CalEEMod Construction Default Updates
June 2023

The California Emission Estimator Model (CalEEMod)[1] quantifies construction and operations emissions from land use development and linear projects in California for ozone precursors, criteria pollutants, and greenhouse gas emissions. To develop emission estimates with CalEEMod for a project, CalEEMod can be populated with project specific activity inputs and emission rates, or defaults available in the model may be used. Several current construction activity input defaults were developed over a decade ago; for some inputs the default is no or very limited activity (e.g., import/export material quantity, on-site truck duration, vendor trips).

At the request of the Sacramento Metropolitan Air Quality Management District (Sac Metro Air District), Ramboll developed new defaults for select CalEEMod construction activity inputs. This memorandum describes the (i) process by which data was gathered to inform new defaults (via estimator survey), (ii) incorporation into the analysis of construction survey data previously gathered by the South Coast Air Quality Management District (SCAQMD), (iii) the methodologies used to analyze estimator survey data, and (iv) new CalEEMod defaults for select inputs.

1. Survey Development

In collaboration with the Sac Metro Air District, a simple survey was developed to solicit representative construction activity inputs from construction industry estimators. The survey was designed to be flexible to allow estimators to provide data for land use types and subtypes, and project phases within each estimator's area of expertise. The survey requested a range of construction project inputs applicable to development of CalEEMod defaults such as:

- Project size (e.g., building square footage, lot acreage)
- Land use type and terrain types
- Construction duration by phase
- Equipment types, quantities, and use
- Import and export material quantities
- Haul truck activity
- On-site truck activity
- Vendor truck trips
- Worker trips

The survey form is included as Appendix A.

Ramboll performed outreach and engaged construction industry estimators to fill out the survey with representative construction activity estimates.

[1] CalEEMod® | ©2022 California Air Pollution Control Officers Association. All Rights Reserved. Available at https://www.caleemod.com/.

2. Survey Results

Four estimators filled-out and submitted surveys. Survey data were provided for 27 representative CalEEMod land use subtypes (see Table 1) across all project phases (see Table 2). Survey submissions were limited to project lot sizes less than 30 acres (see Table 3). Analysis of CalEEMod default updates was limited to lot sizes for which survey data were submitted.

Table 1. Summary of estimator survey coverage by CalEEMod land use subtype.

CalEEMod Land Use Subtype	Estimator 1	Estimator 2	Estimator 3	Estimator 4
Residential				
Apartments Low Rise	✓	✓		
Single Family Housing	✓			
Educational				
Day-Care Center	✓	✓		
Elementary School	✓			
High School	✓			
Junior College (2Yr)	✓			
Junior High School	✓			
Library		✓		
Recreational				
Hotel	✓		✓	
Parking				
Enclosed Parking Structure	✓			
Other Asphalt Surfaces	✓			
Parking Lot	✓			
Retail				
Discount Club	✓			
Gasoline/Service Station	✓			
Commercial				
General Office Building	✓			
Government (Civic Center)	✓			
Government Office Building	✓			
Medical Office Building	✓			
Industrial				
Industrial Park	✓			
Unrefrigerated Warehouse-No Rail	✓			✓

Table 2. Estimator survey data coverage by CalEEMod construction phase.

CalEEMod Construction Phase	Estimator 1	Estimator 2	Estimator 3	Estimator 4
Demolition	✓	✓		
Site-preparation	✓	✓	✓	✓
Grading	✓	✓	✓	✓
Building construction		✓	✓	✓
Paving	✓	✓	✓	✓
Architectural coatings			✓	✓

Table 3. Estimator survey data coverage by lot acreage.

CalEEMod Subtype	Lot Acreage						
	≥1	≥2	≥3	≥5	≥10	≥15	≥25
Apartments Low Rise		✓			✓		
Day-Care Center	✓		✓				
Discount Club					✓		
Elementary School					✓		
Enclosed Parking Structure		✓					
Gasoline/Service Station	✓						
General Office Building	✓		✓				
Government (Civic Center)			✓				
Government Office Building		✓		✓			
High School		✓					
Hotel	✓		✓				
Industrial Park							✓
Junior College (2Yr)				✓			
Junior High School	✓						
Library	✓		✓				
Medical Office Building				✓			
Other Asphalt Surfaces	✓						
Parking Lot	✓						
Single Family Housing						✓	
Unrefrigerated Warehouse-No Rail			✓				

3. CalEEMod Default Construction Inputs Analysis

Ramboll compiled data from the estimator surveys. To increase the robustness of the survey dataset, estimator survey data was combined with survey data collected previously by SCAQMD[2]. The SCAQMD survey (South Coast survey) data is the basis of several CalEEMod default construction inputs. Table 4 shows the CalEEMod default inputs that were evaluated and survey data availability by input.

Table 4. Summary of SCAQMD survey and estimator survey data coverage by CalEEMod default input.

CalEEMod Default Input	SCAQMD Survey Data	Estimator Survey Data
Phase Length	✓	✓
Equipment Quantity	✓	✓
Equipment Phase Length	✓	✓
Equipment Days	✓	✓
Import/Export Quantity	-	✓
On-site Truck Duration	-	✓
Haul Truck Capacity	-	✓
Worker Trip Rate	✓	✓
Vendor Trip Rate	-	✓

Ramboll prepared scatter plots for each CalEEMod default input to aid in the review and assessment of estimator survey data, SCAQMD survey data, and current CalEEMod defaults. The scatter plots were used to understand the relationship of the data compiled for each parameter by construction phase and lot acreage. In collaboration with the Sac Metro Air District and the California Air Pollution Control Officers Association (CAPCOA) Planning Managers, Ramboll developed new CalEEMod defaults for selected inputs. The section below discusses the analysis for each CalEEMod default construction input and presents new defaults.

4. Results and Recommendations

Analysis results are provided below in tables and figures. Analyses were restricted to project lot acreages less than 30 acres (corresponding to CalEEMod lot acreage bins ≥1 to ≥25). New defaults are suggested mainly in cases where survey data suggests that current metrics are low relative to available survey data or for inputs for which there are no current defaults in CalEEMod.

4.1 Construction Phase Length

Construction phase length refers to the number of days associated with each phase of construction. Construction phase length from estimator surveys, the South Coast survey, current CalEEMod defaults and new CalEEMod defaults is shown by lot acreage for building construction and grading phases in Figure 1.

For the building construction phase, the average phase length for estimator and South Coast survey data for the acreage ≥1 bin is higher (131 days) compared to the current

[2] Email from Sac Metro (Karen Huss) to Ramboll (John Grant), December 21, 2022

CalEEMod default (100 days); therefore, a new CalEEMod default was developed. For the other lot acreage bins, updated defaults were not developed.

For the grading phase, estimator and South Coast survey data indicate longer phase lengths than current CalEEMod defaults for lot acreage bins (≥1, ≥2, ≥3 and ≥5); therefore, new CalEEMod defaults were developed. For ≥ 10 and higher lot acreage bins, survey data available are very limited, therefore updates were not developed for these bins.

Table 5 summarizes the current and new CalEEMod construction default input values for building construction and grading phase lengths for lot acreage bins with updates. For demolition, paving, and site preparation phases, there were either no sufficient data to support an update or current CalEEMod defaults were representative of the compiled data and therefore did not require an update. Scatter plots for these phases are available in Appendix B (Figure B1).

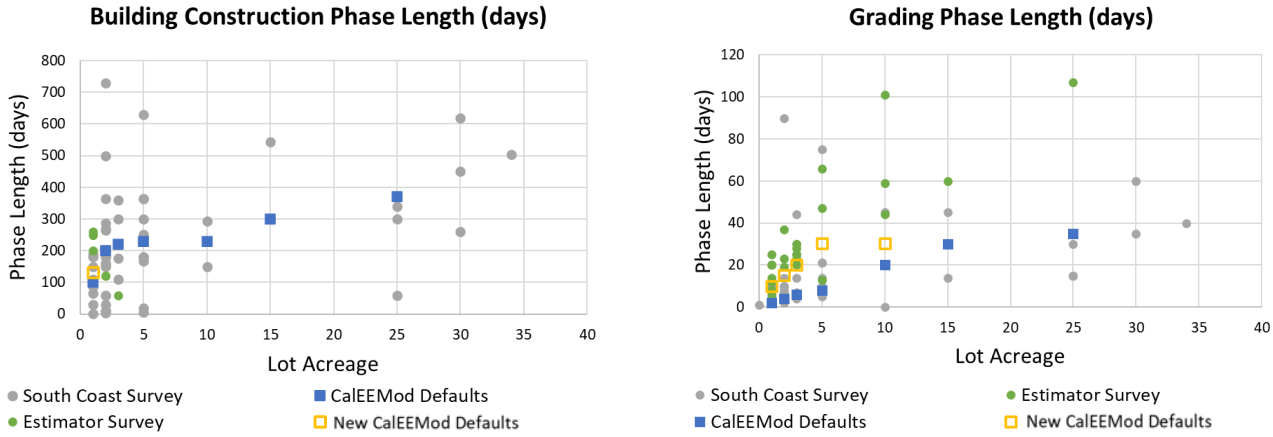


Figure 1. Construction phase length by project lot acreage for the building construction phase (left panel) and grading phase (right panel).

Table 5. Summary of current and new CalEEMod defaults for phase length.

Lot Acreage	Previous CalEEMod Defaults (days)	New CalEEMod Defaults (days)
Building Construction		
≥1	100	131
Grading		
≥1	2	10
≥2	4	15
≥3	6	20
≥5	8	30

4.2 Equipment Quantity and Usage

Equipment quantity refers to the number of equipment used for a given construction phase. We compiled estimates of equipment work in horsepower-hours (hp-hr) as the sum of the product of each equipment's quantity by phase, hours of use by phase, and rated power. Equipment work provides a measure that is more closely related to equipment emissions than equipment quantity, hours of use, or equipment rated power, alone. Analysis of survey-based and CalEEMod default equipment work allowed us to compare overall activity to determine there were substantial discrepancies between survey-based and CalEEMod default equipment activity.

Equipment work for the demolition phase by lot acreage is shown in Figure 2. For ≥2 to ≥25 lot acreage bins, survey-based equipment work is substantially less than CalEEMod defaults (with the exception of a single South Coast survey value in lot acreage bin ≥5). We have therefore adjusted the number of equipment used in the demolition phase downward. The resulting adjusted new equipment work for this phase remains conservative relative to most of the survey data, but substantially lower than previous estimates. The new CalEEMod default number of equipment is provided in Table 6.

For all phases except demolition, the estimator and South Coast survey equipment activity data were reasonably consistent with CalEEMod defaults; therefore, equipment activity-related default updates were not developed for these phases (see Appendix B, Figure B2).

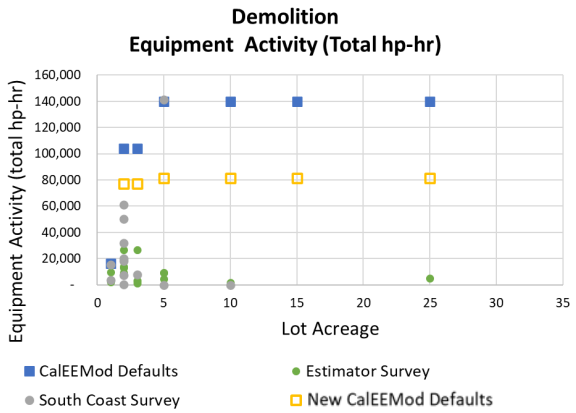


Figure 2. Demolition phase equipment activity (total hp-hr) by project lot acreage.

Table 6. Summary of current and new CalEEMod defaults for demolition phase equipment quantity (count).

Equipment Type	Previous CalEEMod Defaults (No. of Equipment)	New CalEEMod Defaults (No. of Equipment)
Lot Acreages ≥2 acres and ≥3 acres bins (Demolition Phase)		
Rubber Tired Dozers	1	1
Concrete Saw	1	1
Tractors/Loaders/Backhoes	3	1
Lot Acreages ≥5 acres to ≥25 acres bins (Demolition Phase)		
Rubber Tired Dozers	2	1
Concrete Saw	1	1
Excavators	3	3

4.3 Import/Export Material Quantity

Import/export material quantity refers to the amount of material imported or exported by haul trucks for a given project, including aggregate, fill, topsoil, or other raw materials. There is currently no CalEEMod default for import/export material quantity; only if a user provides a project specific quantity imported/exported are emissions estimated from associated haul truck trips.

Analysis of the estimator survey data indicated that, in general, imports were associated with grading and paving phases while the exports were associated with demolition and grading phases. A majority of surveyed projects included both import and export activity. In several projects, the grading phase included both import and export. Data were not sufficient to assess import/export activity by project type.

Figure 3 shows the imported and exported material quantity per acre by lot acreage. New CalEEMod defaults were estimated for both import and export material quantity as the average over all survey estimates, applied uniformly across lot acreage bins. Table 7 shows new CalEEMod import and export quantity estimates.

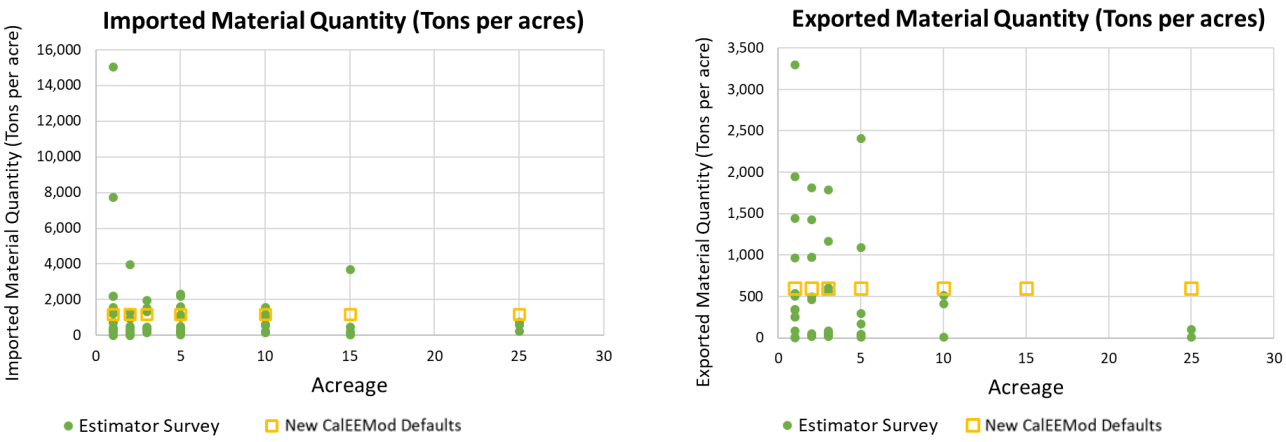


Figure 3. Import (left panel) and export (right panel) material quantity by project lot acreage.

Table 7. Summary of new CalEEMod defaults for import/export material quantity (ton/acres).

Lot Acreage	Import Quantity (ton/acre)	Export Quantity (ton/acre)
≥1	1,190	600
≥2	1,190	600
≥3	1,190	600
≥5	1,190	600
≥10	1,190	600
≥15	1,190	600
≥25	1,190	600

4.4 Haul-truck Capacity

Haul-truck capacity is used with import and export material quantities to estimate haul truck trips. Estimator survey responses confirmed that the current CalEEMod defaults assumption for the haul-truck capacity (16 cubic yards of material per trip) is reasonable; therefore, no new defaults are presented.

4.5 On-site Truck Duration

On-site truck duration refers to activity associated with operation of trucks (e.g., water trucks, aggregate hauling, waste hauling, asphalt hauling) at the construction site. There is currently no CalEEMod default for on-site truck duration; only if a user specifies on-site truck duration are emissions from this activity estimated.

As shown in Figure 4, on-site truck duration data were collected mostly for projects with lot acreage less than 10 acres. We estimated new CalEEMod default inputs for on-site truck duration by averaging on-site truck duration per acre over all lot acreages. Table 8 summarizes the new CalEEMod defaults for demolition, grading paving and site-preparation.

Sufficient estimator survey data was not available to develop new defaults for on-site truck duration associated with building construction and architectural coating phases.

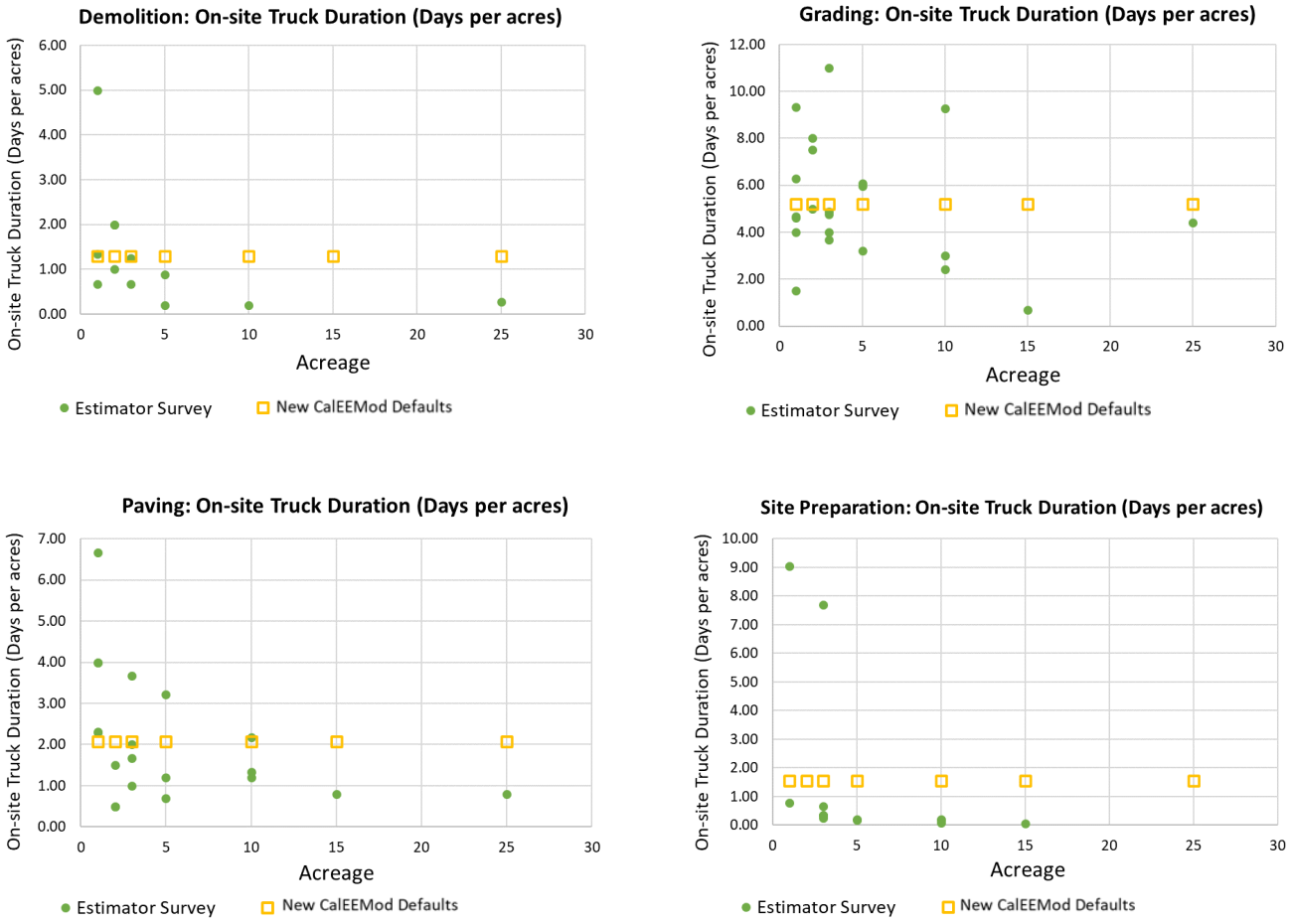


Figure 4. Onsite truck duration by project lot acreage for demolition (top left), Grading (top right), paving (bottom left), and site preparation (bottom right) phases.

Table 8. Summary of new caleemod defaults for onsite truck duration (days per acre).

Lot Acreage	Demolition (days per acre)	Grading (days per acre)	Paving (days per acre)	Site Preparation (days per acre)
≥1	1.3	5.2	2.1	1.5
≥2	1.3	5.2	2.1	1.5
≥3	1.3	5.2	2.1	1.5
≥5	1.3	5.2	2.1	1.5
≥10	1.3	5.2	2.1	1.5
≥15	1.3	5.2	2.1	1.5
≥25	1.3	5.2	2.1	1.5

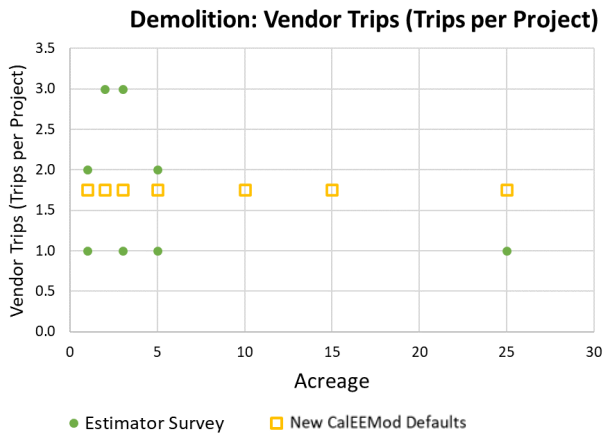
4.6 Worker Trips

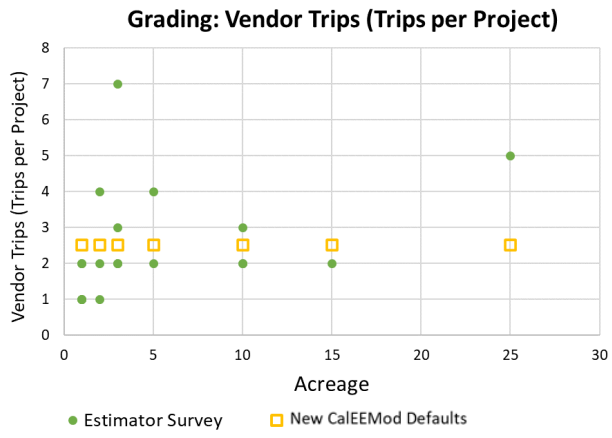
The CalEEMod default assumption is 1.25 worker round trips per equipment used by phase except for building construction for which default worker trips which are specified for single family (0.36 daily trips per dwelling unit), multi-family (0.72 daily trips per dwelling unit), commercial/retail (0.32 daily trips per 1000 square-feet of building construction), and office/industrial (0.42 daily trips per 1000 square-feet of building construction)[3]. Architectural coating phase worker trips are 20% of building construction phase trips. The estimator survey data confirms that the current CalEEMod defaults assumption for the worker trip rate is reasonable; therefore, no new defaults are presented.

4.7 Vendor Trips

Vendor trips refers to activity associated with trucks visiting construction sites for construction materials delivery or other delivered items. There is currently no CalEEMod default for vendor trips except for the building construction phase (0.1069 daily trips per dwelling unit for single and multi-family construction and 0.1639 daily trips per 1000 square-feet of building construction for commercial/retail and office/industrial construction). For all phases except the building construction phase, only if a user specifies vendor trips are emissions estimated for this emission source.

As shown in Figure 5, on-site truck duration data were collected mostly for projects with lot acreage less than 10 acres. We estimated new CalEEMod default inputs for vendor trips by averaging vendor trips per acre over all lot acreages. Table 9 summarizes the new CalEEMod defaults for demolition, grading, paving, and site-preparation phases. Sufficient estimator survey data was not available to develop new defaults for building construction and architectural coating phases.





[3] CAPCOA, 2022. "User Guide for CalEEMod Version 2022.1". https://www.caleemod.com/user-guide

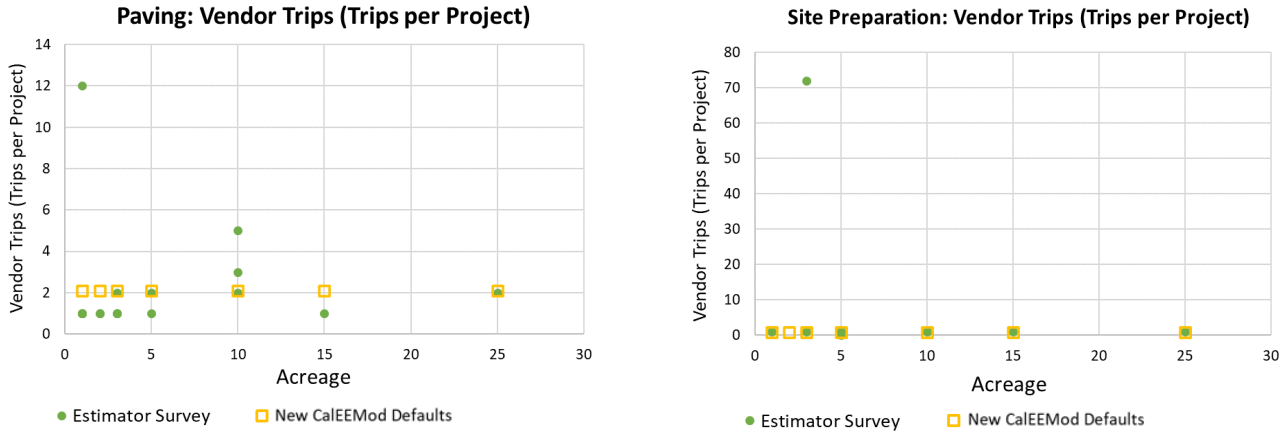


Figure 5. Vendor vehicle trips per project for demolition (top left), grading (top right), paving (bottom left), and site preparation (bottom right) phases.

Table 9. Summary of new CalEEMod defaults for vendor vehicle trips (trips per project).

Lot Acreage	Demolition (trips per project)	Grading (trips per project)	Paving (trips per project)	Site Preparation (trips per project)
≥1	2	3	2	1
≥2	2	3	2	1
≥3	2	3	2	1
≥5	2	3	2	1
≥10	2	3	2	1
≥15	2	3	2	1
≥25	2	3	2	1

5. Limitations/Uncertainties

We developed new CalEEMod construction input defaults if the survey data included in the analysis suggests increases from current CalEEMod defaults or for inputs for which there is no current default. We did not suggest new defaults if the current defaults were deemed reasonable and/or conservatively high. As shown in the Figures presented above, most of the survey data available were for project lot acreages less than 10 acres. Additional data, especially for project lot acreages greater than 10 acres could potentially allow for estimate of more representative defaults for these larger lot sizes.

CalEEMod defaults are meant to provide reasonable default estimates; however, project specific activity may differ considerably. Site conditions, construction specifications, and other factors will result in project specific construction activities that differ from the defaults.

Import/export material quantities are expected to be very sensitive to project site (e.g., terrain) and development requirements. If defaults are adopted in CalEEMod for import/export material quantities, CalEEMod users should pay particular attention to reviewing the defaults and, if necessary, provide project specific inputs.

APPENDIX A: ESTIMATOR SURVEY FORM

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Survey Responses

The estimator will provide complete responses to the questions in Section I and Section III, and if feasible Section II, below for all project types for which you have experience.

Section I. Please provide the following representative inputs for sample projects:

1. Project Information
    a. Project description
    b. Project size (square footage and lot acreage)
    c. Project terrain
    d. Project topography
    e. Geographic area
    f. Project phases[4] description (including the duration of each phase)
2. Material outlay (provide information below by phase[4])
    a. Material types (e.g., dirt, fill, soil, rock)
    b. Material quantities imported (cubic yards or tons)
    c. Material quantities exported (cubic yards or tons)
3. Equipment outlay (provide information below by phase[4])
    a. Equipment types (e.g., excavator, loader)
    b. Number of pieces of equipment by equipment type
    c. Days on-site and hours of use per day
4. Haul trucks outlay (provide information below by phase[4])
    a. Purpose / use description (e.g., aggregate hauling, waste hauling, asphalt hauling)
    b. Haul capacity (cubic yards or tons)
    c. Number of trips to the project site
    d. Typical trip origin and destination

Section II. Provide the information below, if readily available:

1. On-site Trucks (provide information below by phase[4])
    a. Purpose / use description (e.g., water trucks, aggregate hauling, waste hauling, asphalt hauling)
    b. Number of trips / days of use
2. Vendor Trucks (provide information below by phase[4])
    a. Purpose / use description (e.g., materials delivery)
    b. Number of trips to the project site (by phase if relevant)
3. Worker Trips (provide information below by phase)
    a. Number of workers per day
4. Architectural Coating (provide information below by phase[4])
    a. Volume by type of coating
5. Temporary Onsite Office
    a. Square footage

Section III. Supplemental Information

1. If feasible, submit multiple representative inputs for each project type such that CalEEMod defaults can be developed for a range of project inputs (e.g., project size, project terrain, and/or other factors)
2. How can the provided survey response(s) be scaled to account for changes to project size, project terrain, and/or other project factors?
3. Over what range of project inputs (e.g., project size, project terrain) is the survey response(s) provided valid?

[4] Project Phases: Demolition, Site Preparation, Grading, Building Construction, Architectural Coating, Paving

APPENDIX B: SCATTER PLOTS FOR WHICH NO NEW CALEEMOD UPDATES WERE DEVELOPED

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APPENDIX B. SCATTER PLOTS FOR WHICH NO NEW CALEEMOD UPDATES WERE DEVELOPED

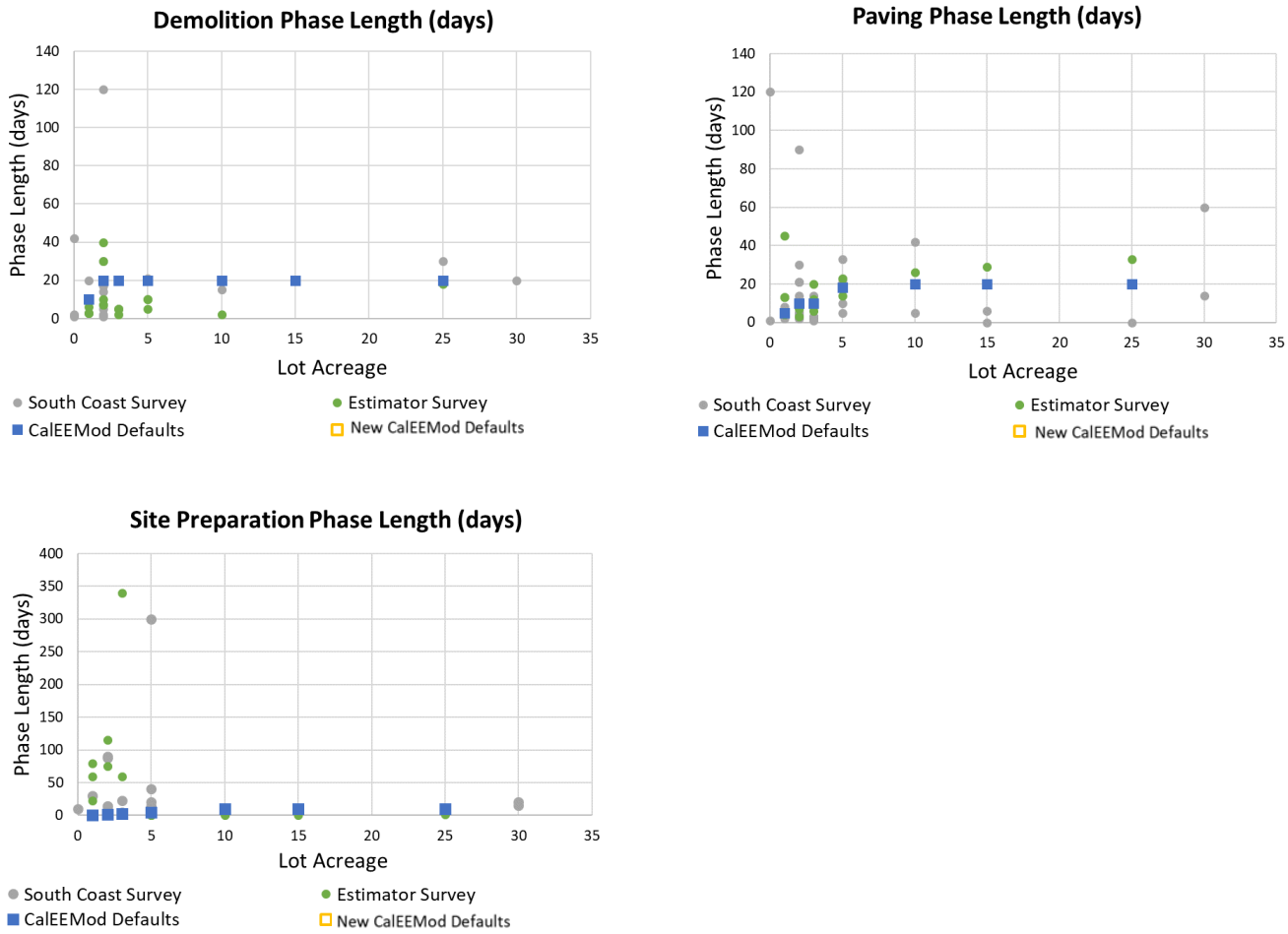

Figure B1. Excluded Construction Phase Length Plots by Project Lot Acreage for the demolition construction phase (upper left), paving phase (upper right), and site preparation phase (lower left)

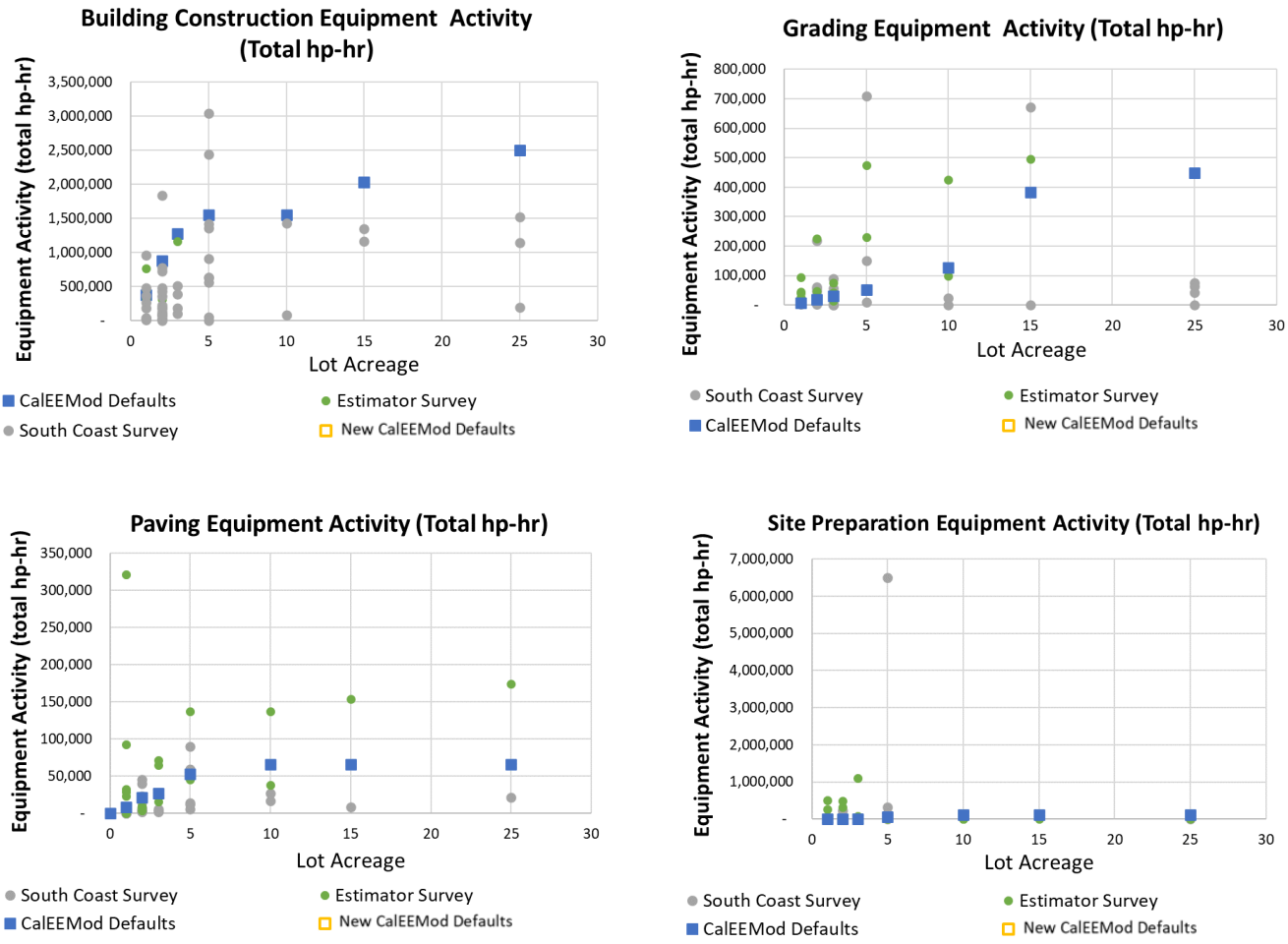

Figure B2. Excluded Phase Equipment Activity (Total hp-hr) Plot by Lot Acreage for the building construction phase (upper left), grading construction phase (upper right), paving phase (lower left), and site preparation phase (lower right)