terms of the conservation easement, and also to track key ecological factors as identified by project monitors. While there are differences in the format and content of each monitoring report, the examples that the Project Team reviewed as part of the data collection sample were thorough and appeared to be tailored to the specific objectives and monitoring goals of each project.

- **High quality remote sensing imagery is available from proprietary sources but would involve ongoing costs.** As part of the data collection process, the Project Team assessed the availability of high resolution imagery from companies such as Planet to determine whether this could serve as a resource for POR purposes. Planet is a geospatial imaging company that operates a fleet of satellites which continually collect detailed imagery of the earth's surface. The resolution of collected imagery ranges from a ground sample distance of 6.5 meters for its RapidEye satellites to as low as 0.72 meters for multispectral imagery from its SkySat satellites.[90] The available resolution of this proprietary imagery is much more precise than that of publicly available sources such as Landsat, which currently provides 30-meter spatial resolution.[91] This type of imagery is also updated more

[90] Planet, "Planet Imagery Product Specifications," (February 2021), https://assets.planet.com/docs/Planet_Combined_Imagery_Product_Specs_letter_screen.pdf

[91] NASA Landsat Science, "Landsat 8 Overview," https://landsat.gsfc.nasa.gov/landsat-8/landsat-8-overview

frequently than NAIP imagery, which is typically collected less than annually.[92] While this level of detail and frequency could allow for more precise assessment of metrics such as tree mortality and scale of disturbances, access must be purchased. This would likely involve an ongoing subscription-based license, and these costs may be prohibitive unless CARB or administering agencies have available funds for POR data collection or organizational needs for this imagery outside of POR.

- **Quantitative analysis of imagery requires remote sensing expertise.** In addition to the challenge of acquiring detailed imagery on a frequent basis, analytical requirements may serve as a barrier to using this type of imagery for POR or other evaluation and monitoring efforts. Researchers have used high spatial resolution satellite imagery to conduct studies on land cover change and tree mortality.[93] Similar studies conducted for Forest Health project sites may provide valuable insight into project outcomes. These types of in-depth studies have required the development of a tailored analytical approach to assess specific metrics and research objectives.

  While manual observation of detailed imagery collected from sources such as Planet or through aerial flyovers could be used to qualitatively assess disturbances or conduct limited tree counts, systematic quantification of metrics such as tree mortality rates may involve an in-depth image processing stage and subsequent statistical analysis.[94] These types of tasks could be completed by remote sensing labs within government or academic institutions, other private labs, or expert staff within administering agencies, if available. Based on discussions with CARB and administering agencies, the resources or expertise required to conduct advanced remote sensing imagery analysis may not be available on a consistent basis for POR purposes.

- **Drone-based surveying may serve as a useful tool in project monitoring if agencies develop standard protocols and technical resources.** As part of reviewing available remote sensing resources, the Project Team met with researchers at the UC Davis Department of Plant Sciences who are involved in forest research using aerial drones. Researchers have used imagery collected with drones to map forests and construct three-dimensional models of sites with algorithms that identify and classify individual trees, providing visualizations similar to those achievable with laser-scanned Light Detection and Ranging (LiDAR) data. UC Davis researcher feedback indicated that these models could be combined with available software packages and algorithms to analyze metrics such as tree mortality rates and the presence of disturbances in a sample site over time.[95]

  Preliminary estimates for this process are that full mapping of over 300 hectares of land, including using a single drone for data collection and analyzing the data to model the site, could be completed

[92] United States Geological Survey: Mapping, Remote Sensing, and Geospatial Data, "How often is orthoimagery in The National Map updated and what are the acquisition dates?," https://www.usgs.gov/faqs/how-often-orthoimagery-national-map-updated-and-what-are-acquisition-dates?qt-news_science_products=0#qt-news_science_products.

[93] Steven R. Garrity et al., "Quantifying Tree Mortality in a Mixed Species Woodland Using Multitemporal High Spatial Resolution Satellite Imagery," *Remote Sensing of Environment* 129 (February 15, 2013): 54–65, https://doi.org/10.1016/j.rse.2012.10.029.;

M. F. McCabe et al., "CubeSats in Hydrology: Ultrahigh-Resolution Insights Into Vegetation Dynamics and Terrestrial Evaporation," *Water Resources Research* 53, no. 12 (2017): 10017–24, https://doi.org/10.1002/2017WR022240.

[94] Arjan J. H. Meddens, Jeffrey A. Hicke, and Lee A. Vierling, "Evaluating the Potential of Multispectral Imagery to Map Multiple Stages of Tree Mortality," *Remote Sensing of Environment* 115, no. 7 (July 15, 2011): 1632–42, https://doi.org/10.1016/j.rse.2011.02.018.

[95] For example, the ForestTools package for R software is used to analyze remotely sensed forest data: https://cran.r-project.org/web/packages/ForestTools/

in approximately five days with the proper equipment and expertise.[96] This suggests that one benefit of a drone-based monitoring approach is the efficiency of data collection and analysis as compared to traditional on-site monitoring, which may involve several days of data collection for a smaller sample area. There may also be barriers to the approach described here, as it requires access to aerial drones, technicians for drone-based data collection, substantial computing power for analyzing collected imagery, and expertise in the use of necessary software tools.

CAL FIRE is developing a drone protocol which will provide guidelines for site monitoring and data collection using aerial drones, and program staff have expressed interest in the use of drones as an alternative to traditional on-site monitoring. The extent to which this type of data collection and analysis may serve as a feasible option for monitoring of California Climate Investments projects is currently unclear. If the drone protocol and available resources allow, CAL FIRE may have the capability to implement a full monitoring and analysis approach that is more efficient than traditional methods and results in quantified metrics such as tree mortality rates that could be reported as part of POR or other evaluation efforts. Alternatively, CAL FIRE and other administering agencies may choose to use drones to supplement other monitoring and remote sensing approaches. As this is a developing matter, these considerations are preliminary and further coordination among CARB, CAL FIRE, and other administering agencies is needed in order to determine the role of drone monitoring in POR and California Climate Investments overall.

- **Satellite-based disturbance detection systems may serve as a useful tool in project monitoring if the technology can be tailored to specific program objectives and overcome certain limitations.** Through observation of sampled sites, the Project Team was able to use the eDaRT sample products to detect a variety of disturbances associated with project treatments and non-treatment sources. The timing of image processing limited the extent to which the Project Team was able to assess disturbances in the outcome periods for these sites. However, success in detecting disturbances such as fuels thinning during project implementation suggests that instances of fire, drought, pests, and other factors which can result in tree stress and mortality would be detectable during the years following project completion. This method offers substantial efficiency in data collection as compared to on-site monitoring, as it uses readily available imagery and continually processes data independent of a specific project request. In addition to potential uses within POR, this type of disturbance detection could serve as a useful quality assurance resource for verifying the location, scope, and timing of project treatments during the implementation period.

  There are certain limitations associated with automated disturbance detection, as described in Section 8.4.2, such as the timing of detected disturbances and the applicability of these tools to some projects such as those occurring in developed areas. Effective use of eDaRT also requires knowledge of GIS software and is intended for use by GIS managers and analysts. Additionally, the Project Team identified instances where additional documentation or knowledge of the site would be needed in order to distinguish intentional disturbances such as treatments from unintentional or unexpected disturbances. Based on this, a high degree of familiarity with the project, the region being assessed, land management practices, and relevant ecological factors would be essential in properly assessing sites and developing reliable findings regarding the extent and cause of detected disturbances.

  Finally, the primary functionality of the current algorithms is to detect disturbances and assign an associated tree canopy cover loss value for an individual pixel, and eDaRT does not estimate specific POR metrics such as average tree mortality rates or the acreage of disturbances for a specified

[96] Derek Young, "Drones, AI, and big data in forest ecology," Accessed June 21, 2021. https://www.changingforests.com/drones-ai/.

project area. The eDaRT developer indicated that it would be possible to combine the software with other datasets or existing algorithms to quantify these and other metrics, and recommended that users work with developers to tailor the tool to the specific needs of a project or program. The time and resources required for this process were not assessed as part of the current effort. Further exploration of this and similar tools by CARB and administering agencies would be needed in order to determine the potential role of automated disturbance detection for California Climate Investments programs.

8.7. Recommendations

The following recommendations are provided for CARB and CAL FIRE consideration.

- **Consider referring to the CAL FIRE monitoring manual as an example for other forestry programs and encourage agencies to develop a POR data collection plan.** The monitoring methods proposed by CAL FIRE to collect POR metrics are thorough and together represent one of the most comprehensive approaches to the outcomes phase among programs reviewed by the Project Team. Within California Climate Investments forestry and land management programs such as Regional Forest and Fire Capacity and Climate Adaptation and Resiliency, the proposed CAL FIRE monitoring approaches for metrics such as tree mortality and fuel load may provide useful guidance for agencies in their POR planning processes. While CAL FIRE appears to be well positioned to conduct in-depth monitoring of project sites, other agencies may have different resource or technical limitations that require the development of alternative monitoring approaches. The Project Team does not recommend that CARB require all agencies to strictly comply with the approaches specified by CAL FIRE unless additional training and support can be provided to agencies as needed. If there is a high degree of variation in the level of data collection rigor achievable by different agencies across similar project types, this may indicate a need for additional resources dedicated to the evaluation of certain programs.

  Regarding the broader scope of California Climate Investments programs, evaluation planning in the form of a data collection manual can serve as a valuable resource that improves the consistency and accuracy of results, and it may be useful to encourage other agencies to develop plans for POR within their programs. For programs for which agencies will conduct POR data collection, these plans could include data collection and analysis procedures. For programs for which grantees will conduct POR data collection, agencies could develop plans for use by grantees for standardized collection and reporting of metrics.

- **Continue development of the CAL FIRE drone monitoring protocol and explore the use of this monitoring as an efficient alternative to traditional methods.** CAL FIRE is in the process of developing a drone monitoring protocol, and based on findings from a review of remote sensing resources, drone monitoring may serve as an efficient method of collecting data to inform the outcomes for Forest Health and other land management programs. The scope of CAL FIRE drone capabilities is yet to be determined at the time of this assessment, and this approach may serve as a primary form of monitoring and analysis, a supplementary tool to verify project status during implementation or closeout, or may provide another purpose within the range of activities conducted by CAL FIRE. Finalization of a drone protocol and coordination with researchers in this field may provide an opportunity for improvements in monitoring efficiency and potential implementation of advanced remote sensing analysis using drone imagery.

- **Conduct full monitoring for POR when possible, but consider disturbance detection as an initial or alternative approach within POR.** The on-site monitoring methods proposed by CAL FIRE in its monitoring manual appear to be consistent with best practices in forestry and land management and allow for the collection of metrics such as fuel load and ecological factors which can be difficult

to assess as part of remote sensing. Based on discussions with CAL FIRE and other administering agencies, some agencies may experience barriers to conducting consistent on-site monitoring such as limited staffing resources or site access issues. If these or other barriers become prohibitive to the evaluation of projects, the Project Team recommends that CARB consider allowing agencies to review sites for overall disturbances as an initial step or alternative to full on-site monitoring.

This could be conducted through the use of an automated disturbance detection method, such as the tool reviewed as part of this project, or through a detailed manual assessment of recent high resolution imagery if available through NAIP or accessible through a license with proprietary image providers. Sites that appear to have experienced meaningful unexpected tree mortality from fires, drought, pests, or other factors could be flagged for subsequent in-depth monitoring, while sites that have minimal disturbances could be deferred for monitoring until the following outcome period. The specific threshold of disturbances indicating a need for full monitoring should be defined through discussions and agreements between CARB and administering agencies. The current POR framework for project types such as prescribed fire and fuels reduction operates in a similar fashion, with POR metrics being required only for sites which experienced wildfire disturbances. The Project Team recommends that CARB consider expanding this concept to other project types as needed based on barriers to data collection for individual projects and agencies.

- **Continue requiring thorough documentation from grantees, including detailed progress reports, updated QM calculations as needed, and final closeout reports.** During this review process, the Project Team found the documentation provided for sampled Forest Health projects to be highly useful in understanding the key considerations related to each project and in characterizing the disturbances detected as part of demonstrative site observation. Similar to establishing a baseline prior to project implementation, documenting the final status of project components at the end of the implementation period provides a reference point for data collected in the outcome period during the years following implementation. While projects from older funding cycles were less consistent in this regard, reviews of more recent projects suggest that Forest Health Program currently has thorough and effective documentation requirements for funded projects. This includes a requirement for grantees to report updates on the status of funded activities and to estimate project GHG reductions and other benefits based on the activities completed to date. The Project Team encourages CAL FIRE to continue its practice of collecting this level of documentation and conducting quality assurance on the information submitted by grantees during the application process, progress reports, and final closeout reports. These records increase the transparency of projects and may be useful resources for POR or other future evaluation activities.
- **Assess the availability of remote sensing data, analysis resources, and techniques over time.** Based on the findings of this effort, availability of remote sensing data is improving, and it is possible that CARB or administering agencies may gain access to more detailed imagery and analysis through partnerships with data providers or the development of internal resources.[97] Additionally, based on the findings of this effort the field of remote sensing analysis is rapidly evolving and emerging technologies or approaches may provide useful monitoring options in upcoming program years. The Project Team recommends that CARB and administering agencies continue to consider possibilities for using remote sensing approaches in POR and overall program evaluation, as these methods may increasingly offer an efficient and cost-saving solution for California Climate Investments project monitoring over time.

[97] California Air Resources Board, "California partners on new initiative using satellites to combat climate change," (September 25, 2019), https://ww2.arb.ca.gov/news/california-partners-new-initiative-using-satellites-combat-climate-change.

- **Recommended POR purpose within Forest Health:** Based on this data collection and review effort, the Project Team finds that POR can serve as a valuable monitoring tool to assess the status of project sites over time and identify issues such as disturbances resulting from fire or other ecological distress. Assuming that CAL FIRE and other administering agencies are able to conduct consistent in-depth monitoring of sites, POR can also be used to collect key metrics that relate to project GHG benefits such as tree mortality rates from fire, mortality of planted trees, and annual biomass utilization.

  As CAL FIRE currently requires grantees to report on the status of project activities and provide updates on the expected project benefits according to program QM tools, GHG-related data collected through POR could potentially be combined with QM calculators to quantitatively assess projects during the outcome period. It should be noted that at this time, using outcome-related data to recalculate project benefits is outside the scope of the current POR framework. In the absence of a quantitative evaluation component for individual projects within POR, collection of these metrics could be used to validate QM assumptions at the program level and provide insight into the relative outcomes of different project types.

  If there are persistent barriers to this level of data collection, POR may have a more limited scope that focuses on tracking disturbances and identifying major issues that conflict with expectations for individual projects or project types.

9. Urban Forestry and Tree Planting

Within California Climate Investments, the Urban and Community Forestry (UCF) and Urban Greening (UG) programs provide grants for projects that focus on expanding, enhancing, and managing forestry and green infrastructure in urban environments and community spaces. These projects may also include components such as active transportation infrastructure, biomass generation, and associated management and maintenance activities. For POR assessment and reporting purposes, the Project Team combined the UCF and UG programs into a single Urban Forestry and Tree Planting program group.

UCF is administered by CAL FIRE, and UG is administered by the California Natural Resources Agency (CNRA).

9.1. Project Sample

At the time of project sampling in October 2019, there were 56 UCF projects and 4 UG projects eligible for POR based on information received from CARB. The final project sample included three projects from UCF and one project from UG. Brief descriptions of these sampled projects are as follows:

9.1.1. Urban and Community Forestry (UCF) Sampled Projects

- **UCF Project 1: City of Santa Cruz Urban Tree Inventory and Planting. Grantee: City of Santa Cruz, CCIRTS Project ID 8GG16436.** This project involves planting approximately 500 trees and implementing a GIS tree monitoring system for tree inventory management purposes.
- **UCF Project 2: Trejuvenation. Grantee: Tree San Diego, CCIRTS Project ID 8GG16410.** This is a biomass utilization project that is designed to divert end-of-life urban trees away from landfills and provide biomass for lumber, biochar, and other products.
- **UCF Project 3: Tree Planting in Disadvantaged San Fernando Valley Communities. Grantee: Hollywood Beautification Team/Los Angeles Beautification Team, CCIRTS Project ID 8GG14420.** This project involves planting and distributing approximately 1,550 trees within disadvantaged communities in the San Fernando Valley, which includes 350 shade and fruit trees directly distributed to low-income residents.

9.1.2. Urban Greening (UG) Sampled Project

- **UG Project 1: Ramona Gardens Green Connections Project. Grantee: North East Trees, Inc., CCIRTS Project ID U29122-0.** This project involves the rehabilitation of a 2-acre park in Los Angeles, CA. The project includes planting of approximately 65 drought tolerant trees and shrubs as well as 250 canopy shade trees, the implementation of stormwater management features such as bioswales, and the installation of amenities such as benches and ADA accessibility features.

9.2. Activities Conducted

Data collection for the sampled Urban Forestry and Tree Planting projects consisted of the following activities:

9.2.1. Administering Agency Interviews

At the start of the data collection task, the Project Team held interviews with CAL FIRE and California Natural Resources Agency (CNRA) staff to discuss Urban Forestry and Tree Planting projects and review

existing data collection and reporting procedures. This included requesting documentation for the sampled UCF and UG projects such as grant agreements, progress reports, and other records.

9.2.2. Project Documentation Reviews

Upon receiving available records from CAL FIRE and CNRA for the sampled grants, the Project Team conducted documentation reviews in order to gain an understanding of the components of each project, the applicable POR metrics, and considerations related to POR and data collection.

9.2.3. Review of Remote Sensing Resources

The Project Team met with several organizations and subject matter experts to determine the availability of aerial imagery that could be used to assess POR metrics for Urban Forestry and Tree Planting projects. This included conducting interviews with staff from Planet, the UC Davis Center for Spatial Technologies and Remote Sensing (CSTARS), and CARB.

9.2.4. Remote Site Observation

In discussions with administering agencies, the Project Team considered whether it would be possible for urban foresters associated with Urban Forestry and Tree Planting projects to conduct POR data collection by monitoring sites with aerial imagery rather than conducting on-site visits. In order to explore this concept, the Project Team requested workbooks containing characteristics of each tree that was planted for two of the sampled projects. As these workbooks included geographic coordinates of the planted trees, the Project Team matched these coordinates to Google Earth and NAIP imagery to observe project sites and assess the possibility of using aerial imagery to verify the presence and health of planted trees.

9.3. Data Collection and Analysis Limitations

The Project Team encountered a series of factors which restricted the assessment of individual POR metrics for Urban Forestry and Tree Planting projects. First, due to issues associated with the COVID-19 pandemic and other factors, each of the sampled projects experienced delays or extensions beyond their expected completion dates. One of the sampled projects were not yet complete at the time of this report, and the remaining three projects were completed in late 2020 or early 2021. This limited the number of projects for which an outcome period had begun, and delayed and limited the availability of certain project documentation such as final inspection reports.

Additionally, the Project Team planned to conduct a sample of in-depth assessments of sites using high resolution aerial imagery. However based on a review of available remote sensing resources, the Project Team determined that it would not be feasible to obtain and analyze high spatial resolution imagery for the Urban Forestry and Tree Planting sites that were sampled as part of this data collection effort. Data such as high resolution multispectral imagery was not available from CARB or other agencies at the time of the data collection request, and obtaining a license for proprietary imagery was beyond the resources available for this project.

Finally, the Project Team initially planned to conduct site visits for each of these sampled projects in order to verify the status of project components and demonstrate POR activities such as performing tree mortality counts and monitoring active transportation facilities. Due to issues presented by the COVID-19 pandemic, these site visits were not possible during the data collection period.

As a result, the Project Team focused on conducting a qualitative assessment of considerations related to POR metrics for Urban Forestry and Tree Planting projects rather than collecting data to quantify these metrics for the project sample. Specifically, the assessment for these programs is focused on conducting reviews of available project documentation, and for sampled projects for which CAL FIRE provided tree implementation data, conducting exploratory observations of treatment sites.

9.4. POR Metrics Recommendations

Table 9-1 displays the CARB-approved UCF and UG POR metrics as of the start of the data collection task.

Table 9-1. Initially Approved Urban Forestry and Tree Planting POR Metrics

Program	Sub-Program Component	Metrics
Urban and Community Forestry	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Urban Forest Expansion and Improvement	Confirmation that the tree planting sites are still being managed in accordance with the terms of the grant agreement including tree establishment and replacement care
		Tree mortality rate to date
		Quantity of replacement trees planted
	Urban Forest Management Activities	Confirmation that the tree planting sites are still being managed in accordance with the terms of the grant agreement including tree establishment and replacement care
		Tree mortality rate to date
		Description of impacts from the funded management activity (e.g. utilization of tree inventory, urban forest mapping and analysis, long-term management plan)
	Biomass Utilization (applicable to GGRF funded infrastructure)	Biomass delivered to a renewable energy facility
		Harvested wood delivered to a mill
		If producing wood products, mill efficiency and wood product classes, if available from mill
		If producing energy or fuel, renewable energy generated
Urban Greening	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Urban Forestry	Confirmation that the tree planting sites are still being managed in accordance with the terms of the grant agreement including tree establishment and replacement care
		Tree mortality rate to date
		Stormwater captured/treated
		Quantity of replacement trees planted
	Active Transportation	Average traffic of bicycle and pedestrian facilities

During the process of reviewing project documentation and discussing POR with administering agency staff, the Project Team identified the need to recommend modifications to this list of approved metrics. The revisions proposed for use in future rounds of POR are described below.

9.4.1. Revised Metrics

In discussions related to the timing of POR, the Project Team determined that certain metrics may not be applicable to all UG and UCF projects. For UG, CNRA indicated that grantees typically agree to conduct operations and maintenance (O&M) for a period of 10-25 years after projects are completed, depending on the size of the grant. In contrast, CAL FIRE explained that UCF grantees are required to conduct extensive data collection and reporting during the term of the grant but are not under an obligation to continue this process after the end of the grant period.

The current POR framework for Urban Forestry and Tree Planting defines the outcome period as beginning once tree planting is completed, and for many grants the tree planting process occurs over the course of several years and is only fully completed near the end of the grant period. The POR period would therefore occur after the end of the grant when grantees are no longer under an obligation to abide by the terms of the grant agreement.

Based on this, the POR metric of "Confirmation that the tree planting sites are still being managed in accordance with the terms of the grant agreement including tree establishment and replacement care" would not be meaningful in many cases as the terms of the grant agreement are no longer in effect during the outcome period. Additionally, the metric of "Quantity of replacement trees planted" would not be applicable to UCF POR, as grantees are only required to conduct tree replacement during the maintenance period which corresponds to the grant term.

CAL FIRE indicated that while the grants themselves cannot issue requirements that extend beyond the grant period, CAL FIRE has established post-project maintenance agreements with a small pilot sample of grantees who were willing to continue providing tree care after the end of the grant. In the current UCF Program structure these are the only cases in which grantees would be under an obligation to comply with specific management practices and conduct tree replacements in the outcome period that follows the grant term.

Based on this, the Project Team revised the two Urban Forestry and Tree Planting POR metrics of "Confirmation that the tree planting sites are still being managed in accordance with the terms of the grant agreement including tree establishment and replacement care", and "Quantity of replacement trees planted" as follows:

- **Confirmation that the tree planting sites are still being managed in accordance with the terms of the maintenance agreement including tree establishment and replacement care *(if applicable based on post-grant agreement with grantee)***
- **Quantity of replacement trees planted *(if applicable based on post-grant agreement with grantee)***

This reflects that these metrics are only applicable to UG projects with O&M agreements and UCF projects with similar agreements that extend beyond the grant period.

9.4.2. Deferred Metric

The Project Team identified one Urban Forestry and Tree Planting POR metric that does not appear to align with POR's current intent of gathering primary data from grantees in a manner that aligns with available resources and expertise.

As of the beginning of this data collection effort, the UG POR guidelines required projects to report on the amount of stormwater captured or treated during the outcome period based on an evaluation of rainfall totals. The original intent of the methodology for capturing this metric was unclear, as POR metrics have typically been defined by CARB as metrics that require primary data from grantees, and rainfall totals could be assessed by CARB or administering agencies as needed using publicly available data.[98] Additionally, stormwater capture is currently estimated as part of UCF and UG QM tools using outputs from i-Tree software and this approach could continue to be used during the outcome period if this metric is not meant to include primary data from project sites. Under the assumption that POR metrics are intended to use project-specific primary data, the Project Team investigated this metric in order to determine the feasibility of requiring grantees to collect data on stormwater capture for planted trees.

Methodologies and guidance described by the United States Geological Survey (USGS) indicate that runoff reduction and stormwater capture from planted trees is difficult to measure directly and volume reduction varies by tree size and type. Best practices in measurement of water impacts from tree planting require extensive monitoring with equipment such as rain gauges and soil moisture data loggers.[99] Based on discussions with administering agencies, this type of in-depth monitoring is likely outside the scope of resources and expertise available to grantees and is beyond the level of rigor currently expected for other POR metrics. While some grants include the establishment of test plots or installation of monitoring equipment which may report on stormwater capture during the grant period, this is not common to all Urban Forestry and Tree Planting grants and may not continue through the outcome period.

The Project Team considers stormwater capture to be an important factor for tree planting projects and encourages administering agencies to continue efforts in collecting data on this metric in order to gain insight into program impacts. However based on the information reviewed, requiring grantees to provide primary data on stormwater captured by project trees may not be effective. Additionally, methodologies that involve publicly available data or existing calculators may be more appropriately conducted by CARB or administering agencies rather than as part of POR requirements which typically focus on data collection. The Project Team defers to CARB for final determinations regarding the inclusion of this metric in POR and it is categorized as deferred in the table below.

9.4.3. Final Recommended POR Metrics

Table 9-2 summarizes the revised and deferred metrics described above, with modified metrics highlighted.

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[98] NOAA's National Weather Service- CNRFC, "California Nevada River Forecast Center," accessed June 4, 2021, https://www.cnrfc.noaa.gov/ol.php?type=precip.

[99] Bill Selbig and Rebecca Dohn, "Investigating the Stormwater: Quantity and Quality Impacts of Urban Trees - US Forest Service Research & Development," (Webinar) accessed June 4, 2021, https://www.fs.fed.us/research/urban-webinars/investigating-the-stormwater.php.;

William Selbig et al., "Monitoring and Predicting the Impacts of Trees on Urban Stormwater Volume Reduction" (Upper Midwest Water Science Center, n.d.), https://www.usgs.gov/centers/umid-water/science/monitoring-and-predicting-impacts-trees-urban-stormwater-volume-reduction.

Table 9-2. Revised Urban Forestry and Tree Planting POR Metrics Recommendations

Program	Sub-Program Component	Recommended Metrics
Urban and Community Forestry	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Urban Forest Expansion and Improvement	**Confirmation that the tree planting sites are still being managed in accordance with the terms of the maintenance agreement including tree establishment and replacement care (if applicable based on post-grant agreement with grantee)**
		Tree mortality rate to date
		Quantity of replacement trees planted (if applicable based on post-grant agreement with grantee)
	Urban Forest Management Activities	**Confirmation that the tree planting sites are still being managed in accordance with the terms of the maintenance agreement including tree establishment and replacement care (if applicable based on post-grant agreement with grantee)**
		Tree mortality rate to date
		Description of impacts from the funded management activity (e.g. utilization of tree inventory, urban forest mapping and analysis, long-term management plan)
	Biomass Utilization (applicable to GGRF funded infrastructure)	Biomass delivered to a renewable energy facility
		Harvested wood delivered to a mill
		If producing wood products, mill efficiency and wood product classes, if available from mill
		If producing energy or fuel, renewable energy generated
Urban Greening	All	Tracking dates of data submission (i.e. time period represented by reported metrics)
	Urban Forestry	**Confirmation that the tree planting sites are still being managed in accordance with the terms of the maintenance agreement including tree establishment and replacement care (if applicable based on post-grant agreement with grantee)**
		Tree mortality rate to date
		Quantity of replacement trees planted (if applicable based on post-grant agreement with grantee)
	Active Transportation	Average traffic of bicycle and pedestrian facilities
	Deferred Metrics	
	Stormwater captured/treated	

9.5. Results by Sampled Project

This section summarizes the results of the data collection effort by sampled UCF and UG project. Due to limitations associated with assessing outcome-related metrics for the project sample, the data collection effort focused on conducting reviews of available project documentation and conducting exploratory observations of treatment sites.

9.5.1. UCF Project 1: City of Santa Cruz Urban Tree Inventory and Planting, CCIRTS Project ID 8GG16436

This project involves planting approximately 500 trees, creating an inventory of approximately 45,000 existing trees within the Santa Cruz, CA region, and implementing a GIS-based tree monitoring system for inventory management purposes.

According to tree planting records, the project began planting trees in December 2017. At the time of project sampling, the CCIRTS database indicated that this project had an expected completion date of October 2018. However, the project received grant extensions and was completed in March 2021. CCIRTS lists the total California Climate Investments funding for this project as $366,289 with total project GHG reductions of 1,355 MTCO2e.

9.5.1.1. Data Collected

Data collected for this project included:

1. An Excel file provided by CAL FIRE containing the locations and characteristics of each tree planted through this project;
2. The project grant agreement and initial application;
3. Progress reports; and
4. Interim inspection reports.

9.5.1.2. Activities Conducted

Activities conducted for this project included:

- **Documentation review:** The Project Team reviewed the above project documentation to gain an understanding of project history, components, data collection, and overall evaluation considerations.
- **Satellite imagery observation of tree planting sites:** The Project Team observed the treatment sites using satellite imagery and the tree planting coordinates provided by CAL FIRE in order to explore the potential of conducting remote verification of tree presence during the outcome period.

9.5.1.3. Results

This section presents the findings from the above activities for this project.

Review of Grant Agreement and Initial Application

The grant agreement specifies the scope, expectations, implementation requirements, and monitoring and reporting requirements of the UCF project. The agreement states that UCF projects are required to provide quarterly reports which include GHG metrics such as increased carbon sequestration through tree

growth, GHG emissions resulting from project implementation activities, avoided GHG emissions from biomass utilization, and overall estimated GHG benefits achieved to date.

The application attached to the grant agreement outlines the scope of the project, which includes planting approximately 500 trees, completing a full GIS-based inventory of existing trees in the city of Santa Cruz, and conducting related maintenance and outreach to the community to encourage long-term health of the urban tree canopy. The application provides an extensive narrative regarding the purpose of the project and individual components, including partner organizations and roles.

The grantee lists a variety of co-benefits associated with the project including stormwater interception and storage by planted trees, energy efficiency from increased tree shade, reduction of co-pollutants in the air, improved urban management through the development of the GIS tree inventory, and improved resident knowledge and engagement in environmental health as a result of community outreach activities.

The application includes screenshots of the UCF QM tool displaying all relevant inputs and results, as well as project site maps depicting the planned location of tree planting sites. The application does not provide detailed information regarding ongoing monitoring and reporting on project outcomes, but the GHG methodology includes an assumption that maintenance and replacement care will be provided by the city of Santa Cruz for at least eight years. As this period extends beyond the expected term of the grant, this suggests that the grantee may be able to conduct or facilitate the collection of POR data for the project, though this was not confirmed by the Project Team.

Progress Report Review

CAL FIRE provided several progress reports that were submitted by the grantee during 2019 and 2020. The Project Team reviewed these documents to gain further understanding of project components and the data collected during the implementation process.

The progress reports submitted for this project each identify the number of trees planted, associated GHG reductions, expenditures for the reporting period, co-benefits achieved, and overall project activities conducted. For tree plantings and GHG estimates, the report for January through March 2019 indicates that 312 trees were planted to date and that no mortality was observed during the period. The progress report for April through September 2019 indicates that 5 trees were planted during that period, but notes that 33 trees which were planted during January through March were not reported on the previous progress report. The April through September 2019 report therefore claims GHG reductions for 38 trees total, including the previously omitted trees. The October 2019 through March 2020 progress report indicates that 500 trees were planted to date, resulting in expected GHG benefits of 1,620 MTCO2e.

The primary co-benefit listed in the progress reports is improvement in air quality. Each of the progress reports estimates the reduction in co-pollutants such as Nitrogen Oxide (NOx) and reactive organic gases (ROG) using outputs from the UCF QM tool.

The April through September 2019 progress report describes the process of developing a work specification with Davey Resource Group, the contractor hired to develop the GIS-based inventory of approximately 45,750 trees in the city of Santa Cruz. An attachment to this progress report lists each of the data points to be collected by Davey Resource Group in this process, including tree species and other characteristics, maintenance needs, and issues such as whether trees are blocking streets or sidewalks. The October 2019 through March 2020 progress report describes the progress made by Davey Resource

Group in establishing the inventory process, and notes that staff have been trained on the tree inventory software.

Each progress report includes updated UCF QM workbooks as attachments, which display updated GHG reduction estimates based on project activities to date. The progress reports also include detailed MDCA workbooks with characteristics of each individual planted tree, and maps of the project area with markers to indicate the locations of tree planting sites and the placement of individual trees.

Overall Progress Report Review Findings

The Project Team found these progress reports and supplementary documentation to be very detailed and thorough. The inclusion of updated QM tools and MDCA workbooks results in a high degree of transparency into any differences in expected impacts between the initial planning process and implementation process.

Interim Inspection Reports

This project had not yet received its final inspection as of the end of the data collection process conducted by the Project Team. CAL FIRE provided two interim inspection reports that were completed by the urban forester assigned to the project, and this section summarizes a review of these documents.

The first annual inspection report was completed in December 2018. The urban forester noted that approximately 150 trees had been planted as of the inspection and provided a series of observations related to the tree planting efforts. For example, observations noted that the plantings were in alignment with CAL FIRE planting standards and maintenance criteria, aside from infrequent occurrences of weeds or the need for additional watering. The urban forester provided a series of recommendations such as noting that the grantee should monitor possible emerging issues such as mildew on some project trees, continue to protect trees against dogs and deer through the use of fencing, and conduct pruning of trees as needed. Additionally as the grantee had developed a request for proposal (RFP) for a contractor to conduct the inventory process for existing trees, the forester indicated that they would provide feedback on this document and assist the grantee with soliciting bids. This progress report also includes photos of existing and future planting sites.

The second inspection report was completed in December 2019 and is brief in comparison to the first inspection report. Observations in this report were limited to updating the tree planting count; the report noted that approximately 350 trees had been planted to date. Requirements issued to the grantee included ensuring that trees are properly spaced and that stunted or non-viable trees are replaced as needed.

Overall Inspection Report Review Findings

Based on this review, the interim inspection reports serve as a quality assurance tool that provide grantees with guidance regarding issues and procedures for future project activities. The information in these reports suggests that urban foresters work closely with grantees to support the success of projects and the long-term health of treatment sites.

Site Observation and Imagery Assessment

Figure 9-1 displays the geographic coordinates of planted trees as provided by CAL FIRE, shown with yellow markers and overlaid on satellite imagery from Google Earth. This project involves multiple planting locations across the city of Santa Cruz.

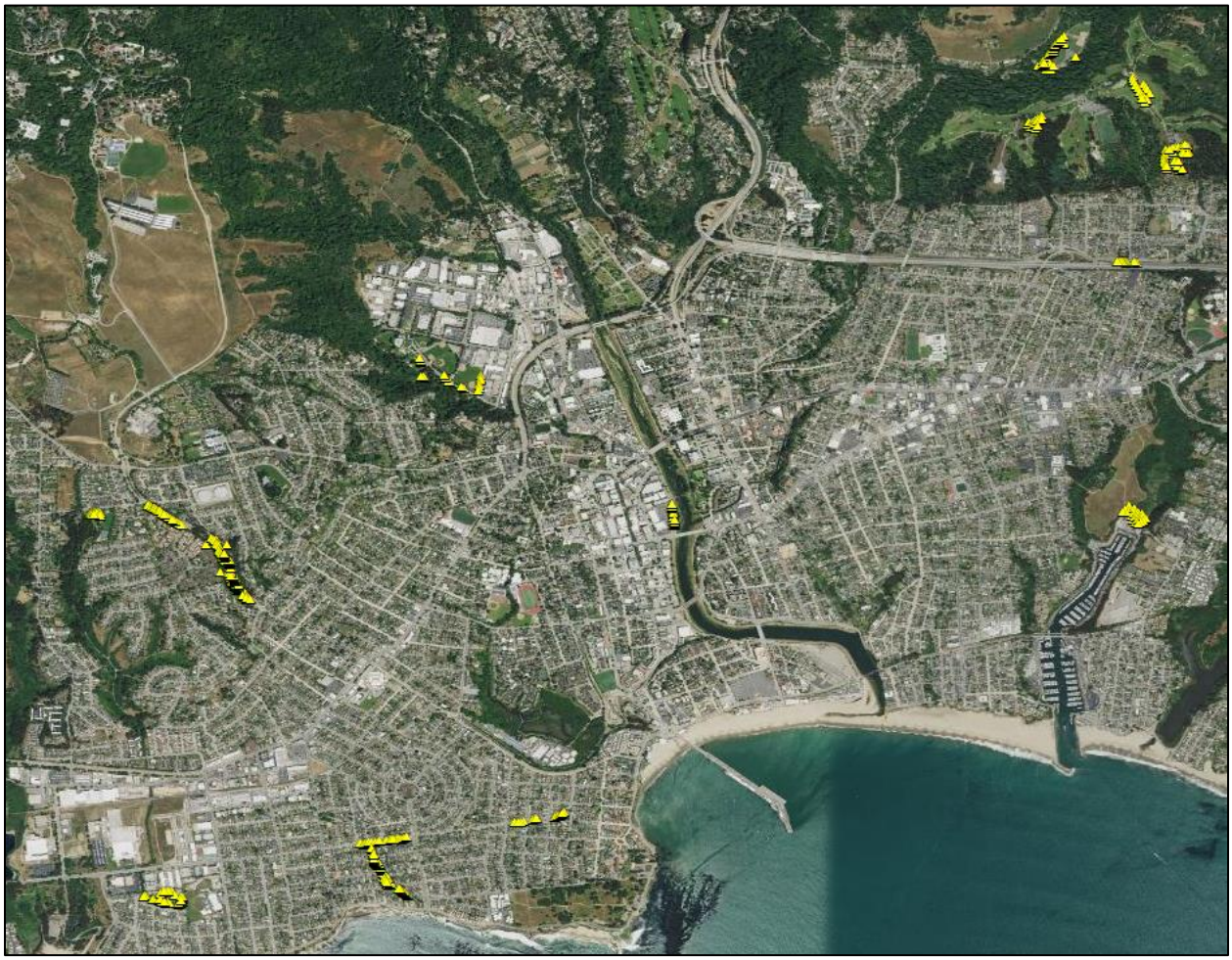

Figure 9-1. UCF Project 1 Project Sites

The Project Team selected an area of interest within the project site as an exploratory example of aerial imagery observation and verification. Figure 9-2 shows an enlarged section of the project area in NAIP imagery. This image depicts tree planting sites as yellow markers along a multi-use path known as Bethany Curve. Additionally, trees were planted along the median of Delaware Avenue, the four-lane street at the top of the image. According to project records, tree planting occurred along the multi-use path during October 2019, and tree planting occurred along the median in December 2018 and May 2019.

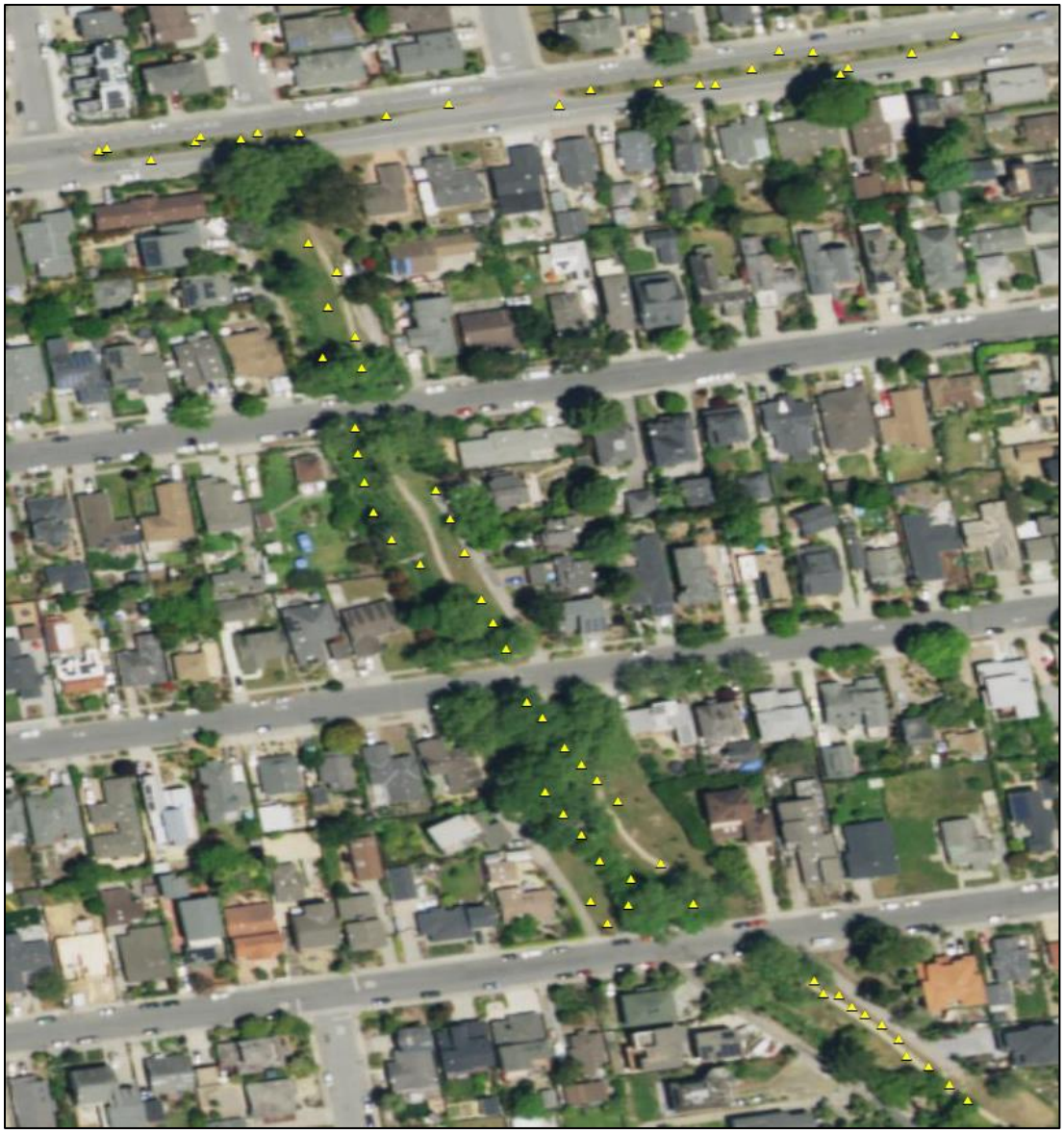

Figure 9-2. UCF Project 1 Bethany Curve Example Treatment Area

To assess the possibility of verifying the presence of planted trees using an aerial imagery approach, the Project Team first observed the street median location with historical Google Earth imagery. Figure 9-3 depicts enlarged images of this location from 2018 (top image), prior to the planting date, and from 2020 (bottom image), between one and two years after the planting date. The 2020 image clearly shows evidence of the tree planting activity, with sufficient resolution to distinguish individual trees from their surroundings. As this treatment is located on a street, it would also be possible to conduct a close inspection of these trees using Google Street View imagery.

Figure 9-3. UCT Project 1 Tree Planting along Median, 2018 vs. 2020

One limitation of Google Earth and Google Street View is that the timing of historical imagery and the image quality varies by location, and recent high resolution images may not be available in some cases. For comparison purposes, the Project Team also viewed this site using NAIP imagery, which is publicly available and is typically collected every two years.[100]

Figure 9-4 displays two views of this location using 2020 NAIP imagery. The top image shows the site in natural color, with project tree coordinates overlaid as yellow markers. This view appears less clear than the historical Google Earth imagery displayed above. Additionally, the NAIP imagery dataset accessed by the Project Team included the normalized difference vegetation index (NDVI) as a viewing mode, and the bottom image shows this site using NDVI with geographic tree coordinates omitted. NDVI provides a visual representation of the presence of live vegetation by comparing the near-infrared light and visible light at a specific point.[101] Researchers have used NDVI with adjusted color scales in combination with other data sets to map urban canopies and quantify metrics such as urban forestry carbon sequestration.[102] These approaches are more in-depth than the manual observation conducted as part of this exercise.

[100] 2020 NAIP imagery was accessed on June 1, 2021 through the California Department of Fish and Wildlife (CDFW) Map Services website: https://wildlife.ca.gov/Data/GIS/Map-Services

[101] NASA Earth Observatory, "Measuring Vegetation (NDVI & EVI)," (August 30, 2000), https://earthobservatory.nasa.gov/features/MeasuringVegetation.

[102] Xun Li et al., "Remote Sensing in Urban Forestry: Recent Applications and Future Directions," *Remote Sensing* 11, no. 10 (January 2019): 1144, https://doi.org/10.3390/rs11101144.

The color scale of the NDVI imagery shows live and healthy vegetation in green, and the absence of vegetation in red or brown. The NDVI image displays individual trees in bright green along the median, though not necessarily more clearly than the natural color NAIP imagery or historical Google Earth imagery.

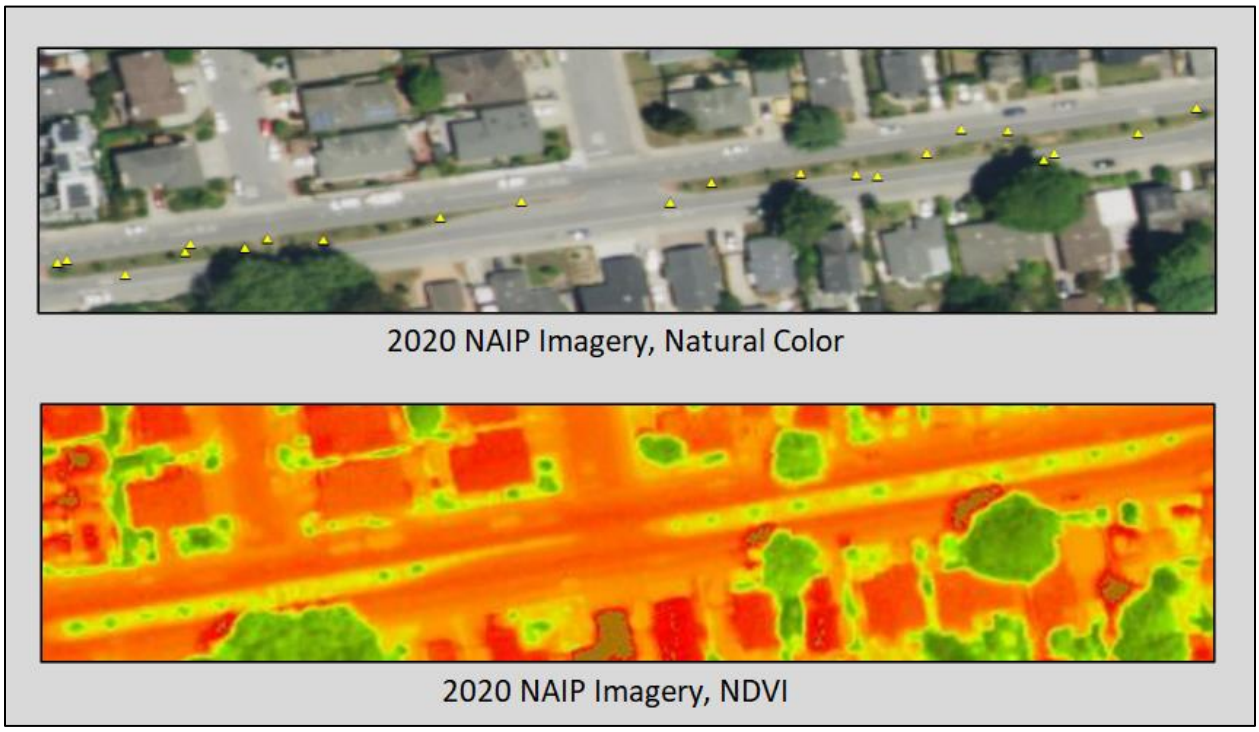

Figure 9-4. UCF Project 1 Tree Planting along Median, 2020 NAIP Imagery

The median location is an example of a treatment site where planted trees can be fairly easily distinguished from the surrounding urban environment. In contrast, the multi-use path near this location provides an example of observing urban tree planting sites that are surrounded by other existing vegetation. Figure 9-5 displays the segment of the path that received tree planting treatments according to the geographic coordinates provided for this project.

The left image depicts this location in May 2018 prior to tree planting, and the right image depicts the location in September 2020 approximately 11 months after trees were planted. The Project Team was able to identify several apparent trees along the areas of that path that are not covered by the existing tree canopy, though the presence of canopy coverage and the relatively small size of the newly planted trees did not allow for reliable verification of a specific tree quantity. The Project Team was able to observe a portion of this path from the Google Street View imagery of Delaware Avenue which clearly depicted newly planted trees along the path, but Street View imagery was not available along the path itself, which represents a limitation to this form of inspection.

Figure 9-5. UCF Project 1 Tree Planting along Bethany Curve, 2018 vs. 2020

For comparison, Figure 9-6 displays this location using NAIP imagery. The natural color image on the left includes tree coordinates as yellow markers and appears to display several small trees or shrubs in the bottom section of the image that are not visible in 2018 Google Earth imagery. These trees do not precisely align with the tree coordinates and it is not clear whether they are part of the planting treatment. The NDVI NAIP image on the left depicts the predominance of vegetation at the site but was not useful in identifying individual smaller trees for this area type. Overall, the Project Team was not able to distinguish possible project trees from existing vegetation for the treatment area along this multi-use path. In addition to the presence of surrounding vegetation, this may be due to the planted trees being in an early growth stage.

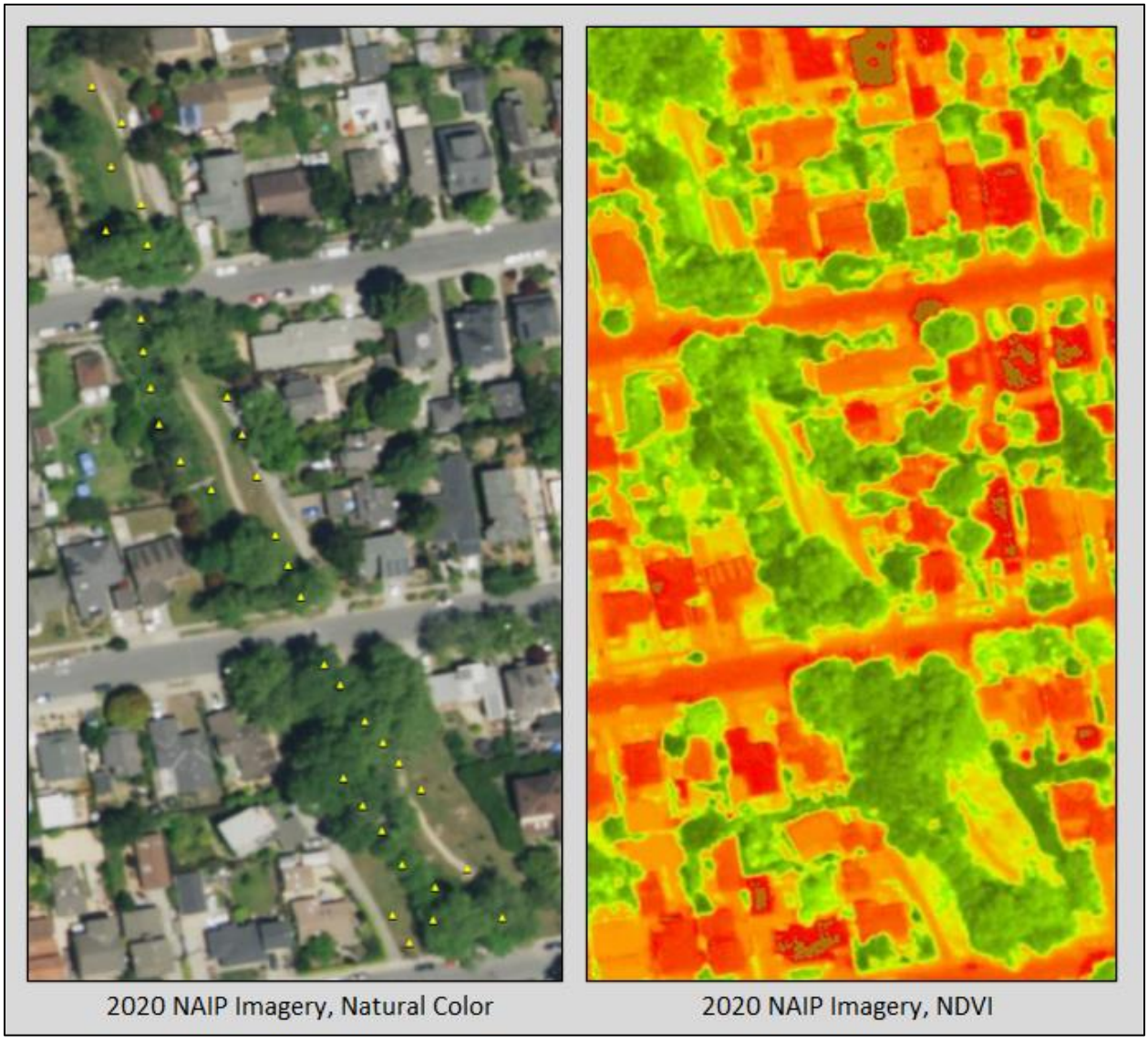

Figure 9-6. UCF Project 1 Tree Planting along Bethany Curve, 2020 NAIP Imagery

The review of available imagery for the selected areas of interest suggests that a manual remote sensing approach may be useful for certain treatment areas such as trees planted in unobstructed urban environments, but that monitors would likely encounter significant barriers to conducting individual tree counts in areas with existing tree canopy cover. Additionally, aerial imagery monitoring may not be effective during the first year or more after planting for sites with less established project tree stock.

9.5.2. UCF Project 2: Trejuvenation, CCIRTS Project ID 8GG16410)

This is categorized as an Urban Wood and Biomass Utilization project and is focused on developing biomass infrastructure rather than tree planting. The project is designed to divert end-of-life urban trees away from landfills and provide biomass for lumber, biochar, and other products in San Diego County, CA.

At the time of project sampling, the CCIRTS database indicated that this project had an expected operational date of March 2020. However the project received grant extensions and was instead completed in March 2021. CCIRTS lists the total California Climate Investments funding for this project as $749,728 with total project GHG reductions of 2,025 MTCO2e.

9.5.2.1. Data Collected

Data collected for this project consisted of documentation including the grant agreement, initial application, and sample progress reports.

9.5.2.2. Activities Conducted

Activities conducted for this project included reviews of the collected project documentation to identify project history, scope, and data reporting procedures in comparison to the other sampled Urban Forestry and Tree Planting projects.

9.5.2.3. Results

This section presents the findings from the documentation review for this project.

Review of Grant Agreement and Application

The grant agreement specifies all of the expectations and requirements for the grantee in relation to this UCF project, including monitoring and reporting requirements. The application attached to the grant agreement lists the project type as Urban Wood and Biomass Utilization, and states that the project will create an urban lumber and biomass utilization business sector in the San Diego region. The project description notes that this will provide jobs and training to individuals in disadvantaged communities in addition to achieving GHG benefits from carbon sequestration and avoided emissions.

Project Activities and Benefits

The application provides a detailed scope of work summarizing each project component, activity, and partner organization, and indicates an expected project duration of 33 months ending in March 2020. The application narrative explains that the Trejuvenation project will source and mill logs from San Diego County, and provides an estimate of the GHG benefits of these activities over the course of 10 years. These calculations incorporate a variety of assumptions regarding log size, tree type, and mill efficiency. The GHG methodology also states that a high proportion of biomass waste will be captured as biochar which will sequester carbon in soil and result in improved soil health. The application includes screenshots of the UCF QM tool that was used to generate expected GHG benefits, including all inputs and results.

Co-benefits listed for the project within the application include stormwater reduction and improved water quality resulting from the use of biochar, energy savings from biomass used as a renewable energy source, reduction in vehicle miles traveled due to the use of local sites for delivering urban logs, and the creation of jobs as a result of ongoing lumber acquisition and milling activities.

Project Monitoring and Tracking

The Project Team identified a difference between the application template used for this project and the template that was in place for prior rounds of UCF funding. In the application for sampled project ID 8GG14420, which was submitted in 2015, the section requesting an estimate of project GHG benefits asks grantees to provide information about how project benefits will be monitored and tracked. However, the version of the application that was used for this project, which was submitted in 2017, does not request monitoring and tracking information. As a biomass infrastructure project, current POR requirements include tracking the tonnage of biomass, mill efficiency, and wood product classes associated with annual biomass utilization activities. The application does not confirm whether these or other metrics will be available on an ongoing basis.

Overall Grant Agreement and Application Findings

The grant agreement and attached application provide a variety of details regarding project scope, resources, timing, and expected impacts. The inclusion of the UCF QM tool inputs and outputs allows for verification of GHG calculations the source of quantifiable co-benefits. The application for this funding period did not appear to include requirements for grantees to describe ongoing data collection and reporting plans for projects, such as whether biomass generation records or weight receipts will be made available to CAL FIRE for review during the implementation period.

Review of Progress Report

Due to extensions issued for the grant, this project was not yet complete as of the end of the data collection process and therefore a final inspection report was not available. The Project Team instead reviewed a sample of quarterly progress reports provided by CAL FIRE for this project to gain further understanding of this data collection phase of the program.

Project Activities and Benefits

The sample progress reports covered each quarter of the 2020 year. As this grant did not include a tree planting component, the progress reports state that no project trees were planted during the year. The progress report for January through March 2020 also indicates that logs were not salvaged during the quarter and that no GHG reductions were achieved for the project during this period.

For GHG benefits, the progress report for April through June 2020 indicates that no GHG reductions were achieved during that quarter but shows total to-date GHG reductions as 221.35 MTCO2e. As the previous quarterly report for January through March indicated that zero GHG reductions had been achieved as of that quarter, the origin and timing of these reported impacts is unclear. The July through September and October through December 2020 progress reports each continue to report this GHG reduction value of 221.35 MTCO2e to date.

Regarding co-benefits, the progress reports indicate that jobs were created during the January through March quarter and that the project milling activities resulted in donations of lumber to a neighboring city and a nonprofit organization. In the section related to project partnerships, the reports describe the progress made on various activities by contractors associated with the project. This includes organizing existing lumber yard logs, working with a contractor to make improvements in a log tracking and inventory system, and completing installation of a biochar demonstration site which will result in increased carbon sequestration.

Issues and Challenges

In the sections relating to issues and challenges encountered by the project, the January through March 2020 report indicates that the introduction of California Assembly Bill 5 (AB5) caused the biomass utilization process to shut down in order to verify that vendors were in compliance with new requirements related to independent contractor classifications.

The report for July through September 2020 explains that the grantee had to make adjustments to its milling operations at the lumber yard due to noise and dust complaints, and that in September 2020 the lumber yard owner issued a notice for the project activities to be moved out of the lumber yard. The progress report indicates that this required project staff to locate a new lumber yard for Trejuvenation activities, and the October through December 2020 progress report states that the project was being temporarily hosted at a lumber yard by one of the project contractors and that a search for a more permanent location was in progress.

Overall Progress Report Summary

Overall, the progress reports reviewed for this project were more focused on qualitative narratives than quantification of project benefits, but provide detailed summaries of recent activities and challenges which may be useful from a grant administration perspective. The documents provided to the Project Team did not include records such as biomass weight receipts or information regarding mill efficiency and wood product classes, and it is not clear whether these details were provided to CAL FIRE throughout the course of this period. This type of documentation is needed in order to comply with current POR requirements for biomass infrastructure projects.

9.5.3. UCF Project 3: Tree Planting in Disadvantaged San Fernando Valley Communities, CCIRTS Project ID 8GG14420

This project involves planting approximately 1,900 trees within disadvantaged communities in the San Fernando Valley and distributing 350 shade and fruit trees to low-income residents.[103] One objective of the project is to increase the shade canopy over air-conditioned buildings to improve building energy efficiency and achieve avoided emissions and air pollution. The project also includes the removal of approximately 11,000 square feet of concrete to be replaced by planted trees and improve stormwater capture within the San Fernando Valley Aquifer.

According to tree planting records, the project began planting trees in December 2015. At the time of project sampling, the CCIRTS database indicated that this project had an expected completion date of December 2019. However, the project received extensions in its grant period and was instead completed in December 2020. CCIRTS lists the total California Climate Investments funding for this project as $750,000 with total project GHG reductions of 5,679 MTCO2e.

9.5.3.1. Data Collected

Data collected for this project included:

1. An Excel file provided by CAL FIRE containing the locations and characteristics of each tree planted through this project;
2. The project grant agreement and initial application;
3. Quarterly progress reports; and
4. The final inspection report conducted upon project closeout.

9.5.3.2. Activities Conducted

- **Documentation review:** The Project Team reviewed the above project documentation to gain an understanding of project history, components, data collection, and overall evaluation considerations.
- **Satellite imagery observation of tree planting sites:** The Project Team observed the treatment sites using satellite imagery and the tree planting coordinates provided by CAL FIRE in order to explore the potential of conducting remote verification of tree presence during the outcome period.

9.5.3.3. Results

This section presents the findings from the above activities for this project.

Review of Grant Agreement

CAL FIRE provided the grant agreement associated with this project, which includes a copy of the initial project application. The Project Team reviewed this document to gain insight into the type of data collected prior to project implementation, the requirements issued to grantees as part of UCF grants, and information related to plans for project monitoring and reporting.

[103] The project application states that the project would plant 1,200 trees, but the final inspection report notes that 1,923 trees were planted in total, not including the 350 trees distributed to low-income households.

As with the other reviewed UCF grant agreements, the agreement for this project specifies the funding amount, scope, and requirements for grantees including invoicing and reporting on GHG metrics. The application attached to the grant agreement for this project includes a detailed summary of project components, staff, expected costs and benefits, and timeline. The application details the methodology for calculating expected GHG benefits resulting from the project, which were based on calculator tools specified by CAL FIRE. The GHG impact section of the application asks grantees to provide information related to how the project benefits will be monitored and tracked. In response, the application narrative states that the grantee will conduct site visits and administer surveys to tree recipients to track ongoing GHG benefits. Additionally, the application notes that students from Occidental College will track growth and carbon sequestration for a sample of trees. The project timeline states that this monitoring activity will begin in the second year of the project and end after the fourth year of the project once all trees are planted.

In order to depict the disadvantaged communities that will benefit from the project, the application also includes a map of the CalEnviroScreen scoring results for the project area; the results indicate a high pollution burden for much of the region.

Overall Grant Agreement Review Findings

Based on this review, the UCF Program requires grantees to provide thorough details regarding the expected implementation plan, GHG benefits and other impacts, and monitoring and reporting for funded projects. For this project, the duration of expected monitoring and reporting efforts appears to align with the grant period, and the application does not indicate whether additional monitoring and reporting will take place after the grant is closed out.

Review of Quarterly Progress Report

CAL FIRE provided a sample of progress reports that were submitted by this grantee in 2018 and 2019 during the project implementation period. This section summarizes the fields included in the quarterly report template as an example of the type of information CAL FIRE collects from grantees on a regular basis.

The quarterly progress report template for UCF includes fields for grantees to indicate the total California Climate Investments and matching funding expended for the project during the reporting period and for the full project to date. The report asks grantees to state how many trees and other plants were planted during the reporting period and for the entire project to date, and includes a description of the recent treatment activities. The report includes fields for grantees to indicate the GHG benefits from recent treatments as well as the total GHG impacts of the project to date. For this project, the grantee provided GHG estimates based on the i-Tree Planting calculator which is the basis for UCF QM calculations.

The report requests information on co-benefits achieved, and for this project the grantee described benefits such as stormwater runoff reductions, jobs created, and biomass diverted. Grantees are also able to provide information on partnerships that have been established within the project. The reporting template asks grantees to indicate the disadvantaged community (DAC) census tracts served during the reporting period based on CARB guidelines for defining benefits to disadvantaged communities from urban forestry projects. Finally, the report includes a section for grantees to report on challenges faced during the period; for example in one progress report, the grantee for this project stated that several of the planted trees had been removed through vandalism and that these trees would be replaced.

As part of the progress reporting process, the grantee submitted workbooks containing information about each individual tree that was planted during the reporting period. The format and content of these workbooks is based on the Minimum Data Collection Attributes (MDCA) specified by CAL FIRE, which requires grantees to list the species, address, X and Y geographic coordinates, census tract, DAC status, planting date, tree size, and the dimensions of the planting site for each tree.

Overall Progress Report Review Findings

Review of these sample progress reports shows that UCF collects ongoing updates regarding GHG calculations and expenditures during the course of project implementation, as well as qualitative information on project progress and any issues encountered. The level of detail included in tree planting MDCA datasets is very thorough and would likely allow for in-depth verification of project activities and impacts.

Review of Final Inspection Report

CAL FIRE urban foresters conduct annual inspections of UCF projects in order to verify that treatments and maintenance are being conducted in compliance with best practices and in accordance with the terms of the grant agreement. Urban foresters also conduct a final inspection after all treatments are completed, as part of the project close out process. CAL FIRE provided the final inspection report that was completed for this project on December 19, 2019, and this section presents a review of this document as an example of the data collected during this phase of the program.

The inspection report consisted of brief narratives from the urban forester regarding overall observations of the project and characterizations of the work performed. Attached to the report were a series of photos of project treatment sites. In the narrative section of the report, the urban forester noted that the grantee exceeded the number of planted trees required by the grant agreement by planting 1,923 trees rather than 1,200 trees, an increase of 723 trees. The grantee also provided 350 shade and fruit trees to low-income residents as expected. The forester noted that while the trees appeared to be sufficiently healthy and met UCF guidelines, approximately six trees were in poor health due to lack of water and would need to be replaced. Overall, the forester noted that GHG requirements of the project had been met.

Overall Final Inspection Report Review Findings

Based on this review, final inspections of UCF projects involve verifying that projects have met all requirements as per the grant agreement and serve as an opportunity for the urban forester to recommend any necessary corrections such as tree replacement. While the final inspection report for this project was fairly brief and did not include a detailed description of the inspection process and findings, the quantitative information regarding the verified number of trees planted may be useful in validating project GHG estimates. With the documentation available to the Project Team, it was not clear whether GHG benefits would be updated within the CCIRTS database to reflect the additional 723 trees that were planted by this project. The final inspection report did not include an estimate of the total GHG reductions attributable to the project.

Site Observation and Imagery Assessment

The Project Team viewed the tree planting coordinates provided by CAL FIRE using available satellite imagery of the project area in order to identify treatment sites and review pre- and post-project images

for a subset of planted trees. Figure 9-7 displays the full span of the project area in NAIP imagery based on the tree coordinates provided. Planted tree locations are indicated as yellow markers.

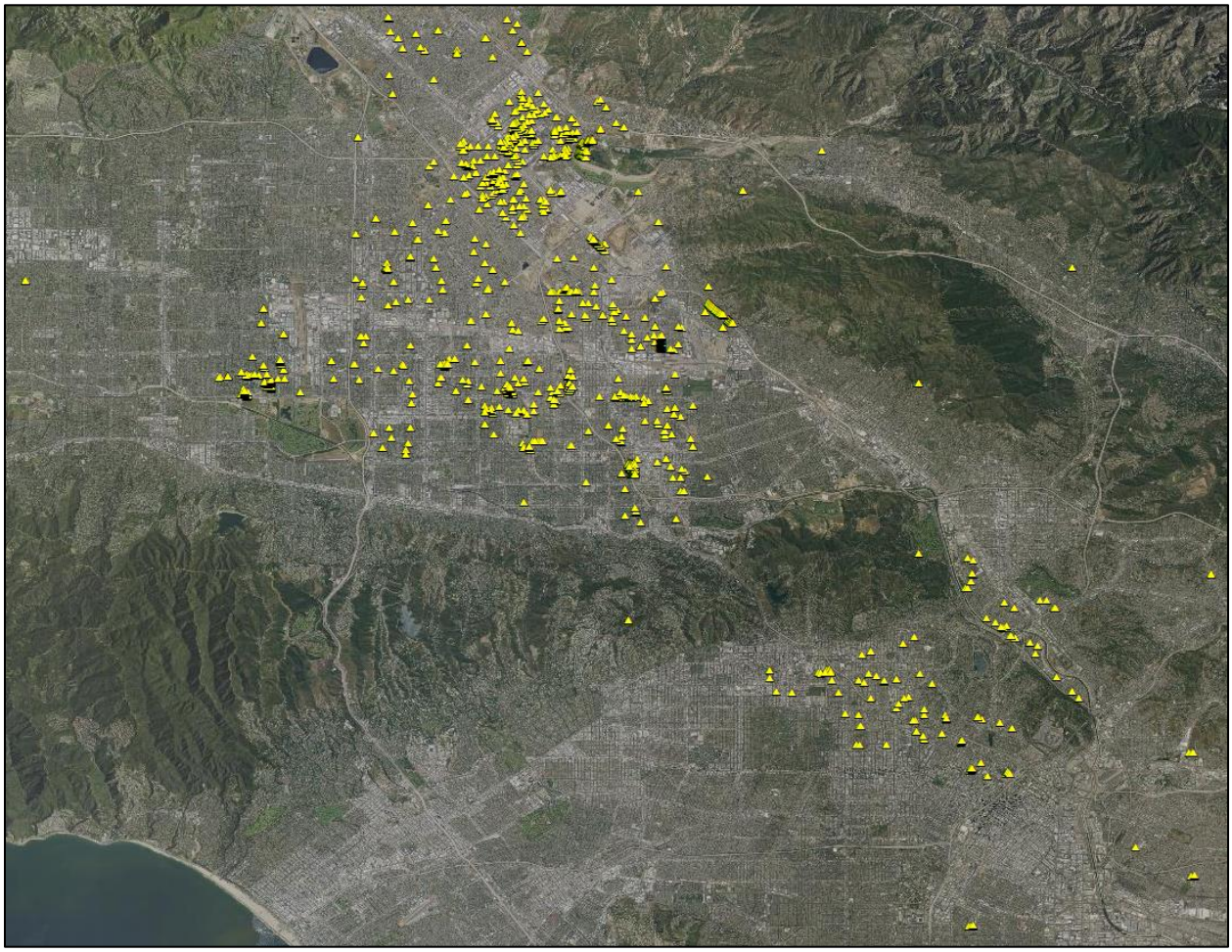

Figure 9-7. UCF Project 3 Project Sites

The Project Team selected two sites of interest within the project area to use as examples of aerial imagery observation of urban tree planting. The first selected treatment site was located along Interstate 5 (I-5) and Glenoaks Blvd. in Sun Valley, CA. According to project records, trees were planted at this site in July 2016. Figure 9-8 depicts an enlarged section of this treatment site using NAIP imagery prior to the tree planting date in 2016 (top image) and NAIP imagery from several years after the tree planting date in 2020 (bottom image). Yellow markers show the reported location of planted trees.

The 2020 image shows evidence of project treatments, with a series of trees being visible along the roadway in alignment with the row of tree planting data points. The quantity and location of trees does not appear to precisely match the reported coordinates in some cases. Several of the data points are also located in close proximity to one another, and with the current image resolution it is unclear whether the visible trees are similarly clustered together. Overall, this site appears to show more tree planting data points than are visible within the NAIP imagery.

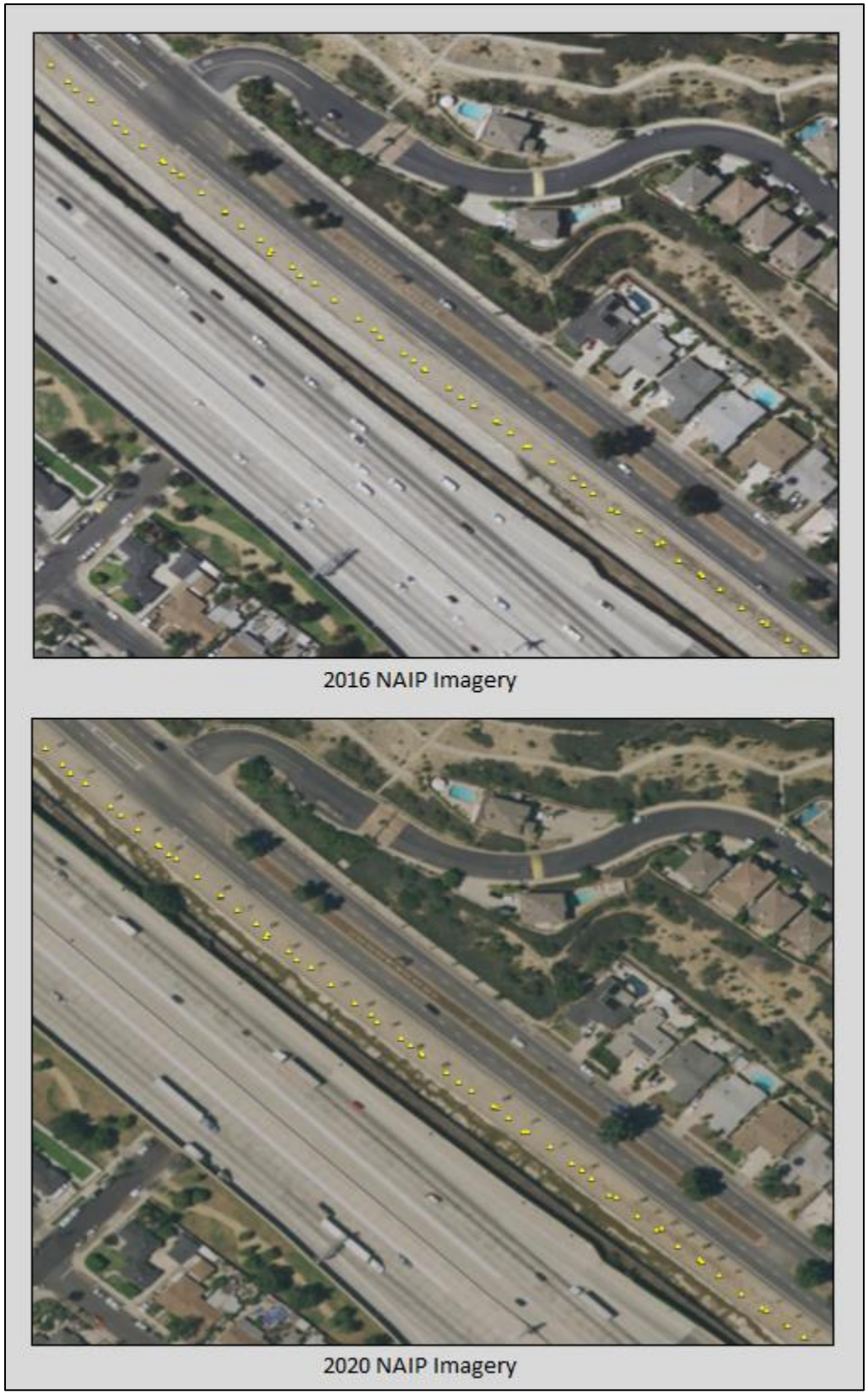

Figure 9-8. UCF Project 3 Example Treatment Site 1, 2016 vs. 2020 NAIP Imagery

As this treatment was located along a street, the Project Team was able to closely inspect the site using Google Street View imagery and found that newly planted trees were clearly visible and were fairly evenly spaced along Glenoaks Blvd (Figure 9-9). The tree coordinate locations that appear closely clustered do not appear to be an accurate representation of the actual tree locations, though this does not necessarily indicate that fewer trees were planted than were reported. The Project Team was not able to view the tree coordinate locations within the Google Street View imagery and did not conduct a precise count of trees compared to coordinate locations.

Figure 9-9. UCF Project 3 Example Treatment Site 1, 2019 Google Street View Imagery

The second selected area of interest was a tree planting site located in a park within Hansen Dam Recreation Area. Project records indicate that trees were planted at this site in July and August of 2018. Figure 9-10 depicts an enlarged section of this site using NAIP imagery prior to tree planting in 2016 (top image) and NAIP imagery from two years after the planting date in 2020 (bottom image). The 2016 image includes yellow markers to represent the tree planting data points, while the 2020 image omits these points to improve visibility of the site.

Google Street View imagery was available for some portions of the roadways bordering the park but the most recent imagery date was February 2018 prior to the tree planting activity. The Street View imagery also showed other newly planted trees within this park that did not appear to be associated with the UCF project based on their location and the timing of treatment.

Based on review of the 2020 NAIP image, clear evidence of tree planting and growth is apparent in several areas of the park. Trees that do not appear in the 2016 image but are present in the 2020 image appear to roughly align with the pattern of reported data points, though not precisely. This level of imagery is sufficient to verify the presence of treatment activities and may be sufficient to identify major disturbances or severe mortality in the treatment area, but may not allow for reliable matching of individual trees with their associated data points to calculate a verification or mortality rate.

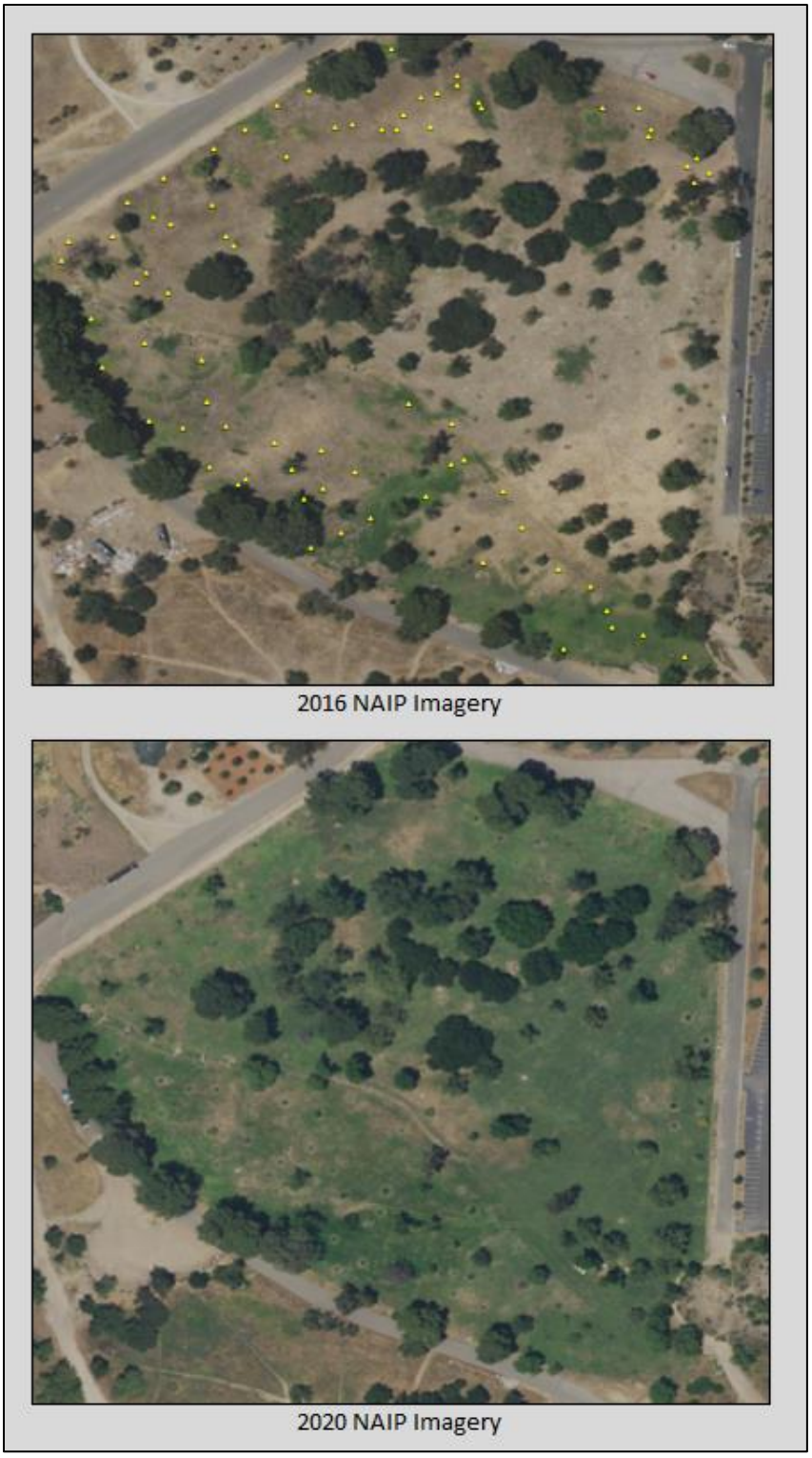

Figure 9-10. UCF Project 3 Example Treatment Site 2, 2016 vs. 2020 NAIP Imagery

Overall the review of publicly available imagery for this project further suggests that it is possible to verify the presence of tree planting treatments and identify individual trees in some instances. Identifying the exact quantity of planted and living project trees may be difficult depending on tree size, surrounding landscape, and location of trees as compared to the reported geographic coordinates.

9.5.4. UG Project 1: Ramona Gardens Green Connections Project, CCIRTS Project ID U29122-0

This project involves the rehabilitation of a 2-acre park and greening improvements to nearby pedestrian areas surrounding the Ramona Gardens affordable housing development in Los Angeles, CA. The project includes planting of approximately 65 drought tolerant trees and shrubs as well as 250 canopy shade trees, the implementation of stormwater management features such as bioswales, and the installation of amenities such as benches and ADA accessibility features.

At the time of project sampling, the CCIRTS database indicated that this project had an expected operational date of May 2020. However, the project received grant extensions and as of the end of the data collection effort had an expected completion date of May 2023. CCIRTS lists the California Climate Investments funding for this project as $1,200,000 with total project GHG reductions of 859 MTCO2e.

9.5.4.1. Data Collected

Information collected for this project consisted of the initial project application and supporting documentation.

9.5.4.2. Activities Conducted

Activities conducted for this project included a review of the project application and supporting documents to identify project scope, and data collection and reporting procedures as compared to other Urban Forestry and Tree Planting projects.

9.5.4.3. Results

This section presents the findings from the documentation review for this project.

Review of Project Application

Similar to UCF, UG requires applicants to provide extensive information regarding the components, objectives, cost, and timeline of the proposed project. The application includes a series of questions and templates which are completed by the grantee in order to verify that the project is eligible to be funded and that project staff have sufficient resources and expertise to complete the stated project activities.

Project Evaluation Questions

The UG application template includes a Project Evaluation Questions section which requires grantees to answer a series of questions related to how the project meets program eligibility requirements. This includes providing narrative explanations of how the project components meet the objectives of the program such as creating, enhancing, or expanding community parks; how the project generates GHG reductions and other benefits; expected characteristics of planted trees and the tree selection strategy; and how the project will support resilience to climate change. This section also includes questions about project partnerships, community outreach, and other expected project activities and components.

The Project Evaluation Questions section also asks grantees to describe how the project will benefit a disadvantaged or critically underserved community. For this project, the application explains that the Ramona Gardens housing development is a severely disadvantaged and low-income community and that the treatment activities will provide a variety of benefits to housing development residents and others in the neighborhood. The application narrative provides details regarding resident demographics, current issues with community open spaces, and how the UG project will allow for improved recreation,

aesthetics, and environmental impacts such as GHG emission reductions and overall health benefits. The application asks whether the project will result in certain co-benefits to the disadvantaged community such as reduced flood risk, reduced air pollution, and job benefits to the community in the form of work hours performed on the project. For the Ramona Gardens project, the application states that the project will provide each of these benefits.

The Project Evaluation Questions section includes a series of questions related to project readiness that ask applicants to verify that the project has sufficient staff, performance measurement plans, environmental compliance approval, additional funding sources such as in-kind funds, and contingencies in the event that the project exceeds its budget or timeline.

Quantitative Information

Regarding quantitative benefits, the application asks grantees to provide a series of metrics regarding the expected scope of the project such as how many trees and plants will be planted and how much stormwater will be captured or treated. For this project, the application states that the project will plant 315 trees and 3,000 other plants, treat 3 acres of open space, create 5 miles of commuter trails, and capture or treat 4.8 acre-feet of stormwater. These parameters are linked to the GHG impacts of the project, which are provided as screenshots of the program QM tool and display all key inputs and outputs from the calculations. The QM outputs indicate GHG benefits of 822 MTCO2e from carbon sequestration, 218 MTCO2e from energy savings resulting from increased tree shade over air-conditioned buildings, and 44 MTCO2e from avoided emissions due to increased active transportation on installed bicycle and pedestrian paths. Additionally, the QM estimates that the project will generate 52 MTCO2e in emissions during project implementation, which is subtracted from the GHG benefits to obtain a net expected GHG benefit of 1,032 MTCO2e.

Supplemental Documentation

The Ramona Gardens application includes a series of maps and photographs of project treatment sites and a visual depiction of expected tree planting, walking paths, and stormwater management improvements within the proposed community park site. Supporting documentation attached to the application includes a proposed project timeline, letters of support, a budget summary, CEQA compliance letter, CalEnviroScreen results indicating that the project area is a disadvantaged community, and legal documents describing site characteristics and ownership.

Data Collection and Monitoring

Regarding data collection and monitoring, the application asks who will conduct long-term maintenance of the project site. Unlike CAL FIRE for the UCF Program, CNRA requires grantees to commit to operations and maintenance (O&M) activities for UG projects for a period of 10 to 25 years following the grant, depending on the size of the award. The Ramona Gardens application states that the Ramona Gardens housing development is a Housing Authority of the City of Los Angeles (HACLA) site and that HACLA will conduct this maintenance for the portion of the project located within the housing development. For the street trees and related improvements, the application states that the grantee and community partners and members will perform maintenance as per City of Los Angeles Bureau of Street Services regulations.

The application includes an attached letter from HACLA to the grantee, North East Trees, which authorizes the grantee to conduct the planned treatment activities and verifies that HACLA plans to assume the O&M responsibilities for the housing development portion of the project for a period of at least 25 years. In the

letter HACLA states that it will be making an in-kind contribution towards maintenance costs during the grant period as well as $20,000 annually to cover 25 years of project O&M activities. The application does not specifically describe whether North East Trees has a dedicated funding source for conducting O&M after the grant period.

Overall Application Review Findings

The UG application requirements appear to be in-depth and comprehensive in collecting information regarding the scope, benefits, costs, readiness, risks, and other characteristics of proposed projects. The detailed Project Evaluation Questions suggest that program staff use a robust eligibility verification process to screen applicants and gain a thorough understanding of proposed projects. The inclusion of program QM inputs and outputs allows for verification of project GHG calculations and provides clear information regarding the sources of project benefits. Requiring grantees to indicate who will conduct ongoing maintenance of sites likely encourages long-term project success and tree health, and may facilitate the collection of outcome-related data by grantees and project partners during the POR period.

9.6. Key Data Collection and Analysis Findings

This section summarizes overall findings from the data collection effort including project documentation reviews, discussions with administering agencies, and remote observation of sampled sites.

- **The data collection effort encountered significant limitations resulting from the COVID-19 pandemic and other factors.** The Project Team initially planned to conduct on-site visits of sampled projects and collect outcome-related data for each sampled site. Due to travel restrictions and other barriers presented by the COVID-19 pandemic it was not feasible to engage in on-site activities, and each sampled grant experienced delays and received extensions beyond its expected completion date. This limited the availability of outcome-related data and the time available to the Project Team for assessing each project. Further coordination among CARB and administering agencies, such as pilot data collection efforts, may be needed in order to identify additional considerations related to POR for these programs.
- **Projects include extensive data collection and reporting during the grant period, but there are challenges associated with data collection and reporting following the end of the grant period.** The information currently required from grantees for Urban Forestry and Tree Planting projects is fairly comprehensive and includes detailed qualitative and quantitative information on treatment activities conducted, project expenditures, and associated GHG impacts and co-benefits. Additionally, projects receive annual inspections and final inspections to verify that the work was completed in accordance with the grant and to identify any necessary corrections. However, the outcome period for these projects would commonly occur after the end of the grant, and administering agencies are likely limited in their ability to require grantees to continue data collection and reporting activities outside of the grant term. UG currently establishes operations and maintenance (O&M) agreements with grantees for a period of 10 to 25 years following project implementation, but the success of these agreements in achieving ongoing O&M or facilitating data collection was not clear to the Project Team based on information available at the time of this exercise. CAL FIRE indicated that a small portion of grantees have agreed to continue conducting maintenance after the end of the grant, but these arrangements are uncommon and currently in their early stages. Due to these factors, it may be straightforward to collect certain outcome-related information from grantees such as biomass receipts and qualitative descriptions of ongoing project impacts. Substantial involvement from administering agencies and the urban foresters associated with projects may be needed in order to reliably quantitative metrics such as tree mortality.

- **Projects plant trees throughout the grant period and POR would require verification and assessment of tree mortality for both newly planted and well established trees.** Administering agency staff explained that urban foresters regularly inspect planted trees throughout the grant period in order to assess their health and ultimately verify that they are sufficiently established and have a low chance of mortality. The length of the establishment period depends on the climate and type of tree but is typically considered to be the first several years after planting, and trees may experience a greater risk of mortality during this period.[104] While established trees are generally larger and more easily identifiable using aerial imagery, the higher mortality rate associated with newly planted trees suggests that verification of both groups would be needed to calculate a representative mortality rate during the outcome period.

- **There may be substantial challenges in conducting reliable assessments of tree mortality using publicly available imagery.** The level of difficulty in conducting aerial imagery-based verification for Urban Forestry and Tree Planting projects likely varies greatly based on the location of planted trees, their proximity to non-project trees and other vegetation, and the type of imagery used. Additionally, it may be difficult to identify trees in the first few years following project implementation until they are of sufficient size to distinguish within their surrounding environments. Some level of verification is possible with non-aerial sources such as Google Street View, but imagery may not be updated on an annual basis and this would not be a viable option for planting sites located away from roadways or other monitored areas.

  The Project Team observed sites using historical imagery available through Google Earth, Google Street View, and publicly available NAIP imagery. Agencies may be able to achieve greater success in remote verification with the use of alternative approaches that allow for more frequent and detailed monitoring, such as high resolution daily imagery or the use of analytical tools that allow for assisted tree identification and verification.[105] The Project Team is not able to make a specific recommendation for a preferred approach based on the results of the current effort.

- **Based on viewing the geographic data points of planted trees for these sampled projects, the latitude and longitude data provided for projects may not exactly match the location where some trees were planted.** For example, trees planted in the median of a roadway may have a geographic data point that is located in the roadway rather than on the median. CAL FIRE indicated that CARB staff review the coordinate data and may make corrections prior to adding the datasets to the CCIRTS database, though the Project Team did not conduct a comparison of datasets prior to and following this review. While the differences in reported location and observed location appeared to be fairly minor, instances where a project tree is located close to a non-project tree could create challenges to conducting reliable verification of continued growth. Involvement from individuals who are familiar with the project and the precise locations of plantings may help to reduce uncertainties in the verification process.

- **Urban Forestry and Tree Planting projects may soon benefit from improved recordkeeping tools.** CAL FIRE staff indicated that UCF is currently testing the use of a mobile software application that will assist in the recording and verification of tree planting data in future program years. CAL FIRE plans to provide a version of the application to grantees so that they can input information such as

[104] Lara A. Roman, John J. Battles, and Joe R. McBride, "Urban Tree Mortality: A Primer on Demographic Approaches" (Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, 2016), https://doi.org/10.2737/NRS-GTR-158.

[105] Urban forestry monitoring approaches were not specifically assessed during this data collection effort. However, Chapter 8 of this report provides additional details on proprietary imagery and alternate data collection approaches such as drone monitoring for Forest Health projects, which may have relevance to these projects in future program years.

tree types and locations as trees are planted. Inspection staff will also have a version of the application containing these records to use during verification visits. CAL FIRE expects that this will significantly improve the efficiency and accuracy of project records moving forward.

9.7. Recommendations

The following recommendations are presented for CARB, CAL FIRE, and CNRA consideration. These recommendations are designed to support improved evaluability and evaluation of Urban Forestry and Tree Planting projects moving forward:

- **Continue collecting detailed documentation of project activities and updated GHG estimates.** The thorough level of detail within currently collected documentation for Urban Forestry and Tree Planting projects is likely a valuable resource for both the POR phase as well as California Climate Investments project closeout and other evaluation efforts. Accurate records of final project characteristics and treatment activities can serve as a baseline for comparison against data collected during the outcome period, and the inclusion of QM inputs in these records allows for updated GHG benefits estimates using program calculators. The Project Team recommends that administering agencies continue to collect thorough project records and GHG inputs throughout the implementation period.

  A review of documentation for the biomass infrastructure project that was sampled as part of this data collection effort found that applicants may not clearly indicate whether and how biomass generation records will be provided to the administering agency for review, and that these records may not be included with periodic progress reports. The Project Team recommends that administering agencies collect and verify the sufficiency of this type of documentation during the implementation period, as this would facilitate successful reporting of this information during the outcome period.

- **Consider collecting final GHG values from administering agencies for each project upon completion for reporting purposes.** Based on feedback from CARB, administering agencies are able to notify CARB of scope changes that result in significant differences between expected and actual GHG impacts and other benefits for an individual project, with the general guidance being that agencies should report a difference that results in a 10% or greater shift in scope and impacts. However, as Urban Forestry and Tree Planting projects collect updated QM outputs from grantees throughout the project and upon grant closeout, most or all projects should be able to report final GHG estimates following project completion.

  As this information appears to be readily available based on the grants reviewed, the Project Team recommends that administering agencies submit any final QM calculations to CARB during the closeout period so that any differences due to minor or significant changes in project characteristics are reflected in the CCIRTS database. This practice would improve the transparency of reported expenditures and impacts, and mitigate potential issues in comparing CCIRTS data and reporting with individual project documentation for evaluation purposes.

- **Coordinate with urban foresters to determine the feasibility of conducting periodic inspections of planted trees using aerial imagery.** For trees that have been classified by urban foresters as being fully established prior to the end of the grant period, periodic observation through aerial imagery may be sufficient to verify continued tree presence and health during POR. As these trees would be larger than newly planted trees, there may be fewer visibility issues associated with remote verification. However based on imagery observed by the Project Team, on-site monitoring may be necessary in order to reliably identify and verify trees which were planted close to the end of the grant period and are less visible through aerial imagery.

Determinations regarding the POR monitoring approach could be made by an urban forester associated with each project. If the urban forester finds that aerial observation is effective for a given project, the POR process could involve conducting remote verification for a random sample of planted trees and using this to report a representative mortality rate for the project. If the urban forester determines that aerial observation of a representative sample of planted trees is not feasible, the Project Team recommends that administering agencies use an on-site verification approach to the extent possible.

- **Assess verification options for tree giveaway components of Urban Forestry and Tree Planting projects.** For trees which are planted directly by the grantee on public property, grantees are able to record the precise geographic coordinates of the tree and return to the site to verify ongoing survival and growth. There is greater uncertainty associated with trees which are distributed to residents through tree giveaways. Unless the grantee oversees the planting process for trees distributed through these giveaways, tree recipients may decide to plant the tree at various points on their property, may decide to give the tree to someone else, or may ultimately decide not to plant the tree. Remote observation of these trees may not be feasible as the precise geographic coordinates of the planting site are not known. Based on reviewed documentation, giveaway trees do not appear to be included in project MDCA reporting and the extent to which projects conduct verification or monitoring of these trees during the implementation period is not clear.

  If projects are able to collect contact information from recipients at the time of tree distribution, surveys or sample site visits may be an effective method of verifying initial tree planting during the implementation period and then verifying continued growth and survival during the outcome period. A study by researchers at UC Berkeley and the USDA Forest Service which used site visits to assess the survival rate of giveaway trees found survivorship to be lower than expected and emphasized the importance of verification for these types of projects.[106] Documentation for sampled project 8GG14420 indicated that the grantee would be conducting surveys with recipients from the tree giveaway component to verify planting and survival of distributed trees, and other grantees may be engaging in similar activities. The Project Team recommends that administering agencies assess the extent to which grantees are currently conducting surveys or site visits with tree giveaway recipients to determine the overall success of these efforts and whether additional support or guidance from agencies may be needed in order to develop verification procedures for these project components for use during implementation or POR.

- **Continue exploring the concept of establishing maintenance and data collection agreements with grantees for the POR period following the end of the grant.** For UG, CNRA requires grantees to agree to conducting O&M activities for a period of 10 to 25 years following the end of the grant period. The Project Team was not able to verify the success of these agreements in motivating grantees to conduct long-term O&M, but if CNRA finds that this program component is effective then it may be possible to modify these agreements to include collection and reporting of metrics such as tree mortality rates for the three-to-five year duration of the POR period. Unlike UG, UCF grantees are currently not required to conduct data collection and reporting after the end of the grant period and CAL FIRE indicated that it would not be possible to add this as a program requirement. It may be useful to establish continued maintenance and reporting agreements with grantees for the duration of POR on an optional basis. This could involve encouraging grantees to secure outside funding sources to cover these ongoing activities, similar to the HACLA in-kind

[106] Lara A. Roman, John J. Battles, and Joe R. McBride, "Determinants of Establishment Survival for Residential Trees in Sacramento County, CA," *Landscape and Urban Planning* 129 (September 2014): 22–31, https://doi.org/10.1016/j.landurbplan.2014.05.004.

contribution described in the sampled UG application, or reserving a small portion of grant funding for post-project monitoring and reporting.

In discussions with the Project Team, CAL FIRE indicated that a small set of UCF grantees have previously accepted a similar maintenance agreement on a pilot basis. Continued use of this type of agreement would likely improve the efficiency and reliability of POR data collection, and may encourage grantees to remain invested in the long-term success of project sites. Community-based stewardship to conduct maintenance for trees in the first several years following planting may improve tree survival rates.[107] Additionally based on reviews of project documents, some UCF grantees are already planning to conduct a degree of project monitoring after the end of the grant term, and agencies may be able to guide these efforts to align with the goals of POR.

- **Consider developing an active transportation monitoring plan during project planning, or prioritize active transportation improvements with embedded data collection features.** The Project Team was not able to examine the active transportation improvements associated with the sampled UG project as they were not complete as of the end of the data collection effort. Based on a review of active transportation sites within other sampled programs such as AHSC, the level of existing monitoring for active transportation improvements funded through California Climate Investments is low. In order to improve the likelihood that active daily traffic (ADT) from active transportation improvements will be available for POR or other post-project evaluation purposes, it would be useful for CNRA to establish a monitoring plan with grantees as part of the UG project application process. Alternatively, it may be possible to incorporate automatic monitoring tools, such as traffic detectors on bicycle lanes, as part of the construction process. Prioritization of active transportation improvements that include a data component would reduce the need to conduct manual monitoring after projects are complete. In either case, early planning for active transportation monitoring would improve the availability of this type of data during project closeout, POR, or other potential evaluation activities.
- **Recommended purpose of POR within Urban Forestry and Tree Planting:** Based on this data collection effort, aerial imagery monitoring or on-site visits conducted as part of POR can serve as a method of tracking project status and tree health over time. Additionally, the detailed narratives collected by administering agencies during the implementation period suggest that grantees may be willing to provide ongoing qualitative information regarding project status upon request.

  If collected, quantitative metrics such as tree mortality rates and biomass generation could be used to validate QM assumptions and develop revised GHG estimates during the outcome period for comparison to initial estimates. The ability of POR to consistently collect information on tree mortality rates likely depends on whether urban foresters are successful in conducting monitoring using aerial imagery, whether available resources allow urban foresters to collect this information as part of on-site visits, and whether administering agencies are able to require grantees to collect this information as part of ongoing maintenance agreements. Further discussions among CARB, administering agencies, and grantees are likely needed, as well as possible pilot data collection efforts, in order to determine the feasibility of implementing one or more of these methods in support of POR.

[107] Steven Boyce, "It Takes a Stewardship Village: Effect of Volunteer Tree Stewardship on Urban Street Tree Mortality Rates," *Cities and the Environment* 3 (January 1, 2010): 1–8, https://doi.org/10.15365/cate.3132010.

10. Low Carbon Transportation: Clean/Shared Mobility Options

The California Climate Investments portfolio includes several programs that are focused on funding low carbon transportation improvements for mobile sources such as light-duty and heavy-duty vehicles. CARB groups several of these initiatives into an overall Low Carbon Transportation program that contains individual sub-programs and pilots such as Clean Cars for All, Clean Mobility Options, Clean Off-Road Equipment Voucher Incentive Project, and Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project.

In the POR framework provided to the Project Team, CARB distinguishes among Low Carbon Transportation sub-programs by defining separate sets of POR metrics for Advanced Technology Demonstrations, Clean/Shared Mobility Options, and Active Transportation Infrastructure.[108]

This section presents the approach and findings of the data collection activities conducted for the Clean/Shared Mobility Options sub-program group. Programs associated with this group include Clean Mobility Options (CMO) and the Sustainable Transportation Equity Project (STEP).

10.1. Project Sample

The Project Team sampled one project from the Clean/Shared Mobility Options sub-program group. This project is listed in the CCIRTS database as being funded through the Car Sharing and Mobility Options Pilot Program, which was a precursor to the current Clean Mobility Options (CMO) Program. At the time of project sampling in October 2019, there were five Car Sharing and Mobility Options Pilot projects eligible for POR based on information received from CARB. A brief description of the sampled project is as follows:

- **Our Community CarShare Sacramento Pilot Project. Grantee: Sacramento Metropolitan Air Quality Management District, CCIRTS Project ID G14-LCTI-07.** Our Community CarShare Sacramento (OCCS) involves the implementation of electric carsharing and other transportation services for residents of affordable housing communities in the Sacramento region. The project was initiated by the Sacramento Metropolitan Air Quality Management District (Sac Metro Air District) and partners with the nonprofit organization Breathe California Sacramento Region (BCSR) for program management and outreach, and with Zipcar for vehicle operations and telematics data.

10.2. Activities Conducted

Data collection and analysis for this project consisted of the following activities:

10.2.1. Administering Agency and Project Staff Interviews

At the start of the data collection task the Project Team conducted interviews with staff from CARB who are involved in administering the CMO Program and oversee this project, and interviewed project partners including Sac Metro Air District and BCSR. The purpose of these interviews was to gain an understanding of the project, review current POR requirements, assess the extent of current data collection processes, and identify key considerations related to evaluation of OCCS and CMO projects.

[108] According to the current framework, consumer based incentive programs such as clean vehicle rebates, financing assistance, and zero-emission truck and bus vouchers are excluded from POR requirements.

10.2.2. Project Documentation Reviews

Sac Metro Air District provided project documentation for OCCS including existing survey instruments and quarterly reports summarizing vehicle operational data and member activity. The survey instruments consisted of an overall participant survey, to be completed periodically by enrolled and active members, and a post-trip survey, to be completed by members following individual carsharing trips. The Project Team reviewed each of these items. These reviews focused on gaining additional insight into the structure and operation of OCCS, identifying the level of detail available within vehicle telematics and member data, and assessing the content of surveys to determine possible modifications in order to collect POR metrics.

10.2.3. Coordination of Survey Design and Distribution

Based on the documentation review, the Project Team provided initial recommendations for additions and adjustments to existing OCCS survey instruments. These recommendations were designed to allow for the collection of POR metrics and to improve the overall clarity of survey content and the quality of data collected. Following these recommendations, the OCCS team developed a revised Participant Survey and Trip Survey, and throughout this development process the Project Team coordinated with CARB, Sac Metro Air District, and BCSR staff to make recommendations regarding the timing, method, incentives, and other details related to administering surveys to OCCS members.

10.2.4. Analysis of Data Records

OCCS began administering the revised Participant and Trip surveys in March 2021. In order to conduct an example assessment of survey-based POR metrics for this project, the Project Team issued a data request in May 2021 for all Participant and Trip survey data that had been collected from March through May 2021, which represented a six-week data collection period. The Project Team also requested quarterly reports for 2020 and 2021 in order to assess POR metrics related to project operations.

Upon receiving these items, the Project Team analyzed survey data and quarterly report information to develop POR metrics for this sample project. As the survey data provided for OCCS represent less than two months of data collection which occurred during 2021, and the quarterly report associated with this survey data collection period was not yet available at the time of this assessment, the Project Team defined a one-year POR period based on the dates represented by the most recent quarterly reports.

10.2.5. Assessment of Barriers and Evaluation Considerations

Throughout the above activities, the Project Team identified data collection issues and analysis considerations that may present challenges to the POR phase or may indicate opportunities for improvement in data collection and analysis approaches for this and similar projects. This included assessing the overall role and limitations of POR as an evaluation tool in relation to the Clean/Shared Mobility Options sub-program group.

10.3. Survey Approach

The Project Team coordinated with Sac Metro Air District, BCSR, and CARB to develop revised Participant Survey and Trip Survey instruments for distribution to OCCS members. These surveys were designed to collect information to allow for the assessment of POR metrics and also included additional topics of interest to OCCS staff. This section describes the objectives, content, and data collection approach for each of these two surveys.

10.3.1. Participant Survey

The Participant Survey was designed to be completed by OCCS members on a quarterly basis. This survey collected information such as how the service has affected member lives and transportation behaviors, satisfaction with the service, and feedback on potential changes to the service. Specifically, the OCCS Participant Survey distributed as part of this data collection effort included the following topics:

1. The location of the carsharing site associated with the respondent based on their OCCS enrollment;
2. How, if at all, the service has affected the respondent's daily life (such as saving money on gas, improved ability to access goods and services, reduced time waiting for public transit);
3. Frequency of public transit use before joining the service, and after joining the service;
4. Estimated monthly gas expenses before joining the service, and after joining the service;
5. Whether the service has affected the number of vehicles owned or leased by the respondent;
6. Whether the respondent has considered buying an electric vehicle because of the service;
7. Respondent concerns about air quality and pollution;
8. Whether the respondent has a bank account, and whether the introduction of a service fee would affect the respondent's use of the program; and
9. Overall satisfaction and suggestions for changes to the service.

OCCS administered the Participant Survey over the course of six weeks beginning in March 2021 and ending in May 2021. Survey invitations were sent by email and by text message to all OCCS members who had been enrolled in the service for at least 90 days.[109] As an incentive, the Participant Survey informed respondents that they would be entered into a raffle to win one of three multicooker kitchen appliances.

During the six-week data collection period, OCCS sent multiple reminders to unresponsive members in order to increase participation. In total, OCCS sent 515 email invitations or reminders and 392 text message invitations or reminders during this period and 62 unique members responded to the survey.[110]

10.3.2. Trip Survey

The Trip Survey was designed to be taken by members following the completion of each reservation. This survey referred to OCCS reservations as trips and collected information specific to the respondent's most recent trip. Specifically, the OCCS Trip Survey distributed as part of this data collection effort included the following topics:

1. The location of the carsharing site where the respondent began their most recent reservation;
2. The amount of vehicle charge available at the start of the reservation;

[109] As the survey included questions regarding how OCCS had affected member transportation patterns and other factors, the 90-day threshold was designed to target members who had been enrolled in the service long enough for these effects to become apparent.

[110] The Participant Survey received 67 completed responses, but 5 of these were from members who submitted more than one response. After removing these duplicates from the dataset, 62 responses from unique members remained.

3. Purpose of the reservation (such as work related, medical related, or household errands);
4. Whether the respondent would have made the trip in the absence of the service;
5. If the respondent would have made the trip in the absence of the service, what form of travel they would have used; and
6. Whether the respondent was an Our Community CarShare Representative (CCR) during this trip.

CCRs are members who volunteer to drive OCCS vehicles and provide rides to other OCCS members who are unable or prefer not to drive. CCRs also use OCCS as typical members for their own transportation needs. CCRs were invited to complete the Trip Survey after each of their volunteer or personal trips. OCCS staff also asked CCRs to invite their volunteer trip passengers to complete the survey. OCCS does not receive information on which members are receiving rides from CCRs until the CCRs submit their monthly ride reports, and was therefore unable to identify and directly invite volunteer trip passengers to complete the Trip Survey.

OCCS administered the Trip Survey over the course of six weeks beginning in March 2021 and ending in May 2021. Survey invitations were sent by email and by text message each Friday to members who had completed an OCCS reservation during that week. As an incentive, the Trip Survey informed respondents that they would be entered into a weekly raffle to win one of two gift cards in the amount of $25. Members who completed multiple reservations in a week were able to complete multiple Trip Surveys and receive an entry in the raffle for each survey completion.

In total, OCCS sent 52 email invitations and 52 text message invitations during the six-week data collection period and received 34 responses.[111]

Surveys were administered electronically and contained skip logic and input validation. Transcribed copies of the Participant Survey and Trip Survey instruments can be found in Appendix C.

10.4. POR Metrics Recommendations

Table 10-1 displays the list of Clean/Shared Mobility Options POR metrics approved by CARB at the start of this data collection task. The metrics of “Avoided internal combustion engine VMT” and “Miles associated with improved mobility” were recommended additions by the Project Team as part of the initial metrics and methods assessment.

[111] The Trip Survey received 36 complete responses, but 2 of these appeared to be duplicates of another Trip Survey response for the same trip. After removing these duplicates, 34 unique responses remained.

Table 10-1. Initially Approved Clean/Shared Mobility Options POR Metrics

Program Name/Sub-Program Component	Metrics
All	Tracking dates of data submission (i.e. time period represented by reported metrics)
Low Carbon Transportation: Clean/Shared Mobility Options	Quantity of trips
	Quantity of riders
	Quantity of vehicle miles traveled
	Avoided internal combustion engine VMT
	Miles of improved mobility

During the process of reviewing project documentation and coordinating with OCCS staff to revise the Participant and Trip survey instruments, the Project Team identified the need to modify and add to this list of approved metrics. These revisions and additions are described in the following subsections.

10.4.1. Revised Metrics

In discussions with OCCS staff, the Project Team determined that the metrics of "Avoided internal combustion engine VMT" and "Miles of improved mobility" require a level of detail that is not available within OCCS operational data. These metrics, as originally proposed by the Project Team, involved using the Trip Survey to ask members what mode of travel, if any, they would have used to complete a specific trip in the absence of the carsharing service to determine the counterfactual, or non-program scenario, mode that would have been used for that trip. The Trip Survey response would then be linked to the vehicle telematics data for that trip to assess the mileage that would have been traveled for that trip using the counterfactual mode if the service was not available. However, OCCS staff indicated that Zipcar is not able to collect trip-level mileage data due to legal and privacy concerns, meaning that it would not be feasible to link Trip Survey responses to data for individual trips.

Based on this feedback, the Project Team developed and assessed a simplified version of these metrics which did not require trip-level telematics data and relied on Trip Survey data only. Descriptions of these revised metrics are as follows.

Percentage of trips associated with avoided internal combustion engine (ICE) use

The purpose of this metric is to assess the degree to which the EV carsharing project is replacing the use of traditional private ICE vehicle use.

For this exercise, this metric was calculated based on a series of Trip Survey questions. First, respondents were asked the following question:

> ***"If Our Community CarShare had not been available, would you have made this trip?"***

Respondents indicating responses of either *"Yes, I would have made the same trip"* or *"Yes, but I would have gone to a different location"* were then asked the following question:

> ***"What form of travel would you have most likely used for the trip if Our Community CarShare were not available?"***

Respondents indicating responses of *"Driven my own car"*, *"Borrowed someone's car"*, *"Rented a car"*, or *"Taken a taxi, Uber, Lyft, or other similar service"* were then asked the following question:

> ***"Is the car that you would have used for this trip an alternative fuel vehicle (e.g. plug-in hybrid, battery electric vehicle, fuel cell vehicle)?"***

Respondents indicating a response of *"No"* to this question were considered to have avoided the use of an ICE vehicle due to the availability of the carsharing service.[112] This quantity of respondents was divided by the total number of Trip Survey respondents to calculate the percentage of trips associated with avoided ICE travel.

Responses of "unsure" or "prefer not to respond" to these questions were excluded from the calculation of total survey respondents. Trip Survey responses from members who indicated that they were serving as CCR drivers for the trip were also excluded, as these members were acting as service providers rather than service users.

Percentage of trips associated with improved mobility

The purpose of this metric is to assess the degree to which the EV carsharing project is allowing participants to make trips that they otherwise would not have made in the absence of the service.

For this exercise, this metric was calculated based on the following Trip Survey question:

> ***"If Our Community CarShare had not been available, would you have made this trip?"***

Respondents indicating a response of *"No, I would not have made the trip"* were considered to have experienced improved mobility and transportation access due to the availability of the carsharing service for this trip. This quantity of respondents was divided by the total number of Trip Survey respondents to calculate the percentage of trips associated with improved mobility.

Responses of "unsure" or "prefer not to respond" to these questions were excluded from the calculation of total survey respondents. Trip Survey responses from members who indicated that they were serving as CCR drivers for the trip were also excluded, as these members were acting as service providers rather than service users.

[112] For respondents indicating that they would have taken a taxi, Uber, Lyft, or other ride-hailing service, this calculation assumes that the ride-hailing vehicle would have been an ICE vehicle.

10.4.2. Additional Metrics

When reviewing the existing OCCS Participant Survey and survey metrics that have been assessed within other carsharing programs, the Project Team identified several metrics to recommend for inclusion in POR for Clean/Shared Mobility Options projects. These metrics are in alignment with several of the metrics that have been commonly assessed for carsharing services and provide general insight into how the project is affecting member use of personal vehicles and transportation costs:[113]

Percentage of members who have reduced the number of personal household vehicles as a result of the service

This metric was calculated based on the following question within the Participant Survey:

> ***"Has Our Community CarShare affected the number of personal vehicles that you own or lease?"***

The quantity of respondents selecting the response option of *"Yes, I have sold or scrapped one or more personal vehicles* due *to the availability of Our Community CarShare"* was divided by the total number of respondents to the survey question to calculate the percentage for this metric.

Percentage of members who have avoided or delayed the purchase or lease of a personal vehicle as a result of the service

This metric was calculated based on the following question within the Participant Survey:

> ***"Has Our Community CarShare affected the number of personal vehicles that you own or lease?"***

The quantity of respondents selecting the response option of *"Yes, I am delaying the purchase or lease of one or more personal vehicles due to the availability of Our Community CarShare"* was divided by the total number of respondents to the survey question to calculate the percentage for this metric.

Percentage of members who have reduced the amount they spend on gas since using the service

This metric was calculated based on the following questions within the Participant Survey:

> ***"How much did you spend on gas, per month, before Our Community CarShare?"*; and**
>
> ***"How much do you spend on gas, per month, after becoming an Our Community CarShare member?"***

The quantity of respondents indicating a lower monthly expense for the period since using the service compared to the period before using the service was divided by the total number of respondents to calculate the percentage for this metric.

[113] Susan Shaheen et al., "Shared Mobility Policy Playbook," December 2019, 21–23, https://escholarship.org/uc/item/9678b4xs.

10.4.3. Final Recommended POR Metrics

Table 10-2 displays the complete list of POR metrics that the Project Team referenced during the data collection effort, with additions highlighted. This list represents the final POR metrics proposed for these projects as of the end of the data collection effort.

Table 10-2. Updated Clean/Shared Mobility Options POR Metrics for Sample Data Collection

Program Name/Sub-Program Component	Recommended Metrics
All	Tracking dates of data submission (i.e. time period represented by reported metrics)
Low Carbon Transportation: Clean/Shared Mobility Options	Quantity of trips
	Quantity of riders
	Quantity of vehicle miles traveled
	Percentage of trips associated with avoided internal combustion engine (ICE) use
	Percentage of trips associated with improved mobility
	Percentage of members who have reduced the number of personal household vehicles as a result of the service
	Percentage of members who have avoided or delayed the purchase or lease of a personal vehicle as a result of the service
	Percentage of members who have reduced the amount they spend on gas since using the service

In addition to the above POR metrics, the Project Team assessed and reported summary survey metrics including the total number of responses received for each survey and the survey response rates.

10.5. Sampled Project Results

This section presents the results of the data collection effort for the sampled Clean/Shared Mobility Options Project. The survey results presented in this section are based on the pilot data collection activities described above and are not intended to be representative of the population of members for this project or the CMO Program overall. Additionally, this data collection process coincided with the COVID-19 pandemic and data collected regarding recent transportation behaviors and perspectives may not reflect typical conditions.

10.5.1. Our Community CarShare Sacramento Pilot Project, CCIRTS Project ID G14-LCTI-07

Sacramento Our Community CarShare (OCCS) involves the implementation of electric carsharing services for residents of affordable housing communities in the Sacramento region. The project was initiated by the Sacramento Metropolitan Air Quality Management District (Sac Metro Air District) and partners with the nonprofit organization Breathe California Sacramento Region (BCSR) for program management and outreach, and with Zipcar for vehicle operations and telematics data. This project first received funding in

the 2014-2015 FY through the Car Sharing and Mobility Options Pilot Program and has since received funding through CMO to continue and expand operations in each subsequent funding cycle.

The Project Team sampled grants by California Climate Investments project ID within the CCIRTS database, and the G14-LCTI-07 Amendment 1 project ID represents the first phase of the project. As this project has since expanded to include additional vehicles and carsharing hubs, the Project Team collected operations and survey data applicable to the full scope of current project activities rather than for a limited component associated with the first year of funding.

10.5.1.1. Data Collected

Data collected for this project included:

1. Responses to the Participant Survey and Trip Survey administered by OCCS staff;
2. Information regarding survey distribution including the methodology and total number of survey invitations sent; and
3. Quarterly project reports containing operational information for the 12-month period of October 1, 2019 through September 30, 2020.

10.5.1.2. Results by Metric

The POR results for this project based on the data collection and analysis effort are summarized below.

Tracking dates of data submission: October 1, 2019 – September 30, 2020

Differences between the timing of quarterly reports and survey data collection create challenges in defining a meaningful outcome period for this sample project. The current POR framework for Clean/Shared Mobility Options projects specifies that outcome reporting begins when funded vehicles or equipment become operational and extends for 36 months. As the OCCS pilot launched in 2017, the project is currently in its fifth year of operation.

For the purpose of reporting operational data in a format that aligns with POR guidelines for this demonstration exercise, the Project Team defined a one-year outcome period based on the dates of the most recent available OCCS quarterly reports. However, this date range is not applicable to survey metrics, as survey data collection occurred during April and May of 2021 after the end of this specified period.

Quantity of trips: 9,918

Each quarterly report for OCCS provided information on the number of vehicle reservations, or trips, made for each carsharing site during the reporting period.[114] Total reservations per quarter for the period of October 1, 2019 through September 30, 2020 were reported as follows:

[114] The POR framework refers to quantity of trips but does not distinguish between individual trip legs and vehicle reservations which may involve multiple trip legs. The QM calculator for CMO also uses estimates of the quantity of trips and average trip distance as inputs for calculating project GHG benefits. The Project Team interpreted the term "trip" as referring to the total period between the time when a member begins to use a carsharing vehicle and the time that the member returns the vehicle to a carsharing hub for use by other members. Within OCCS, this is also referred to as a "reservation".

- 15th Quarterly Report (October 1, 2019 – December 31, 2019): 3,622 reservations
- 16th Quarterly Report (January 1, 2020 – March 31, 2020): 3,501 reservations
- 17th Quarterly Report (April 1, 2020 – June 30, 2020): 497 reservations
- 18th Quarterly Report (July 1, 2020 – September 30, 2020): 2,298 reservations

The total number of trips for the specified outcome period is the sum of these quarterly values. The outcome period coincided with the COVID-19 pandemic and services were partially or fully suspended starting in March 2020, resulting in a lower number of reservations.

Quantity of riders: Not available

The current POR framework specifies that this metric is to be calculated based on service operating records. Based on a review of the quarterly reports and feedback from project staff, OCCS does not currently report this metric or require members to provide information regarding the number of passengers riding in carsharing vehicles for each reservation. OCCS staff indicated that they had previously included a question regarding passengers per trip within the Trip Survey, but that the quality and quantity of response data was not sufficient to make project-level rider estimates. A question regarding passengers per trip was not included in the version of the Trip Survey that was used during this data collection period.

Quantity of vehicle miles traveled: 142,313

Each quarterly report for OCCS provided information on the number of miles traveled by OCCS vehicles during the reporting period. Total miles traveled per quarter for the period of October 1, 2019 through September 30, 2020 were reported as follows:

- 15th Quarterly Report (October 1, 2019 – December 31, 2019): 52,393 miles traveled
- 16th Quarterly Report (January 1, 2020 – March 31, 2020): 51,556 miles traveled
- 17th Quarterly Report (April 1, 2020 – June 30, 2020): 2,766 miles traveled
- 18th Quarterly Report (July 1, 2020 – September 30, 2020): 35,598 miles traveled

The total vehicle miles traveled for the specified outcome period is the sum of these quarterly values. The outcome period coincided with the COVID-19 pandemic and services were partially or fully suspended starting in March 2020, resulting in a lower number of miles traveled.

Total surveys completed and survey response rate:

- Participant Survey: 62 responses, 16% response rate
- Trip Survey: 34 responses, response rate not available

According to OCCS staff, approximately 392 unique members met the requirements to be invited to complete the Participant Survey and received invitations during the data collection period. The Participant Survey received 67 complete responses, but the Project Team identified four members who had submitted more than one response to the Participant Survey during the six-week data collection period. As this survey was designed to be completed by members once per quarter, the Project Team removed the 5 additional responses which were submitted by these members so that the data set included only one response per member. This resulted in a total of 62 Participant Survey responses, each completed by a unique member. This represents a response rate of 16%.

The Trip Survey received 36 complete responses, but three of these responses were submitted by a single member and appeared to be erroneous duplicates. While the Trip Survey is designed to allow members to respond multiple times, the content of these three responses was identical and they were submitted within several minutes of each other. The Project Team retained the first response and removed the two duplicate responses from the dataset, resulting in a total of 34 responses. OCCS staff did not confirm the number of reservations that were completed during the data collection period or how many unique reservations received a Trip Survey invitation, which would be needed in order to compute a response rate in terms of percentage of total reservations. OCCS indicated that a total of 104 Trip Survey invitations were sent to OCCS members during the data collection period.

Percentage of trips associated with avoided internal combustion engine (ICE) use: 13%

This metric was calculated using responses to the Trip Survey. In conducting data preparation for this metric, the Project Team excluded two responses of "unsure" or "prefer not to respond" to the question regarding travel in the absence of the service. The Project Team also excluded 16 responses from members who indicated that they were providing trips as CCRs.[115] As a result, 16 of 34 responses were included in the calculation of this metric.

Of these remaining respondents, five respondents (28%) stated that they still would have made their most recent trip in the absence of OCCS, and two respondents (11%) stated that they would have made a trip but to a different location. When asked what form of travel they would have used for these trips, responses from this subset of respondents were as follows:

- Two of five respondents indicated that they would have taken the bus;
- Two respondents did not specify a mode;
- One respondent indicated that they would have walked;
- One respondent indicated that they would have driven their own car and that this car would not have been an alternative fuel vehicle; and
- One respondent indicated that they would have taken a taxi, Uber, Lyft, or similar service.

Based on the methodology for this metric described in Section 10.4.1, the two respondents indicating that they would have either driven their own car or taken a ride-hailing service in the absence of OCCS were considered to have avoided ICE travel for their most recent OCCS trip. Divided by the subset of 16 respondents assessed for this metric, this results in an avoided ICE trip rate of approximately 13%.

This calculation is based on a small sample size and is provided as an example of this methodology rather than as representative of the project or CMO Program.

Percentage of trips associated with improved mobility: 56%

This metric was calculated using responses to the Trip Survey. In conducting data preparation for this metric, the Project Team excluded blank responses and responses of "unsure" or "prefer not to respond" to the question regarding travel in the absence of the service. The Project Team also excluded responses

[115] Fourteen respondents provided a response of "Yes" to the question "Were you a Community CarShare Representative for this trip" and two additional respondents provided open-ended responses indicating that they were serving as CCR drivers for these trips.

from members who were providing trips as CCRs. As a result, 16 of 36 responses were included in the calculation of this metric.

Of these remaining respondents, nine respondents (56%) stated that they would not have made their most recent trip in the absence of OCCS. These respondents were considered to have experienced improved mobility and had the ability to take their most recent trip due to the availability of OCCS.

Percentage of members who have reduced the number of personal household vehicles as a result of the service: 6%

This metric was calculated using responses to the Participant Survey. In conducting data preparation for this metric, the Project Team excluded eight blank responses to the question regarding OCCS effects on personal vehicles. As a result, 54 of 62 responses were included in the calculation of this metric.

Of these respondents, three respondents (6%) stated that they had sold or scrapped one or more personal vehicles due to the availability of OCCS.

Percentage of members who have avoided or delayed the purchase or lease of a personal vehicle as a result of the service: 13%

This metric was calculated from responses to the Participant Survey, using the same data preparation process as above.

Of the 54 respondents included in the calculation of this metric, seven respondents (13%) stated that they were delaying the purchase or lease of one or more personal vehicles due to the availability of OCCS.

Percentage of members who have reduced the amount they spend on gas since using the service: 63%

This metric was calculated using responses to the Participant Survey. In conducting data preparation for this metric, the Project Team excluded eight surveys that had blank responses to either of the two questions regarding gas expense estimates. As a result, 54 of 62 responses were included in the calculation of this metric.

For each of these respondents, the Project Team compared the respondent's estimate for how much they spent per month on gas prior to joining OCCS to the respondent's estimate for how much they spend per month on gas since joining OCCS. Responses were provided as dollar amount ranges (e.g. $5-10, $41-60) selected from a list of options. A summary of the results of this comparison is shown below in Table 10-3.

Table 10-3. Comparison of Pre-Project and Post-Project Gas Expenses from Participant Survey

Indication from comparison of expense estimates for pre-service and post-service period	Percent of Respondents (n = 54)
Decrease in gas expenses	63%
Increase in gas expenses	4%
No change in gas expenses	9%
Not applicable (may indicate zero gas expenses in both pre-service and post-service period)	24%

These results suggest that 63% of respondents spend less on gas since joining OCCS than they did prior to joining OCCS.

Table 10-4 summarizes the above POR metrics for this project.

Table 10-4. Clean/Shared Mobility Options Project Outcome Metrics Summary

Program Name/Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	10/1/2019 – 9/30/2020
Low Carbon Transportation: Clean/Shared Mobility Options	Quantity of trips	9,918
	Quantity of riders	Not available
	Quantity of vehicle miles traveled	142,313
	Percentage of trips associated with avoided internal combustion engine (ICE) use	10%
	Percentage of trips associated with improved mobility	65%
	Percentage of members who have reduced the number of personal household vehicles as a result of the service	5%
	Percentage of members who have avoided or delayed the purchase or lease of a personal vehicle as a result of the service	12%
	Percentage of members who have reduced the amount they spend on gas since using the service	63%
Note: The outcome period coincided with the COVID-19 pandemic and services were partially or fully suspended starting in March 2020, resulting in a lower quantity of trips and miles traveled.		

10.5.1.3. Selected Additional Results

In addition to collecting information to inform the above POR metrics, the Participant Survey and Trip Survey included questions selected by OCCS staff based on several project-specific evaluation and planning objectives. These topics were not assessed as POR metrics but may provide insight into member characteristics, perspectives, and transportation decisions. This section summarizes responses to several of these additional topics from the Participant Survey and Trip Survey.

Participant Survey

The Participant Survey asked respondents to indicate which OCCS site they belonged to based on their residence. OCCS currently operates carsharing hubs at seven affordable housing locations in the Sacramento Region. As shown in Table 10-5, the Participant Survey dataset represents respondents from each of these seven locations. Based on member data summarized in the 18th Quarterly Report, this distribution of respondents is somewhat more uniform than the distribution of total OCCS members at

these locations.[116] The SHRA Alder Grove site has both the largest share of OCCS members and the largest share of survey responses.

Table 10-5. Primary Carsharing Site Locations of OCCS Participant Survey Respondents

Select your OCCS site.	Percent of Respondents (n = 62)	Percent of Members as of 18th Quarterly Report (n = 525)
SHRA Alder Grove	19%	27%
Mutual Housing River Garden	15%	11%
SHRA Edgewater	15%	16%
SHRA Riverview	15%	16%
Mutual Housing Greenway	13%	6%
Mutual Housing Sky Park	13%	10%
Mutual Housing Lemon Hill	11%	14%

The Participant Survey also asked respondents to indicate how often they used public transit prior to joining OCCS and how often they use public transit since joining OCCS. As shown in Table 10-6, a majority of respondents (59%) indicated that they used public transit at least once per month before joining the service. In contrast, a majority of respondents (74%) indicated that they use public transit less than once per month since joining the service. Comparing individual responses, 58% of respondents provided responses to these two questions indicating that they have decreased their use of public transit since joining OCCS, 35% indicated that there had been no change, and 7% indicated that their use of public transit had increased. This may indicate that OCCS is having an effect on public transit use, though it should be emphasized that the data collection effort coincided with the COVID-19 pandemic which also substantially affected transit availability and travel preferences. It is possible that some of the responses related to transit use may be influenced by that external factor.

Table 10-6. Use of Public Transit Prior to and Since Joining OCCS

Frequency of public transit use	Before CarShare, how often did you take public transit? (n = 56)	Since becoming a CarShare member, how often have you taken public transit? (n = 55)
Never	29%	45%
Less than once a month	13%	29%
1-2 times per month	21%	11%
1-2 times per week	20%	13%
Almost every day	16%	2%
More than once a day	2%	0%

[116] Source: Our Community CarShare – Sacramento Pilot Project 18th Quarterly Report. The member quantities shown in the table represent all enrolled members, including those who do not drive OCCS vehicles and only use project-funded Transit Incentive Cards (TIC) or receive rides from CCR members.

When asked how OCCS has affected their daily lives, Participant Survey respondents indicated that the service has had a variety of effects (Table 10-7). Respondents were able to select multiple responses for this question, and respondents most commonly indicated that they are able to access goods and services due to the availability of OCCS (52% of respondents). Respondents also indicated that OCCS is allowing them to save money on gas (37%), reducing their time spent waiting for public transit (26%), providing them with a vehicle when they previously did not have one (21%), and allowing them to see friends and family more (16%).

The 16% of respondents who selected a response of "Other" provided a variety of open-ended responses, such as conveying their overall satisfaction with OCCS, stating that it allows them to help neighbors travel from place to place, or mentioning questions related to their membership status or reservation issues that they would like project staff to address.

Table 10-7. OCCS Effects on Daily Lives of Participant Survey Respondents

How, if at all, has Our Community CarShare changed your daily life?	Percent of Respondents (n = 62)
I am able to have access to goods and services (run errands, see a doctor, buy groceries)	52%
I am saving money on gas	37%
I am no longer spending time waiting for public transit	26%
I did not have a car to use before CarShare	21%
I am able to see friends and family more	16%
Our Community CarShare has not changed my life	6%
Other	16%

The survey also included a satisfaction question that asked respondents to rate OCCS on a scale of 1 to 5 stars, where 1 star is the worst rating and 5 stars is the best rating. As shown in Table 10-8, a majority of respondents (52%) provided a 5-star rating and the average rating was 4.2 stars.

Table 10-8. OCCS Satisfaction Rating by Participant Survey Respondents

How would you rate Our Community CarShare on a scale of 1 to 5 stars, where 1 star is the worst rating and 5 stars is the best rating?	Percent of Respondents (n = 52)
1 Star	4%
2 Stars	2%
3 Stars	13%
4 Stars	29%
5 Stars	52%
Average rating	4.2

Trip Survey

The Trip Survey asked members to report what level of charge the OCCS vehicle had at the beginning of the reservation. According to the 18th Quarterly Report, OCCS encountered an issue where certain EVs were not reliably holding their charge while parked at carsharing hubs, which required project staff to start the vehicles every few hours to keep them from losing a charge. The vehicles associated with this issue have since been replaced, but this question was included in the Trip Survey as a quality assurance measure. As shown in Table 10-9, approximately three-quarters of respondents (76%) stated that their vehicle had between 75% to 100% charge. Three percent of respondents stated that their vehicle had 0% to 25% charge.

Table 10-9. Level of Charge in OCCS Vehicles for Trip Survey Respondents

How much charge did the vehicle have?	Percent of Respondents (n = 34)
0-25% charge	3%
25-50% charge	6%
50-75% charge	15%
75-100% charge	76%

The Trip Survey also asked members a variety of questions related to their most recent OCCS reservation (Table 10-10). When asked what type of trip they had made during their last reservation, a majority of respondents (71%) indicated that the purpose of their trip had been grocery or household shopping. Other respondents stated that their trip had been for a health care or medical appointment (12%), that it was work or job related (9%), that it was school related (9%), or that it was for an entertainment, recreational, or social activity (3%).

Table 10-10. Type of Most Recent Trip Taken by Trip Survey Respondents

What type of trip did you make?	Percent of Respondents (n = 34)
Grocery or Household Shopping	71%
Health Care or Medical Appointment	12%
Work or Job Related	9%
School Related	9%
Entertainment, Recreational, or Social Activity	3%
Household Errands	0%
Civic or Religious Activity	0%
Other	18%

Of the six respondents who provided a response of “Other”, five reported that the purpose of their trip was to provide transportation for another OCCS member, as a CCR driver. In total, 16 of 34 Trip Survey respondents (47%) provided responses indicating that they were acting as a CCR driver for their most recent OCCS reservation.

In this case, the Trip Survey was distributed to all OCCS members who completed reservations as drivers during the data collection period, whether they were acting as CCRs and driving other members or driving themselves for their own transportation needs. The presence of CCRs and similar volunteer driver arrangements in other Clean/Shared Mobility Options projects may merit targeted data collection efforts to assess volunteer driver perspectives, the rider experience, and how these components are affecting transportation access and behaviors for individuals who may be unable to drive the vehicles themselves. Overall, the differences in services and features across projects within the Clean/Shared Mobility Options sub-program group suggest that there may be opportunities for a range of novel research questions and approaches in addition to the metrics and methods prescribed by POR.

10.6. Key Data Collection and Analysis Findings

This section summarizes overall findings from the data collection and analysis process for the Clean/Shared Mobility Options sub-program group.

- **Involvement from project partners is likely a key component of data collection for these projects.** Staff from Sac Metro Air District and BCSR assisted in guiding the development of the Participant Survey and Trip Survey and coordinated the member engagement process, including distributing survey invitations and determining and distributing incentives. This included conducting targeted outreach to members through channels that are specific to OCCS, such as contacting CCRs to ask them to encourage their riders to fill out the Trip Surveys. OCCS staff also recommended specific incentives to increase member interest in the surveys based on feedback that had been gathered during project-related events in the past. The Project Team found this existing relationship between project partners and members to be a useful resource in the data collection process. Due to the distinct operating environments and service characteristics associated with the range of projects completed under CMO and STEP, the involvement of project partners to develop a strategy that fits the individual project may be essential in conducting a successful survey data collection effort.
- **Overcoming data collection barriers and maintaining sufficient response rates may require increased survey resources and ongoing management of the data collection strategy.** The response rate for the Participant Survey was 16%, and the Trip Survey received 34 responses with 104 sent invitations. The data collection period for the POR metrics reported for OCCS was limited to six weeks, and the long-term response rate for the Participant Survey and Trip Survey is not yet clear. In general, it may be challenging for Clean/Shared Mobility Options projects to consistently collect a level of data that adequately represents the entire participant population or allows for statistically significant observations.

  Projects may encounter challenges associated with language barriers, technological literacy, and other characteristics that can create hard-to-reach groups for data collection. Analyzing survey data for representativeness and conducting activities such as holding focus groups may be necessary steps in identifying these barriers and developing strategies to overcome them. Additionally, strategies such as increasing survey incentives require additional funds, and projects may or may not have dedicated incentive budgets. Whether grantees have access to resources such as staff with survey expertise likely varies from project to project, and grantees may require support from administering agencies or third parties in order to conduct a successful and informative data collection effort.
- **Differences in data availability among projects may affect the ability of grantees to report certain POR metrics.** OCCS partners with Zipcar, which provides the EVs and analytics software for monitoring operational data such as vehicle use and charging activity. Zipcar provides the data to Sac Metro Air District in a format and level of detail according to a data sharing agreement that was

established during the project planning process. As noted in Section 10.4, the datasets provided by Zipcar did not include mileage for individual trips which created a barrier to using Trip Surveys to assess improved mobility VMT and avoided ICE VMT for the project.

Based on discussions with CARB and shared mobility project staff, this level of detail is available for some projects and not others, and there are significant differences among shared mobility data sharing agreements depending on the data provider, project characteristics, and vehicle telematics software. For projects which receive detailed vehicle-specific and trip-specific data, it may be possible to analyze additional metrics such as the originally proposed improved mobility and avoided ICE VMT POR metrics. However, as POR is intended to stipulate a uniform set of metrics for programs as a whole, requirements must be developed based on the available data points that are common to all projects.

The Project Team is not aware of any instances where grantees would be unable to report the current POR metrics that rely on operational data such as number of trips and VMT. If this does occur, it may be necessary to either further revise POR or work more closely with grantees to ensure that the data sharing agreements for funded projects will allow for reporting of key metrics. Data barriers may also apply to POR metrics which rely on surveys if there are projects that do not collect and retain participant contact information, or if service agreements restrict grantees' ability to communicate directly with participants for this purpose.

- **Differences in the components and objectives of Clean/Shared Mobility Options projects may create challenges in defining a single set of POR metrics and methodologies.** OCCS was the single project sampled from the Clean/Shared Mobility Options sub-program group, and the Project Team focused on developing a POR data collection and analysis approach that suited the structure of this specific carsharing project. However, the projects that have been funded and are eligible for funding through Clean/Shared Mobility Options programs can vary substantially in the types of services they offer, the benefits they seek to provide, and evaluation considerations such as the availability of operational data and their ability to collect information from project participants.

  Beyond basic operational metrics that are linked to program QM tools such as VMT and quantity of vehicle reservations, it may not be possible to define a uniform set of POR metrics that is equally reportable and relevant across the range of projects in this sub-program group. For example, metrics that rely on Trip Survey data may not be accessible for projects that do not receive timely information on which participants are completing trips, and grantees for projects which have a strong focus on a particular socioeconomic benefit may feel that POR is an inadequate portrayal of their project unless that benefit is included as a metric. Similarly, in-depth assessments of operational objectives such as financial sustainability for individual carsharing services would be difficult to capture under the prescriptive metrics-based POR format. Further coordination with administering agencies and grantees may be useful in defining the goals of POR for these programs and identifying potential challenges and considerations for individual projects.

- **Shared mobility surveys provide an opportunity to collect a variety of information and outcome-related metrics.** The Participant Survey and Trip Survey issued by OCCS contained questions related to a number of topics such as how members are using the service, how the service has affected member transportation, how satisfied members are with the service, and feedback on upcoming service changes. Some of these topics were used to assess POR metrics, and others were included in the surveys based on OCCS staff evaluation and project planning objectives. The POR metrics assessed by the Project Team focused on a set of indicators that could be linked to project GHG reductions and reduced cost to participants (e.g. improved mobility trips, avoided ICE trips, delayed vehicle purchase, reductions in gas expenses). However, as shared mobility projects can be designed to meet many objectives including encouraging increased transit use, improving participant ability

to complete specific activities such as traveling to work or medical appointments, and improving public health, there are many metrics that could be used to characterize project performance and the benefits being generated.

In communications with the Project Team, CARB staff representing the Clean/Shared Mobility Options sub-program group indicated that they are planning to have internal discussions to determine specific socioeconomic metrics that should be included in these surveys as part of evaluating the benefits being achieved within priority populations. It is possible that some or all of these metrics could be useful additions to the POR phase. Due to this, the Project Team does not consider the current list of POR metrics to be exhaustive and expects that POR for these programs may continue to evolve as these discussions move forward.

- **Quarterly reports for Clean/Shared Mobility Options provide context, metrics, and qualitative information that extends beyond POR and may be difficult to convey under the current POR framework.** CMO and STEP currently require grantees to submit quarterly reports which contain extensive information on program expenditures, performance, challenges, strategies for and assessments of potential financial sustainability of services, and other updates. The quarterly updates reviewed for OCCS also included updated GHG emission reductions, particulate matter and fossil fuel reductions, VMT reductions, and travel cost savings, which were based on incorporating program activity inputs for the reporting period into the STEP QM calculator. While POR is not currently intended to provide updated GHG estimates for sampled projects, certain metrics have been selected for inclusion in POR because they are inputs in program QM calculators and could allow for CARB or other evaluators to complete this type of M&V activity during the outcome period.

  As it appears that Clean/Shared Mobility Options project grantees are already completing these calculations and providing thorough project narratives on a regular basis, the quarterly reports are likely a more complete representation of project operational status than would be conveyed within the more limited format of POR reporting fields. These reports may serve as a valuable supplemental resource to develop findings as part of POR or other evaluation efforts.

- **Analysis of surveys requires quality assurance such as data cleaning, and may be an involved process.** Data cleaning procedures such as identifying duplicate, incomplete, or inconsistent responses is an important aspect of preparing datasets for analysis. For the sampled project, both the Trip Survey and Participant Survey contained instances of duplicate or incomplete responses which were excluded from the calculation of total responses when assessing percentages such as the percentage of trips associated with improved mobility and the percentage of members who have avoided the purchase of a personal vehicle due to the availability of the service. With larger datasets or longer surveys, data preparation may become more time consuming and complex. Projects may benefit from establishing a consistent process for cleaning data at the beginning of the survey effort, and from having periodic quality assurance conducted by administering agencies to ensure that appropriate procedures are being followed.

10.7. Recommendations

The following recommendations are presented for administering agency consideration. These recommendations are designed to support improved evaluability and evaluation of Clean/Shared Mobility Options programs moving forward.

- **Monitor survey response rates and explore methods of increasing engagement from participants.** As noted above, the long-term response rate for the sampled OCCS project is unclear based on the limited data collection time frame used for this exercise. There may be opportunities to increase response rates within this project and within other Clean/Shared Mobility Options projects which

seek to collect participant survey data. The following types of activities may be effective in efforts to increase survey response rates:

- **Ensuring continued involvement from project partners:** Based on the data collection process for this program and other California Climate Investments programs such as AHSC, survey data collection may benefit significantly from the ability to leverage existing working relationships between project staff and participants. Project staff may offer valuable insights for the development of the data collection strategy, and an existing level of trust and communication with project staff may encourage participants to provide feedback through surveys. For the sampled OCCS project, staff have regularly engaged with members at project outreach events and were directly involved in administering and communicating with members about the survey effort. The effects of this type of engagement may increase as members become more aware of surveys and incentives through continued events and other outreach. For long-term data collection activities, it may also be useful to inform members at the time of enrollment that the project includes a survey effort so that they are prepared for later survey communications and invitations.
- **Identifying and overcoming survey accessibility issues:** One challenge in obtaining high response rates can be accessibility issues such as language barriers, technological literacy or access for online surveys, and limited survey awareness among participants who are less engaged with certain outreach formats such as in-person events. Project staff may have initial thoughts regarding specific accessibility issues within the participant population, but should continually assess these issues and determine whether changes are needed to the data collection strategy. An example of this is analyzing participant characteristics collected within survey data to determine whether the survey sample is representative of the larger participant population. Additionally, conducting formal focus groups or gathering informal feedback during day-to-day communications with participants may help to identify hard-to-reach groups and develop strategies for improved member engagement.
- **Determining effective incentives:** Conducting an initial assessment of the type and level of incentives to offer for the completion of surveys, and testing different incentives during the data collection process can be useful activities in improving participant response. For the sampled OCCS project, staff sought initial feedback on incentives during member engagement events and determined to use a combination of a gift card raffle for the Trip Survey and a raffle for kitchen multicookers for the Participant Survey.

  For shared mobility projects that include a fee for membership or vehicle usage, it may also be useful to offer service credits such as for free vehicle hours as an incentive for completing surveys. These credits could represent a cost savings for the project as compared to gift cards and may encourage increased use of the service along with improved survey response rates. OCCS is currently offered at no charge to members, but project staff indicated that they will likely soon be implementing a small fee for using the vehicles. The Project Team recommends that grantees explore the use of this and other incentive formats to assess their relative effectiveness in motivating member participation.

- **Survey data collection should be conducted in a manner that appropriately engages, informs, and protects participants.** While the current POR framework is not intended to serve as a form of human subjects research, surveying of shared mobility participants should be viewed as a sensitive activity that requires consideration of participant consent, privacy, and overall risk. For example, surveys

should avoid collecting PII unless additional protocols are taken to protect this information. Surveys should also make efforts to fully inform participants of the purpose of data collection and how the information will be used. If possible, POR surveying should be conducted or overseen by individuals with expertise in survey administration, data collection protocols, and equity considerations related to the evaluation of shared mobility projects such as community engagement best practices.[117]

- **Refer to the quarterly reports that are submitted for Clean/Shared Mobility Options projects as a supplementary resource for POR assessments.** As these quarterly reports provide additional context and narrative surrounding operational metrics such as quantity of trips and VMT and also include revised estimates of project GHG reductions and other benefits, they are likely a valuable resource for gaining insight into the ongoing performance and impacts of funded Clean/Shared Mobility Options projects. Additionally, these reports contain information related to project operational strategies, outreach and education, potential solutions to financial sustainability, and other topics that would be difficult to include in the metrics-based POR framework.
- **Refer to the results of current and upcoming studies on CMO and STEP which may provide further insight into evaluation approaches and standards for these projects.** Shared mobility is an evolving topic that is associated with a high level of interest from academic and industry researchers, and several in-depth studies are being conducted to evaluate and understand the benefits and business models of these projects. For example, OCCS was the subject of a case study conducted by the Shared-Use Mobility Center in February 2020, and OCCS and many other projects in the Clean/Shared Mobility Options program subgroup were included in equity evaluations as part of The Greenlining Institute's Clean Mobility Equity Playbook which was completed in 2021.[118] The Clean Mobility Equity Playbook also provides summaries of ongoing measurement and analysis activities that are being conducted for these projects, some of which involve in-depth evaluations being completed by academic or industry researchers. Additionally, based on discussions with CARB staff, several other CMO and STEP projects are in the process of being evaluated as part of an extensive UC Berkeley study of metrics and evaluation methodologies for these project types.

  While these other studies may not specifically focus on the POR phase, they may provide insight that could help to further develop POR, guide the overall development of evaluation procedures for these programs, or provide further insight into potential long-term and future implementation of shared mobility services. This may include identifying additional key metrics, standardized methodologies, or findings related to GHG impacts and other benefits of one or more current California Climate Investments projects. The Project Team recommends that CARB monitor the results and recommendations from current and upcoming in-depth studies as part of finalizing the metrics, methodologies, and scope of POR for Clean/Shared Mobility Options projects.
- **Recommended purpose of POR within Clean/Shared Mobility Options:** POR may be used as a method of validating project QM estimates and as a broader evaluation tool, depending on the metrics collected. In the currently approved list of POR metrics for these projects, some metrics are based on program QM inputs and others were developed independently. For example, the CMO

[117] The Greenlining Institute, "Making Equity Real in Mobility Pilots Toolkit," July 8, 2019, https://greenlining.org/publications/reports/2019/making-equity-real-in-mobility-pilots-toolkit/.

[118] MOD Learning Center, "Our Community CarShare Case Study," 2020, https://learn.sharedusemobilitycenter.org/overview/our-community-carshare-case-study-sacramento-ca-2020/.;

The Greenlining Institute, *Clean Mobility Equity: A Playbook. Lessons from California's Clean Transportation Programs*, 2021, https://greenlining.org/publications/reports/2021/clean-mobility-transportation-equity-report/.

QM calculator currently uses inputs including average occupancy per vehicle and length of average trip to compute GHG reductions associated with carsharing services. POR metrics such as quantity of trips, riders, and VMT could be used to calculate these inputs and obtain updated GHG reductions estimates. As projects such as OCCS include revised GHG reductions estimates in quarterly reporting, this could be used as a method of validating those calculations if GHG assessment were to be added as a component of POR.

In contrast, survey-based metrics such as the percentage of trips associated with avoided ICE travel cannot be directly linked to a specific QM input but may provide additional insight into the extent to which the carsharing service is affecting mode share. With robust data collection efforts, these metrics could be compared across projects to identify outliers for further analysis. CARB and project staff may also identify additional metrics to include in these surveys based on the results of upcoming in-depth shared mobility studies or as part of assessing socioeconomic and equity impacts of funded projects. POR in its current form may be limited in its ability to use survey results to provide quantitative insight into project GHG reductions.

Past studies have used participant surveys to quantify the GHG effects of carsharing services, such as by assessing how access to carsharing has changed participants' driving behaviors, whether the availability of shared vehicles has caused them to sell or avoid the purchase of a private vehicle, and combining these responses with fuel efficiency factors of vehicles used by respondents to calculate the increase or decrease in emissions associated with access to the service.[119] There may be an opportunity for expanded use of surveying to assess GHG impacts of programs such as CMO and STEP, but obtaining reliable and representative results from these efforts would likely require additional data collection resources and active involvement from individuals with expertise in research design and statistical analysis.

As an initial step, the Project Team recommends that CARB first work with Clean/Shared Mobility Options project staff to determine whether reliable and sustainable survey data collection processes can be implemented with the existing resources that are available to projects. This may require pilot survey efforts similar to those conducted as part of this data collection exercise. If CARB determines that many projects would be unable to meet survey-based POR requirements due to insufficient resources, data collection barriers, or other issues, it may be necessary to temporarily focus on collecting POR metrics that rely on operational data and explore options for improving survey capabilities. This may include assigning administering agency staff to assist with the process, facilitating targeted in-depth evaluations, or other alternatives as determined by California Climate Investments.

[119] Elliot W. Martin and Susan A. Shaheen, "Greenhouse Gas Emission Impacts of Carsharing in North America," *IEEE Transactions on Intelligent Transportation Systems* 12, no. 4 (December 2011): 1074–86, https://doi.org/10.1109/TITS.2011.2158539.

11. Low Carbon Transportation: Advanced Technology Demonstrations

The California Climate Investments portfolio includes several programs that are focused on funding low carbon transportation improvements for mobile sources such as light-duty and heavy-duty vehicles. CARB groups several of these initiatives into an overall Low Carbon Transportation program that contains individual sub-programs and pilots such as Clean Cars for All, Clean Mobility Options, Clean Off-Road Equipment Voucher Incentive Project, and Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project. In the POR framework provided to the Project Team, CARB distinguishes among Low Carbon Transportation sub-programs by defining separate sets of POR metrics for Advanced Technology Demonstrations, Clean/Shared Mobility Options, and Active Transportation Infrastructure.

This section presents the approach and findings of the data collection activities conducted for the Advanced Technology Demonstrations sub-program group. This group includes a variety of pilot programs and projects which are administered by CARB, such as the Advanced Technology Freight Demonstration Program, Zero-Emission Truck and Bus Pilot, and the Off-Road and On-Road Advanced Technology Demonstrations pilots.

11.1. Project Sample

The Project Team sampled four projects within the Low Carbon Demonstrations program group. Based on information received from CARB, at the time that the Project Team sampled projects in October 2019 there were eight projects eligible for POR within the Zero-Emission Truck and Bus Pilots, six projects eligible for POR within the Off-Road Advanced Technology Demonstrations Pilots, two projects eligible for POR within the On-Road Advanced Technology Demonstrations Pilots, and three projects eligible for POR within the Advanced Technology Freight Demonstration Program. The final project sample included one project from each of these programs.

Brief descriptions of the sampled projects are as follows:

- **Zero-Emission Truck and Bus Pilot. Fuel Cell Electric Bus Commercialization Consortium (FCEBCC), CCIRTS Project ID G16-ZBUS-01.** This project consists of building 20 fuel cell electric buses for use by Alameda-Contra Costa Transit District (AC Transit) and Orange County Transportation Authority (OCTA), implementing infrastructure improvements including hydrogen fueling stations, and providing necessary maintenance during the demonstration period.
- **Advanced Technology Freight Demonstration Projects. Multi-Source Facility Demonstration Project: Multi-Class Heavy-Duty Zero-Emission Truck Development Project for Intermodal and Warehouse Facilities, CCIRTS Project ID G14-LCTI-06.** This project consists of designing and manufacturing electric yard tractors and service trucks for use in heavy-duty rail yard and freight facility operations. The project includes deploying 26 of these vehicles in field demonstrations at two rail yard locations and one freight logistics facility.
- **Off-Road Advanced Technology Demonstration Project. C-PORT: The Commercialization of POLB Off-Road Technology Demonstration, CCIRTS Project ID G16-DEMO-03.** This project consists of the deployment of four zero-emissions cargo handling vehicles including three battery-electric top handlers and one battery-electric yard truck at container terminals within the Port of Long Beach (POLB). The project includes installing charging stations for each vehicle.
- **On-Road Advanced Technology Demonstration Project. Opposed Piston Engine Class 8 Heavy Duty On-Road Demonstration, CCIRTS Project ID G16-DEMO-01.** This project consists of building four diesel engines which use an opposed piston (OP) design and incorporate a Nitrogen Oxide

(NOx) aftertreatment to result in improved fuel efficiency and reduced NOx emissions. The project includes deploying these engines in a field demonstration and conducting laboratory monitoring with a dynamometer to demonstrate performance and efficiency.

11.2. Activities Conducted

Data collection for the sampled Low Carbon Demonstrations projects consisted of the following activities:

11.2.1. Project Documentation Reviews

The Project Team reviewed the grant applications and publicly available project summary documents for each sampled project in order to gain a more thorough understanding of components, scope, and timeline.[120] A primary objective of these reviews was to identify the data collection and monitoring plans associated with each pilot or demonstration project and consider these plans in the context of POR and from an overall project evaluation perspective.

11.2.2. Administering Agency Interviews

The Project Team held interviews with CARB staff who were involved in administering the pilot programs and demonstration projects. The purpose of these interviews was to gain an understanding of each project, identify current data collection and reporting procedures, and determine the availability of POR metrics and related documentation. As part of these interviews the Project Team requested the applications that were submitted by grantees for each sampled project. The Project Team also requested that CARB send final evaluation reports for each sampled project upon completion.

11.2.3. Final Report Reviews

Each grantee is required to conduct a field demonstration of the funded vehicle or technology, during which operational and performance data are collected and analyzed. Grantees are required to provide a final report for each project which includes the result of the field demonstration and related findings. Based on discussions with CARB, the Project Team determined that these final reports would be the best source of POR data and metrics for Advanced Technology Demonstrations. CARB indicated that these reports would address most or all of the POR requirements for these projects. Due to project delays and grant extensions, final reports were not available for two of the four sampled projects as of the end of the data collection effort. As a result the Project Team reviewed the final report for two of the sampled projects to gain insight into results and collect applicable POR metrics.

11.2.4. Assessment of Barriers and Evaluation Considerations

Throughout the above activities, the Project Team considered whether there are data collection barriers or analytical issues that may present challenges to POR or represent opportunities for improvement in evaluation of Advanced Technology Demonstrations projects.

Table 11-1 displays the list of Advanced Technology Demonstration POR Metrics approved by CARB as of the start of this data collection task.

[120] CARB provides publicly available project summaries for each Heavy-duty Pilot and Demonstration Project: https://ww3.arb.ca.gov/msprog/lct/posters_heavy.htm.

Table 11-1. Low Carbon Demonstrations POR Metrics

Program Name/Sub-Program Component	Metrics
All	Tracking dates of data submission (i.e. time period represented by reported metrics)
Low Carbon Transportation: Advanced Technology Demonstrations	Change in fuel consumption compared to baseline
	Change in energy use compared to baseline
	Change in vehicle miles traveled compared to baseline
	Change in GHG emissions compared to baseline
	Change in emissions of criteria air pollutants compared to baseline
	Change in cost compared to baseline
	Qualitative assessment of advancement of technology (e.g. continued use by funding recipient, increase in market share, potential commercialization of technology)

As noted above, the final grant reports were identified as the most reliable source of POR data and metrics for these projects, but reports were not yet available for two of the four sampled projects due to extensions in the project timelines. The Project Team was therefore able to review final reports for project G16-ZBUS-01 and project G14-LCTI-06 and provide POR metrics as reported within those documents. For the two remaining projects, the Project Team instead focused on using application reviews to characterize and compare data collection and evaluation approaches across projects.

11.3. Results by Sampled Project

This section summarizes the results of the data collection effort by sampled project.

11.3.1. Fuel Cell Electric Bus Commercialization Consortium (FCEBCC), CCIRTS Project ID G16-ZBUS-01

This project consists of building 20 fuel cell electric buses for use by Alameda-Contra Costa Transit District (AC Transit) and Orange County Transportation Authority (OCTA), implementing infrastructure improvements including hydrogen fueling stations, and providing necessary maintenance during the demonstration period.

This project was funded in the 2016-2017 FY and the CCIRTS database lists total GGRF funding as $22,347,502 with expected GHG reductions of 9,760 MTCO2e. At the time of project sampling the CCIRTS database showed an expected completion date of March 2020, but the project received an extension and the demonstration and data collection period continued through February 2021. The final report was submitted in May 2021.

11.3.1.1. Data Collected

Data collected for this project included:

1. The final report submitted by the grantee; and
2. Supporting documentation consisting of the project application and publicly available project summary document.

11.3.1.2. Results by Metric

The final report submitted by CTE provides details regarding the demonstration period of the fuel cell electric buses (FCEBs) under operation by AC Transit and OCTA, with results and metrics reported separately for each transit agency. The report summarizes operational metrics such as fuel consumption, energy use, and VMT of the FCEBs as compared to baseline vehicles which were operated concurrently by the transit agencies. Each of the agencies purchased 10 FCEBs to operate during the demonstration period. AC Transit used 5 conventional diesel buses as its baseline fleet during the demonstration period, while OCTA used 10 compressed natural gas (CNG) buses as its baseline fleet.[121] Data on vehicle performance was provided to CTE directly by each agency.

The following POR metrics are inclusive of data reported for both the AC Transit and OCTA demonstration periods and represent all 20 FCEBs deployed through this project. It should be noted that the final report for this project provides additional detail, context, and metrics, and the information presented in this section is for summary purposes in accordance with the current POR framework.

The POR results for this project based on the final report submitted by the grantee are summarized below.

Tracking dates of data submission: January 1, 2020 – February 28, 2021

The current POR framework for Advanced Technology Demonstrations projects specifies that the outcome period begins once vehicles or equipment are operational. For this project, the operational date is the point at which the buses begin providing service as part of the data collection and demonstration period, which differed between the two transit agencies. The demonstration period for the 10 buses operated by AC Transit began on January 1, 2020, and the demonstration period for the 10 buses operated by OCTA began on February 9, 2020. Both agencies ended their data collection and demonstration on February 28, 2021.

The above outcome period of January 1, 2020 through February 28, 2021 uses the earlier of these two dates and extends through the end of the demonstration period in order to represent all outcome-related data available for this project as of the final report. This time frame is longer than one year and while some metrics could be prorated to estimate values for a 12-month outcome period, the Project Team determined that aligning the outcome period with the full demonstration period would be a more appropriate reflection of the monitoring and reporting activities conducted for these vehicles.

Change in fuel consumption compared to baseline: -74,250 DGE

The final report states that the 10 FCEBs operated under AC Transit had total VMT of 274,195 miles during the demonstration period, while the 10 FCEBs operated under OCTA had total VMT of 295,862 miles. The

[121] According to the report, OCTA operates a 100% CNG fleet.

report also displays the fuel economy of the FCEBs and baseline diesel or CNG buses in units of miles per diesel gallon equivalent (DGE).

For AC Transit, the report shows an average fuel economy of 9.14 miles per DGE for the FCEBs and an average fuel economy of 4.15 miles per DGE for the diesel buses. For OCTA, the report shows an average fuel economy of 9.56 miles per DGE for the FCEBs and an average fuel economy of 4.28 miles per DGE for the CNG buses.

To estimate the DGE used by the FCEBs during the demonstration period, the Project Team divided the FCEB VMT associated with each agency by the average fuel economy of its FCEBs.

Due to differences in operational schedules, the baseline vehicles for each agency traveled a different number of miles than the FCEBs during the demonstration period. In order to compare baseline fleet fuel consumption to FCEB fuel consumption, the Project Team divided the FCEB VMT for each agency by the average fuel economy of its baseline fleet. This resulted in an estimate of the DGE that would be used by the baseline vehicles to travel the same number of miles as the FCEBs.

Based on these calculations, total fuel consumption by FCEBs for the demonstration period was estimated to be approximately 60,947 DGE, and total fuel consumption to travel the same number of miles using baseline vehicles was estimated to be approximately 135,198 DGE. The change in fuel consumption was therefore calculated by subtracting the baseline usage from the FCEB usage, resulting in -74,250 DGE which indicates a reduction in fuel usage compared to a baseline scenario.[122]

Change in energy use compared to baseline: -9,984,398 MJ

The report summarizes consumption in terms of energy use by converting DGE to megajoules (MJ) with a multiplication factor of 146.52. Applying that factor to the change in fuel consumption of -74,250 DGE above, the change in energy use between FCEBs compared to diesel baseline vehicles would be approximately -10,879,162 MJ. However, the California Climate Investments Quantification Methodology Emission Factor Database defines the energy density of diesel fuel as 134.47 MJ/gallon.[123] The Project Team chose to use the energy density value as defined by California Climate Investments in the calculation of this metric. Applying that factor to the fuel consumption metric results in a change in energy use value of -9,984,398 MJ.

Change in vehicle miles traveled compared to baseline: Not applicable

While the baseline vehicles traveled a different number of miles than the FCEBs during the demonstration period, POR metrics were normalized by VMT to allow for comparison between FCEBs and baseline vehicles traveling an equivalent number of miles. The Project Team did not consider the change in VMT as compared to a baseline scenario to be an applicable metric for this type of project.

Change in GHG emissions compared to baseline: -628.91 MTCO2e

The report summarizes a benefits analysis that was conducted by the grantee in order to estimate the emission reductions associated with the FCEBs during the demonstration period. Similar to the metrics

[122] These values are rounded.

[123] "California Climate Investments Quantification, Benefits, and Reporting Materials | California Air Resources Board," accessed June 10, 2021, https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials.

summarized above, this involved calculating the emissions of the FCEBs during the demonstration period and comparing this to the emissions of the baseline buses traveling an equivalent number of miles. The calculation used the measured amount of hydrogen used by the FCEBs and actual fuel economy of FCEBs and baseline buses during the baseline period rather than assumed or approximated values. The calculation also used Carbon Intensity (CI) values based on the natural gas reforming plants serving the AC Transit and OCTA stations where the FCEBs were operated.[124] The result of these calculations shows an estimated emissions reduction of 628.91 MTCO2e for FCEBs as compared to the baseline buses.

Change in emissions of criteria air pollutants compared to baseline:

- NOx: -0.54 tons
- ROG: -1.04 tons
- PM10: -0.025 tons
- WER: -1.149 tons

The benefits analysis described above and presented in the final report provides estimates of criteria pollutant reductions including nitrogen oxides (NOx), reactive organic gases (ROG), particulate matter (PM10), as well as a weighted emissions reduction factor (WER).

Change in cost compared to baseline: $404,016

The report provides information on the maintenance cost per mile and the fuel cost per mile for FCEBs and the baseline buses. For AC Transit, FCEB maintenance cost per mile was estimated to be $0.63 and fuel cost per mile was estimated to be $1.08. Baseline diesel maintenance cost per mile was estimated to be $0.43 with fuel cost per mile of $0.40.

For OCTA, FCEB maintenance cost per mile was estimated to be $0.56 and fuel cost per mile was estimated to be $0.96. Baseline CNG maintenance cost per mile was estimated to be $0.60 with fuel cost per mile of $0.37.[125]

The Project Team calculated operating costs of FCEBs for the demonstration period by multiplying the costs per mile by the total VMT of FCEBs (274,195 miles for AC Transit and 295,862 miles for OCTA). This resulted in total maintenance and fuel costs of approximately $918,584.

As with the baseline comparisons for the above metrics, these FCEB costs were compared to the operating costs of baseline vehicles traveling an equivalent number of miles. The total maintenance and fuel costs of baseline vehicles was estimated to be approximately $514,568. Subtracting the total baseline cost from the total FCEB cost results in $404,016, which represents the estimated additional maintenance and fuel costs associated with operating the 20 FCEBs over the course of the demonstration period.

Qualitative assessment of advancement of technology: According to the final report, the results of the demonstration project suggest that FCEBs are a viable and emerging option for transit agencies in their transition to zero-emission fleets. The report summarizes a variety of outreach events that were conducted to promote the FCEBs during the project period and indicates that the project helped to gain increased industry support for FCEBs. Project staff expect the prominence of FCEBs to increase

[124] The calculation used a CI value of 165.88 gCO_2e/MJ for AC Transit and 131.39 gCO_2e/MJ for OCTA.

[125] The report notes that maintenance cost estimates do not reflect costs that are covered under vehicle warranties.

significantly in the coming years. The report also provides a summary of lessons learned regarding project partnerships, scheduling, and operational considerations which may inform future FCEB deployments.

Table 11-2 summarizes the above metrics for this project.

Table 11-2. Project G16-ZBUS-01 Outcome Metrics

Program Name/Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	1/1/2020 - 2/28/2021
Low Carbon Transportation: Advanced Technology Demonstrations	Change in fuel consumption compared to baseline	-74,250 DGE
	Change in energy use compared to baseline	-9,984,398 MJ
	Change in vehicle miles traveled compared to baseline	Not applicable
	Change in GHG emissions compared to baseline	-628.91 MTCO2e
	Change in emissions of criteria air pollutants compared to baseline	NOx: -0.54 tons ROG: -1.04 tons PM10: -0.025 tons WER: -1.149 tons
	Change in cost compared to baseline	$404,016
	Qualitative assessment of advancement of technology (e.g. continued use by funding recipient, increase in market share, potential commercialization of technology)	(summarized above)

The information summarized above is intended to serve as an overview of this project within the context of current POR requirements for Advanced Technology Demonstration projects. The final report developed by the grantee and used as the source of this information provides more extensive details regarding the planning, implementation, and results of this demonstration project. This includes appendices which provide supplemental metrics, cost-effectiveness calculations, and additional information on the data collection and analysis approaches used by the grantee. Additionally, these POR metrics were calculated using aggregated project-level values and averages appearing in the report and may differ from results that could be obtained by using more granular data such as vehicle-specific operational records. The Project Team relied on the project report for outcome-related data and did not directly communicate with project staff as part of this assessment.

11.3.2. Multi-Source Facility Demonstration Project: Multi-Class Heavy-Duty Zero-Emission Truck Development Project for Intermodal and Warehouse Facilities, CCIRTS Project ID G14-LCTI-06

This project consists of designing and manufacturing heavy-duty battery-electric vehicles including 23 yard trucks and 3 service trucks for use in heavy-duty rail yard and freight facility operations. The project includes deploying these vehicles in field demonstrations at two rail yard locations and one freight logistics facility.

The project grantee is the San Bernardino County Transportation Authority. Monitoring, analysis, and data reporting for this project was conducted by Ricardo, Inc. ("Ricardo"). Ricardo was contracted by CARB to perform third-party quantification of performance and impacts of vehicles and equipment funded through a series of Advanced Technology Demonstration projects.[126]

This project was funded in the 2014-2015 FY and the CCIRTS database lists total GGRF funding as $9,100,800 with expected GHG reductions of 5,235 MTCO2e. At the time of project sampling the CCIRTS database showed an expected completion date of April 2019, but due to extensions the demonstration and data collection period continued through December 2019. The final report from the San Bernardino County Transportation Authority was submitted in March 2020, and the companion final data analysis report by Ricardo was submitted in May 2021.

11.3.2.1. Data Collected

Data collected for this project included:

1. The final report submitted by the San Bernardino County Transportation Authority summarizing the project approach, milestones, and results;
2. The companion final monitoring and data analysis report submitted by Ricardo; and
3. Supporting documentation consisting of the project application and publicly available project summary document.

11.3.2.2. Results by Metric

While the San Bernardino County Transportation Authority report provides information on initial monitoring results, they are preliminary and were developed prior to the end of the data monitoring period. The companion report prepared by Ricardo provides final results for the entire monitoring period and includes in-depth information regarding the monitoring, analysis, and reporting approach used to quantify the performance of these vehicles. The Project Team primarily referenced the Ricardo report for POR metrics applicable to this project.

Ricardo indicates that this project included the deployment and demonstration of 23 battery-electric yard trucks and 3 battery-electric service trucks manufactured by BYD Motors ("BYD"). Vehicles were manufactured and deployed over time rather than simultaneously, and design improvements were made to the newly manufactured vehicles over the course of the project. The report notes that vehicles were categorized into phases in order to reflect their relative design features, with Phase 0 referring to the earliest vehicles, Phase 1 referring to the second deployment of vehicles, and Phase 2 referring to the final

[126] "Ricardo Awarded Key Heavy-Duty Zero-Emissions Vehicle Project by CARB," October 24, 2017, https://ricardo.com/news-and-media/news-and-press/ricardo-awarded-key-heavy-duty-zero-emissions-vehi.

deployment of vehicles. Each subsequent phase offered incremental improvements over the previous phase such as increased battery life. The vehicles were deployed to three facilities during the project for demonstration purposes. This included two rail facilities operated by BNSF Railway ("BNSF") and one freight logistics facility operated by Daylight Transport. According to the report, several vehicles were moved from one facility to the other during the demonstration period, but the final deployment locations of battery-electric vehicles at these facilities were as follows:

- The BNSF San Bernardino Facility had seven (7) Phase 2 yard trucks and two (2) Phase 1 service trucks;[127]
- The BNSF Hobart Facility had three (3) Phase 1 yard trucks, seven (7) Phase 2 yard trucks, and one (1) Phase 1 service truck; and
- The Daylight Transport Facility had three (3) Phase 0 yard trucks and three (3) Phase 1 yard trucks.

Data loggers were installed on each vehicle by Ricardo to collect telematics data on operations and performance. The facility operators Daylight Transport and BNSF also collected manual odometer readings and information on maintenance and repairs during the demonstration period.

One diesel yard tractor at a Daylight Transport facility and one diesel yard tractor at a BNSF facility were designated as the baseline vehicles for this demonstration. Data loggers were used to monitor the performance of these two baseline diesel vehicles for comparison to the battery-electric vehicles.

The Ricardo report presents analyses and results separately for each demonstration facility rather than providing a project-level summary of quantitative findings. The Project Team assessed metrics by facility and summed these values to present project-level POR metrics.

When possible, the Project Team calculated POR metrics based on the actual operational characteristics of battery-electric vehicles, such as miles traveled, during the demonstration period. However for some metrics, the reports represented an estimate of operating conditions for battery-electric vehicles in a typical year rather than the mileage and energy use measured for battery-electric vehicles during the demonstration period. While this is reasonable and serves the objective of Advanced Technology Demonstrations in providing insight into the benefits of commercializing demonstrated vehicles for everyday use, it is somewhat out of alignment with the current intent of POR metrics in capturing outcomes for a specific period in time. The Project Team was limited to using the information available in the report, and the result is that the set of POR metrics presented for this project should be considered individually rather than compared as part of any project-level assessment.

The POR approaches and results for this project based on the final reports submitted by the San Bernardino County Transportation Authority and Ricardo are summarized below. It should be noted that the final reports for this project provide additional detail, context, and metrics, and the information presented in this section is for summary purposes in accordance with the current POR framework.

Tracking dates of data submission: April 11, 2018 – December 31, 2019

[127] The Ricardo report notes that one of the Phase 1 service trucks deployed to the BNSF San Bernardino Facility experienced limited operation during the demonstration period and was excluded from analysis. Additionally, no data were collected on the performance of the other battery-electric service truck at BNSF San Bernardino and it was also excluded from analysis. Therefore the Ricardo analysis of the BNSF San Bernardino site includes battery-electric yard trucks only.

The Project Team defined the operational date for the funded vehicles as the date when demonstration monitoring began. The Ricardo report provides detailed information on the monitoring period for each vehicle. Monitoring periods varied by vehicle; the start date of monitoring ranged from April 2018 to May 2019 and the end date of monitoring ranged from March 2019 to December 2019. The difference in monitoring start, end, and duration for different vehicles makes it difficult to define a single outcome period at the project level.

The above outcome period of April 11, 2018 through December 31, 2019 is based on the earliest monitoring start date and the latest monitoring end date across all funded vehicles to represent all outcome-related data collected for this project and presented in the Ricardo report. The Project Team determined that aligning the outcome period with the full expanse of the demonstration period would be the most informative reflection of project outcomes.

Change in fuel consumption compared to baseline: -52,726 DGE

- BNSF San Bernardino: -21,181 DGE
- BNSF Hobart: -22,883 DGE
- Daylight Transport: -8,662 DGE

Ricardo calculated fuel efficiency in terms of miles per DGE for each battery-electric vehicle and baseline vehicle used in this project. The report also estimates the total miles traveled by battery-electric vehicles as recorded by manual logs and electronic data loggers. These two sources resulted in different estimates of mileage, and the report notes that this could be due to logger errors, missing operational logs, or other issues. For the purpose of calculating POR metrics, the Project Team used the greater of the two mileage values reported for each vehicle, whether manual or electronic.

In order to estimate the DGE consumption of battery-electric vehicles during the demonstration period, the Project Team divided the total miles traveled by each vehicle by its fuel efficiency value. To compare this to the DGE that would be consumed by baseline diesel vehicles traveling an equivalent distance, the Project Team divided the total miles traveled by all battery-electric vehicles by the fuel efficiency of the diesel baseline vehicles. Subtracting the DGE for baseline vehicles from the DGE result for battery-electric vehicles provided the estimated change in fuel consumption for the demonstration period, where a negative value indicates a reduction in fuel consumption compared to a baseline scenario.

For the BNSF San Bernardino facility, no data was available on estimated fuel efficiency for one of the Phase 2 yard trucks. The Project Team applied the average Phase 2 yard truck fuel efficiency of 19.9 miles/DGE at this facility to the fuel consumption calculation for this vehicle. Additionally, the electric service truck at BNSF San Bernardino did not receive a data logger and no performance data was available for this vehicle. Ricardo excluded this service truck from its calculation of demonstration outcomes, and the Project Team similarly did not include this service truck in the calculation of the fuel consumption POR metric. Finally, there were no baseline diesel yard trucks operating at the BNSF San Bernardino facility during the demonstration period. Ricardo calculations for BNSF San Bernardino used the BNSF Hobart diesel yard truck as a baseline, and the Project Team also used this diesel yard truck and its estimated fuel efficiency of 4.8 miles/DGE to calculate change in fuel consumption for this site.

Table 11-3 provides additional details regarding estimated average fuel efficiency and total VMT of vehicles at each demonstration facility.

Table 11-3. Fuel Efficiency and VMT of G14-LCTI-06 Demonstration Facilities

BNSF San Bernardino	
Average battery-electric yard truck fuel efficiency (Phase 1 and 2)	20.0 miles/DGE
Baseline diesel yard truck fuel efficiency	4.8 miles/DGE
Total VMT estimate of battery-electric yard trucks during demonstration	133,943 miles
BNSF Hobart	
Battery-electric Yard Trucks	
Average battery-electric yard truck fuel efficiency (Phase 1 and 2)	22.1 miles/DGE
Baseline diesel yard truck fuel efficiency	4.8 miles/DGE
Total VMT estimate of battery-electric yard trucks during demonstration	135,602 miles
Battery-electric Service Truck	
Electric service truck fuel efficiency	40.3 miles/DGE
Baseline diesel service truck fuel efficiency	15.0 miles/DGE[128]
Total VMT estimate of battery-electric service truck during demonstration	814 miles
Daylight Transport	
Average battery-electric yard truck fuel efficiency (Phase 0 and 1)	11.9 miles/DGE
Baseline diesel yard truck fuel efficiency	2.1 miles/DGE
Total VMT estimate of battery-electric yard trucks during demonstration	22,107 miles

Change in energy use compared to baseline: -7,090,065 MJ

- BNSF San Bernardino: -2,848,209 MJ
- BNSF Hobart: -3,077,077 MJ
- Daylight Transport: -1,164,779 MJ

As defined in the California Climate Investments Quantification Methodology Emission Factor Database, diesel fuel has an energy density of 134.47 MJ/gallon. The Project Team applied this multiplication factor to the change in fuel metric above in order to provide an estimate of the change in energy use compared to baseline diesel vehicles.

Change in vehicle miles traveled compared to baseline: Not applicable

While the baseline diesel trucks traveled a different number of miles than the battery-electric yard trucks and service trucks during the demonstration period, the project assumes that battery-electric yard trucks

[128] The demonstration did not include any baseline diesel service trucks. The Ricardo report estimates that a baseline diesel service truck is 1.7 times less efficient than an electric service truck and would consume 31 gallons per year with an assumed annual mileage of 465 miles. This equals a fuel efficiency of 15 miles per gallon.

would typically travel the same distance as baseline diesel vehicles under regular operating conditions and VMT reduction was not an objective of this demonstration.

Change in cost compared to baseline: -$26,988

- BNSF San Bernardino: -$12,323
- BNSF Hobart: -$46,279
- Daylight Transport: $26,000

The report provides estimates of cost per mile in terms of energy costs for battery-electric vehicles and diesel costs for baseline vehicles. For battery-electric vehicles at the Daylight Transport and BNSF San Bernardino facilities, Ricardo quantified both the energy cost in dollars per kilowatt-hour ($/kWh) and the demand-based electricity costs in dollars per kilowatt ($/kW) which accounted for electricity usage during peak, mid-peak, and off-peak hours as these facilities were subject to a demand charge from the electric utility during peak periods.

The Project Team summed the reported energy and demand costs to obtain the total cost per mile for battery-electric vehicles and multiplied this by the distance traveled by all battery-electric vehicles during the demonstration period to estimate the total cost. BNSF Hobart was exempt from demand charges and its estimated mileage costs included energy costs in $/kWh only.

For diesel yard trucks, Ricardo calculated the cost per mile associated with a range of different fuel prices. The Project Team used the average cost per mile from this assessment and multiplied this by the total distance traveled by battery-electric vehicles during the demonstration period to estimate the cost that would have been incurred by diesel vehicles traveling an equivalent distance.[129] Subtracting the baseline diesel operating cost from the battery-electric vehicle operating cost provided an estimate of the change in cost compared to the baseline for each facility for the demonstration period.

The negative cost values for BNSF San Bernardino and BNSF Hobart above therefore represent decreases in operational costs as compared to the baseline scenario, while the cost value for Daylight Transport represents an increase in operating costs for the battery-electric vehicles as compared to the diesel baseline. The total change in cost compared to the baseline across all three facilities was estimated to be -$26,988.

The operating cost estimates for BNSF San Bernardino did not include the battery-electric service truck, as no data were available for miles traveled by this truck during the demonstration period.

The report does not include a comparison of maintenance costs of battery-electric vehicles to baseline diesel vehicles. Ricardo explains that this is intentional, as demonstration vehicles would have higher repair and maintenance costs than would be typical for a commercialized vehicle and that this does not allow for an appropriate comparison.

Table 11-4 provides additional details regarding the estimated costs per mile for battery-electric and diesel vehicles for each demonstration facility.

[129] The average diesel cost per mile is based on a fuel price of $3 per DGE.

Table 11-4. Estimated Costs per Mile of G14-LCTI-06 Vehicles by Demonstration Facility

BNSF San Bernardino[130]	
Estimated battery-electric yard truck electricity energy cost per mile	$0.42
Estimated battery-electric yard truck electricity cost per mile from demand charges	$0.11
Estimated diesel yard truck cost per mile (average assuming $3/DGE)	$0.62
BNSF Hobart	
Battery-electric yard trucks (Phase 1 and 2)	
Estimated battery-electric yard truck electricity energy cost per mile	$0.28
Estimated battery-electric yard truck electricity cost per mile from demand charges	N/A
Estimated diesel yard truck cost per mile (average assuming $3/DGE)	$0.62
Battery-electric service truck	
Estimated battery-electric service truck electricity energy cost per mile	$0.15
Estimated battery-electric service truck electricity cost per mile from demand charges	N/A
Estimated diesel service truck cost per mile (average assuming $3/DGE)[131]	$0.20
Daylight Transport	
Phase 0 battery-electric yard trucks	
Estimated battery-electric yard truck electricity energy cost per mile	$0.08
Estimated battery-electric yard truck electricity cost per mile from demand charges	$2.94
Phase 1 battery-electric yard trucks	
Estimated battery-electric yard truck electricity energy cost per mile	$0.10
Estimated battery-electric yard truck electricity cost per mile from demand charges	$1.95
Estimated diesel yard truck cost per mile (average assuming $3/DGE)	$1.43

[130] As the report did not include an estimate for yard truck diesel cost per mile for BNSF San Bernardino, the Project Team used the average yard truck diesel cost per mile of $0.62 from BNSF Hobart in its calculation of baseline operating costs for this facility.

[131] The Ricardo report does not provide an estimate the cost per mile associated with a baseline diesel service truck, but using the Ricardo estimate of 15 miles/DGE for these vehicles and an average diesel fuel price of $3 per DGE the Project Team estimated that baseline service trucks would have a cost of $0.20 per mile.

Change in GHG emissions compared to baseline (for a typical operating year): -1,544.5 MTCO2e

- BNSF San Bernardino: -611.8 MTCO2e
- BNSF Hobart: -780.3 MTCO2e
- Daylight Transport: -152.4 MTCO2e

The Ricardo report explains that to compare the emissions of battery-electric vehicles to baseline vehicles, Ricardo calculated the emissions of baseline vehicles using their actual operational mileage and then estimated the emissions of battery-electric vehicles traveling an equivalent distance. This is in contrast to the approach used by the grantee for sampled project ID G16-ZBUS-01, where the mileage traveled by the efficient vehicles was used as the basis for comparison. Ricardo explains that the reason for framing the calculations around the mileage of baseline diesel vehicles is that this mileage is likely more representative of typical operations for yard trucks and service trucks.

Therefore, the above GHG emission reductions represent an estimate for typical operation of these vehicles over a one-year period rather than the actual operation of these vehicles during the demonstration period. The Project Team multiplied the facility-specific GHG reduction estimates for a single battery-electric vehicle by the number of vehicles at each facility in order to reflect the GHG reductions attributable to all battery-electric vehicles on an annual basis under typical operating conditions.

As several vehicles moved from one facility to another during the demonstration period, the Project Team used the quantity of vehicles at each facility at the end of the demonstration period as the basis for calculation. Table 11-5 provides information on the emissions estimates provided by Ricardo in the report and the quantity of vehicles used by the Project Team in the total emissions reduction calculations for each facility. Due to lack of data, Ricardo did not calculate emissions reduction estimates for service trucks at the BNSF San Bernardino facility and the Project Team did not include these vehicles in the POR emissions calculations.

Table 11-5. Emissions Reduction Estimates for G14-LCTI-06 Vehicles by Demonstration Facility

	BNSF San Bernardino: Yard Trucks	BNSF Hobart: Yard Trucks	BNSF Hobart: Service Trucks	Daylight Transport: Yard Trucks
Annual GHG emissions reduction per vehicle (MTCO2e)	87.40	78.00	0.290	25.40
Annual NOx emissions reduction per vehicle (tons)	0.039	0.035	0.00027	0.012
Annual ROG emissions reduction per vehicle (tons)	0.008	0.007	0.00003	0.002
Annual PM10 emissions reduction per vehicle (tons)	0.001	0.001	0.000001	0.0004
Number of vehicles included in calculation	7	10	1	6

The negative values above represent a reduction in GHG emissions for battery-electric vehicles as compared to an equal quantity of baseline vehicles.

Change in emissions of criteria air pollutants compared to baseline (for a typical operating year):
-0.695 tons NOx; -0.138 tons ROG; -0.019 tons PM10

- BNSF San Bernardino
  - NOx: -0.273 tons
  - ROG: -0.056 tons
  - PM10: -0.007 tons
- BNSF Hobart
  - NOx: -0.350 tons
  - ROG: -0.070 tons
  - PM10: -0.010 tons
- Daylight Transport
  - NOx: -0.072 tons
  - ROG: -0.012 tons
  - PM10: -0.002 tons

These values are based on the analysis conducted by Ricardo which compares emissions of battery-electric vehicles to baseline diesel vehicles. As with the GHG emissions reduction estimates, these criteria air pollutant values represent an estimate for typical operation of these vehicles over a one-year period rather than the actual operation of these vehicles during the demonstration period.

The Project Team multiplied the reduction in criteria air pollutants for an individual battery-electric vehicle by the number of vehicles at each facility in order to reflect the pollutant reductions attributable to all battery-electric vehicles on an annual basis under typical operating conditions. The negative values above represent a reduction in criteria air pollutants for battery-electric vehicles as compared to an equal quantity of baseline vehicles. Table 11-5 above provides additional information on the emissions reduction estimates provided by Ricardo and the quantity of vehicles used in calculations by the Project Team to estimate POR emissions metrics.

Qualitative assessment of advancement of technology: According to the Ricardo report, the demonstration serves as evidence that battery-electric yard trucks can potentially replace diesel yard trucks on a broader scale. The report provides a variety of lessons learned and recommendations for future deployment of battery-electric trucks such as suggestions for improved charging techniques, reduced costs, increased training, continued engagement between fleet operators and vehicle manufacturers, and other topics. The report also recommends additional future demonstrations of this vehicle technology and emphasizes the importance of third-party data collection and monitoring.

Table 11-6 summarizes the above metrics for this project.

Table 11-6. Project G14-LCTI-06 Outcome Metrics

Program Name/Sub-Program Component	Metrics	Result
All	Tracking dates of data submission (i.e. time period represented by reported metrics)	4/11/2018 – 12/31/2019
Low Carbon Transportation: Advanced Technology Demonstrations	Change in fuel consumption compared to baseline	-52,726 DGE
	Change in energy use compared to baseline	-7,090,065 MJ
	Change in vehicle miles traveled compared to baseline	Not applicable
	Change in GHG emissions compared to baseline (for a typical operating year)	-1,544.5 MTCO2e
	Change in emissions of criteria air pollutants compared to baseline (for a typical operating year)	NOx: -0.695 tons ROG: -0.138 tons PM10: -0.019 tons
	Change in cost compared to baseline	-$26,988
	Qualitative assessment of advancement of technology (e.g. continued use by funding recipient, increase in market share, potential commercialization of technology)	(summarized above)

The information summarized above is intended to serve as an overview of this project within the context of current POR requirements for Advanced Technology Demonstration projects. The final report submitted by the San Bernardino County Transportation Authority, and the Ricardo report that was used as the source of this information, provide more extensive details regarding the planning, implementation, monitoring, analysis, and results of this demonstration project. This includes additional and more granular metrics, data collection parameters and analysis considerations, and other contextual information that may affect interpretation of project data and results.

Additionally, these POR metrics were calculated based solely on content presented in the project report without direct communication with project staff. These metrics may differ from results that could be obtained using raw project data, and may represent a different approach than would be used by the grantee to quantify project outcomes.

11.3.3. C-PORT: The Commercialization of POLB Off-Road Technology Demonstration. Port of Long Beach, CCIRTS Project ID G16-DEMO-03

This project consists of the deployment of four zero-emissions cargo handling vehicles including three battery-electric top handlers and one battery-electric yard truck at container terminals within the Port of Long Beach (POLB). The project includes installing charging stations for each vehicle.

This project was funded in the 2016-2017 FY and according to the most recent available public project summary, the project received GGRF funding of $5,249,820 and has total expected GHG reductions of 347 MTCO2e.[132] At the time of project sampling the CCIRTS database showed an expected completion date of March 2020, but the project received extensions and was not yet complete as of the end of the data collection period for this assessment.

11.3.3.1. Data Collected

Data collected for this project consisted of documentation including the project application, publicly available project summary document, and a sample of monthly reporting materials.

The Project Team used final project reports as the source of POR metrics for Advanced Technology Demonstrations as these projects receive in-depth evaluations that provide detailed information on project impacts and outcomes.

As the final report for this project was not available as of the end of the data collection period, the Project Team focused on reviewing the initial application to characterize the planned data collection and monitoring procedures for the project and make comparisons to evaluation characteristics of the other sampled Advanced Technology Demonstrations projects.

11.3.3.2. Results

This section presents brief findings from the documentation review for this project.

Application Overview

The project application was submitted by POLB in September 2017. It provides detailed information regarding the scope, cost, timing, project partners, expected impacts, and other characteristics of the proposed C-PORT demonstration. This includes a thorough work plan, information on the project site and demonstration technology characteristics, and narratives related to the potential for commercialization of the battery-electric top handlers and yard trucks. The application also includes supplemental documentation related to Disadvantaged Communities (DAC) Eligibility, CEQA compliance, letters of commitment and support, and applicant qualifications.

Data Collection, Analysis, and Evaluation Information within Application

Regarding the proposed demonstration and monitoring process, the application states that Tetra Tech will serve as the data collection and analysis contractor for the project and will conduct an in-depth evaluation of performance and impact results. The application states that Tetra Tech will conduct emissions testing of baseline diesel-powered cargo equipment for comparison to the battery-electric

[132] At the time of project sampling the CCIRTS database listed total GGRF funding as $5,399,820 with total expected GHG reductions of 694 $MTCO_2e$.

demonstration vehicles. Tetra Tech will also be responsible for developing the final report summarizing the results of the demonstration.

The proposed project budget includes funds for Tetra Tech to conduct these activities during the demonstration period and estimates that three-quarters of the proposed budget for Tetra Tech data collection and analysis will be paid through POLB funds with the remaining one-quarter being covered by California Climate Investments.

The information in the application suggests that the grantee planned to conduct an in-depth data collection effort and analysis of demonstration vehicle performance relative to an appropriate baseline in order to quantify impacts from emissions reduction, differences in operational cost, and other factors. These activities would likely allow for successful reporting of POR metrics and provide valuable insight into the outcomes of the project as compared to initial expectations.

Progress Report Overview

As an example, the Project Team reviewed a progress report submitted by the grantee for the month of February 2020. The progress report provides updates on each project task and activities conducted by POLB, Tetra Tech, and other project partners. The progress report also identifies current challenges and activities planned for the next reporting period. Attached to the progress report are a variety of supplemental documents including site maps and plans, photos, permits, and Field Evaluation Reports generated through site inspections.

Data Collection, Analysis, and Evaluation Information within Progress Report

The progress report for February 2020 provides information on progress made by Tetra Tech in implementing the baseline emissions testing process and initiating the demonstration and data collection phase of the project. Attached to the progress report is a Demonstration Data Collection Progress Report prepared by Tetra Tech, which includes information on the monitoring equipment selected for data collection, the current data collection strategy, and preliminary monitoring results.

Based on the example progress report reviewed, the data collection and analysis efforts being conducted for the C-PORT project are in alignment with those described in the initial application. The content of the progress report appears to be comprehensive and this type of detailed documentation would likely serve as useful resources for third-party review of project methods and results.

Overall Documentation Review Findings

The documents reviewed for this project contain several characteristics that likely improve the ability of the project to conduct data collection and generate informative evaluation results:

- **Planning for evaluation as part of the project design phase:** The project application outlines an evaluation plan for the demonstration period and identifies the data collection and analysis activities to be conducted.
- **Allocating dedicated funding to evaluation activities:** The project application includes evaluation tasks in its proposed budget, a portion of which are to be funded by the California Climate Investments grant.
- **Collecting primary data to calculate observed impacts:** The project documents indicate that the data collected during the demonstration period will be used to evaluate specific performance claims of the battery-electric vehicles.

- **Establishing a baseline of comparison:** The project application and progress report describe how the funded vehicles will be compared to a measured baseline in order to quantify the difference in cost, emissions, energy use, and other factors between the demonstration scenario and a baseline scenario.

The Project Team suggests that these procedures may serve as examples to inform possible future development of evaluation protocols within other California Climate Investments programs.

11.3.4. Opposed Piston Engine Class 8 Heavy Duty On-Road Demonstration, CCIRTS Project ID G16-DEMO-01

This project consists of building four diesel engines which use an opposed piston (OP) design and incorporate a Nitrogen Oxide (NOx) aftertreatment to result in improved fuel efficiency and reduced NOx emissions. The project includes deploying these engines in a field demonstration and conducting laboratory monitoring with a dynamometer to demonstrate performance and efficiency.

This project was funded in the 2016-2017 FY and the CCIRTS database lists total expected GHG reductions for the project as 30 MTCO2e. According to the most recent available public project summary, the project received GGRF funding of $6,994,601. At the time of project sampling the CCIRTS database showed an expected completion date of April 2020, but the project received extensions and was not yet complete as of the end of the data collection period for this assessment.

11.3.4.1. Data Collected

Data collected for this project consisted of documentation including the project application and publicly available project summary document.

The Project Team used final project reports as the source of POR metrics for Advanced Technology Demonstrations as these projects receive in-depth evaluations that provide detailed information on project impacts and outcomes.

As the final report for this project was not available as of the end of the data collection period, the Project Team focused on reviewing the initial application to characterize the planned data collection and monitoring procedures for the project and make comparisons to evaluation characteristics of the other sampled Advanced Technology Demonstrations projects.

11.3.4.2. Results

This section presents brief findings from the documentation review for this project.

Application Overview

The project application was submitted by CALSTART in August 2017. It provides details on the project scope, objectives, technologies to be demonstrated, partner participants, and expected benefits and outcomes. This includes a detailed narrative and work plan that provides background on the history of opposed piston (OP) engines and the advancement that this demonstration would represent for this technology. The application lists many research and technology development partners who will assist with the project including manufacturers, laboratory operators, and suppliers of engine equipment and other material components of the demonstration. The application defines the roles of each of these partners and provides a detailed budget and project timeline.

For expected benefits, the application outlines all inputs, calculations, and outputs related to expected emission reductions and project cost-effectiveness in accordance with CARB methodologies and requirements. Attached to the application are a variety of supplemental documents including site maps, DAC Eligibility determination, letters of support, CEQA compliance, and applicant qualifications. The application also includes appendices containing technical specifications of the OP engines and components, as well as relevant research papers and a technology commercialization plan.

Data Collection, Analysis, and Evaluation Information within Application

The application explains that the OP engines will be tested through both on-road demonstration in tractors and through laboratory testing with dynamometers. The project also involves the establishment of a baseline scenario by operating tractors with standard diesel engines along the same routes for comparison to the OP engines. The emission reductions estimates provided within the application are based on comparisons between the OP engine and the diesel engine that will be operated as the baseline during the demonstration.

The application indicates that testing and demonstration data collection will be conducted by project partners including Peterbilt and Aramco, and that a primary objective of the demonstration is to verify the claimed emissions reduction capabilities of the OP engine. A statement regarding expected emissions improvements states that the demonstration will provide evidence that the OP engine is at least 15% more efficient than the diesel baseline. CALSTART as the grantee will be responsible for overseeing the data collection, analysis, and reporting process, and will install monitoring equipment on the vehicles and measure emissions using a Portable Emissions Measurement System (PEMS).

The proposed project budget includes funds for the above testing, data collection, and analysis. The budget estimates that the data collection and analysis task will be fully funded through the California Climate Investments grant, though the grantee and partners are estimated to provide in-kind funding for other project components.

Overall, the information included in documentation for project G16-DEMO-01 indicates that the project will incorporate in-depth data collection and analysis to validate the expected benefits of the funded technology.

Overall Documentation Review Findings

As with the other reviewed Advanced Technology Demonstration projects, this project contains several characteristics that are consistent with rigorous data collection and evaluation. This includes incorporating evaluation planning early in the project process, dedicating funds specifically to monitoring and analysis, using primary data to validate expected impacts, and measuring an appropriate baseline to determine the relative increase in efficiency and performance of the demonstration technology as compared to industry standard technology.

11.4. Key Data Collection and Analysis Findings

This section summarizes overall findings from the process of reviewing project applications, progress reports, final reports, and other documentation for the above projects:

- **Advanced Technology Demonstration projects receive extensive impact and process evaluations using primary data collected during the demonstration period.** Unlike many projects within other California Climate Investments programs, Advanced Technology Demonstrations incorporate in-depth primary data collection and analysis activities to measure project benefits against baseline scenarios and validate initial impact estimates. The final reports reviewed for the project sample included updated GHG emissions reduction estimates using primary data collected during the demonstration, and also provided a variety of quantitative findings related to the specific objectives of the project.

  Some of these calculations involved applying updated inputs to existing QM tools, while others referenced CARB stipulated values such as emissions factors but were mainly based on primary data. Additionally, grantees used information gathered during the demonstration to make qualitative statements regarding lessons learned and provide recommendations for further advancement and deployment of funded equipment and activities. This level of data collection and evaluation allows Advanced Technology Demonstration projects to report specific, verified, and informative findings related to the impact of California Climate Investments funds.

- **Evaluation is planned early in the project process and is accounted for by project resources.** The reviewed documentation indicates that grantees must indicate how projects will be measured and analyzed as part of the project application, and that evaluation is embedded in the structure of Advanced Technology Demonstration projects. Requiring a data collection and analysis plan likely helps to ensure the evaluability of projects, and including evaluation staff on the grantee team facilitates the use of evaluation activities throughout the implementation process rather than only following the completion of projects.

  While California Climate Investments Funding Guidelines indicate that POR data collection is typically considered an administrative cost that is outside the scope of grant funds, data collection and analysis for demonstration projects is accounted for within the project budget and partially or fully funded by the grant. This use of dedicated funding for evaluation activities is in contrast with most other California Climate Investments programs, whose projects must rely on existing agency or grantee resources to conduct POR data collection or otherwise assess project outcomes.

- **Evaluations are developed with project-specific metrics, analyses, and considerations.** The range of projects funded within the Advanced Technology Demonstrations sub-program group is broad and includes on-road and off-road vehicles, transportation infrastructure, and engines and other equipment targeting a variety of end uses and industries.[133] Grantees and program partners develop tailored monitoring and analysis techniques based on the features of the funded technology and research questions of the demonstration. Because of this, each project and its associated evaluation approach is fairly unique. Findings and metrics that are key indicators of success in one project, such as operator survey results for FCEBs or soot measurements for OP engines may not be as relevant

[133] "Advanced Technology Demonstration Projects | California Air Resources Board," accessed June 11, 2021, https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program-0.

or available within another project.[134] While it appears that projects would generally be able to report the standardized set of metrics currently required by POR, the methods for obtaining these metrics would vary substantially among projects which creates a challenge in using POR to compare results across projects in a way that provides insight about the broader scope of demonstration programs.

11.5. Recommendations

The following recommendations are provided for CARB consideration and are designed to support improved POR and evaluation procedures for Advanced Technology Demonstration projects:

- **Consider aligning the POR outcome period with the project demonstration period in the absence of continued data availability.** The current POR framework for Advanced Technology Demonstrations projects specifies that the outcome period begins once vehicles or equipment are operational and continues for 36 months after the operational date. Based on discussions with CARB and reviews of project documentation, many demonstration pilots are limited-term projects that may not continue to operate or receive data monitoring after the demonstration period. Additionally these projects currently receive extensive evaluations which may be sufficient to gain insight into the potential long-term benefits of a particular vehicle or technology. The final reports developed for each grant are intended to serve as in-depth evaluations of project performance and impacts using data collected during the demonstration period. These reports represent a degree of primary data collection and analysis that is not found in the other California Climate Investments programs that were reviewed by the Project Team.

  Due to these factors, the Project Team recommends that CARB coordinate with Advanced Technology Demonstrations project staff to determine which projects will continue to operate and receive data monitoring after the end of the demonstration period that is covered in the final report. For projects for which data will continue to be available, POR can continue collecting key metrics to provide insight into longer-term outcomes. For projects that will discontinue operations after the demonstration period, or for which continued data collection would be associated with prohibitively high costs or other barriers, the Project Team recommends that CARB refer to the final demonstration reports as the source of POR metrics and define the outcome period for these projects as aligning with the demonstration period.

- **Request that projects report metrics in a format that aligns with the needs of POR or other evaluation efforts.** The reviewed final reports for sampled demonstration projects generally contained sufficient information to assess the current set of Advanced Technology Demonstration POR metrics, though the reports were not uniform in their method and format of calculating and presenting this information. For example, some metrics were presented in relation to impacts that occurred during the demonstration period, and other metrics were presented as a reflection of typical operating conditions beyond the demonstration period. It may be useful to coordinate with Advanced Technology Demonstrations program staff and grantees to ensure that they are familiar with the POR phase and required metrics prior to the development of the final report. As an alternative to referencing the final reports for POR metrics, it may also be useful for CARB to request these metrics directly from grantees as a separate reporting document. This would help to avoid

[134] The G16-DEMO-01 project application attached an OP engine study which emphasizes NOx and soot emissions as essential metrics: Neerav Abani et al., "Developing a 55% BTE Commercial Heavy-Duty Opposed-Piston Engine without a Waste Heat Recovery System," 2017, 2017-01–0638, https://doi.org/10.4271/2017-01-0638.;

Project G16-ZBUS-01 conducted operator surveys as part of its assessment of FCEB commercialization.

potential errors associated with using aggregated information rather than raw data, or misinterpreting information due to a lack of familiarity with the project.

- **Consider referring to aspects of Advanced Technology Demonstration projects as examples for evaluation of other programs.** Projects within this sub-program group contain several characteristics which facilitate reliable data collection, analysis, and informative results. Concepts such as asking grantees to plan for primary data collection and reporting as part of the project design process, identifying a baseline that can be measured for comparison against the project treatment or equipment, dedicating a specific amount of funds to the evaluation component, using a third-party evaluator, and using the results to validate initial estimates are found to varying degrees within other project types. There may be opportunities to add, refine, or expand these and similar processes within certain programs or develop a more uniform framework for evaluation across the California Climate Investments portfolio.

  The extensive evaluations conducted for Advanced Technology Demonstrations are designed to measure and validate technologies that may be associated with a high degree of performance uncertainty, and this level of data collection and analysis may be beyond the needs of programs with more consistent and industry-proven treatments. For any possible future efforts related to expanded evaluation requirements within California Climate Investments, the Project Team recommends that CARB assesses the appropriate level of evaluation rigor for each program and consider which of these or other processes may be most beneficial in providing insight into the impacts of California Climate Investments funds.

- **Recommended POR purpose within Advanced Technology Demonstrations:** As these projects currently receive in-depth evaluations, POR can be used as a method of aggregating metrics across various projects and ensuring that grantees are reporting a standardized set of relevant metrics. It may be difficult to use POR to gain insights at the program level due to the distinct structure and objectives of different demonstration projects. POR data collection may also be limited to the duration of the demonstration period, depending on the status of continued operation and monitoring of vehicles and equipment.

  Rather than relying on individual POR metrics to interpret results, the in-depth final reports completed for each of these grants may be the best source of information on project outcomes due to the additional context and data that they provide. The final reports also provide revised estimates of project GHG reductions and other benefits using primary data collected during the demonstration period, which is a step beyond the current scope of POR. In combination with these reports, POR can continue to serve as a quality assurance tool by collecting key metrics that can be compared to initial project expectations and potentially identify issues that require further assessment or review.

12. Overall Findings and Recommendations

This section presents findings and discussion items that were developed through the course of the POR data collection and analysis efforts across all reviewed California Climate Investments programs and projects. While the individual program sections present findings and discussion items for specific project and program types, these findings and recommendations are more broadly applicable to multiple program types or to the overall California Climate Investments portfolio.

12.1. Challenges and Limitations of POR

During the course of assessing POR metrics, collecting data, and communicating with administering agencies, the Project Team identified a series of data collection challenges, analytical barriers, and other issues which present limitations to the use of POR as an evaluation tool for California Climate Investments programs. Key limitations and challenges are characterized as follows:

- **The scope and depth of POR is dependent on the existing resources and expertise available to grantees and administering agencies.** POR is currently designed to be a straightforward, repeatable, and low-cost approach for assessing operational projects. Costs incurred by administering agencies for POR data collection and reporting are considered to be administrative; neither grantees nor agencies receive funding from the legislature in a form that is specifically dedicated to POR or project EM&V, and administrative funds are used for a variety of other purposes in addition to POR.

  As agencies and grantees may not have the funding to contract with third-party evaluators or subject matter experts for POR, CARB has specified that data collection and analysis methods must be accessible to individuals who may not have expertise in topics such as statistics, survey research, technical data monitoring, or experimental design. This reduces the level of rigor that can be required, and limits the extent to which POR can align with evaluation best practices or provide insight into metrics such as changes in ridership or energy use resulting from funded activities.

- **Rather than serving as a comprehensive EM&V phase, POR focuses on one aspect of program evaluation and is not applicable to some California Climate Investments projects.** POR occurs during the years following project implementation and collects long-term data for operational projects. Due to this structure, CARB has exempted projects from POR if they involve one-time transactions or limited-term operation that ends at the closeout of the grant period. Examples of this include funds spent to deliver a single shipment of biomass to a renewable energy facility, incentives provided to consumers for the purchase of zero-emissions vehicles, and limited-term expansions of transit service that cease to operate once California Climate Investments funds are expended. These projects are not considered to be operational beyond project closeout and therefore do not result in an outcome period that can be periodically measured over an anticipated lifetime. However, projects that lack a long-term operational period may still benefit from other forms of impact or process evaluation. POR currently focuses on one aspect of program evaluation, and this limits its ability to represent the full scope of project types that are funded through California Climate Investments.

- **Insight into project benefits and outcomes is somewhat dependent on whether additional M&V occurs outside of the POR phase.** POR is not designed to serve as a final inspection of implemented projects, and outcomes are not reported at the time of project closeout. This type of closeout M&V is conducted for some POR-exempt projects, such as verifying the quantity of biomass delivered, but may not be conducted for other POR-exempt projects such as limited transit expansions, transit vouchers, or other consumer-based incentive projects. Similarly, POR-eligible projects may or may

not receive M&V at the time of closeout to verify that measures or treatments were implemented as planned. Practices vary by administering agency, program, and project type. Clear records indicating the status of projects at closeout would serve as a reference point of final scope and characteristics that could later be compared to data collected during the outcome period. In the absence of this information, it may be difficult to use POR data to develop conclusions about changes in projects between the point of closeout and the outcome period.

Additionally, M&V conducted at the end of project implementation could be used to calculate updated QM estimates of GHG emissions reductions and other benefits based on final project characteristics, which is outside the current POR scope. Expanding POR to include closeout inspections or developing a new M&V phase that involves verification and primary data collection for all project types would represent a major shift in the current structure of California Climate Investments program evaluation and would likely require additional dedicated resources.

- **There are challenges in requiring grantees to collect and report data beyond the term of the grant period.** POR is intended to continue for several years after the operational date for most programs, which typically extends beyond the term of the grant agreement between administering agencies and grantees. Administering agencies have indicated that they cannot enforce data collection and reporting requirements that occur beyond the period of the grant agreement and that grantees may have little incentive to participate in POR once all funds have been expended.

  Some programs such as urban forestry programs have made efforts to develop ongoing project maintenance agreements with grantees, though the long-term success of these agreements is not yet clear. Administering agencies have also indicated that extending the duration of grant periods to account for POR may not be feasible due to stipulated restrictions related to the expenditure of funds. In the absence of dedicated funding or enforceable agreements, it may be difficult to obtain reliable involvement from grantees in the collection of POR data on a long-term basis.

- **Projects with low evaluability may not be selected for POR, which may limit the representativeness of POR data.** During the project sampling task, administering agencies indicated that several sampled projects may not be suitable candidates for POR due to project complexity or data collection barriers. In their past selection of POR projects, some administering agencies have used a random sampling approach, while others have selected projects that are likely to allow for sufficient data collection and have excluded projects that may be difficult to measure. Excluded projects have included projects with grantees who do not wish to cooperate with POR requirements, projects that lack proper data recording procedures, and projects with key external variables that cannot be controlled. If a significant portion of California Climate Investments projects are systematically excluded from POR due to these evaluability issues, the subset of projects that complete outcome reporting may not be representative of programs.

- **There is not yet a formally defined process for using POR data as an evaluation tool, which creates challenges in determining an appropriate set of metrics and may discourage participation in reporting.** While POR was designed to focus on collecting metrics that are linked to project GHG emission reductions, it is not necessarily intended to formally compare project measurements to initial expectations, calculate revised GHG estimates, or assess the cost-effectiveness of funded projects. Additionally, limitations and challenges associated with POR have created barriers to achieving the overall POR purpose of supporting accountability and transparency in communicating program successes. Without a precise and achievable POR goal for each program, it is difficult to determine what data should be collected. Administering agencies have expressed concerns about increased reporting requirements and may be adverse to collecting POR data or asking grantees to participate unless there is a clear process for applying the collected data toward a specific purpose.

There are a variety of potential evaluation objectives and considerations for California Climate Investments projects which could correspond to different sets of POR metrics. If POR data were intended to support cost-benefit analysis through alternative methods beyond the currently required cost-effectiveness ratio of GGRF dollars to GHG benefits, metrics could be expanded to collect additional information on the costs incurred by grantees and project participants during the outcome period as compared to before the project. If POR data were intended to verify the continued accrual of co-benefits, metrics could be determined based CARB co-benefit calculator inputs to allow for updated calculations during the outcome period. A more comprehensive POR phase could include a wide range of metrics with multiple defined objectives. Increased complexity and scope would likely be associated with increased challenges and a greater need to overcome existing limitations.

12.2. Potential Purposes of POR as an Evaluation Tool

Based on the assessment of POR metrics, sample data collection, and the above challenges and limitations, the effective purpose of POR may vary depending on the data availability, analytical considerations, and objectives of each program. The Project Team identified four main purposes that POR is able to serve in its current form, which can be summarized as follows:

- **Validating project QM inputs and resulting calculations:** For programs whose QM equations include inputs that can be measured during the outcome period, POR could be used to collect those inputs and recalculate GHG reductions and other benefits for comparison to initial estimates. Examples of these inputs based on current QM equations include average passenger trip length for transit projects, average daily traffic of active transportation improvements, average occupancy per vehicle for carsharing projects, pumping efficiency for agricultural water savings projects, and mill efficiency for biomass generation projects.

  This approach would have similarities to Option A of the International Performance Measurement and Verification Protocol (IPMVP) for energy and water savings programs, which involves conducting measurement of key inputs in combination with stipulated values and equations to determine the impacts of a project treatment.[135] Option A is characterized as the least rigorous evaluation approach within IPMVP and is not recommended for projects with high levels of uncertainty. However, this approach would still represent an incremental increase in analytical rigor for programs that rely on initial QM calculations and do not use primary data to update benefits estimates following project implementation.

- **Verifying the availability of datasets for later analysis:** For projects that generate datasets which could be analyzed against baseline or control group data to determine treatment impacts, POR could be used to verify the availability of these data for possible in-depth evaluations. Examples of these datasets include utility data for water or energy efficiency projects and ridership data for transit projects. While POR is not currently intended to involve in-depth analyses such as regression analysis of billing data or counterfactual modeling of transit ridership, California Climate Investments may identify opportunities to conduct these types of activities as part of third-party contracts or other targeted studies. POR metrics that require the availability of data records could be used as a method of verifying that grantees are recording data in a manner that supports potential future evaluation.

[135] *International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings Volume I* (Efficiency Valuation Organization, 2012).

- **Conducting basic verification of project components:** For many projects, POR can be used as a quality assurance tool for verifying that funded equipment, vehicles, or other improvements were implemented and continue to operate as planned. Post-installation verification is a key component of M&V as recommended by the U.S. Department of Energy Federal Energy Management Program (FEMP) for energy projects.[136]

  Some California Climate Investments programs such as UCF, UG, Forest Health, LIWP, and SWEEP conduct final inspections at the end of the project to verify that measures or treatments were properly implemented, but few projects receive such inspections after the end of the grant period. GHG reductions and other benefits for California Climate Investments projects are calculated based on an assumed project lifetime. Conducting basic verification a year or more after project implementation would allow programs to demonstrate that their projects continue to have the potential to generate expected benefits and identify any operational issues that should be corrected.

  This could also include verifying that projects continue to meet their expected level of benefits to priority populations including disadvantaged and low-income communities. Verifying that funded vehicles or equipment continues to operate in priority population areas as specified in project documentation would allow administering agencies to correct issues related to benefits deviating from these populations, or revise benefits estimates as needed to account for the portion of projects continuing to serve these areas.

- **Performing quality assurance and informing program decision-making:** POR can be used to collect information that is of interest to administering agencies in understanding the outcomes of individual projects and potentially identifying opportunities for program level improvements. While there are challenges and limitations to using POR as an in-depth evaluation of quantitative project benefits such as GHG reductions, many POR metrics can serve as key indicators of success or of potential issues. Survey data collected from affordable housing residents or carsharing participants may provide insight into whether project mode shift objectives are being met, and ecological changes noted by foresters may inform program staff about the success of treatment activities.

  Collecting a standardized set of POR metrics across projects within a program may assist CARB or other administering agencies in identifying outliers or trends that may indicate a need for further investigation. Over time, it is possible that POR metrics would suggest consistent overperformance or underperformance of a particular project type which could motivate agencies to reassess program funding decisions, benefits calculations, or M&V procedures.

  POR may serve multiple purposes per program, and the objectives of POR data collection and analysis may shift over time based on changes to program procedures, project components, QM tools, and the general evaluation framework for California Climate Investments as a funding source. The individual program chapters contain summaries of the recommended role of POR in relation to program-specific components and metrics.

12.3. Limitations of this Study

The activities and findings of this project were associated with several limitations, including:

- **Analytical procedures were limited due to the intended scope and role of POR.** This project was intended to conduct POR data collection and analysis in a manner that could serve as a model for

[136] U.S. Department of Energy, *M&V Guidelines: Measurement and Verification for Performance-Based Contracts (Version 4.0)*, sec. 2.2.5, https://www.energy.gov/eere/femp/downloads/mv-guidelines-measurement-and-verification-performance-based-contracts-version.

administering agencies and grantees. The analytical methods applied were in alignment with the role of POR as a straightforward, repeatable reporting process that can be completed at low cost by non-technical staff and grantees. Advanced analytical methods and more rigorous data collection may yield different findings than those presented through this study.

- **The COVID-19 pandemic limited the ability to collect data for certain projects and POR metrics, and restricted data collection procedures.** Additionally, collected data for some metrics may not be representative of typical operating or behavioral conditions.
- **Data and findings reflect a small portion of California Climate Investments projects and do not reflect all California Climate Investments programs.** This project involved review and analysis of a subset of California Climate Investments programs and a small subset of projects within those programs. Findings developed from this effort may not necessarily apply to programs and projects that were not reviewed, and should not be interpreted as generalizations. Additionally, there may be data collection barriers, analysis issues, or evaluation opportunities associated with other programs and projects which were not identified during this study.

12.4. Overall Recommendations

The following recommendations are provided for CARB consideration and are applicable to POR and evaluation within the overall California Climate Investments portfolio of programs:

- **Consider opportunities for enhanced evaluation of California Climate Investments programs, including appropriating or allocating additional resources to primary data collection.** CARB has expressed interest in obtaining actionable insights into California Climate Investments programs from primary project data. Program evaluations can measure the success of programs in meeting their goals, inform investment decisions, and improve performance with respect to the effectiveness of treatments, measures, and program resources. While POR may be further developed to provide valuable information in assessing outcomes of California Climate Investments programs, it faces challenges in serving as a comprehensive or reliable program evaluation tool, due in part to limitations in the resources and evaluation expertise available to administering agencies and grantees. There may be opportunities to improve upon the current level of rigor used to evaluate program processes, GHG benefits, and other impacts of GGRF investments. Specific opportunities for enhanced evaluation of California Climate Investments programs may include:
    - **Conducting in-depth evaluations for a small sample of projects:** As a first step in improving evaluation procedures within California Climate Investments, a small sample of in-depth third-party evaluations could serve as case studies of how verified and measured project results compare to QM-based expectations. These targeted evaluations would use best practices in data collection and analysis and allow for the development and refinement of evaluation methods for selected project types. Evaluation efforts would then be expanded to larger samples of projects based on the availability of funds and key issues identified through the initial case studies.
    - **Allocating dedicated evaluation funding based on a percentage of grant funds:** Evaluation funding equal to a small percentage of total grant dollars would allow agencies or grantees to contract with third-party evaluators with subject matter expertise in data collection and analysis. CARB Advanced Technology Demonstrations projects serve as an example of incorporating EM&V into the grant structure. Efforts at this scale would use primary data to obtain measured and verified GHG benefits estimates for comparison with project expectations.

As CARB does not have the authority to allocate California Climate Investments funding to program evaluation, implementing this framework would require another dedicated funding source or a legislative modification to funding allocations. If this approach would result in funds being shifted from project implementation towards evaluation, it would be necessary to carefully balance the potential benefits of evaluation against the benefits of implementation by determining the appropriate evaluation resources for each program depending on program size, evaluation research questions, and uncertainty in GHG benefits estimates.

- **Conducting expanded EM&V through contract dollars:** Developing a formal framework for issuing contracts to third-party evaluators would allow California Climate Investments to conduct in-depth evaluations of programs. The evaluation types present within other program portfolios such as the Regional Greenhouse Gas Initiative, including impact evaluations, process evaluations, market evaluations, and evaluability assessments, may serve as examples for California Climate Investments. The frequency of these evaluations could be annual, biannual, or determined for each program based on the availability of funds and identification of program-specific issues that may benefit from evaluation.
- **Developing internal evaluation resources:** As the agency responsible for developing funding and data collection requirements, it may be appropriate for CARB to increase its role in the evaluation of California Climate Investments programs. This could involve establishing a work group that is responsible for assisting agencies and grantees with primary data collection and analysis, either as part of POR or to assess verified GHG reductions and co-benefits. Direct involvement from staff with expertise in program evaluation may improve the success of data collection efforts and the reliability of results. Development of internal evaluation expertise may be achievable to some extent with existing CARB resources, or may be more formally and widely implemented depending on legislative guidance.
- **Conducting increased measurement and verification (M&V) during closeout for operational projects:** Currently, the data collected upon project closeout for some programs exclusively involves verifying that funds have been expended or that the grantee indicates that the work was completed. For projects that are operational by the time of grant closeout, conducting a thorough verification of project components at closeout and adjusting QM inputs as needed would improve the reliability of reported benefits. Additionally, thorough documentation of final project characteristics at the point of closeout would facilitate successful data collection and assessment during the outcome period.

- **Conduct POR sampling on behalf of agencies, or advise agencies to use a statistical sampling method that can be reviewed.** Current POR guidelines specify that a subset of projects must be selected for outcome reporting, but do not include guidance for how to conduct project selection. Based on discussions with administering agencies, forms of statistical sampling such as simple random sampling are being conducted in many cases, though adjustments must be made due to issues with funding recipient cooperation, project timing, data availability, and other factors. It would be useful for CARB use a statistical sampling method such as random sampling to select projects within each program for POR, to better ensure objectivity and allow CARB to identify evaluability issues if agencies indicate that a sampled project cannot comply with POR requirements. While it may still be necessary to re-sample a portion of projects due to evaluability issues, this approach would improve the visibility of these issues and potentially lead to strategies to overcome them.

If California Climate Investments has a goal of using POR to make program-level generalizations, CARB should also ensure that POR samples are statistically representative of programs in terms of project types, amount of funding, and GHG benefits included in the sample. Otherwise, POR findings should be viewed as reflective of individual projects rather than programs as a whole. If agencies are to continue selecting projects for POR, it would be beneficial for CARB to provide formal guidance regarding POR sampling methods to ensure that agencies are selecting subsets of projects that are representative of programs.

- **Consider emphasizing first-year POR and assess findings over time to determine the appropriate POR duration for each project type.** Due to the current challenges facing POR, it may be useful to first focus on developing an effective foundation of data collection and reporting for the first year following project implementation. Many projects are still within their grant period during this time, which facilitates the involvement of grantees in establishing data collection and reporting procedures. After developing a reliable process for obtaining first-year POR data, California Climate Investments may have greater success in collecting POR data for subsequent years. It is also difficult to determine the appropriate duration of POR for each project type in the absence of short-term evaluation results. CARB should assess POR findings over time to determine whether shorter or longer POR periods may be appropriate for individual project types based on the stability of POR metrics and the presence of ongoing issues.
- **Facilitate improvements in communications and program materials to ensure that administering agencies and grantees have a clear understanding of data collection requirements, metrics definitions, and reporting expectations.** Many grantees of sampled projects were unaware that they may be asked to provide data to support the assessment of POR metrics, and several administering agencies were not familiar with POR guidelines. Additionally, grantees of sampled projects had different interpretations of certain POR metrics and QM inputs. Further communication with agencies and grantees to clarify the definitions of QM inputs and POR metrics would help to improve the consistency of reported data. Administering agencies should also notify grant applicants that they may be expected to provide outcome-related data for their projects and ensure that grantees understand these requirements prior to the outcome period.
- **Clarify how POR data will be used for each program and ensure data are collected and retained in a manner that is sufficient for necessary analyses and interpretations.** POR may serve several possible purposes given its current structure and the structure of other California Climate Investments project phases. Developing a clear process for using data collected through POR, either by project type or for California Climate Investments as a whole, would help to guide data collection efforts and make improvements to POR. This would involve determining whether and how metrics will be used to inform QM calculations, make quality assurance improvements, track and report applicable co-benefits, or serve other evaluation purposes. Upon defining how each metric will be used within each program, it will be important to create program-specific data templates that clearly organize metrics and contain all fields necessary to reliably interpret collected outcomes.
- **Explore opportunities to strengthen the link between research studies and reported program results.** In-depth research studies have been conducted through GGRF and non-GGRF funds to assess the impacts and processes of individual California Climate Investments projects and program components. Some of these studies may provide insight into project-specific GHG impacts or accrued co-benefits, and may thereby fulfill certain EM&V needs that are not currently met with POR. As California Climate Investments primarily relies on QM calculator estimates to assess and communicate the results of projects, there may be opportunities for CARB to incorporate results of relevant analytical research into its publicly presented materials that describe the impacts of GGRF as a funding mechanism.

Appendix A: List of Recommended POR Metrics

This appendix presents the final set of POR metrics recommended by the Project Team. This includes POR metrics that were in place prior to the project and that the Project Team recommends retaining in POR, as well as recommended additional or revised metrics based on the findings from this project. Bold text denotes a recommended additional metric that was not in place at the start of this project. Italicized text denotes an existing metric with minor recommended revisions to wording or applicability, or an existing metric that has been added to a sub-program component that did not previously require that metric.

Program Name	Sub-Program Component	Metric	Unit	Method
Low-Income Weatherization	All	Tracking dates of data submission	mm/dd/yyyy	n/a
		Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)	**n/a**	**Data requests from program provider or contractor**
	Energy Efficiency and Solar Water Heating	**For multi-family sites, confirmation that common area measures remain in place and operational**	**Y/N**	**Information obtained from property owner or manager**
		Total energy use	**kWh, MMBtu, scf, or therms/year**	**Evaluation of utility bills or utility records obtained directly from utility, residents, or building managers**
	Solar Photovoltaic (PV)	**For multi-family sites, confirmation that solar PV remains in place and operational**	**Y/N**	**Information obtained from property owner or manager**
		Energy generated by solar PV	kWh/year	Evaluation of utility bills or utility records obtained directly from utility, residents, or building manager
Water-Energy Grants	All	Tracking dates of data submission	mm/dd/yyyy	n/a
		Information on selected locations, including program tracking data (measure mix, home characteristics, etc.)	**n/a**	**Data requests from program provider or contractor**
		Total water use	*Mgal/year*	*Evaluation of utility bills or utility records obtained*

Program Name	Sub-Program Component	Metric	Unit	Method
Water-Energy Grants (Continued)	All (Continued)			*directly from utility or residents*
		Total energy use	**kWh or scf/year**	**Evaluation of utility bills or utility records obtained directly from utility or residents**
State Water Efficiency and Enhancement Program	All	Tracking dates of data submission	mm/dd/yyyy	n/a
		Confirmation that SWEEP measures remain in-place and operational	**Y/N**	**On-site visit or survey of grantee**
		Indication of substantial change to irrigation system, acreage, or land use	**Y/N**	**On-site visit or survey of grantee**
	Energy Efficiency	**Total SWEEP project on-farm energy use**	**kWh, MMBtu, scf, or therms/growing season**	**Assessment of utility bills and/or field operational logs**
	Water Efficiency	**Total SWEEP project on-farm water use**	**Gallons/growing season**	**Assessment of utility bills and/or field operational logs**
	Solar Photovoltaic (PV)	Energy generated	kWh/growing season	Evaluation of utility bills, fuel receipts, and/or field operational logs
Forest Health	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Reforestation	Tree mortality of planted trees	Percentage	On-site visit and sampling or current aerial imagery
		Qualitative assessment of project impacts on ecological factors	**n/a**	**On-site visit and sampling, reports from grantee, or current aerial imagery**
		Fuel load	**Tons/acre of 1,10,100, 1000 hour dead fuels, duff, litter depth**	**On-site visit and sampling**

Program Name	Sub-Program Component	Metric	Unit	Method
Forest Health (Continued)	Pest Management	Tree mortality in treatment and impact boundaries since treatment	Percentage	On-site visit and sampling or current aerial imagery
		Qualitative assessment of project impacts on ecological factors	**n/a**	**On-site visit and sampling, reports from grantee, or current aerial imagery**
		Fuel load	**Tons/acre of 1,10,100, 1000 hour dead fuels, duff, litter depth**	**On-site visit and sampling**
	Forest Fuels Treatment (if wildfire has occurred in treatment or impact boundary)	Wildfire disturbance in treatment boundary	Y/N	On-site visit and sampling or current aerial imagery
		Wildfire disturbance in impact boundary	Y/N	On-site visit and sampling or current aerial imagery
		Description of disturbance impacts	n/a	On-site visit and sampling or current aerial imagery
		Forestland within treatment and impact boundary impacted	Acres	On-site visit and sampling or current aerial imagery
		Tree mortality in treatment and impact boundaries as a result of disturbance	Percentage	On-site visit and sampling or current aerial imagery
		Fuel load	**Tons/acre of 1,10,100, 1000 hour dead fuels, duff, litter depth**	**On-site visit and sampling**
	Forest Conservation	Verification that the land is being managed in accordance with the terms of the forest conservation easement	Y/N	On-site visit and sampling or current aerial imagery
		Biomass delivered to a renewable energy facility	Bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination

Program Name	Sub-Program Component	Metric	Unit	Method
Forest Health (Continued)	Forest Conservation (Continued)	Harvested wood delivered to a mill	Board feet or bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination
		Mill efficiency and wood product classes, if available from mill	Percentage	Mill reports used to document mill efficiency and wood product classes
		Qualitative assessment of project impacts on ecological factors	**n/a**	**On-site visit and sampling, reports from easement holder, or current aerial imagery**
	Biomass Utilization	Biomass delivered to a renewable energy facility	Bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination
		Harvested wood delivered to a mill	Board feet or bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination
		If producing wood products, mill efficiency and wood product classes, if available from mill	Percentage	Mill reports used to document mill efficiency and wood product classes
		If producing energy or fuel, renewable energy generated	kWh, MMBtu, scf, therms, or gallons/year	Evaluation of metered data, sale receipts, or operational logs
	Research	Quantity of publications resulting from funded research	Publications	Follow-up survey of grantee regarding the impact of funded research
		Quantity of publications resulting from funded research that are freely available to the public	Publications	Follow-up survey of grantee regarding the impact of funded research

Program Name	Sub-Program Component	Metric	Unit	Method
Forest Health (Continued)	Research (Continued)	Quantity of conferences, panels, etc. where research findings were presented	Conferences, Panels	Follow-up survey of grantee regarding the impact of funded research
		Quantity of citations to published works since publication	Citations	Follow-up survey of grantee regarding the impact of funded research
Regional Forest and Fire Capacity	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Forest Fuels Treatment (if wildfire has occurred in treatment or impact boundary)	Wildfire disturbance in treatment boundary	Y/N	On-site visit and sampling or current aerial imagery
		Wildfire disturbance in impact boundary	Y/N	On-site visit and sampling or current aerial imagery
		Description of disturbance impacts	n/a	On-site visit and sampling or current aerial imagery
		Vegetated land within treatment and impact boundary impacted	Acres	On-site visit and sampling or current aerial imagery
		Fuel load	**Tons/acre of 1,10,100, 1000 hour dead fuels, duff, litter depth**	**On-site visit and sampling**
		Tree mortality in treatment and impact boundaries as a result of disturbance	Percentage	On-site visit and sampling or current aerial imagery
	Forest Conservation	Verification that the land is being managed in accordance with the terms of the forest conservation easement	Y/N	On-site visit and sampling or current aerial imagery
		Biomass delivered to a renewable energy facility	Bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination
		Harvested wood delivered to a mill	Board feet or bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination

Program Name	Sub-Program Component	Metric	Unit	Method
Regional Forest and Fire Capacity (Continued)	Forest Conservation (Continued)	Mill efficiency and wood product classes, if available from mill	Percentage	Mill reports used to document mill efficiency and wood product classes
		Qualitative assessment of project impacts on ecological factors	**n/a**	**On-site visit and sampling, reports from easement holder, or current aerial imagery**
	Biomass Utilization	Biomass delivered to a renewable energy facility	Bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination
		Harvested wood delivered to a mill	Board feet or bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers indicating the delivery destination
		If producing wood products, mill efficiency and wood product classes, if available from mill	Percentage	Mill reports used to document mill efficiency and wood product classes
		If producing energy or fuel, renewable energy generated	kWh, MMBtu, scf, therms, or gallons/year	Evaluation of metered data, sale receipts, or operational logs
	Forest and Fire Project Implementation Planning	Number of permitted acres that received permitted treatment	Acres	Follow-up survey of grantee
		New or revised plan adopted by jurisdiction or other appropriate body	Y/N	Follow-up survey of grantee regarding the impact of planning efforts
		New or revised plan is publicly available	Y/N	Follow-up survey of grantee regarding the impact of planning efforts
		Qualitative description of measures implemented as a result of the plan	n/a	Follow-up survey of grantee regarding the impact of planning efforts

Program Name	Sub-Program Component	Metric	Unit	Method
Fire Prevention Grants	All	Tracking dates of data submission	mm/dd/yyyy	n/a
		Wildfire disturbance in treatment boundary	Y/N	On-site visit and sampling or current aerial imagery (if appropriate)
		Wildfire disturbance in impact boundary	Y/N	On-site visit and sampling or current aerial imagery (if appropriate)
		Description of disturbance impacts	n/a	On-site visit and sampling or current aerial imagery (if appropriate)
		Vegetated land within treatment and impact boundary impacted	Acres	On-site visit and sampling or current aerial imagery (if appropriate)
		Fuel load	**Tons/acre of 1,10,100, 1000 hour dead fuels, duff, litter depth**	**On-site visit and sampling**
		Tree mortality in treatment and impact boundaries as a result of disturbance	Percentage	On-site visit and sampling or current aerial imagery (if appropriate)
Sustainable Agricultural Lands Conservation	All	Tracking dates of data submission	Mm/dd/yyyy	n/a
	Conservation Acquisitions	Verification that the land remains permanently protected as required by the terms of the easement	Y/N	On-site visit, reports from easement holder, or current aerial imagery
		Qualitative assessment of project impacts on ecological factors	**n/a**	**On-site visit and sampling, reports from easement holder, or current aerial imagery**

Program Name	Sub-Program Component	Metric	Unit	Method
California Conservation Corps	All Project Types: Employment and Training Outcomes	Corpsmembers who worked on GGRF project(s) and completed high school diploma during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
		Corpsmembers who worked on GGRF project(s) and completed Cal/OSHA 10 Training during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
		Corpsmembers who worked on GGRF project(s) and completed Cal/OSHA-compliant Fall Arrest Certification during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
		Corpsmembers who worked on GGRF project(s) and completed Cal/OSHA-compliant Lockout/Tagout Training during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
		Corpsmembers who worked on GGRF project(s) and completed Cal/OSHA-compliant Scaffold and Aerial Lift Certifications during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
		Corpsmembers who worked on GGRF project(s) and completed Introduction to Energy Surveys Training during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
		Corpsmembers who worked on GGRF project(s) and completed Introduction to Wiring and Lighting Retrofits	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni

Program Name	Sub-Program Component	Metric	Unit	Method
California Conservation Corps (Continued)	All Project Types: Employment and Training Outcomes (Continued)	Training during service year		
		Corpsmembers who worked on GGRF project(s) and completed S-12 Chainsaw Training during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
		Corpsmembers who worked on GGRF project(s) and completed Chipper Training during service year	Total from cohort who left Corps in year of project completion	CCC records on Corpsmembers and alumni
CA State Coastal Conservancy Climate Ready Program	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	On-site Restoration	Public access	Y/N	On-site visit or survey of grantee
		If project involves tree planting, tree mortality rate to date	Percentage	Extrapolated from conditions of a sample of project tree sites
		If project incentivizes particular agricultural practices, land on which conservation management practices are still being implemented	Acres	On-site visit or survey of grantee
		If project involves construction of living shorelines, qualitative assessment on project impacts (e.g. erosion, sediment removal, habitat, water quality) (Report separately for each relevant factor)	n/a	On-site visit or survey of grantee

Program Name	Sub-Program Component	Metric	Unit	Method
CA State Coastal Conservancy Climate Ready Program (Continued)	On-site Restoration (Continued)	If project involves habitat restoration, qualitative assessment of project impacts on species (e.g. biodiversity, population, stability) (Report separately for each relevant factor)	n/a	On-site visit or survey of grantee
	Planning and Vulnerability Assessments	New or revised plan adopted by jurisdiction or other appropriate body	Y/N	Follow-up survey of grantee regarding the impact of planning or assessment efforts
		New or revised plan or vulnerability assessment is publicly available	Y/N	Follow-up survey of grantee regarding the impact of planning or assessment efforts
		Qualitative description of measures implemented as a result of the plan or vulnerability assessment	n/a	Follow-up survey of grantee regarding the impact of planning or assessment efforts
	Outreach and Education	Qualitative description of outcomes resulting from outreach and education efforts (e.g. behavior change in targeted community, increase in level of participation)	n/a	Follow-up survey of grantee regarding the impact of outreach and education efforts
	Research	Quantity of publications resulting from funded research	Publications	Follow-up survey of grantee regarding the impact of funded research
		Quantity of publications resulting from funded research that are freely available to the public	Publications	Follow-up survey of grantee regarding the impact of funded research
		Quantity of conferences, panels, etc. where research findings were presented	Conferences, etc.	Follow-up survey of grantee regarding the impact of funded research

Program Name	Sub-Program Component	Metric	Unit	Method
CA State Coastal Conservancy Climate Ready Program (Continued)	Research (Continued)	Quantity of citations to published works since publication	Citations	Follow-up survey of grantee regarding the impact of funded research
Climate Adaptation and Resiliency Program	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	On-site Restoration	Public access	Y/N	On-site visit or survey of grantee
		If project involves tree planting, tree mortality rate to date	Percentage	Extrapolated from conditions of a sample of project tree sites
		If project incentivizes particular agricultural practices, land on which conservation management practices are still being implemented	Acres	On-site visit or survey of grantee
		If project involves construction of living shorelines, qualitative or quantitative assessment on project impacts (e.g. erosion, sediment removal, habitat, water quality) (Report separately for each relevant factor)	n/a	On-site visit or survey of grantee
		If project involves habitat restoration, qualitative or quantitative assessment of project impacts on species (e.g. biodiversity, population, stability) (Report separately for each relevant factor)	n/a	On-site visit or survey of grantee
	Conservation Easements	Verification that the land is being managed in accordance with the terms of the forest conservation easement	Y/N	On-site visit or current aerial imagery (if appropriate)

Program Name	Sub-Program Component	Metric	Unit	Method
Climate Adaptation and Resiliency Program (Continued)	Resiliency Planning	New or revised plan adopted by jurisdiction or other appropriate body	Y/N	Follow-up survey of grantee regarding the impact of planning efforts
		New or revised plan or vulnerability assessment is publicly available	Y/N	Follow-up survey of grantee regarding the impact of planning efforts
		Qualitative description of measures implemented as a result of the plan or vulnerability assessment	n/a	Follow-up survey of grantee regarding the impact of planning efforts
Low Carbon Transportation	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Advanced Technology	Change in fuel consumption compared to baseline	Gallons/year by fuel type	Evaluation of fueling or operating records
		Change in energy use compared to baseline	kWh/year	Evaluation of utility bills or records
		Change in vehicle miles traveled compared to baseline	Vehicle miles traveled/year	Evaluation of mileage or operating records
		Change in GHG emissions compared to baseline	MTCO2e/year	Evaluation of monitored emissions
		Change in emissions of criteria air pollutants compared to baseline	lbs/year	Evaluation of monitored emissions
		Cost savings compared to baseline	$/year	Evaluation of fueling or operating records
		Qualitative assessment of advancement of technology (e.g. potential commercialization of technology)	n/a	Survey of funding recipients and/or manufacturer
	Clean/Shared Mobility Options	Quantity of trips	Trips/year	Evaluation of operating records
		Quantity of riders	Riders/year	Evaluation of operating records
		Quantity of vehicle miles traveled	VMT/year	Evaluation of mileage or operating records
		Percentage of trips associated with avoided ICE travel	**Percentage of trips**	**Survey of users**

Program Name	Sub-Program Component	Metric	Unit	Method
Low Carbon Transportation (Continued)	Clean/Shared Mobility Options (Continued)	**Percentage of trips associated with improved mobility**	**Percentage of trips**	**Survey of users**
		Percentage of users who have reduced the number of personal household vehicles as a result of the service	**Percentage of users**	**Survey of users**
		Percentage of users who have avoided or delayed the purchase or lease of a personal vehicle as a result of the service	**Percentage of users**	**Survey of users**
		Percentage of users who have reduced the amount they spend on gas since using the service	**Percentage of users**	**Survey of users**
	Active Transportation Infrastructure	Average traffic of bicycle and pedestrian facilities	Users/day	Usage survey conducted by city, county, district/authority, metropolitan planning organization, non-profit, or academia
Low Carbon Fuel Production	All	Tracking dates of data submission	mm/dd/yyyy	n/a
		Quantity of surplus fuel produced	Gallons, scf, kg, or kWh/year	Evaluation of metered data, sale receipts, or operational logs
		Primary fuel type	n/a	Report from grantee
		Secondary fuel type, if applicable	n/a	Report from grantee
		Tertiary fuel type, if applicable	n/a	Report from grantee
		If project involves organic feedstock, feedstock type	n/a	Report from grantee
		Indication of Low Carbon Fuel Standard (LCFS) Carbon Intensity Score	**gCO_2e/MJ**	**Report from grantee**

Program Name	Sub-Program Component	Metric	Unit	Method
Low Carbon Fuel Production (Continued)	All (Continued)	**Non-fuel coproducts generated (if applicable)**	**gallons/year or tons/year**	**Report from grantee**
Low Carbon Transit Operations Program	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year	Days/year	Evaluation of service schedule
		Average daily ridership (separated into weekday, Saturday, and Sunday ridership)	*Unlinked trips/day*	*Ridership survey, ticket and transit pass sales, automatic passenger counter, driver counts, etc.*
		Average passenger trip length	**Miles**	**Ridership survey, ticket and transit pass sales, automatic passenger counter, driver counts, etc.**
		Indication of whether the capital improvements continue to operate as stated within project closeout documentation (if not, provide description of change)	**Y/N**	**Site visit or survey of grantee**
		Fuel/energy consumption or vehicle miles traveled	*Gallons/year by fuel type, kWh/year, scf/year, or vehicle miles traveled/year*	*Evaluation of fueling, utility, mileage, or other operating records*
	New Vehicle(s) for Existing Transit Service	Fuel/energy consumption or vehicle miles traveled	Gallons/year by fuel type, kWh/year, scf/year, or vehicle miles traveled/year	Evaluation of fueling, utility, mileage, or other operating records

Program Name	Sub-Program Component	Metric	Unit	Method
Low Carbon Transit Operations Program (Continued)	New Vehicle(s) for Existing Transit Service (Continued)	**Confirmation that the purchased vehicles continue to be operated as stated within project close-out documentation (if not, provide explanation)**	**Y/N**	**Site visit or survey of grantee**
Transit and Intercity Rail Capital Program	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year	Days/year	Evaluation of service schedule
		Average daily ridership (separated into weekday, Saturday, and Sunday ridership)	*Unlinked trips/day*	*Ridership survey, ticket and transit pass sales, automatic passenger counter, driver counts, etc.*
		Average passenger trip length	**Miles**	**Ridership survey, ticket and transit pass sales, automatic passenger counter, driver counts, etc.**
		Indication of whether the capital improvements continue to operate as stated within project closeout documentation (if not, provide description of change)	**Y/N**	**Site visit or survey of grantee**
		Fuel/energy consumption or vehicle miles traveled	*Gallons/year by fuel type, kWh/year, scf/year, or vehicle miles traveled/year*	*Evaluation of fueling, utility, mileage, or other operating records*
	New Vehicle(s) for Existing Transit Service	Fuel/energy consumption or vehicle miles traveled	Gallons/year by fuel type, kWh/year, scf/year, or vehicle miles traveled/year	Evaluation of fueling, utility, mileage, or other operating records

Program Name	Sub-Program Component	Metric	Unit	Method
Transit and Intercity Rail Capital Program (Continued)	New Vehicle(s) for Existing Transit Service (Continued)	**Indication of whether the purchased vehicles continue to be operated as stated within project close-out documentation (if not, provide explanation)**	**Y/N**	**Site visit or survey of grantee**
Affordable Housing and Sustainable Communities	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Affordable Housing	Housing unit occupancy rate	Percent of occupied units	Annual Occupancy and Compliance Reports
		Income-restricted housing units occupancy rate	Percent of occupied units	Annual Occupancy and Compliance Reports
		Percentage of resident households with access to one or more owned, leased, or regularly borrowed cars	**Percentage of resident households**	**Surveys of residential occupants**
		Primary commuting and non-commuting modes (percentage of households by primary mode)	**Percentages by mode**	**Surveys of residential occupants**
		Percentage of resident households with reliable access to transportation	**Percentage of resident households**	**Surveys of residential occupants**
		Residents using transit passes, as applicable	Percent of residents using transit passes	Surveys of building managers or residential occupants
		For mixed-use projects, occupancy of commercial space	Percent of available square footage	Surveys of building managers/leasing agents or commercial occupants
		Energy generated by solar PV (if applicable)	*kWh/year*	*Evaluation of utility bills or utility records obtained directly from utility, residents, or building managers*

Program Name	Sub-Program Component	Metric	Unit	Method
Affordable Housing and Sustainable Communities (Continued)	Capital Improvements that Result in New or Expanded Transit Service or Increase Mode Share on Existing Transit Service	Days of operation per year	Days/year	Evaluation of service schedule
		Average daily ridership (separated into weekday, Saturday, and Sunday ridership)	*Unlinked trips/day*	*Ridership survey, ticket and transit pass sales, automatic passenger counter, driver counts, etc.*
		Fuel/energy consumption or vehicle miles traveled	*Gallons/year by fuel type, kWh/year, scf/year, or vehicle miles traveled/year*	*Evaluation of fueling, utility, mileage, or other operating records*
		Average passenger trip length	**Miles**	**Ridership survey, ticket and transit pass sales, automatic passenger counter, driver counts, etc.**
		Confirmation that the purchased vehicles continue to be operated as stated within project close-out documentation (if not, provide explanation)	**Y/N**	**Site visit or survey of grantee**
	Active Transportation	Average traffic of bicycle and pedestrian facilities	Users/day	Usage survey conducted by city, county district/authority, metropolitan planning organization, non-profit, or academia
Urban and Community Forestry	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Urban Forest Expansion and Improvement	*Confirmation that the tree planting sites are still being managed in accordance with the terms of the maintenance agreement including tree establishment and replacement care (if applicable based on post-grant agreement with grantee)*	*Y/N*	*On-site visit, recipient survey, or current aerial images (if appropriate)*

Program Name	Sub-Program Component	Metric	Unit	Method
Urban and Community Forestry (Continued)	Urban Forest Expansion and Improvement (Continued)	Tree mortality rate to date	Percentage	Extrapolated from conditions of a sample of project tree sites (assessed through on-site visits, aerial imagery, or recipient survey)
		Quantity of replacement trees planted (if applicable based on post-grant agreement with grantee)	**Trees**	**Maintenance and replacement records**
	Urban Forest Management Activities	*Confirmation that the tree planting sites are still being managed in accordance with the terms of the maintenance agreement including tree establishment and replacement care (if applicable based on post-grant agreement with grantee)*	*Y/N*	*On-site visit or current aerial images (if appropriate)*
		Tree mortality rate to date	Percentage	Extrapolated from conditions of a sample of project tree sites
		Description of impacts from the funded management activity (e.g. utilization of tree inventory, urban forest mapping and analysis, long-term management plan)	n/a	Records from jurisdiction
	Biomass Utilization (applicable to GGRF funded infrastructure)	Biomass delivered to a renewable energy facility	Bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers
		Harvested wood delivered to a mill	Board feet or bone dry tons/year	Evaluation of weight receipts from certified scales or tonnage reports from haulers

Program Name	Sub-Program Component	Metric	Unit	Method
Urban and Community Forestry (Continued)	Biomass Utilization (applicable to GGRF funded infrastructure) (Continued)	If producing wood products, mill efficiency and wood product classes, if available from mill	Percentage	Mill reports used to document mill efficiency and wood product classes
		If producing energy or fuel, renewable energy generated	kWh, MMBtu, scf, therms, or gallons/year	Evaluation of metered data, sale receipts, or operational logs
Urban Greening	All	Tracking dates of data submission	mm/dd/yyyy	n/a
	Urban Forestry	*Confirmation that the tree planting sites are still being managed in accordance with the terms of the maintenance agreement including tree establishment and replacement care (if applicable based on post-grant agreement with grantee)*	*Y/N*	*On-site visit or current aerial images (if appropriate)*
		Tree mortality rate to date	Percentage	Extrapolated from conditions of a sample of project tree sites (assessed through on-site visits, aerial imagery, or recipient survey)
		Quantity of replacement trees planted (if applicable based on post-grant agreement with grantee)	**Trees**	**Maintenance and replacement records**
	Active Transportation	Average traffic of bicycle and pedestrian facilities	Users/day	Usage survey conducted by city, county, district/authority, metropolitan planning organization, non-profit, or academia

Program Name	Sub-Program Component	Metric	Unit	Method
Healthy Soils Program	All	Tracking dates of data submission	mm/dd/yyyy	n/a
		Agricultural land on which conservation management practices are still being implemented (report separately for each management practice)	Acres	On-site visit or survey of grantee
		If practice involves compost application or mulch, rate of application	Dry short tons/acre/year	On-site visit or survey of grantee
		If practice involves compost application, indicate whether the carbon:nitrogen ratio of the compost applied greater than 11	Y/N	On-site visit or survey of grantee
		If practice involves tree planting, number of trees planted, by species, since last report	Number of trees, by species	On-site visit or survey of grantee
		If practice involves cover crops or herbaceous cover, number of acres, by species	Number of acres, by species	On-site visit or survey of grantee
		Soil organic matter concentration	**Percentage**	**Laboratory analysis of soil samples**

Appendix B: Descriptions and Methods for Developed Metrics

This project included developing descriptions and proposed methods of data collection and analysis for the additional POR metrics that were recommended as a result of the initial metrics assessment or data collection effort. Per CARB guidance, descriptions and methods are limited to one to three pages.

Section B.1 of this appendix provides descriptions and methods for the additional metrics that the Project Team recommends including in POR, not including existing POR metrics that were in place prior to this project. The methods included in this section represent methods used by the Project Team in collecting and reporting POR metrics for sampled projects, revised methods based on lessons learned during the data collection process, or proposed methods for new metrics that were not collected during the data collection process.

Section B.2 of this appendix presents descriptions and methods for metrics that were initially developed and proposed by the Project Team but were later categorized as deferred based on findings from the data collection process.

The following table organizes each of the included recommendations by program, for reference. Recommendations that apply to multiple programs are repeated across each relevant program. Programs that have the same set of recommended additional metrics are combined into a single row for brevity.

Table B-1. List of Metrics and Page Numbers

Program	Recommended Metric/Method	Page
Clean Mobility Options/Sustainable Transportation Equity Project	Percentage of trips associated with avoided internal combustion engine use	B-12
	Percentage of trips associated with improved mobility	B-15
	Percentage of users who have reduced the number of personal household vehicles as a result of the service	B-17
	Percentage of users who have avoided or delayed the purchase or lease of a personal vehicle as a result of the service	B-19
	Percentage of users who have reduced the amount they spend on gas since using the service	B-21
Affordable Housing and Sustainable Communities	Primary commuting and non-commuting modes	B-23
	Percentage of households with access to one or more owned, leased, or regularly borrowed cars (not including carsharing programs)	B-31
	Percentage of households with reliable access to transportation	B-33
Low Carbon Transit Operations Program / Transit and Intercity Rail Capital Program	Average passenger trip length	B-35
	Indication of whether the capital improvements/purchased vehicles continue to operate as stated within project closeout documentation (if not, provide description of change)	B-37
Low Carbon Fuel Production	Indication of Low Carbon Fuel Standard (LCFS) Carbon Intensity Score	B-38
	Non-fuel coproducts generated	B-40
Healthy Soils Program	Soil organic matter	B-41
	[Deferred Metric] Soil health indicators	B-54
	[Deferred Metric] Confirmation of continued soil health practices/Agricultural land on which conservation management practices are still being implemented	B-53
Urban and Community Forestry / Urban Greening	Quantity of replacement trees planted (if applicable based on post-grant agreement with grantee)	B-43
Forest Health / Regional Forest and Fire Capacity	Fuel load	B-44
	Qualitative assessment of project impacts on ecological factors	B-47
Fire Prevention Grants	Fuel load	B-44
CA State Coastal Conservancy Climate Ready Program / Climate Adaptation and Resiliency Program / Sustainable Agricultural Lands Conservation	Qualitative assessment of project impacts on ecological factors	B-47

B.1. Recommended Metrics

B.1.1 Description and Method: Information on selected locations, including program tracking data

Description

This metric is applicable to programs that include the installation of energy efficiency or water efficiency measures and conduct CCIRTS reporting of projects by census tract, where a subset of projects in the census tract may be selected for outcome reporting. This includes:

- Low-Income Weatherization; and
- Water-Energy Grants.

The Low-Income Weatherization Program (LIWP) provides a variety of measures to eligible single-family and multi-family residences, including lighting, appliances, space heating and cooling, building envelope, and solar upgrades. The Water-Energy Grants Program provides water and energy saving measures such as dishwashers, clothes washers, faucets, and shower heads, to residential, commercial, and institutional sites.[137] The specific set of measures installed in each participating location is dependent on baseline conditions, available funding, climate zone, energy audit results, and other location-specific characteristics.

Administering agencies currently report funded projects by census tract, with individual census tracts containing one or more residences or facilities. Agencies are required to report the number of residences or buildings selected for outcome reporting within each census tract. In addition to reporting the number of residences per census tract, providing an export of program tracking data including measure quantities, characteristics, and expected savings provides valuable context for assessments of outcome-related data such as energy usage obtained from utility bills.

This level of reporting may also provide insight into the relative impacts of different measure mixes across projects.

Method

Existing project installation records should be used as the default data source for this metric, as funding recipients and administering agencies currently keep records of installed measures by location.

The quantity and types of measures (i.e. the "measure mix") installed in each residence, multi-family building, or commercial or institutional facility should be documented and tracked at the time of installation. All site-level information would ideally be collected and tracked together as part of typical project documentation procedures. However if this is not the case, the measure mix and other project characteristics for each location should be recorded along with a unique identifier (such as site address or utility account number) that will link the measures to the energy usage data that will be collected as part of project outcome reporting.

Reporting

Once administering agencies determine the specific sites that will be selected for outcome reporting, the measure mix and additional tracking data for the selected sites would be provided to CARB in the form of

[137] Eligible measures for these programs are described in program guidelines documents.

a spreadsheet or database containing the following fields for each site selected in the outcome reporting sample:

- Census Tract
- Residence/Site ID (anonymized unique identifier)
- Measure category (e.g. lighting, faucets, showerheads)
- Measure quantity
- Any other available measure characteristics (e.g. wattage, R-value of insulation)
- Pre and post-project home heating type (e.g. natural gas, electric, propane, other)
- Any other available pre- and post-project heating equipment characteristics (e.g. HSPF, BTU, AFUE)
- Pre- and post-project water heating fuel type (e.g. natural gas, electric, propane, other)
- Any other available pre- and post-project water heating equipment characteristics (e.g. tank size, energy factor)

CARB may request additional supporting documentation including individual measure quantities from administering agencies as needed in order to further assess the relative contribution of individual measures to energy savings and GHG emission reductions.

B.1.2 Description and Method: Confirmation that common area measures remain in place and operational (for Multi-family sites)

Description

This metric is applicable to programs that involve the installation of energy efficiency or water efficiency measures in common or shared areas of multi-family residences. This includes:

- Low-Income Weatherization; and
- Water-Energy Grants.

The Low-Income Weatherization Program (LIWP) provides a variety of measures to eligible single-family and multi-family residences, including lighting, appliances, space heating and cooling, building envelope, and solar upgrades. The Water-Energy Grants Program provides water and energy saving measures such as dishwashers, clothes washers, faucets, and shower heads, to residential, commercial, and institutional sites. The specific set of measures installed in each participating location is dependent on baseline conditions, available funding, climate zone, energy audit results, and other location-specific characteristics.

After measures are installed, verification of continued measure installation and operation allows programs to demonstrate that the energy, water, and GHG benefits of projects are persisting, and helps to validate the expected useful life (EUL) of installed measures. While there may be significant barriers to conducting this validation for individual tenant residences or single-family homes, verification of measure persistence within common or shared areas of multi-family residences is designed to be a straightforward process that can be completed as part of outcome reporting.

Method

Data for this metric would be collected through interviews or other correspondence with multi-family residence owners, building managers, or other on-site staff. Administering agencies should contact the site during the outcome period to obtain the following information:

Q1. Whether or not all of the energy efficiency or water efficiency measures that were installed by the program in common or shared areas are still installed *[Yes/No]*;

Q2. Whether or not all of the energy efficiency or water efficiency measures that were installed by the program in common or shared areas are still operating properly *[Yes/No]*;

Q3. If no to either Q1 or Q2, the quantity of each measure that has been removed or is no longer operational along with a brief description (e.g. number of LEDs removed or no longer operational, number of shower heads removed or no longer operational) *[Quantity by Measure and Qualitative Description]*

Reporting

Agencies would then input the results of this verification into the project outcome reporting template. If the site contact answered "Yes" to both Q1 and Q2 above, the content provided for the outcome reporting field can be limited to "Yes". If the site contact provided information regarding quantities of measures removed or no longer operational along with a description of the issue or change, the outcome reporting field should include "No", followed by this information with quantities removed or no longer operational, by measure.

B.1.3 Description and Method: Confirmation that solar PV remains in place and operational (for Multi-family sites)

Description

This metric is applicable to programs that involve the installation of solar photovoltaic (PV) measures in common or shared areas of multi-family residences. This includes the Low-Income Weatherization Program.

After solar PV systems are installed, verification of continued measure installation and operation allows programs to demonstrate that the energy generation benefits of projects are persisting, and helps to validate the expected useful life (EUL) of installed solar PVs. While there may be significant barriers to conducting this validation for individual tenant residences or single-family homes, verification of solar PV persistence for multi-family residences is designed to be a straightforward process that can be completed as part of outcome reporting.

Method

Data for this metric would be collected through interviews or other correspondence with multi-family residence owners, building managers, or other on-site staff. Administering agencies should contact the site during the outcome period to obtain the following information:

Q1. Whether or not the solar PV system that was installed by the program is still in place *[Yes/No]*;

Q2. Whether or not the solar PV system that was installed by the program is connected and operating properly *[Yes/No]*;

Q3. If no to either Q1 or Q2, a description of operational issues or the reason that the solar PV system is not in place or operating properly *[Qualitative open-ended description]*

Reporting

Agencies would then input the results of this verification into the project outcome reporting template. If the site contact answered "Yes" to both Q1 and Q2 above, the content provided for the outcome reporting field can be limited to "Yes". If the site contact provided a description of issues with the solar PV system, the outcome reporting field should include "No", followed by this information.

B.1.4 Description and Method: Total energy use

Description

This metric is applicable to programs that involve the installation of energy efficiency measures in residential, commercial, and industrial buildings. This includes:

- Low-Income Weatherization; and
- Water-Energy Grants.

Reporting of total energy use, including electricity and gas use, is intended to serve as a method of ensuring that grantees are recording and retaining energy usage data in a manner that can be reported for potential assessment and project evaluation. Additionally, energy use values reported for a single site over multiple outcome periods can be compared to replicate the simple difference approach for calculating change in energy use that was previously required under POR guidelines. However, this approach is not recommended as a method of determining the energy savings or GHG benefits that are attributable to project treatments.

Method

The data sources for this metric are utility billing data obtained directly from utility companies, or utility bills provided by residents or building owners. Both gas and electricity billing data should be obtained for each site that was selected for outcome reporting, as applicable based on the utility providers associated with each site (e.g. an all-electric site would report electricity usage data only).

Total energy use is calculated as the sum of kWh or Therms for each month of the applicable outcome period (e.g. a 12-month period). For multi-family sites that involved the installation of energy efficiency measures in both common/shared areas and tenant residences, energy usage metrics should include both area types. If data are available for the common/shared area only, or tenant units only, administering agencies should report the available usage data and provide a description of the data limitation in the outcome reporting workbook.

If the start and end dates of the utility bills does not precisely match the start and end dates of the outcome period, the closest 12 months to the applicable outcome period should be used to report total energy use. For example, if the outcome period ranges from January 1, 2021 through December 31, 2021, but the utility billing cycle begins on the 10th of each month, bills from January 10, 2021 through January 9, 2022 should be used as the basis for energy usage data for the site. During the following outcome

period, bills from January 10, 2022 through January 9, 2023 should be used. If the dates of billing cycles vary throughout the year or between outcome reporting periods, agencies should reference the closest possible date range and provide a description of the dates that were represented by billing data reported for this metric.

As energy generation is a separate outcome metric, energy usage data should be separated from energy generation data when calculating this metric to avoid potential double-counting of energy generation values. However, if energy generation data cannot be isolated and removed from this calculation, agencies should provide a description of this issue in the outcome reporting workbook.

Reporting

Upon determining the total energy use of project sites, administering agencies should report these values in units of kWh (electricity) and Therms (gas) for each site, as applicable based on site utility providers. Additionally, agencies should provide any qualitative information that may be relevant to the interpretation of these values, such as the billing dates used as the basis for these metrics, instances of missing data, or issues identified within the records received.

An example of this information as it would appear in the project outcome reporting template is as follows:

Project ID	Total energy use (Electricity kWh)	Total energy use (Gas Therms)	Energy use notes
18-2-3	30,050	1,250	Electricity data represent 12 months from 1/10/2021 to 1/9/2022. Gas data represent 12 months from 1/1/2021 to 12/31/2021.
18-2-4	8,500	240	Electricity and gas data are missing the month of January 2021 due to a change in site ownership and meter changeout, and barrier to obtaining data for previous owner.

CARB may request additional documentation to support further analysis of project energy usage, such as monthly utility billing data, depending on evaluation needs.

B.1.5 Description and Method: Total SWEEP project on-farm energy use

Description

This metric is applicable to programs that fund outdoor irrigation measures on agricultural project sites. This currently includes the State Water Efficiency and Enhancement Program (SWEEP).

SWEEP funds the implementation of measures such as variable frequency drives (VFDs), pump efficiency improvements, soil moisture sensors, irrigation controls, and drip systems to reduce energy and water use and achieve GHG emission reductions for agricultural project sites.

Reporting of total energy use is intended to serve as a method of ensuring that grantees are recording and retaining energy usage data in a manner that can be reported for potential assessment and project evaluation. Additionally, energy use values reported for a single site over multiple outcome periods can be compared to replicate the simple difference approach for calculating change in energy use that was previously required under POR guidelines. However, this approach is not recommended as a method of determining the energy savings or GHG benefits that are attributable to project treatments.

Method

The data sources for this metric are utility billing data obtained from grantees or directly from utility companies. The data collection and analysis time period for SWEEP project on-farm energy use should coincide with the data collection and analysis time period for SWEEP project on-farm water use for a given project (e.g. both data sets should represent the same outcome period to allow for possible comparison).

This metric is intended to collect information on energy use relevant to the measures that were installed through SWEEP. Energy usage data for site meters that are not associated with equipment or measures implemented through SWEEP should not be included. The administering agency should reference the meter IDs that were provided within initial project documentation when requesting utility data. If a meter ID has changed since project implementation, the agency should work with grantees to determine the meter number(s) associated with installed SWEEP equipment and measures during the outcome period.

Total energy use is calculated as the sum of kWh (or Therms, if applicable) for each month of the applicable outcome period. If the start and end dates of the utility bills does not precisely match the start and end dates of the outcome period, the closest 12 months to the applicable outcome period should be used to report total energy use. For example, if the outcome period ranges from January 1, 2021 through December 31, 2021, but the utility billing cycle begins on the 10th of each month, bills from January 10, 2021 through January 9, 2022 should be used as the basis for energy usage data for the site. During the following outcome period, bills from January 10, 2022 through January 9, 2023 should be used. If the dates of billing cycles vary throughout the year or between outcome reporting periods, the agency should reference the closest possible date range and provide a description of the dates that were represented by billing data reported for this metric.

As energy generation is a separate outcome metric, energy usage data should be separated from energy generation data when calculating this metric to avoid potential double-counting of energy generation values. However, if energy generation data cannot be isolated and removed from this calculation, agencies should provide a description of this issue in the outcome reporting workbook.

Reporting

Upon determining the total energy use associated with SWEEP project measures, the administering agency should report these values in units of kWh (and Therms, if applicable) for each site. Additionally, the agency should provide any qualitative information that may be relevant to the interpretation of these values, such as the billing dates used as the basis for these metrics, instances of missing data, or issues identified within the records received.

An example of this information as it would appear in the project outcome reporting template is as follows:

Project ID	Total SWEEP project on-farm energy use (Electricity kWh)	SWEEP project on-farm energy use notes
SWE7070	240,000	Data represent two meters connected to the installed VFDs.
SWE8855	115,000	Data represent 12 months from 1/10/2021 to 1/9/2022. Data include solar generation kWh for January 2021 as the system was not metered separately until February 2021.

CARB may request additional documentation to support further analysis of SWEEP project energy usage, such as monthly utility billing data, depending on evaluation needs.

B.1.6 Description and Method: Total SWEEP project on-farm water use

Description

This metric is applicable to programs that fund outdoor irrigation measures on agricultural project sites. This currently includes the State Water Efficiency and Enhancement Program (SWEEP).

SWEEP funds the implementation of measures such as soil moisture sensors, irrigation controls, drip systems, pump efficiency improvements, variable frequency drives (VFDs), and renewable energy systems to reduce energy and water use and achieve GHG emission reductions for agricultural operations.

Reporting of total water use is intended to serve as a method of ensuring that grantees are recording and retaining water usage data in a manner that can be reported for potential assessment and project evaluation. Additionally, water use values reported for a single site over multiple outcome periods can be compared to replicate the simple difference approach for calculating change in energy use that was previously required under POR guidelines. However, this approach is not recommended as a method of determining the energy savings or GHG benefits that are attributable to project treatments.

Method

The data sources for this metric are water usage records retained by grantees for the agricultural pumps associated with SWEEP measures. This metric is intended to collect information on water use relevant to the measures that were installed through SWEEP. Water usage data for pumps that are not associated with equipment or measures implemented through SWEEP should not be included.

The data collection and analysis time period for SWEEP project on-farm water use should coincide with the data collection and analysis time period for SWEEP project on-farm energy use for a given project (e.g. both data sets should represent the same outcome period to allow for possible comparison).

The recommended method for data collection of SWEEP project on-farm water use is based on the National Renewable Energy Laboratory (NREL) Outdoor Irrigation Measurement and Verification Protocol.[138] This method addresses data collection for water conservation measures including irrigation system efficiency improvements, advanced irrigation controllers, and irrigation and flow sensors.

Grantees, administering agencies, or third-party verifiers should follow the steps and guidelines outlined in the NREL Protocol for data collection. The protocol recommends the use of a dedicated meter to collect continuous measurements but accounts for the possible use of irrigation system runtime and temporary flow rate measurement to calculate total water use. As SWEEP includes the implementation of flow meters for project sites that do not have pre-existing meters, flow meter records should be available and used if possible.

Total water use is calculated as the sum of gallons used for the SWEEP project site throughout the outcome period.

Reporting

Upon determining the total water use for a given project outcome reporting period, the administering agency should report these values in gallons for each site. Additionally, the agency should provide any

[138] Charles W. Kurnik, Kate M. Stoughton, and Jorge Figueroa, "Outdoor Irrigation Measurement and Verification Protocol," 2017, https://doi.org/10.2172/1412803.

qualitative information that may be relevant to the interpretation of these values, such as instances of missing data or issues identified by the grantee.

An example of this information as it would appear in the project outcome reporting template is as follows:

Project ID	Total SWEEP project on-farm water use (Gallons)	SWEEP project on-farm water use notes
SWE7070	840,000	Data represent 11 months from 2/1/2020 to 12/31/2020. January usage data were unavailable as the grantee began retaining records in February 2020.
SWE8855	1,165,000	One of eight irrigation blocks at the property is not connected to the SWEEP flow meter. Usage for this block was calculated by the grantee based on average flow rate and system runtime.

CARB may request additional documentation to support further analysis of SWEEP project water usage, such as flow meter records or irrigation logs, depending on evaluation needs.

B.1.7 Description and Method: Confirmation that SWEEP measures remain in-place and operational

Description

This metric is applicable to programs that fund outdoor irrigation measures on agricultural project sites. This currently includes the State Water Efficiency and Enhancement Program (SWEEP).

SWEEP funds the implementation of measures such as soil moisture sensors, irrigation controls, drip systems, pump efficiency improvements, variable frequency drives (VFDs), and renewable energy systems to reduce energy and water use and achieve GHG emission reductions for agricultural operations.

After measures are installed, verification of continued measure installation and operation allows programs to demonstrate that the energy, water, and GHG benefits of projects are persisting, and helps to validate the expected useful life (EUL) of installed measures.

Method

Data for this metric would be collected through interviews or other correspondence with grantees or other contact persons at project sites. Administering agencies should contact the site during the outcome period to obtain the following information:

Q1. Whether or not all of the energy efficiency, water efficiency, or energy generation measures (e.g. VFDs, soil moisture sensors, solar PV) that were installed through SWEEP are still installed *[Yes/No]*;

Q2. Whether or not all of the energy efficiency, water efficiency, or energy generation measures that were installed through SWEEP are still operating properly *[Yes/No]*;

Q3. If no to either Q1 or Q2, the quantity of each measure that has been removed or is no longer operational along with a brief description (e.g. one of two pumps removed and replaced due to failure; solar PV system not yet connected) *[Quantity by Measure and Qualitative Description]*

Reporting

Agencies would then input the results of this verification into the project outcome reporting template. If the site contact answered "Yes" to both Q1 and Q2 above for all measures and equipment, the content provided for the outcome reporting field can be limited to "Yes". If the site contact provided information regarding quantities of measures removed or no longer operational along with a description of the issue or change, the outcome reporting field should include "No", followed by this information with quantities removed or no longer operational, by measure.

B.1.8 Description and Method: Indication of substantial change to irrigation system, acreage, or land use

Description

This metric is applicable to programs that fund outdoor irrigation measures on agricultural project sites. This currently includes the State Water Efficiency and Enhancement Program (SWEEP).

SWEEP funds the implementation of measures such as soil moisture sensors, irrigation controls, drip systems, pump efficiency improvements, variable frequency drives (VFDs), and renewable energy systems to reduce energy and water use and achieve GHG emission reductions for agricultural operations.

Tracking the status of project site characteristics such as irrigation system changes, total irrigated acreage, and land use changes including crop changes provides context that may be valuable to potential evaluations of project impacts on energy and water use, and may assist in validating initial assumptions regarding site characteristics over the lifetime of installed measures.

Method

Data for this metric would be collected through interviews or other correspondence with grantees or other contact persons at project sites. The administering agency should contact the site during the outcome period to obtain the following information:

Q1. Whether or not there have been any changes to the irrigation system that may substantially affect the amount of water or energy used to support the agricultural operations associated with the SWEEP project (e.g. additional sensors, upgraded irrigation equipment, new access to surface water source, etc.) *[If Yes, record description of the change];*

Q2. Whether or not there has been a major expansion or reduction of the acreage irrigated by equipment associated with the SWEEP project (i.e. more than 5% change to acreage of project site, due to land disturbance or planned expansion or land management change) *[If Yes, record description of the change]*;

Q3. Whether or not there has been a change in crop selection that was not accounted for within SWEEP documentation and may substantially affect the amount of water or energy used to support the agricultural operations associated with the SWEEP project *[If Yes, record description of the change].*

These topics are designed to provide the administering agency with information about any significant factors that may affect water or energy use in the post-installation period as compared to the baseline condition. If possible, information collected from grantees or site contacts should include any quantitative

information available regarding the scope or magnitude of the relevant factor (such as number of acres on which crops were converted).

An example of this information as it would appear in the project outcome reporting template is below.

Project ID	Indication of substantial change to irrigation system, acreage, or land use	Change to irrigation system, acreage, or land use notes
SWE7070	Yes	Crop converted from alfalfa to almonds on 50 of 200 acres.
SWE8855	Yes	Irrigation system connected to SWEEP flow meters expanded by 30 acres for new vegetable crops.
SWE8889	No	No substantial changes since prior period

Depending on the significance of post-project factors that may affect water or energy use, CARB may request a more detailed description of these factors and their expected impacts on water or energy use.

B.1.9 Description and Method: Percentage of trips associated with avoided internal combustion engine use

Description

This metric is applicable to shared mobility and transportation equity programs that seek to provide low-carbon transportation alternatives such as car-sharing to disadvantaged communities, including Clean Mobility Options (CMO) and the Sustainable Transportation Equity Project (STEP).

These programs achieve GHG reductions by encouraging the use of low-carbon options such as electric vehicles (EVs) as a substitute to conventional options such as internal combustion engine (ICE) vehicles. Avoided internal combustion engine (ICE) use refers to trips that would have been traveled using a conventional, internal combustion engine vehicle in the absence of the mobility service.

The survey questions provided below are intended to represent the minimum number of questions to include in a survey in order to determine whether a trip is replacing an ICE trip. These questions may be added to existing survey instruments that are currently administered by grantees, or if no existing survey process exists, combined with additional questions regarding service user characteristics (such as the purpose of the trip, frequency of use, satisfaction etc.) in order to more fully assess the impacts of the funded project.

Method

This method assumes that grantees are able to track individual uses of shared mobility services and identify, contact, and request information from users. This method also assumes that users of shared mobility services in disadvantaged communities would travel in an ICE rather than an alternative fuel vehicle (e.g. plug-in hybrid, battery electric vehicle, fuel cell vehicle, etc.) if traveling by carsharing service (e.g. Uber, Lyft, or taxi) in the absence of the shared mobility service.

The data sources for this metric consist of self-report survey data collected from users of the shared mobility services.

Self-report survey data would be collected through surveys administered to users after each trip (or reservation) made with the shared mobility service.[139] The method of survey administration may vary depending on the type of contact information available for users, as well as user access to certain mediums. Electronic, telephone, in-person, mail, or other methods may be effective and appropriate. Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

The survey should include the following questions to support calculation of this metric:

Q1. If [Service] had not been available, would you have been able to make this trip?

- *Response options of Yes, would have been able to make the same trip; Yes, but would have gone to a different location; No, would not have been able to make the trip; Unsure/Prefer not to respond*

Q2. (If "Yes, would have made the same trip" or "Yes, but would have gone to a different location" for Q1) What mode of travel would you have most likely used for the trip if [Service] were not available?

- *Response options including Driven my own car; Borrowed someone else's car; Asked for a ride in someone else's car; Rented a car; Walked; Biked; Used a scooter; Taken a bus; Taken a train; Taken a taxi, Uber, Lyft or similar service; Unsure/Prefer not to respond; and Multiple modes/Other*

Q3. (If "driven my own car", "borrowed someone else's car", "asked for a ride in someone else's car", "rented a car" for Q2) is the car that you would have used for this trip an alternative fuel vehicle (e.g. plug-in hybrid, battery electric vehicle, fuel cell vehicle)?

- *Response options including Yes; No; Unsure/Prefer not to respond*

Q4. Do you currently own or lease an advanced technology vehicle (e.g. plug-in hybrid, battery electric vehicle, fuel cell vehicle)?

- *Response options of Yes; No; Unsure/Prefer not to respond*

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines.[140]

Analysis

Once the above data are collected, outcome reporting metrics would be calculated as follows:

Fully Avoided ICE Trips

1. For each survey response where the respondent indicates "Yes, would have made the same trip" in Q1; AND indicates that they would have made the trip using a car (options of "driven my own car", "borrowed someone else's car", "asked for a ride from someone", "rented a car", "taken a taxi, Uber, Lyft, or similar service", or "multiple modes/other" responses that indicate car use from Q2); AND

[139] Depending on the shared mobility service, projects may refer to uses of the service as trips or as reservations (e.g. multiple trips). For simplicity, this methodology refers to trips, but the same methods can be followed in either case.

[140] Ideal survey sample sizes can be determined using a calculator tool such as:
Qualtrics Sample Size Calculator, https://www.qualtrics.com/blog/calculating-sample-size/

indicates that the car is not an alternative fuel vehicle in Q3, the trip associated with that response should be flagged as a **Fully Avoided ICE Trip**.

Partially Avoided ICE Trips

1. For each survey response where the respondent indicates "Yes, but would have gone to a different location" in Q1; AND indicates that they would have made the trip using a car (options of "driven my own car", "borrowed someone else's car", "asked for a ride from someone", "rented a car", "taken a taxi, Uber, Lyft, or similar service", or "multiple modes/other" responses that indicate car use from Q2); AND indicates that the car is not an alternative fuel vehicle in Q3, the trip associated with that response should be flagged as a **Semi-Avoided ICE Trip.**

Avoided ICE Trip Rate

1. The total number of trips captured by the survey sample (after cleaning survey data to exclude incomplete or inconsistent responses) represents the **Total Sample Trips.**

2. Sum all **Fully Avoided ICE Trips** and **Semi-Avoided ICE Trips** to obtain the **Total Avoided ICE Trips.**

3. Divide the **Total Avoided ICE Trips** obtained above by the **Total Sample Trips** to obtain the **Avoided ICE Trip Rate:**

$$Avoided\ ICE\ Trip\ Rate = \frac{Total\ Avoided\ ICE\ Trips}{Total\ Sample\ Trips}$$

The **Avoided ICE Trip Rate** represents the percentage of shared mobility service trips that are replacing the use of a conventional ICE vehicles, including the use of conventional ICE vehicles to alternate destinations. This value represents the outcome metric of percentage of trips associated with avoided ICE use. Prior to calculation, survey data should be cleaned to exclude incomplete responses. Responses of "Unsure/Prefer not to respond" should not be counted towards any of the above categories.

Reporting

Once grantees or administering agencies have performed the above steps, the project outcome reporting template should be populated with the following metrics:

- Avoided ICE Trip Rate (Percentage of trips associated with avoided ICE use); and
- Total Sample Trips.

An example of these metrics as they would appear in the project outcome reporting template is as follows (existing project outcome metrics are included and italicized):

Quantity of Trips (entire project)	*Quantity of Riders (entire project)*	*Quantity of Vehicle Miles Traveled (entire project)*	Percentage of Trips Associated with Avoided ICE use (surveyed)	Total Sample Trips (surveyed)
850	1,450	9,200	0	280

In addition to the metrics provided within outcome templates, CARB may request survey instruments or raw survey data for the purposes of validating data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

B.1.10 Description and Method: Percentage of trips associated with improved mobility

Description

This metric is applicable to shared mobility and transportation equity programs that seek to provide low-carbon transportation alternatives such as carsharing to disadvantaged communities, including Clean Mobility Options (CMO) and the Sustainable Transportation Equity Project (STEP).

These programs are designed to assist individuals who may otherwise be unable to effectively meet their transportation needs. Improved mobility refers to trips that the participant would not have been able to make in the absence of the shared mobility service. The metric as described in this section is primarily focused on identifying benefits to individuals who have limited transportation alternatives.

The survey questions provided below are intended to represent the minimum number of questions to include in a survey in order to determine whether a trip counts as an improved mobility trip. These questions may be added to existing survey instruments that are currently administered by grantees, or if no existing survey process exists, combined with additional questions regarding service user characteristics (such as the purpose of the trip, frequency of use, vehicle ownership, etc.) in order to more fully assess the impacts of the funded project.

Method

This method assumes that grantees are able to track individual uses of shared mobility services and identify, contact, and request information from users. The data sources for this metric consist of self-report survey data collected from users of the shared mobility services.

Self-report survey data would be collected through surveys administered to users after each trip (or reservation) made with the shared mobility service.[141] The method of survey administration may vary depending on the type of contact information available for users, as well as user access to certain mediums. Electronic, telephone, in-person, mail, or other methods may be effective and appropriate. Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

The survey should include the following question to support calculation of this metric:

Q1. If [Service] had not been available, would you have been able to make this trip?

- *Response options of Yes, would have been able to make the same trip; Yes, but would have gone to a different location; No, would not have been able to make the trip; Unsure/Prefer not to respond*

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines.

[141] Depending on the shared mobility service, projects may refer to uses of the service as trips or as reservations (e.g. multiple trips). For simplicity, this methodology refers to trips, but the same methods can be followed in either case.

Analysis

Once the above data are collected, outcome reporting metrics would be calculated as follows:

Fully Improved Mobility Trips

1. For each survey response where the respondent indicates "No, would not have made the trip" in the absence of the shared mobility service (Q1), the trip associated with that response should be flagged as a **Fully Improved Mobility Trip**.

Semi-Improved Mobility Trips

1. For each survey response where the respondent indicates "Yes, but would have gone to a different location" in the absence of the shared mobility service (Q1), the trip associated with that response should be flagged as a **Semi-Improved Mobility Trip**.

Improved Mobility Rate

1. The total number of trips captured by the survey sample (after cleaning survey data to exclude incomplete or inconsistent responses) represents the **Total Sample Trips.**

2. Sum all **Fully Improved Mobility Trips** and **Semi-Improved Mobility Trips** to obtain the **Total Improved Mobility Trips**.

3. Divide the total number of **Total Improved Mobility Trips** by the **Total Sample Trips** to obtain the **Improved Mobility Rate:**

$$Improved\ Mobility\ Rate = \frac{Total\ Improved\ Mobility\ Trips}{Total\ Sample\ Trips}$$

The **Improved Mobility Rate** represents the percentage of shared mobility service trips that would not have been taken at all, or would have involved different destinations in the absence of the project. This value represents the outcome metric for percentage of trips associated with improved mobility.

Prior to calculation, survey data should be cleaned to exclude incomplete responses. Responses of "Unsure/Prefer not to respond" should not be counted towards any of the above categories.

Reporting

Once grantees or administering agencies have performed the above steps, the project outcome reporting template should be populated with the following metrics:

- Improved Mobility Rate (Percentage of trips associated with improved mobility); and
- Total Sample Trips.

An example of these metrics as they would appear in the project outcome reporting template is as follows (with other existing project outcome metrics included and italicized):

Quantity of Trips (entire project)	*Quantity of Riders (entire project)*	*Quantity of Vehicle Miles Traveled (entire project)*	Percentage of Trips Associated with Induced Travel (surveyed)	Total Sample Trips (surveyed)
850	1,450	9,200	15%	280

In addition to the metrics provided within outcome templates, CARB may request survey instruments or raw survey data for the purposes of validating data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

B.1.11 Description and Method: Percentage of users who have reduced the number of personal household vehicles as a result of the service

Description

This metric is applicable to shared mobility and transportation equity programs that seek to provide low-carbon transportation alternatives such as carsharing to disadvantaged communities, including Clean Mobility Options (CMO) and the Sustainable Transportation Equity Project (STEP).

These programs achieve GHG reductions by encouraging the use of low-carbon options such as electric vehicles (EVs) as a substitute to conventional options such as internal combustion engine (ICE) vehicles. In addition to GHG benefits, the funding of shared EVs is intended to result in transportation-related cost savings for project service users. The availability of alternative mobility options may also cause service users to sell, scrap, or otherwise shed one or more of their personal vehicles. This metric is intended to provide insight into how funded mobility services are affecting personal vehicle use and may be contributing to GHG benefits and reduced transportation costs to customers.

The survey questions provided below are intended to represent the minimum number of questions to include in a survey in order to determine whether service users have reduced their number of household vehicles. These questions may be added to existing survey instruments that are currently administered by grantees, or if no existing survey process exists, combined with additional questions regarding service user characteristics in order to more fully assess the impacts of the funded project.

Method

This method assumes that grantees are able to identify, contact, and request information from service users. The data source for this metric consists of self-report survey data collected from users of the shared mobility services.

Self-report survey data would be collected through one-time or periodic surveys administered to users of the shared mobility service. The method of survey administration may vary depending on the type of contact information available for users, as well as user access to certain mediums. Electronic, telephone, in-person, mail, or other methods may be effective and appropriate. Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

The survey should include the following question to support calculation of this metric:

Q1. Has [Project Name] affected the number of personal motor vehicles that you own or lease?

- *Response options of Yes, I have sold, scrapped, or given away one or more personal vehicles due to the availability of [Project Name]; Yes, I have stopped leasing one or more personal vehicles due to the availability of [Project Name]; Yes, I am delaying the purchase or lease of one or more personal vehicles due to the availability of [Project Name]; Yes, I have decided not*

to purchase or lease a personal vehicle due to the availability of [Project Name]; No, [Project Name] has not affected the number of personal vehicles that I own or lease; Unsure/Prefer not to respond

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines.

Analysis

Once the above data are collected, outcome reporting metrics would be calculated as follows:

Users Reducing Personal Vehicles

1. For each survey response where the respondent indicates "Yes, I have sold, scrapped, or given away one or more personal vehicles due to the availability of [Project Name]" or "Yes, I have stopped leasing one or more personal vehicles due to the availability of [Project Name]", the survey response should be flagged as a **User Reducing Personal Vehicles**.

Percentage of Users Reducing Personal Vehicles

1. The total number of users represented by the survey sample (after cleaning survey data to exclude incomplete or inconsistent responses) represents the **Total Sample Users.**

2. Sum all instances of **Users Reducing Personal Vehicles** to obtain the **Total Users Reducing Personal Vehicles**.

3. Divide the total number of **Total Users Reducing Personal Vehicles** by the **Total Sample Users** to obtain the **Percentage of Users Reducing Personal Vehicles:**

$$Percentage\ of\ Users\ Reducing\ Personal\ Vehicles = \frac{Total\ Users\ Reducing\ Personal\ Vehicles}{Total\ Sample\ Users}$$

The **Percentage of Users Reducing Personal Vehicles** represents the percentage of shared mobility service users that have reduced the number of personal motor vehicles that they own or lease due to the availability of the service.

Prior to calculation, survey data should be cleaned to exclude incomplete responses. Responses of "Unsure/Prefer not to respond" should not be counted towards the above categories.

Reporting

Once grantees or administering agencies have performed the above steps, the project outcome reporting template should be populated with the following metrics:

- Percentage of Users Reducing Personal Vehicles; and
- Total Sample Users.

An example of these metrics as they would appear in the project outcome reporting template is as follows (with other existing project outcome metrics included and italicized):

Quantity of Trips (entire project)	*Quantity of Riders (entire project)*	*Quantity of Vehicle Miles Traveled (entire project)*	Percentage of Users Reducing Personal Vehicles (surveyed)	Total Sample Trips (surveyed)
850	1,450	9,200	10%	280

In addition to the metrics provided within outcome templates, CARB may request survey instruments or raw survey data for the purposes of validating data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

B.1.12 Description and Method: Percentage of users who have avoided or delayed the purchase or lease of a personal vehicle as a result of the service

Description

This metric is applicable to shared mobility and transportation equity programs that seek to provide low-carbon transportation alternatives such as carsharing to disadvantaged communities, including Clean Mobility Options (CMO) and the Sustainable Transportation Equity Project (STEP).

These programs achieve GHG reductions by encouraging the use of low-carbon options such as electric vehicles (EVs) as a substitute to conventional options such as internal combustion engine (ICE) vehicles. In addition to GHG benefits, the funding of shared EVs is intended to result in transportation-related cost savings for project service users. The availability of alternative mobility options may also cause service users avoid or delay the purchase or lease of one or more personal vehicles. This metric is intended to provide insight into how funded mobility services are affecting personal vehicle use and may be contributing to GHG benefits and reduced transportation costs to customers.

The survey questions provided below are intended to represent the minimum number of questions to include in a survey in order to determine whether service users have reduced their number of household vehicles. These questions may be added to existing survey instruments that are currently administered by grantees, or if no existing survey process exists, combined with additional questions regarding service user characteristics in order to more fully assess the impacts of the funded project.

Method

This method assumes that grantees are able to identify, contact, and request information from service users. The data source for this metric consists of self-report survey data collected from users of the shared mobility services.

Self-report survey data would be collected through one-time or periodic surveys administered to users of the shared mobility service. The method of survey administration may vary depending on the type of contact information available for users, as well as user access to certain mediums. Electronic, telephone, in-person, mail, or other methods may be effective and appropriate. Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

The survey should include the following question to support calculation of this metric:

Q1. Has [Project Name] affected the number of personal motor vehicles that you own or lease?

- *Response options of Yes, I have sold, scrapped, or given away one or more personal vehicles due to the availability of [Project Name]; Yes, I have stopped leasing one or more personal vehicles due to the availability of [Project Name]; Yes, I am delaying the purchase or lease of one or more personal vehicles due to the availability of [Project Name]; Yes, I have decided not to purchase or lease a personal vehicle due to the availability of [Project Name]; No, [Project Name] has not affected the number of personal vehicles that I own or lease; Unsure/Prefer not to respond*

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines.

Analysis

Once the above data are collected, outcome reporting metrics would be calculated as follows:

Users Avoiding or Delaying Purchase or Lease

1. For each survey response where the respondent indicates "Yes, I am delaying the purchase or lease of one or more personal vehicles due to the availability of [Project Name]" or "Yes, I have decided not to purchase or lease a personal vehicle due to the availability of [Project Name]", the survey response should be flagged as a **User Avoiding or Delaying Purchase or Lease**.

Percentage of Users Avoiding or Delaying Purchase or Lease

1. The total number of users represented by the survey sample (after cleaning survey data to exclude incomplete or inconsistent responses) represents the **Total Sample Users.**

2. Sum all instances of **Users Avoiding or Delaying Purchase or Lease** to obtain the **Total Users Avoiding or Delaying Purchase or Lease**.

3. Divide the total number of **Total Users Avoiding or Delaying Purchase or Lease** by the **Total Sample Users** to obtain the **Percentage of Users Avoiding or Delaying Purchase or Lease:**

$$Percentage\ of\ Users\ Avoiding\ or\ Delaying\ Purchase\ or\ Lease = \frac{Total\ Users\ Avoiding\ or\ Delaying\ Purchase\ or\ Lease}{Total\ Sample\ Users}$$

The **Percentage of Users Avoiding or Delaying Purchase or Lease** represents the percentage of shared mobility service users that have avoided or delayed purchasing or leasing one or more personal motor vehicles due to the availability of the service.

Prior to calculation, survey data should be cleaned to exclude incomplete responses. Responses of "Unsure/Prefer not to respond" should not be counted towards the above categories.

Reporting

Once grantees or administering agencies have performed the above steps, the project outcome reporting template should be populated with the following metrics:

- Percentage of Users Avoiding or Delaying Purchase or Lease of Personal Vehicles; and

- Total Sample Users.

An example of these metrics as they would appear in the project outcome reporting template is as follows (with other existing project outcome metrics included and italicized):

Quantity of Trips (entire project)	*Quantity of Riders (entire project)*	*Quantity of Vehicle Miles Traveled (entire project)*	Percentage of Users Avoiding or Delaying Purchase or Lease of Personal Vehicles (surveyed)	Total Sample Trips (surveyed)
850	1,450	9,200	20%	280

In addition to the metrics provided within outcome templates, CARB may request survey instruments or raw survey data for the purposes of validating data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

B.1.13 Description and Method: Percentage of users who have reduced the amount they spend on gas since using the service

Description

This metric is applicable to shared mobility and transportation equity programs that seek to provide low-carbon transportation alternatives such as carsharing to disadvantaged communities, including Clean Mobility Options (CMO) and the Sustainable Transportation Equity Project (STEP).

These programs achieve GHG reductions by encouraging the use of low-carbon options such as electric vehicles (EVs) as a substitute to conventional options such as internal combustion engine (ICE) vehicles. In addition to GHG benefits, the funding of shared EVs is intended to result in transportation-related cost savings for project service users, such as reductions in gasoline expenses. This metric is intended to provide insight into how funded mobility services are affecting personal vehicle use and may be contributing to GHG benefits and reduced transportation costs to customers.

The survey questions provided below are intended to represent the minimum number of questions to include in a survey in order to determine whether service users have reduced their number of household vehicles. These questions may be added to existing survey instruments that are currently administered by grantees, or if no existing survey process exists, combined with additional questions regarding service user characteristics in order to more fully assess the impacts of the funded project.

Method

This method assumes that grantees are able to identify, contact, and request information from service users. The data source for this metric consists of self-report survey data collected from users of the shared mobility services.

Self-report survey data would be collected through one-time or periodic surveys administered to users of the shared mobility service. The method of survey administration may vary depending on the type of contact information available for users, as well as user access to certain mediums. Electronic, telephone, in-person, mail, or other methods may be effective and appropriate. Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal

communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

The survey should include the following questions to support calculation of this metric:

Q1. Before you started using [Project Name], about how much did you spend on gas per month?

- *Response options of Less than $5; $6 to $10; $11 to $20; $21 to $40; $41 to $60; $61 to $80; More than $80; Unsure/Prefer not to respond*

Q2. About how much do you spend on gas per month now?

- *Response options of Less than $5; $6 to $10; $11 to $20; $21 to $40; $41 to $60; $61 to $80; More than $80; Unsure/Prefer not to respond*

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines.

Analysis

Once the above data are collected, outcome reporting metrics would be calculated as follows:

Comparison of Pre-Service and Post-Service Gas Expenses

1. For each respondent, the respondent's response to Q1 should be compared to the respondent's response to Q2.
2. For each survey response where the respondent indicates a higher dollar value range in response to Q1 than they indicate in response to Q2, the survey response should be flagged as a **User Decreasing Gas Expenses**.
3. For each survey response where the respondent indicates a lower dollar value range in response to Q1 than they indicate in response to Q2, the survey response should be flagged as a **User Increasing Gas Expenses**.
4. For each survey response where the respondent indicates the same dollar value range in response to Q1 that they indicate in response to Q2, the survey response should be flagged as a **User Unchanged Gas Expenses**.
5. For each survey response where the respondent did not indicate a dollar value range or indicated a dollar value range in response to either Q1 or Q2 but not both Q1 and Q2, the survey response should be flagged as a **User Unknown Gas Expenses**.

Percentage of Users Reducing Gas Expenses

1. Sum all instances of **User Decreasing Gas Expenses, User Increasing Gas Expenses**, **User Unchanged Gas Expenses**, and **User Unknown Gas Expenses** to obtain the **Total Sample Users**.
2. Divide the total number of **Users Decreasing Gas Expenses** by the **Total Sample Users** to obtain the **Percentage of Users Reducing Gas Expenses:**

$$Percentage\ of\ Users\ Reducing\ Gas\ Expenses = \frac{Total\ Users\ Decreasing\ Gas\ Expenses}{Total\ Sample\ Users}$$

The **Percentage of Users Reducing Gas Expenses** represents the percentage of shared mobility service users that spent more on gasoline per month prior to using the shared mobility service than they do currently, after joining the shared mobility service.

Reporting

Once grantees or administering agencies have performed the above steps, the project outcome reporting template should be populated with the following metrics:

- Percentage of Users Reducing Gas Expenses; and
- Total Sample Users.

An example of these metrics as they would appear in the project outcome reporting template is as follows (with other existing project outcome metrics included and italicized):

Quantity of Trips (entire project)	*Quantity of Riders (entire project)*	*Quantity of Vehicle Miles Traveled (entire project)*	Percentage of Users Reducing Gas Expenses (surveyed)	Total Sample Trips (surveyed)
850	1,450	9,200	75%	280

In addition to the metrics provided within outcome templates, CARB may request survey instruments or raw survey data for the purposes of validating data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

B.1.14 Description and Method: Primary commuting and non-commuting modes

Description

This metric is applicable to programs that fund affordable housing and housing-related infrastructure. This currently includes the Affordable Housing and Sustainable Communities Program (AHSC). AHSC includes projects that fund housing developments which are designed to provide affordable housing and result in other benefits such as improved air quality, affordable transportation options, and improved access to jobs and community amenities.[142] These projects are designed to achieve GHG emission reductions through increased use of transit and low-carbon transportation alternatives (such as active transportation) and reduced vehicle miles traveled (VMT).

Mode share refers to the percentage of travelers using a particular type of transportation (e.g. public transportation, private vehicle, walking). Collecting data for primary modes used by AHSC residents as part of project outcome reporting provides information regarding expected versus actual transportation behaviors and may be used to inform project estimates of GHG emission reductions.

Method

The data source for determining primary commuting and non-commuting modes under AHSC is self-report surveying administered to residential occupants of AHSC housing sites. For projects in which

[142] "Strategic Growth Council: AHSC Vision," Accessed June 21, 2021. http://sgc.ca.gov/programs/ahsc/vision/.

residential occupant contact information is available and residents have previously agreed to be contacted as part of follow-up data collection, surveys should be administered according to the type of contact information available (e.g. email, telephone, text message). For multi-family sites where residential occupant contact information is not available, administering agencies or grantees should contact property owners or managers to seek their assistance in administering surveys. For example, property owners may be willing to post a link to an online survey in multi-family common areas, or distribute postcards containing survey links or questions to residential units within their buildings.

Offering incentives such as gift cards or transportation vouchers for survey completion may significantly improve response rates.

Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

Survey Design

In addition to questions that allow for the calculation of primary commuting and non-commuting modes, the survey should include any questions needed to capture other existing project outcome metrics (e.g. *Residents Using Transit Passes).* Administering agencies may opt to include additional questions in the survey to capture information related to resident demographics, various other travel behaviors, home comfort and convenience, etc. but these should be treated as secondary objectives to any items relevant to project outcome data.

The specific design of surveys may depend on the mode of survey administration (e.g. the use of screening questions in telephone surveys, the ability to add survey routing logic to online surveys), but examples of core questions to be included for capturing the required project outcome metrics are as follows:

Q1. Do you or any other adults in your household regularly travel to and from work?

- *Responses of Yes; No*

Q2. (If Yes to Q1) What forms of transportation do members of your household primarily use to travel to and from work? If you primarily use more than one form of transportation, please indicate the form of transportation that you use most often or that you use for the greatest distance when traveling to and from work.

- *Responses including Driving a personally owned or leased car alone; Driving a vehicle that is part of a carsharing program; Carpooling in a private vehicle; Taking a bus or shuttle; Taking a train, light rail, or trolley; Taking a taxi, Uber, Lyft, or similar service; Walking; Using a bike or scooter; Other [with explanation]. [Add options as needed to include AHSC project-specific modes such as vanpooling]*[143]

Q3. Which of the following transportation mode(s) do members of your household primarily use during a typical week for non-work purposes such as social activities, appointments, errands, and other trips? If you primarily use more than one form of transportation, please indicate the form of transportation that you use most often or that you use for the greatest distance when taking these other trips.

[143] AHSC project-specific transportation options would be any transportation alternatives created by the project or for which the AHSC project had specific VMT reduction objectives.

- *Responses consisting of transportation modes from Q2*

*Q4. C*an you please indicate whether you and members of your household now uses any of the following transportation modes more or less than you and members of your household did one year ago?

- *Response matrix consisting of modes from Q2 with options of Use much more often; Use more often; Use about the same; Use less often; Use much less often [With explanation of reason for this change]*

Q5. Including yourself, how many people live in your household?

- *Responses from 0 through 6 or more*

Q6. (If property has been open and occupied by residents for more than one year) How long have you lived at [Property Name]?

- *Responses including Less than one year; 1-2 years; 3-4 years; 5 or more years*

The responses to these questions capture 1) Ownership or access to cars, 2) Use of transportation modes for commuting purposes, 3) Use of transportation modes for non-commuting purposes, and 4) Increase or decrease in use of transportation modes.

For the first project outcome reporting period after a project becomes operational, affordable housing project surveys would ideally be administered to residents approximately six months after moving into the housing location in order to capture changes in transportation modes for the pre-AHSC and post-AHSC time periods. As noted above, properties which have been open and occupied by residents for more than one year should include a question asking how long the respondent has lived at the address in order to establish whether changes in transportation mode choice are occurring without a change in housing.

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines. Due to potential challenges in obtaining responses from residents, it may be necessary to oversample (such as making the survey available to a census of residents in a development) rather than targeting a subset of the site population.

Reporting

Upon collecting all survey responses, grantees or administering agencies would report the following metrics (with commuting and non-commuting transportation mode choice reported separately) for each affordable housing site that received a survey as part of project outcome data collection:

- Percentage of households with access to one or more owned, leased, or borrowed cars
- Percentage of households that primarily use a personal or private car for commuting and non-commuting purposes
- Percentage of households that primarily drive a vehicle that is part of a carsharing program for commuting and non-commuting purposes
- Percentage of households that primarily use ride-hailing for commuting and non-commuting purposes
- Percentage of households that primarily use transit for commuting and non-commuting purposes

- Percentage of households that primarily use an active transportation mode for commuting and non-commuting purposes
- (If applicable) Percentage of households that primarily use a transportation mode that is part of an AHSC project-specific objective for commuting and non-commuting purposes; and
- Total number of survey respondents.

Information regarding the calculation of the above metrics from survey responses can be found in the *Supplementary Calculations: Primary commuting and non-commuting modes* section below. Incomplete or inconsistent survey responses should typically be excluded from the calculation of project outcome metrics. In addition to the metrics provided within outcome templates, CARB may request raw survey data or survey instruments for the purposes of validating grantee data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

Supplementary Calculations: Primary commuting and non-commuting modes

This section provides the calculations to be used for obtaining project outcome metrics from survey results conducted for the Affordable Housing and Sustainable Communities Program (AHSC). Calculations reference the numbered survey questions as identified in the method section above.

Percentage of households that primarily use a personal or private car for commuting purposes

$$Car_{commuting}\ \% = \frac{N_{Q2\_drivealone} + N_{Q2\_carpool}}{N_{Q2\_all}}$$

Where,

$Car_{commuting}\ \%$ = Percentage of households that primarily use a car for commuting purposes

$N_{Q2\_drivealone}$ = Number of survey responses indicating "driving a personally owned or leased car alone" as Q2 response

$N_{Q2\_carpool}$ = Number of survey responses indicating "carpooling in a private vehicle" as Q2 response

N_{Q2_all} = Total number of survey responses to Q2 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use a personal or private car for non-commuting purposes

$$Car_{non-commuting}\ \% = \frac{N_{Q3\_drivealone} + N_{Q3\_carpool}}{N_{Q3\_all}}$$

Where,

$Car_{non\text{-}commuting}\ \%$ = Percentage of households that primarily use a car for non-commuting purposes

$N_{Q3\_drivealone}$ = Number of survey responses indicating "driving a personally owned or leased car alone" as Q3 response

$N_{Q3\_carpool}$ = Number of survey responses indicating "carpooling in a private vehicle" as Q3 response

N_{Q3_all} = Total number of survey responses to Q3 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily drive a car that is part of a carsharing program for commuting purposes

$$Carshare_{commuting}\ \% = \frac{N_{Q2\_carshare}}{N_{Q2\_all}}$$

Where,

$Carshare_{commuting}\ \%$ = Percentage of households that primarily drive a car that is part of a carsharing program for commuting purposes

$N_{Q2\_carshare}$ = Number of survey responses indicating "driving a car that is part of a carsharing program" as Q2 response

N_{Q2_all} = Total number of survey responses to Q2 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily drive a car that is part of a carsharing program for non-commuting purposes

$$Carshare_{non-commuting}\ \% = \frac{N_{Q3\_carshare}}{N_{Q3\_all}}$$

Where,

$Carshare_{non\text{-}commuting}\ \%$ = Percentage of households that primarily drive a car that is part of a carsharing program for non-commuting purposes

$N_{Q3\_carshare}$ = Number of survey responses indicating "driving a car that is part of a carsharing program" as Q3 response

N_{Q3_all} = Total number of survey responses to Q3 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use a ride-hailing service for commuting purposes

$$Ridehailing_{commuting}\ \% = \frac{N_{Q2\_ridehailing}}{N_{Q2\_all}}$$

Where,

$Ride\text{-}hailing_{commuting}\ \%$ = Percentage of households that primarily use a ride-hailing service for commuting purposes

$N_{Q2\_ride\text{-}hailing}$ = Number of survey responses indicating "Taking a taxi, Uber, Lyft, or similar service" as Q2 response

N_{Q2_all} = Total number of survey responses to Q2 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use a ride-hailing service for non-commuting purposes

$$Ridehailing_{non-commuting}\ \% = \frac{N_{Q3\_ridehailing}}{N_{Q3\_all}}$$

Where,

$Ride\text{-}hailing_{non\text{-}commuting}\ \%$ = Percentage of households that primarily use a ride-hailing service for non-commuting purposes

$N_{Q3\_ride\text{-}hailing}$ = Number of survey responses indicating "Taking a taxi, Uber, Lyft, or similar service" as Q3 response

N_{Q3_all} = Total number of survey responses to Q3 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use transit for commuting purposes

$$Transit_{commuting}\ \% = \frac{N_{Q2\_bus\_shuttle} + N_{Q2\_train\_lightrail\_trolley}}{N_{Q2\_all}}$$

Where,

$Transit_{commuting}\ \%$ = Percentage of households that primarily use transit for commuting purposes

$N_{Q2\_bus\_shuttle}$ = Number of survey responses indicating "bus or shuttle" as Q2 response

$N_{Q2\_train\_lightrail\_trolley}$ = Number of survey responses indicating "train, light rail, or trolley" as Q2 response

N_{Q2_all} = Total number of survey responses to Q2 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use transit for non-commuting purposes

$$Transit_{non-commuting}\ \% = \frac{N_{Q3\_bus\_shuttle} + N_{Q3\_train\_lightrail\_trolley}}{N_{Q3\_all}}$$

Where,

$Transit_{non\text{-}commuting}\ \%$ = Percentage of households that primarily use transit for non- commuting purposes

$N_{Q3\_bus\_shuttle}$ = Number of survey responses indicating "bus or shuttle" as Q3 response

$N_{Q3\_train\_lightrail\_trolley}$ = Number of survey responses indicating "train, light rail, or trolley" as Q3 response

N_{Q3_all} = Total number of survey responses to Q3 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use active transportation for commuting purposes

$$Active_{commuting}\ \% = \frac{N_{Q2\_walking} + N_{Q2\_bike\_scooter}}{N_{Q2\_all}}$$

Where,

$Active_{commuting}\ \%$ = Percentage of households that primarily use active transportation for commuting purposes

$N_{Q2\_walking}$ = Number of survey responses indicating "walking" as Q2 response

$N_{Q2\_bike\_scooter}$ = Number of survey responses indicating "using a bike or scooter" as Q2 response

N_{Q2_all} = Total number of survey responses to Q2 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use active transportation for non-commuting purposes

$$Active_{non-commuting}\ \% = \frac{N_{Q3\_walking} + N_{Q3\_bike\_scooter}}{N_{Q3\_all}}$$

Where,

$Active_{non\text{-}commuting}\ \%$ = Percentage of households that primarily use active transportation for non-commuting purposes

$N_{Q3\_walking}$ = Number of survey responses indicating "walking" as Q3 response

$N_{Q3\_bike\_scooter}$ = Number of survey responses indicating "using a bike or scooter" as Q3 response

N_{Q3_all} = Total number of survey responses to Q3 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use a transportation mode that is part of an AHSC project-specific objective for commuting purposes (if applicable)

$$AHSC_{commuting}\ \% = \frac{N_{Q2\_AHSC}}{N_{Q2\_all}}$$

Where,

$AHSC_{commuting}\ \%$ = Percentage of households that primarily use an AHSC project-specific mode for commuting purposes

N_{Q2_AHSC} = Number of survey responses indicating the listed AHSC mode as Q2 response

N_{Q2_all} = Total number of survey responses to Q2 (excluding "Unsure/Prefer not to respond" responses)

Percentage of households that primarily use a transportation mode that is part of an AHSC project-specific objective for non-commuting purposes (if applicable)

$$AHSC_{non-commuting}\ \% = \frac{N_{Q3\_AHSC}}{N_{Q3\_all}}$$

Where,

$AHSC_{non\text{-}commuting}\ \%$ = Percentage of households that primarily use an AHSC project-specific mode for non-commuting purposes

N_{Q3_AHSC} = Number of survey responses indicating the listed AHSC mode as Q3 response

N_{Q3_all} = Total number of survey responses to Q3 (excluding "Unsure/Prefer not to respond" responses)

B.1.15 Description and Method: Percentage of households with access to one or more owned, leased, or regularly borrowed cars (not including carsharing programs)

Description

This metric is applicable to programs that fund affordable housing and housing-related infrastructure. This currently includes the Affordable Housing and Sustainable Communities Program (AHSC). AHSC includes projects that fund housing developments which are designed to provide affordable housing and result in other benefits such as improved air quality, affordable transportation options, and improved access to jobs and community amenities.[144] These projects are designed to achieve GHG emission reductions through increased use of transit and low-carbon transportation alternatives (such as active transportation) and reduced vehicle miles traveled (VMT).

Collecting information on resident vehicle access provides additional context to information collected on resident mode share and reliable access to transportation. Households without access to personal vehicles likely need to rely on the alternative transportation modes that are prioritized by AHSC including transit and active transportation, while households with access to personal vehicles may shift their choice in modes due to increased access to these transportation alternatives.

Method

The data source for this metric is self-report surveying administered to residential occupants of AHSC housing sites. For projects in which residential occupant contact information is available and residents have previously agreed to be contacted as part of follow-up data collection, surveys should be administered according to the type of contact information available (e.g. email, telephone, text message). For multi-family sites where residential occupant contact information is not available, administering agencies or grantees should contact property owners or managers to seek their assistance in administering surveys. For example, property owners may be willing to post a link to an online survey in multi-family common areas, or distribute postcards containing survey links or questions to residential units within their buildings.

Offering incentives such as gift cards or transportation vouchers for survey completion may significantly improve response rates.

Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

Survey Design

In addition to questions that allow for the calculation of the percentage of households with access to one or more owned, leased, or regularly borrowed cars, the survey should include any questions needed to capture other existing project outcome metrics (e.g. *Residents Using Transit Passes).* Administering agencies may opt to include additional questions in the survey to capture information related to resident demographics, various other travel behaviors, home comfort and convenience, etc. but these should be treated as secondary objectives to any items relevant to project outcome data.

[144] "Strategic Growth Council: AHSC Vision," Accessed June 21, 2021. http://sgc.ca.gov/programs/ahsc/vision/.

The specific design of surveys may depend on the mode of survey administration (e.g. the use of screening questions in telephone surveys, the ability to add survey routing logic to online surveys), but the core question to be included for capturing this metric is as follows:

> *Q1.* How many cars are available (owned, leased, or can be borrowed on a regular basis) for your household to drive, not including those available through carsharing programs?
>
> - *Responses from 0 through 6 or more*

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines. Due to potential challenges in obtaining responses from residents, it may be necessary to oversample (such as making the survey available to a census of residents in a development) rather than targeting a subset of the site population.

Analysis

Upon collecting the above information, this metric would be calculated as follows:

$$Access\ \% = \frac{N_{Q1\_1}}{N_{Q1\_1} + N_{Q1\_0}}$$

Where,

Access %	=	Percentage of households with access to one or more owned, leased, or regularly borrowed cars
N_{Q1_1}	=	Number of survey responses indicating access to 1 or more cars as Q1 response
N_{Q1_0}	=	Number of survey responses indicating access to 0 cars as Q1 response

Reporting

Upon collecting all survey responses, grantees or administering agencies would report the percentage of households with access to one or more owned, leased, or regularly borrowed cars for each affordable housing site that received a survey as part of project outcome data collection.

The total number of survey respondents should also be reported within the outcome reporting template.

In addition to this information, CARB may request raw survey data or survey instruments for the purposes of validating grantee data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

B.1.16 Description and Method: Percentage of households with reliable access to transportation

Description

This metric is applicable to programs that fund affordable housing and housing-related infrastructure. This currently includes the Affordable Housing and Sustainable Communities Program (AHSC). AHSC includes projects that fund housing developments which are designed to provide affordable housing and result in other benefits such as improved air quality, affordable transportation options, and improved access to jobs and community amenities.[145] These projects are designed to achieve GHG emission reductions through increased use of transit and low-carbon transportation alternatives (such as active transportation) and reduced vehicle miles traveled (VMT).

Collecting information about the reliability of resident transportation is intended as a general representation of transportation access that could be compared across AHSC sites.

Method

The data source for this metric is self-report surveying administered to residential occupants of AHSC housing sites. For projects in which residential occupant contact information is available and residents have previously agreed to be contacted as part of follow-up data collection, surveys should be administered according to the type of contact information available (e.g. email, telephone, text message). For multi-family sites where residential occupant contact information is not available, administering agencies or grantees should contact property owners or managers to seek their assistance in administering surveys. For example, property owners may be willing to post a link to an online survey in multi-family common areas, or distribute postcards containing survey links or questions to residential units within their buildings.

Offering incentives such as gift cards or transportation vouchers for survey completion may significantly improve response rates.

Surveys should be administered in compliance with all local, state, and federal laws regarding telephone, electronic, and postal communications and in alignment with state agency requirements and guidelines from any applicable oversight organization such as an institutional review board.

Survey Design

In addition to questions that allow for the calculation of this metric, the survey should include any questions needed to capture other existing project outcome metrics (e.g. *Residents Using Transit Passes).* Administering agencies may opt to include additional questions in the survey to capture information related to resident demographics, various other travel behaviors, home comfort and convenience, etc. but these should be treated as secondary objectives to any items relevant to project outcome data.

The specific design of surveys may depend on the mode of survey administration (e.g. the use of screening questions in telephone surveys, the ability to add survey routing logic to online surveys), but the core question to be included to capture this outcome metric is as follows:

[145] "Strategic Growth Council: AHSC Vision," Accessed June 21, 2021. http://sgc.ca.gov/programs/ahsc/vision/.

Q1. Thinking about the transportation available to you, how often are you and the members of your household able to travel to where you need to go (such as traveling to and from work, doing errands, traveling to other activities, etc.)?

- *Response options of Always; Usually; Sometimes; Rarely; Never; Unsure/Prefer not to respond*

If possible, surveys should be administered to obtain a sample that meets a target 95% confidence and 10% precision level for the project based on the total resident population, or other confidence and precision target as specified by CARB or program guidelines. Due to potential challenges in obtaining responses from residents, it may be necessary to oversample (such as making the survey available to a census of residents in a development) rather than targeting a subset of the site population.

Analysis

Once the above data are collected, this metric would be calculated as follows:

Reliable and Non-reliable Access to Transportation

1. For each survey response where the respondent indicates a response of "Always" or "Usually", the survey response should be flagged as **Reliable Access to Transportation**.
2. For each survey response where the respondent indicates a response of "Sometimes", "Rarely", or "Never", the survey response should be flagged as **Non-reliable Access to Transportation**.

Percentage of Resident Households with Reliable Access to Transportation

1. Sum all instances of **Reliable Access to Transportation** and **Non-reliable Access to Transportation** to obtain the **Total Sample**.
2. Divide the total number of instances of **Reliable Access to Transportation** by the **Total Sample** to obtain the **Percentage of Resident Households with Reliable Access to Transportation:**

$$Percentage\ of\ Resident\ Households\ with\ Reliable\ Access\ to\ Transportation = \frac{Total\ Reliable\ Access\ to\ Transportation}{Total\ Sample}$$

The **Percentage of Resident Households with Reliable Access to Transportation** result is the value that should be reported for this outcome metric.

Reporting

Upon collecting all survey responses, grantees or administering agencies would report the percentage of households with reliable access to transportation for each affordable housing site that received a survey as part of project outcome data collection.

The total number of survey respondents should also be reported within the outcome reporting template.

In addition to this information, CARB may request raw survey data or survey instruments for the purposes of validating grantee data collection and reporting methodologies. Any survey response data provided to CARB should be anonymized and stored in a standardized spreadsheet format to allow for analysis.

B.1.17 Description and Method: Average passenger trip length

Description

This metric is applicable to programs which fund transit capital improvements or expanded/upgraded transit service projects. This currently includes:

- Low Carbon Transit Operations Program (LCTOP);
- Transit and Intercity Rail Capital Program (TIRCP); and
- Affordable Housing and Sustainable Communities (AHSC) Program.

These programs fund the purchase, development, and operation of transit vehicles and services and are in part designed to achieve GHG reductions through reduced vehicle miles traveled (VMT).

Average passenger trip length as it appears in California Climate Investments QM refers to total passenger miles traveled (PMT) divided by total unlinked passenger trips (UPT). Unlinked passenger trips represents the sum of all individual boardings of a transit vehicle, while passenger miles traveled represent the total distance of all passenger trips.

For existing, new, or expanded service project types under LCTOP, TIRCP, and AHSC, average passenger trip length (L) is multiplied by the increase in annual trips (or increased daily ridership and days of operation), and an adjustment factor (A) accounting for transit dependency, to compute annual auto VMT reduced.[146] In order to prospectively estimate VMT reductions from proposed projects, the QM guidelines allow agencies to input average passenger trip lengths from National Transit Database (NTD) values for similar service.

As per FTA reporting requirements, transit agencies that receive federal funding are responsible for collecting and reporting a detailed set of financial, service, safety, and asset inventory data for inclusion in the NTD. The specific level of detail and types of data reported vary based on the NTD-assigned Reporter Type, which is dependent on agency funding sources, size, and types of transportation provided.[147] Service data are reported on an annual or monthly basis, depending on reporter type. Agencies classified as Full Reporters are required to report both UPT and PMT data in their annual reporting.

Including average passenger trip length based on UPT and PMT as part of project outcome metrics allows for updated estimates of displaced passenger VMT that are based on actual project data and can be compared to stipulated averages.

Method

The data sources for average passenger trip length are service records maintained by transit agencies operating funded transit services.

This method assumes that capital improvements and expanded or upgraded service projects are associated with transit agencies which must meet Federal Transit Administration (FTA) reporting

[146] For example, see Equation 4 in the Low Carbon Transit Operations Program Quantification Methodology: https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/caltrans_lctop_finalqm_18-19.pdf

[147] Data collection and reporting guidelines are contained in the National Transit Database 2019 Policy Manual: https://www.transit.dot.gov/sites/fta.dot.gov/files/filefield_paths/2019-NTD-Reporting-Policy-Manual-v1-1_1.pdf

requirements for PMT and UPT, and that the funded projects are not classified as exempt from this reporting process. This method is intended to use a subset of the UPT and PMT data that are regularly reported to FTA in order to calculate average passenger trip length (L) for individual California Climate Investments projects. However, all agencies that are associated with projects receiving California Climate Investments funding and that are able to collect UPT and PMT data should provide this information for the purposes of outcome reporting if possible.

In order to report average passenger trip length, administering agencies should request UPT and PMT data from the transit agency associated with the funded California Climate Investments project. The requested UPT and PMT data should be specific to the current project outcome reporting period, or if necessary, the most recent fiscal year.

The intention of this metric is to obtain trip length data that are specific to the funded component of transit service systems (e.g. funded vehicles, expanded service lines, new services). Administering agencies should request UPT and PMT data that are specific to the California Climate Investments project, if available. If a transit agency indicates that it is unable to provide data specific to the vehicles or services associated with California Climate Investments funding, the data should be disaggregated to the extent possible in order to most closely reflect the operations of the California Climate Investments-funded components. For example, service data collected for a single route that includes California Climate Investments-funded vehicles and existing similar vehicles could be used to calculate average passenger trip length for the California Climate Investments project.

Generally, any UPT or PMT data provided for the purposes of outcome reporting should be collected according to FTA manual guidelines. This method assumes that transit agencies are familiar with these guidelines, but identifies certain considerations for administering agencies who would request these data:

- Operational data may be collected through the use of automatic passenger counters (APC), manual passenger counters, drivers' logs, fareboxes, or any other method that is accepted by FTA for collecting UPT and PMT.
- The FTA manual indicates that agencies should provide UPT and PMT data based on a census (100% count) of vehicle operations if possible, but allows agencies to use a sampling approach if obtaining a census is not feasible. Any average passenger trip length metrics that are based on sampled UPT and PMT and reported as part of project outcomes should follow protocols described in the NTD Sampling Manual.[148] This manual provides guidance related to sample size, sampling methods, and statistical considerations, and provides sampling templates that account for a variety of transit types. Sampling guidance is based on a target 95% confidence and 10% precision level.
- FTA allows for one-year or three-year sampling cycles depending on the type of service. For some services, transit agencies will only update PMT with primary data once every three years, and will estimate PMT during non-mandatory sampling years. As the approved PMT estimation method is based on UPT and the prior year average passenger trip length, it is not necessary for administering agencies to request updated PMT data if the project outcome reporting period

[148] NTD Sampling Manual: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/The_NTD_Sampling_Manual.pdf

coincides with a non-mandatory sampling year for the relevant transit agency. Instead, administering agencies may report the average passenger trip length from the prior year.

The above information assumes that transit agencies have agreed to provide service data to administering agencies as part of project reporting. Any issues related to accessing collected data should be communicated to CARB in advance of project implementation, if possible.

Analysis and Reporting

Upon collecting UPT and PMT for a California Climate Investments project during a given project outcome reporting period, average passenger trip length would be calculated as:

$$L = \frac{PMT}{UPT}$$

Where,

L = Average Passenger Trip Length

PMT = Total Passenger Miles Traveled

UPT = Total Unlinked Passenger Trips

Agencies should then input the average passenger trip length (L) for the California Climate Investments project within the *Average Passenger Trip Length* field of the project outcome reporting template. Agencies should retain any information related to the sampling approach and data collection method as supplementary documentation.

As noted above, average passenger trip length (L) is a key variable in the QM calculation of VMT reductions resulting from transit projects within existing, new, or expanded transit services. This outcome metric may be used to partially validate or revise the prospective VMT reduction estimate that was used during the project planning phase by replacing the default L value within existing QM calculations with the post-project L value that was obtained through the methods described in this document.

B.1.18 Description and Method: Indication of whether the capital improvements/purchased vehicles continue to operate as stated within project closeout documentation (if not, provide description of change)

Description

This metric is applicable to programs which fund transit capital improvements or expanded/upgraded transit service projects. This currently includes:

- Low Carbon Transit Operations Program (LCTOP);
- Transit and Intercity Rail Capital Program (TIRCP); and
- Affordable Housing and Sustainable Communities (AHSC) Program.

These programs fund the purchase, development, and operation of transit vehicles and services and are in part designed to achieve GHG reductions through reduced vehicle miles traveled (VMT).

Collecting information regarding continued operation of funded capital improvements and services and whether operational characteristics remain consistent with project records provides context for other data that are collected as part of POR and may help to explain observed differences between expected and actual passenger trip length, ridership, and VMT. Additionally, indications of whether funded vehicles or services continue to operate in the same geographic area could be used to determine whether the project continues to serve the same level of disadvantaged or low-income community and validate the expected priority population benefits that were estimated for the project, if applicable.

Method

Data for this metric would be collected through interviews or other correspondence with grantee transit agencies. Administering agencies should contact grantees during the outcome period to obtain the following information:

Q1. Whether or not the funded vehicles, equipment, or expanded services are still in operation *[Yes/No]*;

Q2. Whether or not the funded vehicles, equipment, or expanded services are still serving the same routes or geographical areas noted within project documentation *[Yes/No]*;

Q3. If no to either Q1 or Q2, a description of the change in service or operation of funded vehicles, equipment, or services including information regarding new or modified service areas (e.g. shifting funded vehicles to new routes, expanding service routes to a new location, removing vehicles from service due to malfunctions or lack of service demand) *[Qualitative Description].*

Reporting

Agencies would then input the results of this data collection into the project outcome reporting template. If the grantee agency contact answered "Yes" to both Q1 and Q2 above, the content provided for the outcome reporting field can be limited to "Yes". If grantee agency contact provided information regarding funded activities or equipment that are no longer operating as planned or have experienced modifications due to service needs, issues, or changing operational strategies, the reporting field should include a description of the change with any available information regarding new geographic locations of service, quantities or scope of vehicles or services no longer in operation, and any other relevant details that may assist in the interpretation of other operational metrics collected through POR (e.g. trip length, ridership, etc.).

B.1.19 Description and Method: Indication of Low Carbon Fuel Standard (LCFS) Carbon Intensity Score

Description

This metric is applicable to programs that support the development and production of low-carbon fuels. This currently includes the Low Carbon Fuel Production Program (LCFPP).

The Low Carbon Fuel Standard (LCFS) was established under AB 32 to provide a framework for decreasing the carbon intensity of transportation fuels and facilitate the development of low-carbon and renewable alternative fuels. Providers of petroleum fuels are required to demonstrate compliance with LCFS carbon intensity reduction requirements on an annual basis, by reducing emissions from their production process,

blending in low-carbon alternative fuels, or buying credits from low-carbon fuel producers.[149] Fuel producers are able to apply for Fuel Pathways under LCFS, and if approved, receive certification and designated Carbon Intensity (CI) scores for the registered fuel.[150] CARB currently provides a list of all Current Certified Pathways and their associated CI scores.[151]

The LCFPP Program currently requires that funding recipients calculate CI scores for their fuels using methods that align with LCFS guidelines.[152] As LCFPP applicants may also apply for LCFS Fuel Pathways, reporting whether LCFS certification has been obtained serves as a validation of LCFPP estimates and tracks the progress of LCFPP fuels under the industry-wide LCFS framework.

Method

This metric does not apply to LCFPP funding recipients who have not applied for an LCFS Certified Pathway. LCFPP grantees who are not planning to apply for an LCFS pathway should communicate this decision to administering agencies prior to the project outcomes phase (as part of the project implementation or closeout phases).

For LCFPP funding recipients who have applied for a Tier 1 or Tier 2 LCFS Certified Pathway, the data source for this metric would be documentation issued by LCFS indicating a provisional or final CI score (grams of carbon dioxide equivalent per megajoule of fuel energy, or gCO_2e/MJ) and if applicable, a Fuel Pathway Code for the supported fuel.

In the outcome reporting template, funding recipients or administering agencies would indicate whether a provisional or final LCFS pathway has been obtained, as follows:

Field	Input Options (List)
LCFS Pathway	None
	Provisional
	Final

If "Provisional" or "Final" are selected in this field, users would then add the associated CI score that has been issued by LCFS in the CI Score field, and the fuel pathway code issued by LCFS to the Fuel Pathway Code Field.

An example of this as it would appear in the project outcome reporting template is as follows:

[149] "Low Carbon Fuel Standard (CARB)," Accessed June 21, 2021. https://ww3.arb.ca.gov/fuels/lcfs/lcfs.htm.

[150] Fuel Pathway Application Process (CARB): https://ww3.arb.ca.gov/fuels/lcfs/fuelpathways/pathwayapplicationprocess.htm

[151] LCFS Pathway Certified Carbon Intensities (CARB): https://ww3.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm

[152] Low Carbon Fuel Production Program Guidelines (California Energy Commission): https://efiling.energy.ca.gov/getdocument.aspx?tn=228996

Primary Fuel Type	LCFS Pathway	CI Score (gCO2e/MJ)	Fuel Pathway Code
Biodiesel	Provisional	37.94	BDC2071
Ethanol	Final	64.89	ETH272R
Renewable Diesel	Final	20.28	RDU2021
Liquid Hydrogen	None		

If there has been no change to the LCFS certification status, CI score, or fuel pathway code for a given outcome reporting period, users would input the same information as was included during the prior period.

B.1.20 Description and Method: Non-fuel coproducts generated

Description

This metric is applicable to programs that support the development and production of low-carbon fuels. This currently includes the Low Carbon Fuel Production Program (LCFPP).

In the context of low carbon fuel production, non-fuel coproducts refer to value-adding materials other than fuels that are generated through the fuel production process. Examples of these types of coproducts include feedstock (distiller's grains, soy meal), glycerin, corn oil, biochar, and other bio products.[153] These products have a variety of uses and can be commercialized by fuel production facilities, thereby adding value to the fuel production process. In addition to tracking the fuels produced by LCFPP-supported facilities, capturing the generated coproducts provides a more comprehensive understanding of project outcomes.

Method

Similar to capturing the existing LCFPP project outcome metric for quantity of surplus fuel produced, the data source for collecting non-fuel coproducts would be sale receipts or operational logs from the fuel production facility. Funding recipients must agree in advance to provide these records as part of the project outcome reporting process.

Administering agencies or funding recipients would collect these production facility documents for the relevant outcome reporting period (e.g. January 1st through December 31st) and identify the type and quantity of any applicable non-fuel coproducts that have been generated and tracked during the fuel production process.

The non-fuel coproducts reported for this metric should be limited to those coproducts that are directly associated with the production of the LCFPP supported fuel. If a production facility produces non-fuel coproducts through processes that are unrelated to LCFPP fuel generation, those coproducts should not be reported as part of project outcomes.

[153] Grant S. Forman and Stefan Unnash, "Integration of Non-Fuel Coproducts into the GREET Model | Environmental Science & Technology," *Environmental Science and Technology* 49, no. 7 (October 2015), https://pubs.acs.org/doi/10.1021/es505994w.

The quantity of coproducts to report should be based on the coproducts generated during the period, and not on the quantity of coproducts sold. If the data source for this metric is sale receipts, users should only input sales for coproducts that were generated during the reporting period. This is to prevent double counting of coproducts and to align coproduct production quantities with fuel production quantities.

Users would then input the type, quantity, and unit of coproducts into the outcome reporting template, using a separate field for each coproduct. Coproducts should be reported in units of gallons or kilograms per year, as appropriate.

An example of this as it would appear in the project outcome reporting template is as follows:

Non-fuel Coproduct 1 Description	Quantity of Non-fuel Coproduct 1 Produced	Non-Fuel Coproduct 1 Units (Gallons or kg/year)	Non-fuel Coproduct 2 Description	Quantity of Non-fuel Coproduct 2 Produced	Non-Fuel Coproduct 2 Units (Gallons or kg/year)	Non-fuel Coproduct 3 Description	Quantity of Non-fuel Coproduct 3 Produced	Non-Fuel Coproduct 3 Units (Gallons or kg/year)
Corn oil	1000	Gallons	Feedstock	2000	kg	Biochar	10000	kg

If the facility produces additional nonfuel co-products and there are not enough fields within the project outcome reporting template, agencies may select and report the major nonfuel co-products and provide the remaining coproduct quantities in the form of supporting documentation. If no non-fuel coproducts have been generated for a project in a given outcome reporting period, these fields may be left blank.

B.1.21 Description and Method: Soil organic matter

Description

This metric applies to programs that claim GHG reductions resulting from improved soil management practices. This currently includes the Healthy Soils Program (HSP).

HSP directly incentivizes a wide range of soil management improvements and prospectively calculates GHG reductions resulting from increased carbon sequestration as part of its QM. Measurements of the concentration of soil organic matter indicate the degree to which organic material and carbon are being sequestered in the soil, and tracking these measurements over time provide insight into the long-term effects of implemented soil management practices and assist in validating GHG reduction benefits.

Method

The data source for collecting soil organic matter is a laboratory analysis of soil samples. CDFA currently incorporates laboratory analysis of soil samples into the verification process in order to measure soil organic matter for HSP projects.

As CDFA has processes in place for collecting this metric, this method provides guidance in general terms and refers to existing CDFA protocols (which are based on NRCS guidelines). The purpose of developing a description and methods document for soil organic matter is to add this metric to the California Climate Investments project outcome reporting phase for HSP so that the data that are being collected for these projects can be reported to CARB.

Soil sampling should be conducted in accordance with best practices such as defined by the National Resources Conservation Service (NRCS) or as provided by CDFA within Healthy Soils Program materials.[154] These resources provide information regarding the protocols and considerations for proper soil sampling, including:

- Required materials;
- Timing of soil sampling;
- Sampling location;
- Instructions for taking samples; and
- Instructions for submitting samples for laboratory analysis.

Generally, samples should be taken from representative areas of the project location and should be taken at approximately the same time of year under similar soil moisture conditions. In order to provide a representative composite sample to the selected laboratory, grantees should sample from at least 10 sites (15-20 sample cores is preferred) and mix the cores thoroughly.[155]

Soil samples should be submitted to a soil analytical laboratory that is approved for use by CDFA. Once a grantee receives laboratory analysis results for soil organic matter, metrics for organic matter concentration should be added to the project outcome reporting template along with the other HSP outcome metrics.

An example of minimum data for soil organic matter as it would appear in the project outcome reporting template is as follows (existing project outcome metrics are included and italicized):

Land in Project (acres) *[Healthy Soils]*	***High C:N Ratio (Y/N)*** *[Healthy Soils]*	**Soil organic matter concentration**
200	N	2.16%

If the laboratory analytical report contains metrics for soil carbon or other soil qualities such as pH, presence of key elements (phosphorous, magnesium, potassium, etc.), physical characteristics such as bulk density, or other relevant data, these can be included in the project outcome reporting template as soil health indicators (see the *Soil Health Indicators* methods description).

[154] National Resources Conservation Service, National Soil Survey Center. "Field Book for Describing and Sampling Soils," 2012. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052523.pdf

California Department of Food and Agriculture. "Soil Sampling Protocol for Soil Organic Matter Analysis," https://www.cdfa.ca.gov/oefi/healthysoils/docs/HSP_SoilSampling.pd

[155] USDA Natural Resource Conservation Service. "Soil Sampling," 2002. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022974.pdf

B.1.22 Description and Method: Quantity of replacement trees planted (if applicable based on post-grant agreement with grantee)

Description

This metric applies to programs that involve the planting of trees in urban areas and which may include maintenance agreements that result in the replacement of dead and unhealthy project trees with new trees during the project outcome reporting period. This currently includes:

- Urban Greening Program; and
- Urban and Community Forestry.

These programs include projects that plant trees in urban areas and achieve GHG emission reductions through carbon sequestration, facilitating increased active transportation, and reducing building energy use by strategically planting trees to shade residential and commercial sites.

The quantity of trees to be planted is estimated as part of the project funding agreement, with grantees or project sponsors verifying the total number of trees planted or distributed as part of the project closeout process. In addition to the quantity of trees initially planted, grantees or project sponsors may agree to provide maintenance on the population of planted trees for several years following project completion, which includes the replacement of dead or unhealthy trees with new trees.

This metric is only applicable to projects that include operations and maintenance (O&M) agreements or other arrangements for long-term care and replacement of planted trees during the outcome period.

The quantity of replacement trees planted metric serves to track the number of trees planted throughout the project outcome reporting period. Together with the quantity of initially planted trees, this represents the total number of trees needed to achieve the GHG reductions and other project benefits.

Method

This method assumes that grantees or project sponsors maintain records of individual tree plantings, and that these records are in a standardized format that can be shared with administering agencies.

Data for this metric should be collected from maintenance records created by grantees or project sponsors and provided as reports to administering agencies. The following data should be tracked when planting replacement trees:

- Date of tree replacement;
- Location of tree replacement (address, site ID, or other unique identifier);
- Quantity of new trees planted as replacements;
- Quantity of existing trees replaced; and
- (if possible) Reason for tree replacement (original trees dead, unhealthy, damaged, etc.).

Upon obtaining these tree planting reports for the full duration of a project outcome reporting period, grantees, project sponsors, or administering agencies should use the beginning and end dates of the current project outcome reporting period to identify which instances of tree replacement should be reported in the project outcome reporting template. If a tree at an individual location was replaced

multiple times during the current outcome reporting period, each instance of tree planting should be counted separately.

The total quantity of replacement trees planted during the current outcome reporting period, based on the sum of trees planted during relevant dates from grantee maintenance records, should then be added to the *Quantity of Replacement Trees Planted* field within the project outcome reporting template.

B.1.23 Description and Method: Fuel load

Description

This metric is applicable to programs which fund forestry projects such as pest management, reforestation, and forest fuels reduction to achieve GHG emission reductions through increased carbon sequestration and reduced tree mortality risk. This currently includes:

- Forest Health;
- Regional Forest and Fire Capacity; and
- Fire Prevention Grants.

Fuel load refers to the amount and type of flammable material in an area (e.g. down woody materials or DWM) and can be used to predict the risk, severity, and behavior of a fire. Projects under the above programs typically have direct or indirect impacts on surface and understory fuel loads, both initially as part of the treatment and during the years following the treatment. Including fuel load data collection as part of the project outcome monitoring process provides a quantitative metric of long-term project site changes and can be used to identify sites that need to be re-treated or maintained during the project outcome reporting period. Additionally, tracking fuel load metrics within project sites allows for comparisons to baseline fuel load conditions for the site or comparisons to fuel loads in untreated similar areas over time.

Method

The data source for collecting fuel load is on-site monitoring conducted by grantees, project sponsors, administering agencies, or third-party monitors.

This method assumes that grantees or administering agencies will have access to project sites following the implementation of treatments throughout the duration of the project outcome reporting period. This method also assumes that individuals conducting data collection are familiar with forest monitoring protocols and techniques. Rather than summarizing all relevant protocols and guidelines related to fuel load, this method refers to several manuals and tools which would be considered acceptable resources for collecting this metric and provides additional guidance specific to project outcome reporting procedures.

Prior to project treatment, grantees or administering agencies would ideally collect fuel load data for the project site in order to provide a baseline value for comparison against future data. During project outcome reporting periods, the timing of monitoring should be kept consistent for each year of data collection to account for seasonal differences and to ensure that the fuel load metrics reported across project outcome reporting periods represent a uniform time frame between measurements.

Project outcome metrics are typically reported on an annual or biannual basis. However, due to the resources and time required for extensive on-site monitoring, administering agencies and grantees may agree upon and propose a less frequent schedule for fuel load data collection if all other project outcome metrics for a given reporting period will be collected using methods such as remote sensing.

Collecting fuel load data for project outcome reporting involves estimating tons per acre of down woody material (DWM), including fine woody debris (FWD), coarse woody debris (CWD), and litter and duff depth. Data should be collected using fuels transects randomly implemented across a representative sample of the project area. Monitors should retain records of the geographical location of sampled units and take representative photos of each unit.

Sampling and data collection should be conducted in a manner that is consistent with forest monitoring best practices and results in separate values for each class of CWD and FWD based on diameter (1-hour, 10-hour, 100-hour, and 1000-hour fuels).[156] For example, grantees or administering agencies may use the Forest Inventory & Analysis (FIA) methodologies and definitions provided by the United States Department of Agriculture (USDA) Forest Service.[157] The FIA Program provides field guides for measurement of a wide range of plot characteristics and includes a section for sampling and recording DWM.[158] Grantees or administering agencies may follow the steps and procedures outlined in the FIA Field Guide for establishing fuels transects, sampling CWD and FWD based on specified size categories, and conducting duff and litter depth measurements.

An alternate source for fuel load data collection protocols and analysis is the integrated Fire Ecology Assessment Tool and Fire Effects Monitoring and Inventory System (FEAT/FIREMON Integrated, or FFI), which provides similar step-by-step guidelines and includes accompanying analysis software for the calculation of DWD, duff, and litter biomass for the purposes of reporting tons per acre.[159]

Administering agencies may also use an approach developed as part of an agency-specific forest monitoring manual or set of protocols, pending review and approval by CARB.

Analysis and Reporting

Upon completing data collection for each class of fuel as described above, grantees or administering agencies should calculate tons per acre using an available analytical tool such as FFI, an approved administering agency approach, or manual calculation using formulas for computing tons per acre, as follows:

Tons/acre for 1, 10, 100-hour size class (0-3 inch diameter):

[156] USDA Forest Service. "Wildland Fire Assessment System (Dead Fuel Moisture)," https://www.wfas.net/index.php/dead-fuel-moisture-moisture--drought-38

[157] USDA Forest Service. "Forest Inventory & Analysis," https://www.fia.fs.fed.us/

[158] USDA Forest Service. "Forest Inventory and Analysis National Core Field Guide (Section 10: Down Woody Materials)," https://www.fia.fs.fed.us/library/field-guides-methods-proc/docs/2019/core_ver9-0_10_2019_final.pdf

[159] Fuel Load (FL) Sampling Method: https://www.fs.fed.us/rm/pubs/rmrs_gtr164/rmrs_gtr164_06_fuel_load.pdf;

FFI (FEAT/FIREMON Integrated): https://www.frames.gov/ffi/home

$$Tons\ per\ acre\ = \frac{11.64 \times n \times d^2 \times s \times a \times c}{N_l}$$

Tons/acre for 1000-hour size class (3+ inch diameter):

$$Tons\ per\ acre\ = \frac{11.64 \times \sum d^2 \times s \times a \times c}{N_l}$$

Where,

n	=	count of down woody material
d^2	=	average squared diameter of fuel particle size class
$\sum d^2$	=	the sum of all squared diameters for each 1000-hour piece
s	=	specific gravity per fuel size class
a	=	non-horizontal correction factor
c	=	slope correction factor
N_l	=	length of sampling line

A step-by-step method for determining the above variables is outlined in pages 13-18 of the Handbook for Inventorying Downed Woody Material (Brown, 1974).[160]

Upon calculating the tons per acre of all fuel classifications, the metrics should be added to the project outcome reporting template. An example of fuel load data as it would be reported in the template is as follows:

1-hour fuels (tons/acre)	10-hour fuels (tons/acre)	100-hour fuels (tons/acre)	1000-hour fuels (tons/acre)	Duff depth (inches)	Litter depth (inches)
0.14	0.31	6.20	4.40	3.0	2.0

These values can then be used to estimate a fuel loading model for the project area, compare fuel load metrics to untreated control sites, and track changes to the project site over the course of the outcome reporting period.[161] The above metrics represent the minimum dataset to report for project outcomes related to fuel load, though if additional metrics are collected through the course of monitoring (such as basal area index, tree density, decay class), these data should be retained by the administering agency as supplementary datasets.

Grantees or administering agencies should also retain documentation related to the monitoring process such as field forms, sampling methodologies, and sample unit characteristics. These materials may be

[160] J.K. Brown. "Handbook for Inventorying Downed Woody Material," 1974. https://www.fs.fed.us/rm/pubs_int/int_gtr016.pdf

[161] Fuel Loading Models can be determined using resources such as:

USDA Forest Service. "Field Guide for Identifying Fuel Loading Models". https://www.fs.fed.us/rm/pubs/rmrs_gtr225.pdf;

USDA Forest Service. "Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation". https://www.fs.fed.us/fmsc/ftp/fvs/docs/gtr/FFEguide.pdf

requested as supporting documentation by CARB in order to validate the approach or inform future monitoring guidance.

B.1.24 Description and Method: Qualitative assessment of project impacts on ecological factors

Description

This metric is applicable to programs which fund restoration, reforestation, pest management, or land conservation improvements. This currently includes the following programs:

- Forest Health;
- Regional Forest and Fire Capacity;
- CA State Coastal Conservancy Climate Ready Program;
- Sustainable Agricultural Lands Conservation;
- Climate Adaptation and Resiliency Program.

The projects completed under the above programs include a variety of treatments, strategies, or management plans that achieve GHG reductions or avoid future GHG emissions and result in ecological benefits to the project area or surrounding environments. This includes habitat restoration projects that are designed to improve or stabilize species biodiversity, conservation easements that maintain soil or water quality or have management plans to improve these factors, reforestation projects that may help to control competing or invasive plant life, and other initiatives.

Many of the projects under the above programs list these types of ecological impacts in their California Climate Investments applications or planning materials in the form of a brief description of expected benefits. A qualitative assessment of the extent to which the ecological factors that were cited during the project planning stages have changed during the years following a project allows for validation of expected benefits and may serve to identify emerging issues or trends across outcome reporting periods.

Method

The intention of this metric is to create a mechanism of tracking the status of the ecological benefits that were initially identified and cited during the prospective phases of a project. Thus, this metric is applicable to projects that identify one or more ecological benefits as part of the funding application or planning process, as determined by grantees or administering agencies. Ecological benefits that are commonly identified for these project types include:

- Water: increased availability, improved water composition (factors affecting turbidity/odor/pollutants)
- Soil health: factors affecting water-holding capacity, bulk density, chemical/nutrient composition
- Erosion: reduced likelihood or effects of erosion (such as through improved soil stability)
- Habitat: conservation of wildlife corridors, improved habitat connectivity, restoration of ecological processes to support native habitat

- Biodiversity: protection for species such as those of Greatest Conservation Need, supporting increased population or health of diverse species, controlling invasive species, improving wildlife or vegetation adaptation to climate change

In addition to the above, other benefits may be identified through the course of reviewing and planning projects for implementation. Generally, this metric is not intended to track the status of core objectives such as increased carbon sequestration, reduced fire risk, reduced tree mortality, and other GHG-related factors. Ecological benefits may be identified by prospective grantees as part of the California Climate Investments application process, assessed by grantees or administering agencies as part of a co-benefit assessment (such as the Co-Benefit Assessment Methodology for Climate Adaptation), or otherwise identified and added to the *Other Project Benefits Description* within the California Climate Investments Reporting and Tracking System (CCIRTS). [162]

Projects that cite one or more ecological benefits in CCIRTS would be eligible to report on this metric as part of project outcomes data collection and reporting. To the extent feasible, grantees, project sponsors, or administering agencies should assess the extent to which these ecological factors in the project area or surrounding areas has changed during the current outcome reporting period.

The method of assessment should be determined by the administering agency of the project and would likely vary depending on the type of ecological factor being tracked, but may include:

- On-site visual observation (e.g. visual inspection of erosion);
- On-site measurements or monitoring (e.g. wildlife monitoring);
- Review of available reports or records for the area during the current period (e.g. conservation easement monitoring reports, water quality reports); or
- Basic minimum assessment: Confirmation that the project has continued as expected and likely achieving expected ecological benefits, or identifying any unexpected issues that would prevent or limit such benefits. This approach is intended for projects that may be difficult or resource intensive to directly observe (e.g. reforestation projects that provide nesting habitats to birds could be assumed to achieve this benefit if tree mortality rates and overall forest health are within expected levels).

Upon conducting the necessary assessments, grantees or administering agencies should consider the following questions:

> *Q1. Are there any notable and relevant ecological factors which have shown either an observable improvement or decline during the current outcome reporting period? (Yes / No)*

If the answer to Q1 is *No*, then grantees or administering agencies should indicate “No observed change” for under the “Ecological factor status” field of the outcome reporting template. If the answer

[162] Climate Adaptation Co-Benefit Assessment Methodology: https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/final_adaptation_am.pdf;

A partial export of the CCIRTS database that includes the *Other Project Benefits Description* field and claimed ecological benefits for past projects is publicly available as a data download of the “Implemented Projects Historic Database” here: https://webmaps.arb.ca.gov/ccimap/

to Q1 is *Yes*, then grantees or administering agencies should provide a description of the ecological factor(s) using the following set of criteria:

- Meaningful improvement: Compared to the prior project outcome period (or pre-project condition if no prior outcome period), one or more observed relevant ecological factors have meaningfully improved.
- Meaningful decline or issue: The status of one or more ecological factors has shown a meaningful decline (or meaningful negative impact) as compared to the prior project outcome period (or pre-project condition, if no prior outcome period), or an issue has occurred which may prevent or limit the achievement of ecological benefits.

Upon selecting the appropriate rating above, grantees or administering agencies should provide a qualitative description of the current status and information such as whether the anticipated ecological benefits have been fully realized or if additional improvements are expected. This description may also indicate whether the changes to the observed ecological factors are likely due to the project, or due to external factors (e.g. drought, other disturbances).

A screenshot showing examples of this information as it would appear in the project outcome reporting template is as follows (with descriptions abbreviated):

Project ID	Qualitative assessment of project impacts on ecological factors
8GG77700	Meaningful improvement: On-site observation shows that removal of invasive plants has increased site biodiversity as expected, and these improvements are ongoing.
8GG99555	No observed, meaningful change in ecological factors for the current period
8GG88888	Meaningful decline or issue: Water availability has declined due to non-project factors mainly related to ongoing drought effects.

If there are many observed ecological factors for a project during the outcome period, grantees or administering agencies may choose to provide information on the factors that they consider to be the most relevant to the project, or the factors which showed the most substantial change during the outcome period.

B.2. Deferred Metrics

The below metrics were initially developed and proposed by the Project Team but were later categorized as deferred based on findings from the data collection process or feedback from administering agencies. While these metrics are not recommended for inclusion in the current POR framework unless deemed necessary by CARB, descriptions of these metrics and initially proposed methods are included for reference.

B.2.1 Deferred Metric Description and Method: Change in SWEEP project on-farm water use

Description

This metric would apply to programs that fund outdoor irrigation measures on agricultural project sites. This currently includes the State Water Efficiency and Enhancement Program (SWEEP).

SWEEP funds the implementation of measures such as soil moisture sensors, irrigation controls, drip systems, pump efficiency improvements, variable frequency drives (VFDs), and renewable energy systems to reduce energy and water use and achieve GHG emission reductions for agricultural operations.

Change in SWEEP project on-farm water use refers to the difference between project site water use prior to the implementation of the SWEEP project to the water use following the SWEEP project, after any necessary adjustments.[163] This metric is included in outcome reporting in order to track actual water savings for funded projects, which allows for comparison against prospective estimates.

Method

The recommended method for data collection and analysis of SWEEP project on-farm water use is based on the National Renewable Energy Laboratory (NREL) Outdoor Irrigation Measurement and Verification Protocol.[164] This method addresses data collection for water conservation measures including irrigation system efficiency improvements, advanced irrigation controllers, and irrigation and flow sensors.

The NREL protocol references the International Performance Measurement and Verification Protocol (IPMVP) for determining water and energy savings, which provides four options for measurement and verification. The IPMVP options range in level of rigor and account for different types of projects, and the recommended option for water savings as identified by NREL is Option B, "Retrofit Isolation". Retrofit isolation involves short-term or continuous measurements of the irrigation system throughout the data collection period.

Data Collection

The data collection and analysis time period for SWEEP project on-farm water use should coincide with the data collection and analysis time period for SWEEP project on-farm energy use as specified in current project outcome reporting. This is currently defined as a comparison of the growing season before upgrades to the current growing season.

In order to sufficiently monitor the irrigation system, grantees or administering agencies would need to maintain complete records of baseline irrigation conditions, implemented interventions and measures, and post-installation conditions. This includes documentation of any quantitative or qualitative factors affecting either the baseline or post-project site, such as changes in crops, irrigation system expansion, pre-project irrigation drainage issues, soil type, and other relevant information.

Upon obtaining complete project documentation, grantees, administering agencies, or third-party verifiers should follow the steps and guidelines outlined in the NREL Protocol for data collection. This includes selecting the appropriate data categories, types of monitoring equipment, and measurement frequency depending on the type of project. The protocol recommends the use of a dedicated meter to collect continuous measurements but accounts for the possible use of irrigation system runtime and temporary flow rate measurement to calculate total water use.

In addition to metered water usage data, grantees or administering agencies would need to collect the following data types in the event that baseline or post-project water use is to be normalized:

[163] Normalized for external factors such as weather.

[164] Charles W. Kurnik, Kate M. Stoughton, and Jorge Figueroa, "Outdoor Irrigation Measurement and Verification Protocol," 2017, https://doi.org/10.2172/1412803.

- Weather data including evapotranspiration and precipitation rates, either measured or obtained through historical sources;[165]
- Land area in acres or square feet, including the land area of specific crop or plant types. This information should be included in project applications or obtained through post-project confirmation with the grantee.

Normalization is described in the following section and further detailed in the NREL Protocol.

Analysis

The NREL Protocol also provides guidance regarding analysis of collected data, including establishment and normalization of baseline water use and post-installation water use. The protocol provides a general equation for water savings as:

$$Water\ Use\ Savings = (Baseline\ Water\ Use - Post\ Installation\ Water\ Use) \pm Adjustments$$

Where,

Baseline Water Use	=	Irrigation water use of the existing system prior to measure
Post Installation Water Use	=	Irrigation water use after implementation of measure
Adjustments	=	Factor applied to normalize water use when appropriate

Normalization of water use is conducted in cases where the irrigation schedule is altered due to changes in weather in the post-installation period as compared to the baseline period.[166] Normalizing the post-installation water use provides a representation of the irrigation system during a typical irrigation season.

If the project baseline was established through direct measurement, and the existing baseline system was manually or automatically adjusted to respond to weather conditions (such as through the use of weather or soil sensors or controllers), normalization should be conducted for the baseline water use as well.[167]

[165] The International Water Management Institute (IWMI) provides historical climate summaries to approximate average climate data for specific regions. The NREL Protocol provides a step-by-step guide for using the IWMI web tool.

[166] It may also be necessary to conduct normalization to account for water demands of specific plant types in the post-project period as compared to the pre-project period.

[167] Normalization of baseline water use for systems that received manual adjustments would only be possible if a flow meter was in place to record the resulting fluctuations in water use.

The NREL protocol provides a step-by-step description of the normalization procedure and is based on determining historical and current evapotranspiration (ET) values and applying weighted average plant factors or crop coefficients to determine the water demand of the irrigated system. [168]

For projects where a crop conversion was implemented during the post-project period, it may be necessary to establish a new baseline to estimate the pre-project water demand of the current crop. The SWEEP Irrigation Water Savings Assessment Tool allows for the estimation of the "before" project period based on crop selection and baseline irrigation practices, and may be used for this purpose if primary data collection and normalization of the baseline is not feasible.[169] In general, the specific approach used to analyze the data collected for each project (e.g. normalization procedure, variations from the standard method) should be documented in a way that can be shared with CARB upon request.

Reporting

Upon determining the change in SWEEP project on-farm water use for a given project outcome reporting period, administering agencies should report this value in units of gallons per growing season.

Administering agencies should also provide a qualitative description of any significant factors that may affect water use in the post-installation period as compared to the baseline condition, such as changes in crop selection, land disturbances, or concurrent upgrades or downgrades to the irrigation system. If possible, this description should include any quantitative information available regarding the scope or magnitude of the relevant factor (such as number of acres on which crops were converted).

An example of this information as it would appear in the project outcome reporting template is as follows:

Change in on-farm Energy Use (kWh/growing season)	*Energy Generated (kWh/growing season)*	Change in on-farm water use (gal/growing season)	Qualitative description of project-specific factors affecting water use (site disturbances, crop conversion, concurrent irrigation system changes)
22,000.22	N/A	2,365,000.00	Crop converted from alfalfa to almonds on 50 of 200 acres.

Depending on the significance of post-project factors that may affect water use, CARB may request a more detailed description of these factors, their expected impacts on water use, and to what extent these factors affected the data collection or analysis process.

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[168] Weighted average plant factors are based on the percentage area covered and the evapotranspiration plant factor of each plant. The NREL Protocol references plant factors provided here: American Society of Agricultural and Biological Engineers Standard S623. "Determining Landscape Water Demands," January 2017. https://elibrary.asabe.org/pdfviewer.aspx?GUID=7E66F1CA-348F-4E2A-9731-CEB0A0E3A8C5;

Crop coefficients have been developed for a variety of crops in California and can be calculated based on evapotranspiration zone, as described here: Irrigation and Training Research Center. "California Crop and Soil Evapotranspiration: For water balances and irrigation scheduling/design," 2003. http://www.itrc.org/reports/pdf/californiacrop.pdf

[169] SWEEP Irrigation Water Savings Assessment Tool: https://www.cdfa.ca.gov/oefi/sweep/docs/IrrigationWaterSavingsAssessmentTool.xlsm

B.2.2 Deferred Metric Description and Method: Confirmation of continued soil health practices/Agricultural land on which conservation management practices are still being implemented

Description

These metrics would apply to programs that facilitate the implementation of soil management practices which contribute to increased carbon sequestration. This currently includes:

- State Water Efficiency and Enhancement Program (SWEEP); and
- Healthy Soils Program (HSP).

HSP directly incentivizes a wide range of soil management improvements and prospectively calculates GHG reductions resulting from increased carbon sequestration as part of its QM. In contrast, SWEEP does not directly fund soil management but provides additional funding consideration to applicants whose water efficiency projects will involve one or more practices including cover cropping, mulching, compost application, and resource conserving crop rotation.

For both programs, soil management practices that are included in project applications become part of the grant agreement. Grantees are expected to implement these practices throughout the duration of the grant. While there are no specific requirements for the implementation of these practices beyond the grant period, some grantees may continue implementing some or all of the practices that were initially adopted as part of the project. Confirmation of which practices are being continued during the project outcome reporting period provides information regarding the persistence of water-holding capacity, carbon sequestration, and qualitative soil benefits resulting from California Climate Investments funding.

This metric is not applicable to projects which do not include one or more soil management practices (e.g. SWEEP projects where no soil management practices were indicated on the project application).

Method

Data for this metric would be collected through interviews or other correspondence with grantees or site visits conducted towards the end of each current outcome reporting period.

For HSP, this metric should be collected for each of the soil management practices listed in Section B of the HSP QM document.[170] For SWEEP, this metric should be collected for each of the soil management practices listed as eligible for additional application consideration in the program guidelines or request for grant applications for the relevant funding year.

For projects including one or more soil management practice, administering agencies should contact grantees to obtain the following information (for each practice):

Q1. Whether or not the soil management practice is still being implemented at the project site *[Yes/No]*

Q2. If yes to Q1, whether or not the soil management practice is still being implemented on the same agricultural acreage as stated in the grant agreement *[Yes/No]*

[170] Quantification Methodology for the CDFA Healthy Soils Program: https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/cdfa_hsp_qm_18-19.pdf

Q3. If no to Q2, the number of agricultural acres on which the soil management practice is still being implemented *[Number of Acres]*

Reporting

Agencies would then input the results of this verification into the project outcome reporting template for each applicable soil management practice. This includes whether or not the practice has been continued (from Q1 above), and if applicable, the new agricultural acreage of the practice (from Q3 above). An example of this as it would appear in the project reporting template for a single project is as follows:

Tracking dates of data submission	Cover Cropping	Cover Cropping Acreage	Mulching Continuation	Mulching Acreage	Compost Continuation	Compost Acreage
1/1/2020	Yes	180	No		Yes	240

If the acreage of a practice has not changed during the given project outcome reporting period, the prior acreage (either from the grant agreement or most recent project outcome reporting period) value should be added to the acreage field. If the practice has been discontinued, the acreage field should be left blank. If grantees confirm that a soil management practice is no longer being implemented, it is not necessary to continue verification of that practice in future outcome reporting periods.

B.2.3 Deferred Metric Description and Method: Soil health indicators

Description

This metric would apply to programs that claim GHG reductions resulting from improved soil management practices. This currently includes the Healthy Soils Program (HSP).

HSP directly incentivizes a wide range of soil management improvements and prospectively calculates GHG reductions resulting from increased carbon sequestration as part of its QM. In addition to achieving GHG reductions, the program is designed to facilitate improved soil health that contributes to increased water-holding capacity, soil productivity, erosion control, and other soil benefits.

These benefits can be assessed through the use of soil quality assessments, which capture quantitative and qualitative indicators of soil quality resulting from changes in soil management practices. Collecting the appropriate indicators as part of a soil health assessment during the years following practice implementation may provide valuable information about continued project impacts and benefits.

Method

This method would require grantees and administering agencies to agree on a minimum data set of soil properties for each funded project. The National Resources Conservation Service (NRCS) defines a minimum dataset as the smallest set of soil properties or indicators needed to measure or characterize

soil quality.[171] The minimum data set consists of key attributes that can be tracked over time to characterize changes in soil health and capture continued benefits of soil management practices.

The attributes selected for a given project may vary depending on the type of practices implemented, the project location, and specific concerns or areas of interest related to the project. NRCS states that the selection of soil quality indicators should be based on the following factors:[172]

- Land use;
- Relationship between an indicator and the soil function being assessed;
- Ease and reliability of the measurement;
- Variation between sampling times and variation across the sampling area;
- Sensitivity of the measurement to changes in soil management;
- Compatibility with routing sampling and monitoring; and
- Skills required for use and interpretation.

In addition to soil organic matter and soil organic carbon, examples of soil health indicators that could be collected as part of a minimum data set include:

- Physical characteristics: soil structure, bulk density, water holding capacity
- Chemical characteristics: pH, electrical conductivity, available nutrients (nitrogen, phosphorous, potassium)
- Biological characteristics: microbial biomass carbon and nitrogen, soil respiration

The indicators selected as part of the minimum data set should be assessed prior to project implementation in order to provide a baseline of comparison with post-project data.

The data sources for the selected soil health indicators are on-site soil assessments or laboratory analysis of soil samples. CDFA currently incorporates laboratory analysis of soil samples into the project outcome reporting process for the purpose of measuring soil organic carbon, and grantees may be able to request that additional soil health indicators be included in these analyses. For the purposes of efficiency and cost-effectiveness, grantees and administering agencies may align minimum data sets with the indicators that can be assessed by the laboratory conducting the soil organic matter analysis.

Alternatively, grantees may select a non-laboratory method of soil assessment such as a soil quality test kit. Test kits may be preferred in cases where grantees have sufficient technical knowledge and time

[171] USDA Natural Resources Conservation Service. "Guidelines for Soil Quality Assessment in Conservation Planning," 2001. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051259.pdf;

National Resources Conservation Service, National Soil Survey Center. "Field Book for Describing and Sampling Soils," 2012. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052523.pdf

[172] USDA Natural Resources Conservation Service. "Indicators for Soil Quality Evaluation," 1996. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053149.pdf

resources to apply the kit tools and methods, and are best suited to capturing data such as respiration, bulk density, electrical conductivity, pH, and other standard indicators.[173]

Once a particular method is used for collecting a soil health characteristic during an outcome reporting period, the same method should also be used for collecting that characteristic during future outcome reporting periods, if possible.

Soil assessments and sampling should be conducted in accordance with best practices such as defined by NRCS or as provided by CDFA within Healthy Soils Program materials. These resources provide information regarding the protocols and considerations for proper soil sampling, including:

- Required materials;
- Timing of soil sampling;
- Sampling location;
- Instructions for taking samples; and
- Instructions for submitting samples for laboratory analysis.

Generally, composite samples should be taken from representative areas of the project location and should be taken at approximately the same time of year under similar soil moisture conditions. There may be specific protocols for assessing certain soil health indicators that require adjustments to the timing or location of sampling, or require separate samples to be taken for a single indicator, which should be considered when determining the minimum data set for a given project.[174]

Reporting

Once a grantee or administering agency conducts on-site assessments and receives laboratory analysis results for all selected indicators, the indicator data should be added to the project outcome reporting template, with units of measurement clearly specified.

An example of soil health indicators as they would appear in the project outcome reporting template is as follows (existing project outcome metrics are included and italicized):

Land in Project (acres) *[Healthy Soils]*	***High C:N Ratio (Y/N)*** *[Healthy Soils]*	**Soil health indicator: pH**	**Soil health indicator: bulk density (g/cm^3)**	**Soil health indicator: electrical conductivity EC1:1 (dS/m)**
200	N	6.0	1.30	1.20

In order to track soil health indicators over the duration of project outcome reporting, the same set of indicators should be captured and reported during each project outcome period if possible.

[173] USDA Natural Resources Conservation Service. "Guidelines for Soil Quality Assessment in Conservation Planning," 2001. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051259.pdf;

National Resources Conservation Service, National Soil Survey Center. "Field Book for Describing and Sampling Soils," 2012. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052523.pdf

[174] Daniel Geissler and William R. Horwath, "Sampling for Soil Nitrate Determination," n.d., https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Soil_Sampling_Nitrate.pdf.

Appendix C: Data Collection Instruments

This appendix provides copies of survey and interview instruments that were used to collect POR data as part of this project. Programs for which surveys were used to collect POR data for sampled grants include the Affordable Housing and Sustainable Communities (AHSC) program and the Clean Mobility Options (CMO) program. A grantee interview guide was also developed for the State Water Efficiency and Enhancement Program (SWEEP).

C.1. Sample Affordable Housing Resident Survey Instrument

[Property Name] Transportation Questionnaire

Dear **[Property Name]** resident:

[Property Name] was built using funds from the Affordable Housing and Sustainable Communities (AHSC) Program, which provides affordable housing and improved transportation access to communities across California. AHSC is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment —particularly in disadvantaged communities.

California Climate Investments is asking residents who have benefitted from the program to complete a questionnaire about their household and its use of different types of transportation. While this questionnaire is completely optional, your responses are very important and will help to improve the AHSC program.

This questionnaire will take about 10 minutes to complete. To thank you for completing the questionnaire, we will enter you into a raffle for **[Incentive]**. To be entered in the raffle, please provide your unit number to **[On-site or Project Contact]** when you return the completed questionnaire. Please do not provide any contact information on the questionnaire itself.

Please return the completed questionnaire to **[On-site or Project Contact]** by **[Return Date]** to be entered in the raffle.

Your responses to this questionnaire will not be linked to your individual identity. All questions are optional and you may choose to stop at any point.

1. Do you agree to take this optional questionnaire?

☐ Yes (if yes, please continue)

☐ No (if no, please leave the questionnaire blank and return it to the person who provided it to you)

The following questions ask about your current residence. For these questions, "household" refers to the people who live in your residence most of the time. For each question please mark the box that matches your response.

2. How long have you lived at **[Property Name]**?

☐ Less than 6 months

☐ Between 6 months and 1 year

☐ More than 1 year

☐ I do not live at **[Property Name]**

☐ Prefer not to answer

3. Including yourself, how many people live in your household (including children)?

☐ Number of people (if only you, write "1"): _____

☐ Prefer not to answer

4. Of the people living in your household, how many are adults (18 years of age or older)?

☐ Number of adults (if only you, write "1"): _____

☐ Prefer not to answer

The following questions ask about your household's use of different types of transportation.

5. How many motor vehicles (cars, trucks, motorcycles), if any, are available to your household? This includes vehicles you own, lease, or regularly borrow.

☐ Number of motor vehicles (if none, write "0"): _____

☐ Prefer not to answer

6. (If you have any motor vehicles available to your household) Are any of these motor vehicles alternative fuel vehicles (such as plug-in hybrids, electric vehicles, or fuel cell vehicles)?

☐ Yes (if yes, how many?: _____)

☐ No

☐ Don't know/Prefer not to answer

7. How many adults in your household, if any, regularly leave home to go to work?

☐ Number of adults who leave home to go to work (if none, write "0"): _____

☐ Prefer not to answer

8. **How you get to and from work:** (If you or other adults in your household regularly leave home to go to work) For each row in the following table, please fill in a circle to indicate how often your household uses the listed form of transportation to go to and from work:

How does your household commute to work?		Do not use at all	Use about one day per month	Use a few days per month	Use 5-10 days per month	Use 10-20 days per month	Use on a daily basis
1.	Driving a motor vehicle alone	○	○	○	○	○	○
2.	Carpooling in a private vehicle	○	○	○	○	○	○
3.	Taking a bus	○	○	○	○	○	○
4.	Taking a van or shuttle	○	○	○	○	○	○
5.	Taking a train, light rail, or trolley	○	○	○	○	○	○
6.	Taking a taxi, Uber, Lyft, or similar service	○	○	○	○	○	○
7.	Walking	○	○	○	○	○	○
8.	Using a bicycle	○	○	○	○	○	○
9.	Using a scooter	○	○	○	○	○	○
10.	Other: _____	○	○	○	○	○	○

9. **How you make other trips (non-work):** For each row in the following table, please fill in a circle to indicate how often your household uses the following forms of transportation for other types of trips such as social activities, appointments, and errands:

How does your household make other types of trips?		Do not use at all	Use about one day per month	Use a few days per month	Use 5-10 days per month	Use 10-20 days per month	Use on a daily basis
1.	Driving a motor vehicle alone	○	○	○	○	○	○
2.	Carpooling in a private vehicle	○	○	○	○	○	○
3.	Taking a bus	○	○	○	○	○	○
4.	Taking a van or shuttle	○	○	○	○	○	○
5.	Taking a train, light rail, or trolley	○	○	○	○	○	○
6.	Taking a taxi, Uber, Lyft, or similar service	○	○	○	○	○	○
7.	Walking	○	○	○	○	○	○
8.	Using a bicycle	○	○	○	○	○	○
9.	Using a scooter	○	○	○	○	○	○
10.	Other: _____	○	○	○	○	○	○

10. Thinking about the transportation available to you, how often are you and the members of your household able to travel to where you need to go (such as commuting, doing errands, traveling to other activities, etc.)?

☐ Always

☐ Usually

☐ Sometimes

☐ Rarely

☐ Never

☐ Prefer not to answer

11. (If you answered "Sometimes", "Rarely", or "Never" to the question above) Can you please describe why you or other members of your household are unable to travel to where you need to go? *(For example, difficulty accessing transit, no access to a reliable car)*

Response:_____

12. For this question, please think about how the members of your household traveled from place to place one year ago (whether you lived in your current residence or a different residence). Do the members of your household use any of these forms of transportation more or less than you did one year ago?

Has your use of transportation changed in the last year?		We use this LESS than we did one year ago	We use this MORE than we did one year ago	No change or Not Applicable
1.	Driving a motor vehicle alone	○	○	○
2.	Carpooling in a private vehicle	○	○	○
3.	Taking a bus	○	○	○
4.	Taking a van or shuttle	○	○	○
5.	Taking a train, light rail, or trolley	○	○	○
6.	Taking a taxi, Uber, Lyft, or similar service	○	○	○
7.	Walking	○	○	○
8.	Using a bicycle	○	○	○
9.	Using a scooter	○	○	○
10.	Other: _____	○	○	○

13. (If you indicated that you use any type of transportation more or less than one year ago) Can you please provide some more information about the reason that your household has changed its use of transportation since one year ago? *(For example, why do you now drive more or less, or why do you now take a bus more or less than you did before?)*

Response:_____

_____

14. Finally, do you have any other comments you would like to provide about the AHSC program or your use and access to transportation overall?

Response:_____

_____

This completes the questionnaire. Thank you very much for your participation! Please return the completed questionnaire to [On-site or Project Contact] to be entered into the [Incentive] raffle.

C.2. Clean Mobility Options: Our Community CarShare Survey Instruments

Our Community CarShare Participant Survey

[Note: This survey was administered electronically, and the below content is a transcription of the electronic version].

Please complete the short survey below based on your OCCS experience.

Our Community CarShare is grateful to provide sustainable, zero-emission, transportation to our members. The survey below provides us valuable feedback to develop effective program changes and improvements. As a proud community partner, we want to ensure that we are constantly self-evaluating our program to ensure its longevity and positive impact on our region. Any information you provide is strictly confidential. Your identity and individual information will not be shared with any other agencies or groups. As a thank you for taking this survey, you will be entered into raffle for a chance to win one of three great prizes: an InstantPot/Air Fryer Duo!

15. Please provide your name to be entered into the raffle.

☐ Name: _____

16. Select your OCCS site.

☐ SHRA Alder Grove

☐ SHRA Edgewater

☐ SHRA Riverview

☐ Mutual Housing Lemon Hill

☐ Mutual Housing Sky Park

☐ Mutual Housing River Garden

☐ Mutual Housing Greenway

17. What changes, if any, would you like to see to Our Community CarShare?

☐ Expanded reservation hours

☐ Cleaner cars

☐ More vehicles

☐ More chargers

☐ Better social media presence in order to stay informed

☐ More program information via emails

☐ More CarShare Representatives

☐ Other (please specify): _____

18. How, if at all, has Our Community CarShare changed your daily life? Please check all that apply.

☐ I did not have a car to use before CarShare

☐ I am saving money on gas

☐ I am able to see friends and family more

☐ I am able to have access to goods and services (run errands, see a doctor, buy groceries)

☐ I am no longer spending time waiting on public transit

☐ Our Community CarShare has not changed my life

☐ Other (please specify): _____

19. Before Carshare, how often did you take public transit?

☐ Never

☐ Less than once a month

☐ 1-2 times per month

☐ 1-2 times per week

☐ Almost everyday

☐ More than once a day

20. Since becoming a CarShare member, how often have you taken public transit?

☐ Never

☐ Less than once a month

☐ 1-2 times per month

☐ 1-2 times per week

☐ Almost everyday

☐ More than once a day

21. How much did you spend on gas, per month, before Our Community CarShare?

☐ $5 - $10

☐ $11 - $20

☐ $21 - $40

☐ $41 - $60

☐ $61 - $80

☐ $81 or more

☐ N/A; does not apply

22. How much do you spend on gas, per month, after becoming an Our Community CarShare member?

☐ $5 - $10

☐ $11 - $20

☐ $21 - $40

☐ $41 - $60

☐ $61 - $80

☐ $81 or more

☐ N/A; does not apply

23. Has Our Community CarShare affected the number of personal vehicles that you own or lease?

☐ No, the availability of Our Community CarShare has not affected the number of vehicles I own or lease

☐ No, but I am considering selling or scrapping one or more personal vehicles due to the availability of Our Community CarShare

☐ Yes, I am delaying the purchase or lease of one or more personal vehicles due to the availability of Our Community CarShare

☐ Yes, I have sold or scrapped one or more personal vehicles due to the availability of Our Community CarShare

24. Are you concerned about air quality in your neighborhood?

☐ No

☐ Yes

☐ Prefer not to say

25. (If yes to Q10) What source of pollution are you most concerned about in your community? (check all that apply)

☐ Pollution from cars

☐ Pollution from truck traffic

☐ Pollution from construction sites

☐ Pollution from wildfires

☐ Pollution from local businesses (gas stations, laundromats, manufacturing sites)

☐ Other (please specify): _____

26. Access to Our Community CarShare may require having a traditional bank account in the future. Do you currently have a bank account?

☐ Yes

☐ No

☐ Prefer not to say

27. To keep the CarShare program running for the long-term, OCCS has decided to charge riders a small fee to use the program. If you were charged a small fee of $3/hr or $3/trip, would that affect the way you use the program?

☐ Yes

☐ No

28. (If yes to Q13) How would implementing a small fee of $3/hr or $3/trip affect you?

☐ Response: _____

29. Are there any changes to the CarShare program that would affect your overall decision whether or not to pay for the program?

☐ Response: _____

30. How would you rate Our Community CarShare on a scale of 1 to 5 stars, where 1 star is the worst rating and 5 stars is the best rating?

31. Can you explain why you chose this rating?

☐ Response: _____

Thank you for your valuable responses!

Our Community CarShare Trip Survey

[Note: This survey was administered electronically, and the below content is a transcription of the electronic version].

Please complete this brief survey after each CarShare trip you take.

This survey asks about your most recent completed trip with Our Community CarShare. We appreciate your support for OCCS and would like to evaluate our members' electric vehicle experience to continue improving the program. Any information you provide is strictly confidential. Your identity and individual information will not be shared with any other agencies or groups.

As a thank you for participating in this survey, for each survey you submit, you will be entered into a weekly raffle to win 1 of 2 VISA gift cards worth $25. There is no limit on the number of surveys you can submit within a given week.

1. Where did you begin your trip?

- ☐ Alder Grove
- ☐ Edge Water/Riverview
- ☐ Greenway
- ☐ Lemon Hill
- ☐ River Garden
- ☐ Sky Park
- ☐ Sacramento Valley Train Station

2. How much charge did the vehicle have?

- ☐ 0 – 25% charge
- ☐ 25 – 50% charge
- ☐ 50 – 75% charge
- ☐ 75 – 100% charge

3. What type of trip did you make?

- ☐ Work or Job Related
- ☐ School Related
- ☐ Grocery or Household Shopping
- ☐ Health Care or Medical Appointment
- ☐ Entertainment, Recreation, or Social Activity
- ☐ Civic or Religious Activity

☐ Other (please specify): _____

4. If Our Community CarShare had not been available, would you have made this trip?

☐ Yes, I would have made the same trip

☐ Yes, but I would have gone to a different location

☐ No, I would not have made the trip

☐ Unsure/Prefer not to respond

5. (If yes, I would have made the same trip; or yes, but I would have gone to a different location to Q4) What form of travel would you have most likely used for the trip if Our Community CarShare were not available?

☐ Driven my own car

☐ Borrowed someone else's car

☐ Taken the bus

☐ Walked

☐ Used an e-bike or e-scooter

☐ Rented a car

☐ Taken a train

☐ Taken a taxi, Uber, Lyft, or similar service

☐ Several forms of travel combined

☐ Unsure/Prefer not to say

6. (If driven my own car; or borrowed someone else's car to Q5) Is the car that you would have used for this trip an alternative fuel vehicle (e.g. plug-in hybrid, battery electric vehicle, fuel cell vehicle)?

☐ Yes

☐ No

☐ Unsure/Prefer not to respond

7. Were you a Community CarShare Representative for this trip?

☐ Yes

☐ No

8. Please type your name to be entered into the raffle.

☐ Response: _____

C.3. State Water Efficiency and Enhancement Program (SWEEP) Grantee Interview Guide

SWEEP Grantee Interview Topics (Project Outcome Reporting)

Water Efficiency

1. Have there been any major changes to the irrigation system or land use since project implementation?

2. What do you use to monitor water usage (e.g. flow meters, water bills)?

3. Are you able to provide water usage records for the period since implementation? If not:
    a. For pumps, have you had a recent pump efficiency report completed? If so, can this be provided?

    b. Do you have information on the total dynamic head (TDH) of the operational pumps? If so, can this be provided? (inputs of maximum PSI, elevation head, and friction loss)

Energy Efficiency (if applicable)

1. Are the implemented measures (e.g. VFDs) still in place and operational?

2. How is the equipment metered (e.g. is the equipment on a dedicated meter, or are there multiple pieces of equipment on one or more meters)?

3. Are you able to provide energy usage records for the relevant meter(s) for the period since implementation?

Energy Generation (if applicable)

1. Are the solar panels still in place and operational?

2. Have there been any modifications or changes to the solar system since project implementation?

3. How is the solar system metered (e.g. net metering, dual meter)

4. Are you able to provide energy generation records for the period since implementation?

Other Management Practices as described in the project documentation (if applicable)

1. Are the management practices (cover cropping, mulching, compost application, resource conserving crop rotation) from the project still in place on the property?

2. Has the area/acreage of these practices changed since project implementation?

Wrap-up

1. Do you have any general feedback on the feasibility of you or others providing this type of information moving forward?

2. Do you have any recommendations for how this outcome reporting process should work moving forward, to minimize burden on grantees or improve results?

3. Do you have any other questions for us?